TRANSACTIONS AND PROCEEDINGS

AND

REPORT

OF THE

ROYAL SOCIETY of SOUTH AUSTRALIA

(INCORPORATED).

VOL. XXIX.

[With Thirty-six Plates and Eighteen Figures in the Text.]

EDITED BY WALTER HOWCHIN, F.G.S.

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ERRATA.

Page 119, line 3, for MAIIDÆ read INACHIDÆ.

Page 121, line 21, for "figs. 3, 3*a*" read "fig. 3" only.

Page 124, line 7 from the bottom, for "forwards" read "upwards."

Page 131, omit line 6 of explanation of Plate xxii. In line 2 of explanation of Plate xxiii., for "Enlarged" read "Inferior view of anterior regions. Enlarged."

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Royal Society of South Australia

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APPENDICES.

AN OUTLINE OF A THEORY OF THE GENESIS OF PROTOPLASMIC MOTION AND EXCITATION.

By T. Brailsford Robertson, B.Sc.

From the Physiological Laboratory of the University of Adelaide.

Communicated by E. C. Stirling, M.D., F.R.S.

[Read April 4, 1905.]

Contents.

Introduction.

As far as I have been able to ascertain from the literature to which I have access, the theory which is put forward in this paper has not hitherto been propounded, at least in its entirety.

A number of authors have acknowledged the importance of surface tension in the vital processes of an organism,* but

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* Butschli (Protoplasm and Microscopic Foams: Trans. by E. A. Minchin, 1894, page 289) gives an account of various theories as to the influence of surface tension upon the movements of organisms which had been put forward up to that date. In the same work he develops his own theory, which, however, is quite different in principle from mine.

the influence of electrolytes upon the surface tension, taken in conjunction with the ion-proteid theory, does not appear to have been worked out. Loeb[*] alludes to his conviction that the electrical energy of the ions in an electrolyte is transformed into surface energy at the surface of an organism suspended in it; but, as far as I have read his writings, he does not explain how this is accomplished, nor does he apply the idea. Mann[†] suggests that the electrical charge on colloid particles in solution may be due to the formation of definite compounds between the colloid and one or other of the ions in the solution, an hypothesis of which I make frequent use throughout this paper. Strong[‡] has developed a theory of the nervous impulse, which regards it as due to free ions in the nerve, but as he does not adopt the ion-proteid theory he is forced to make assumptions—such as the semi-permeability of proteid to certain ions—which render his theory of very limited application.

I had already written the greater part of this paper when the *American Journal of Physiology* for March, 1904, arrived, containing Lillie's paper[§] on the toxic and anti-toxic effects of certain salts. In this he suggests that certain phenomena of movement in unicellular organisms may be due to surface tension alterations, due to ions in the medium, and he uses the analogy of the capillary electrometer; but, as far as contractility is concerned he does not appear to have applied the idea or to do more than throw it out as a suggestion; that is, so far as my acquaintance with his writings goes. Still more recently, Matthews' paper on the nature of chemical and electrical stimulation has appeared. In this he does not profess to give an explanation of the physico-chemical mechanisms of protoplasmic movement and excitation. Nevertheless, he concludes, as I do, "that the chemical composition of the ion is of little importance compared with the importance of its electrical condition."[¶] He also considers that electrical stimulation "is due simply to the accumulation of negative

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[*] Jacques Loeb: American Journal of Physiology, 1902, ii., page 411.

[†] Gustav Mann: Physiological Histology: Methods and Theory, 1902, pages 45 and 46.

[‡] W. M. Strong: A Physical Theory of Nerve. Journal of Physiology, 1900, vol. xxv., page 427.

[§] Ralph S. Lillie: The Relation of Ions to Ciliary Movement. American Journal of Physiology, March, 1904.

[||] The Nature of Chemical and Electrical Stimulation: 1. The physiological action of an ion depends upon its electrical state and its electrical stability. A. P. Matthews: American Journal of Physiology, August, 1904.

[¶] American Journal of Physiology, vol. xi., No. 5, page 456.

or positive ions in different places in the tissue, or, in other words, to differences in concentration of the ions." *

These are the only important allusions to theories similar to mine which I have been able to find; but, as the literature to which I have access is limited, my apologies are due to any authors whose published theories I may have put forward as original.

I do not, by any means, regard the whole of the hypotheses and deductions put forward in this paper as proved. Indeed, this paper is rather to be looked upon as providing an outline to be in the future corrected and filled in by an extended series of experimental investigations. My theory of chemotaxis, put forward in section 3, and some of my views on the propagation of excitation in muscle, put forward in section 6, are, however, upon a somewhat different footing, inasmuch as they already receive strong support from the experiments described in these sections, on infusoria, on the one hand, and on the intestine of a fly, on the other. I may state that I am about to bring forward strong experimental evidence in support of my views in section 13 of this paper on rhythmicity in muscle, and, at the same time, of those in sections 6 and 7, on the influence of the *mass* of ions upon the formation of ion-proteids in excitable tissues. I also hope before long to publish further experimental evidence touching my views on the transmission of excitation, and also further experiments on chemotaxis.

In concluding these introductory remarks, I desire to express my gratitude to Professor E. C. Stirling, F.R.S., for his suggestions, for facilities afforded me for experiments, and for the interest which he has taken in the preparation of this paper, and in the experiments; to Dr. C. J. Martin, F.R.S., and to Mr. J. A. Craw, for the care with which they read the paper and for their criticisms; to Professor W. H. Bragg, for a valuable criticism; and to Mr. W. Fuller for his advice and practical assistance in some of the experiments. This paper was written nearly a year ago, but, owing to its having been put into the hands of others, at a distance, for their consideration, its publication has been delayed.

1.—CONTACT DIFFERENCE OF POTENTIAL BETWEEN ELECTROLYTES AND ITS INFLUENCE UPON SURFACE TENSION.

It is a well-known fact that when two electrolytes, or two solutions of different concentration of the same electrolyte, are in contact, there is a difference of electric potential between their bounding surfaces, just as there is a difference

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* American Journal of Physiology, vol. xi., No. 5, page 457.

of potential at the contact surface of two metals, or of a metal and an electrolyte. Nernst explained the difference of potential existing between two solutions of the same salt when the concentrations differ by the ionic theory. If a strong solution of hydrochloric acid is in contact with pure water the acid will diffuse into the water. But, since the hydrions and chloridions are capable of independent motion—the velocity of the hydrion being greater than that of the chloridion—the hydrions will travel faster into the water than the chloridions. But the hydrions carry a positive charge, while the chloridions carry a negative charge; hence the water becomes positively charged owing to an excess of hydrions and the acid solution negatively charged owing to an excess of chloridions. In such a case as this, however, as the process goes on and the water becomes positively charged, an electrostatic repulsion will be produced, tending to retard the incoming hydrions and to accelerate the chloridions. This will go on until the electrostatic repulsion is so great as to cause the hydrions and chloridions to move into the weaker solution at the same rate. As the diffusion goes on the number of ions in the weaker solution will increase, and hence the tendency of the ions to diffuse in from the stronger solution will decrease, and the electrostatic repulsion necessary to maintain the equal velocities of the incoming hydrions and chloridions will diminish. Hence the contact difference of potential will, in this case, diminish as the concentrations of the two solutions approximate to each other.

It is on this principle that Lippmann and von Helmholtz explained the working of the capillary electrometer, and as we shall have to consider an analogous explanation of certain vital phenomena, it may be as well to glance at the method by which the capillary electrometer re-acts to electrical forces. The capillary electrometer in its simplest form consists of a capillary tube in which mercury and sulphuric acid meet. The end of the tube dips into the sulphuric acid, which rises to a point where it is in equilibrium with the mercury, which descends the tube under a certain pressure. At the meniscus there will exist a contact difference of potential; and, since the mercury and the sulphuric acid solution are both conductors, the difference of potential will lead to an accumulation of electricity on the two sides of the bounding surface. The mercury is positive to the solution, and therefore the double layer of electricity at the bounding surface consists of positive electrification on the mercury side and negative electrification on the solution side. If T be the observed surface tension of the surface separating two media, and the area of this surface is increased by an amount S, the work which is done is S T. Now, the surface of separation between the mercury and acid solution with its double layer may be regarded as a condenser of which the two armatures are charged to a potential difference E, where E is the contact difference of potential between the mercury and the solution.

In any condenser of which the plates are kept at a constant difference of potential, the electrical forces tend to *increase* the capacity of the condenser, and hence, in the case of this double layer, there is a tendency for the area of the double layer to increase. That is to say, that on account of the electrical forces the area of the surface of separation between the mercury and the solution tends to increase, so that the electrical forces reduce the amount of work which has to be done against the surface tension when the area of the surface of separation is increased. Thus, if T^1 is the value the surface tension would have, supposing no electrical double layer were present, the work done in increasing the area of the surface of separation by an amount S would be S T^1. Therefore, S T, the actual amount of work done, is less than S T^1, the amount of work which would have been done if no electrical double layer existed, by the amount of work done by the electrical forces owing to the increase in capacity of the double layer. Thus, T, the observed surface tension, is less than T^1, the surface tension if no double layer were present.

"Suppose the contact difference of potential between the mercury and the solution be E, the mercury being at the higher potential. Then, if an external E M F be applied so that the wire X" (leading to the mercury) "is positive, the difference of potential between the mercury and the solution will be greater than E by the amount of the applied E M F, and hence the charges on the double layer will be increased, so that the surface tension will be decreased, and to keep the meniscus in its sighted position the head of mercury . . . must be reduced. If, however, the applied E M F is in such a direction that it acts in the opposite direction to the contact difference of potential at the meniscus, then the strength of the double layer will decrease, and hence the surface tension will increase. This increase will go on till the applied E M F is exactly equal, and opposite to the contact difference of potential, for when this occurs there will be no double layer, and hence the surface tension will possess the value which it would have if no electrical charges were present. If the applied E M F is further increased, then a double layer will again be formed, but with the negative charge on the mercury side. This inverted double layer will cause a decrease in the surface tension, since the presence of such a double layer must decrease the surface tension, whichever side is positive. Hence, by applying an external E M F, so as to make the mercury negative, and increasing it till the surface tension, as indicated by the pressure which has to be applied to bring the meniscus to its sighted position, is a maximum, will be exactly equal and opposite to the contact difference of potential between the mercury and the sulphuric acid solution. In this way Lippmann found that the contact difference of potential between mercury and sulphuric acid solution was about 1 volt."*

2.—THE ION-PROTEID THEORY.

This theory, due to Loeb, is that when an ionised electrolyte diffuses into protoplasm the ions after this diffusion do not remain dissociated, but that they enter into loose combination with some proteid constituent of the protoplasm, this compound being known as ion-proteid. Loeb has brought forward many facts in support of this view, † which we need not enter into here, as we shall find many even more cogent reasons for adopting it in the sequel. I will only quote, after Loeb, a statement made by Dr. W. Pauli, of Vienna:—"We cannot doubt the general existence of ion-proteid compounds in the living organism. We have even urgent reasons for assuming that all the proteids of the protoplasm exist there only in combination with ions." Thus it would appear that the bulk of protoplasm is formed of ion-proteid compounds, and, indeed, it seems probable that they represent the culminating point of anabolism. We shall see the reasons for this view later.

If this be true, then it follows that, owing to metabolism and to dissociation analogous to the dissociation into ions of electrolytes, a number of these ions must, in general, exist in the protoplasm in a dissociated state, so that there will, in general, be a contact difference of potential between any protoplasmic body and the (liquid) medium in which it is suspended. This has been directly proved by W. B. Hardy ‡ in the case of particles of albumin suspended in acid and alkaline solutions. He states his conclusions thus:—"The proteid particles, therefore, have this interesting property: that their electrical characters are conferred upon them by the nature of the re-action, acid or alkaline, of the fluid. If the latter

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* Watson: Textbook of Physics, 1900, page 814.

† *Vide* On Ion-proteid Compounds and their *rôle* in the Mechanics of Life Phenomena. American Journal of Physiology, 1900.

‡ On the Coagulation of Proteid by Electricity. Journal of Physiology, June, 1899.

is alkaline the particles become electro-negative and *vice versa*."

It must be assumed that the ion-proteid is highly unstable in the presence of an excess of ions, and that therefore the nature of the ion-proteid formed depends upon the proportions of the ions present. If this be granted (and we shall see that it is an indispensable assumption in accounting for the various phenomena observed in muscle and nerve) we can at once see that the reason for the proteid particles becoming electro-positive in an acid solution is the high velocity of the hydrion which is the characteristic ion of acids; for far more kations are diffusing into the proteid particle than anions, and therefore the ion-proteid formed is, for the greater part, kation-proteid, and the particle becomes positively charged. Similarly, in alkalies the fastest ion is the anion, and therefore the proteid particles become electro-negative when the solution is alkaline.

3.—The Chemotaxis and Galvanotaxis of Unicellular Organisms.

We have now to consider the application of the principles which we have enunciated to unicellular organisms. We have seen that it is a characteristic of the proteid part of the ion-proteid molecule that it readily forms compounds with any ions which happen to be present in excess, while Hardy's experiments, referred to in the last section, show that the electrical character of the resulting ion-proteid depends upon the relative velocities of the ions in the solution in which the proteid is suspended. In the first case, consider the effect upon a unicellular (amœboid) organism of a constant current in the direction shown in the diagram (A = Anode, K = Kathode), the organism being supposed to be laden with kation-proteid by virtue of the metabolism and dissociation of which

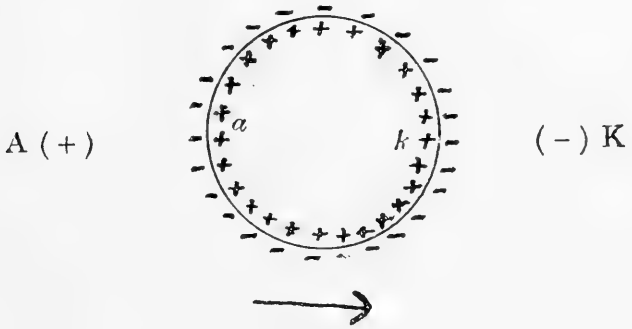

Figure 1.

a difference of potential is maintained between the protoplasmic surface and that of the medium (indicated by the small + and – signs).*

Just as in the analogous case of the capillary electrometer (section 2), the effect of a current travelling from A to K will be to *diminish* the contact difference of potential at points such as *a*, which form the physiological anode, and to *increase* it at points such as *k*, which form the physiological kathode.

Therefore, as we have seen (section 2), the effect will be to *increase* the surface tension at points such as *a*, and to *decrease* it at points such as *k*. The surface, and, consequently, the volume on the kathodic side of the organism will therefore *increase*, while on the anodic side they will *decrease*. The organism will, therefore, move over towards the kathode, as indicated by the arrow—it will be "negatively galvanotactic." Consider now the effect of a similar current upon a "negative" amœboid organism; that is, one which is laden with anion-proteid, so that the difference of potential between the protoplasmic surface and that of the medium is as represented in the diagram. In this case the contact difference of potential will be *increased* at the physiological anode, and *decreased* at the physiological kathode; hence, reasoning as before, the organism will move towards the *anode* —it will be "positively galvanotactic." The effects upon ciliated organisms will be similar, for if the diagram represents one of the cilia of a "positive" organism subjected to a constant current in the sense indicated, the P.D. (difference of

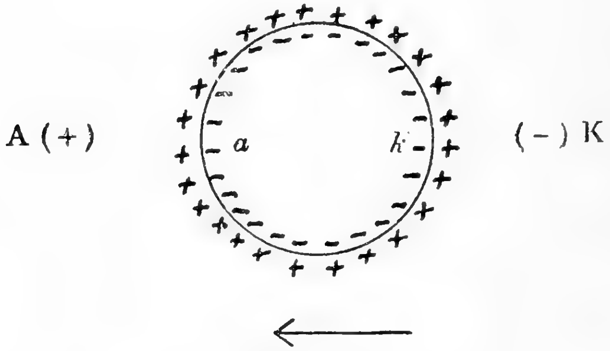

FIGURE 2.

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* As such organisms are electro-positive to the solution in which they are suspended, I will in the future distinguish them as "positive," those which are laden with anion-proteid being designated "negative."

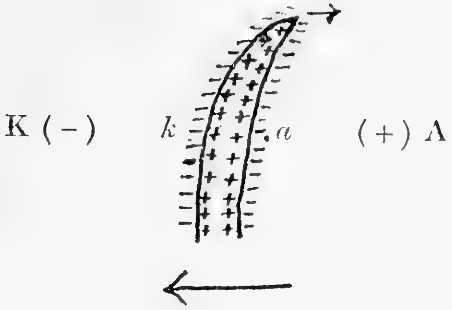

FIGURE 3.

potential) at the surface forming the physiological anode will be diminished, and that at the physiological kathode increased; hence the former surface will diminish owing to the increased surface tension, and the latter will increase; hence the cilium will bend towards the anode, as indicated by the small arrow, and the organism will be propelled towards the kathode —it will be "negatively galvanotactic." The effect of the same current on a "negative" ciliated organism will, of course, be the reverse. Hence, we may formulate the rule that *"positive" organisms will be attracted to the kathode, and "negative" organisms to the anode.* When a very strong current is passed, the lowering of the surface tension at kathodic points in a "positive" organism or at anodic points in a "negative" organism may be so excessive that the parts of the surface no longer cohere, and the organism breaks up. This is the explanation of the disintegration of certain organisms under the action of a constant current, *e.g.*, Pelomyxa.* The effect of the constant current upon organisms which are neither "negative" nor "positive"—that is, which are equally loaded with anions and kations—must obviously be *attraction to both electrodes*, since a contact P.D. would be artificially produced at both surfaces; thus, such organisms would not exhibit any marked preference for either electrode. We have now to consider the effects of chemical re-agents upon these organisms.

From the point of view of the theory which I have put forward, the phenomena of chemotaxis must be attributed to the diffusion of the ions in the re-agents into the protoplasm in different proportions. Consider the effect upon a "positive" amœboid cell (A, Fig. 4), of a salt such as KCl, in which the kation has a greater velocity than the anion, diffusing from a capillary (B). Since the quicker-moving kations will diffuse faster than the anions, more kations will enter the

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* Verworn: General Physiology: Trans. by Frederic S. Lee, page 419.

organism, in a given time, than anions; that is, the contact P.D. at points such as *a* (Fig. 4), will be augmented, and at points such as *b* unaffected or much less augmented (since the concentration of the KCl is as the inverse square). Hence the surface tension at *b* will be greater than that at *a*, and the organism will move *towards* the capillary.

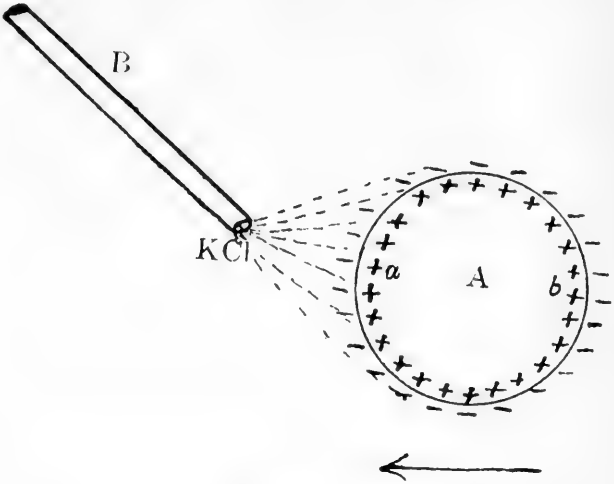

FIGURE 4.

With a salt like $CaCl_2$, in which many more anions would enter the organism, in a given time, than kations, the reverse would be the case.

If the organism were "negative" the above effects would be reversed.

Of course, leaving a "positive" organism within the sphere of influence of $CaCl_2$ for a sufficient time would convert its initial repulsion from the $CaCl_2$ into attraction, for the organism would become "negative" owing to the excess of anions entering from the $CaCl_2$. Similarly, a "negative" organism, exposed for too long a time to the influence of a re-agent in which the kations move faster than the anions (*e.g.*, KCl, or an acid) would become "positive."

"Isotactic" organisms—as we may call those organisms which are equally loaded with anions and kations—would, of course, be attracted by both kinds of re-agents, for an artificial P.D. would be established on the side nearest the re-agent, and the surface tension therefore decreased at those points: but, as this P.D. would be very small except in organisms quite close to the capillary, such organisms would exhibit no marked re-action.

The theoretical results at which we have arrived may be tabulated as below:—

State of Organism.	Nature of Re-agent.		Galvanotaxis.
	Kation faster than Anion.	Anion faster than Kation.	
Positive	Attraction	Repulsion	Attraction to Kathode
Negative	Repulsion	Attraction	Attraction to Anode
Isotactic	Attraction	Attraction	Attraction to Anode and Kathode

The stimulation effect of a re-agent will be proportional to the difference of potential between the organism and the medium. This will be $= k \dfrac{\dfrac{u}{y_1} - \dfrac{v}{y_2}}{u + v} \log_e \dfrac{c_2}{c_1}$. Where k is a constant (the temperature being constant), u and v are the velocities of the kation and anion respectively, y_1 and y_2 are their valencys respectively, and c_2 and c_1 are the concentrations of the electrolyte in the medium and in the organism respectively.* If $\dfrac{c_2}{c_1}$ be constant, and it is probably nearly so when equivalent solutions are used throughout, we have that the stimulation effect of an electrolyte is proportional to $\dfrac{\dfrac{u}{y_1} - \dfrac{v}{y_2}}{u + v}$, which we may call the "stimulation efficiency" of the electrolyte.† Since $\dfrac{v}{u + v}$ is Hittorf's "transport number," and is usually denoted by n, the stimulation efficiency may also be expressed by $\dfrac{1 - n}{y_1} - \dfrac{n}{y_2}$, which reduces to $1 - 2n$, if the ions are mono-valent.

We cannot assume, it is true, that the stimulation effects of different re-agents will be strictly proportional to their

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*Vide Whetham: A Treatise on the Theory of Solution, 1902, page 382.

† I originally defined the "stimulation efficiency" as $\dfrac{u - v}{u + v}$ which, of course, is only true for univalent ions. I am indebted to Mr. J. A. Craw for the above correction.

"stimulation efficiencies" partly because it is uncertain whether $\frac{c_2}{c_1}$, referred to above, is constant, and also because of the ion-proteid already present in the organism, the influence of which will be to lessen or to increase the effect of the testing re-agent. Still, the "stimulation efficiency" of a re-agent will serve as a rough index of its probable effect, and I therefore append a rough table of the re-agents most commonly used as stimuli in physiology, with their ionic velocities and "stimulation efficiencies," the sign + before the stimulation efficiency denoting attraction of a "positive" organism, and the sign − attraction of a "negative" organism.

If the stimulation efficiency be calculated from the ionic velocities it will not be accurate except for very dilute, completely ionised, solutions. A more accurate method is to calculate the stimulation efficiency from the value of the transport number n, at the dilution which we are using. But, in order to make the table more general, I have, except in the cases of the carbonates and $MgCl_2$, calculated the stimulation efficiency from the ionic velocities. It is necessary to bear in mind, however, that solutions of a salt formed by the neutralisation of a strong base by a weak acid, as, for example, Na_2CO_3, always contain OH ions, which have a very high velocity, and which tend to render the stimulation efficiency negative. Finally, in order to observe any proportion between the stimulation effects of different re-agents we must use equivalent solutions. The ionic velocities of Cu, Ba, Ca, SO_4, and Ag, in the accompanying table, are taken from the results given by W. C. D. Whetham in the Philosophical Transactions of the Royal Society.[*] Those of Cl and I are from Kohlrausch's results, quoted by Whetham.[†] Whetham found that his results, obtained by a direct method, corresponded very closely with Kohlrausch's. Those of K, Na, Li, H, NO_3, and OH are from Kohlrausch's results quoted by Watson.[‡] The stimulation efficiencies of K_2CO_3, Na_2CO_3, and $MgCl_2$ are calculated from the transport numbers for dilute solutions (·029, ·093, and ·087 equivalent gramme molecules per litre respectively) given in Fitzpatrick's "The Electro-Chemical Properties of Aqueous Solutions."[§]

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[*] Vol. clxxxiv. A, page 337; and vol. clxxxvi. A, page 507.

[†] *Ibid.*

[‡] Textbook of Physics, 1900, page 798.

[§] British Association Report, 1893. Reprinted by Whetham in his Theory of Solution and Electrolysis.

The re-agents are in the order of their "stimulation efficiencies."

TABLE OF STIMULATION EFFICIENCIES.

Substance.		Velocity of Kation in Centimetres per Second.	Velocity of Anion in Centimetres per Second.	Stimulation Efficiency.
H_2SO_4	...	320×10^{-5}	45×10^{-5}	+ ·815
HCl	...	320×10^{-5}	53×10^{-5}	+ ·716
HNO_3	...	320×10^{-5}	64×10^{-5}	+ ·667
K_2CO_3	...	—	—	+ ·547
K_2SO_4	...	66×10^{-5}	45×10^{-5}	+ ·392
Na_2CO_3	...	—	—	+ ·289
Na_2SO_4	...	45×10^{-5}	45×10^{-5}	+ ·250
KCl	...	66×10^{-5}	53×10^{-5}	+ ·109
KI	...	66×10^{-5}	60×10^{-5}	+ ·048
KNO_3	...	66×10^{-5}	64×10^{-5}	+ ·015
$NaCl$	...	45×10^{-5}	53×10^{-5}	– ·082
$CuSO_4$	...	31×10^{-5}	45×10^{-5}	– ·092
$AgNO_3$	...	49×10^{-5}	64×10^{-5}	– ·133
NaI	...	45×10^{-5}	60×10^{-5}	– ·143
$NaNO_3$	...	45×10^{-5}	64×10^{-5}	– ·174
$LiCl$	...	36×10^{-5}	53×10^{-5}	– ·191
$BaCl_2$	...	39×10^{-5}	53×10^{-5}	– ·364
$CaCl_2$	...	35×10^{-5}	53×10^{-5}	– ·403
$CuCl_2$	...	31×10^{-5}	53×10^{-5}	– ·446
KOH	...	66×10^{-5}	182×10^{-5}	– ·468
$MgCl_2$	...	—	—	– ·517
$NaOH$	...	45×10^{-5}	182×10^{-5}	– ·604
$LiOH$	...	36×10^{-5}	182×10^{-5}	– ·670
$Ba(OH)_2$	...	39×10^{-5}	182×10^{-5}	– ·735
$Ca(OH)_2$	...	35×10^{-5}	182×10^{-5}	– ·758

The third decimal place in the column of stimulation efficiencies is the nearest approximation.

To test the conclusions arrived at in this section, it is necessary to ascertain the state, "positive" or "negative," of the organism, and then to test its re-actions to various reagents, and to the constant current, under the same conditions.

This appears not to have been done hitherto. H. H. Dale, it is true, has made investigations of this nature,* but he nearly always uses acetic acid in his media or in his test

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* Journal of Physiology, 1901, vol. xxvi., page 291.

solutions. For our purposes this choice is most unfortunate, as the dissociation of acetic acid is very small, even in dilute solutions; indeed, it is only half dissociated when the solution contains only about two parts of acetic acid per million.* Moreover, the amount of hydrion due to acetic acid is greatly reduced on its diffusion into a medium containing highly ionised salts (as was the case in Dale's experiments), while the acetanions are not correspondingly reduced, and the resultant proportions of ions depend upon the electrolytes into which it is diffusing.† Hence the theoretical effects of acetic acid are highly uncertain, and this corresponds with the uncertainty of Dale's results. Such sources of ambiguity do not arise when we use strong acids in dilute solution and perfectly ionised solutions of salts. A number of other investigators have tested the effects of various re-agents upon unicellular organisms, but as they did not previously ascertain the nature of the ions in the medium in which the organisms were tested their results tell us nothing with regard to this theory. I therefore carried out a series of experiments with a view towards systematically testing the accuracy of the conclusions put forward in this section. The organisms used were the infusoria in the large intestine and rectum of a frog *(Ranaodea aurea)*. Four species were found and used in these experiments, namely:—1. A species of *Spirostomum*, closely resembling, if not identical with, *S. ambiguum*. 2. A species of *Opalina*, probably *Opalina ranarum*. 3. A large disc-shaped species, more than half the length of *Spirostomum sp.*, and nearly as wide as it is long, much flattened laterally, endoplasm in front of the mouth, triangular in shape, slightly recurved. 4. A much smaller species, only about half the length of *Opalina sp.*, but otherwise resembling the last-mentioned species. The two latter species, in the absence of any expert knowledge of the subject, I am unable to name. I will, therefore, designate them, respectively, species A and species B.

A cell of wax was made on a glass slide. It measured about $\frac{3}{4}$ in. square, and the walls were about 1 millimetre deep. In two opposite walls of the cell were grooves, which were the same depth as the walls. A small portion of the intestinal or rectal contents was placed in the cell, and a large drop of a given solution, the medium, was placed in the cell with it. This was left for a varying period, and then a cover-glass was placed on the cell, any spaces in the cell being

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* Walker: Introduction to Physical Chemistry, third edition, page 236.

† *Vide* Walker: Introduction to Physical Chemistry, third edition, pages 304 and 316.

filled up with some more of the solution. Capillaries containing the test-solutions were then inserted through the grooves, so as to project slightly into the cell, and the remainder of the capillary was sometimes slightly raised by resting it on slips of paper, in order to aid diffusion by gravity. The various parts of the cell, etc., are indicated in the diagram (Fig. 5). The cell was then examined under the low power of a microscope, or with a magnifying glass.

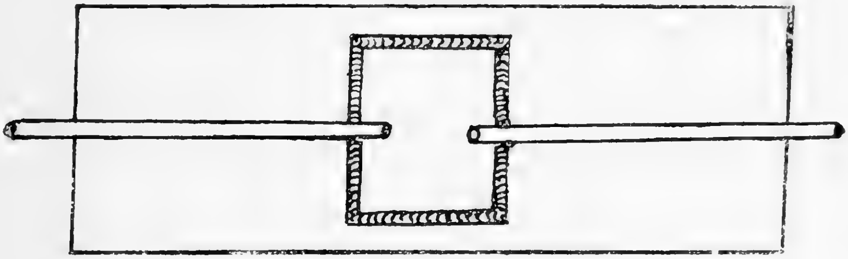

FIGURE 5.

The object of placing the organisms first in a known medium was to ensure their being "positive" or "negative," as desired. Thus an organism which had been placed for ten minutes in a decinormal solution of KCl would be positive, owing to the excess of kations which had entered it; and its reaction, if our reasoning has been correct, should be attraction to a solution with a positive stimulation efficiency, and repulsion from a solution with a negative stimulation efficiency. Of course, it is quite uncertain what salts have been introduced with the rectal contents, but as the proportion of rectal contents in the cell to the volume of the medium was, in each experiment, small, the influence of the introduced salts was negligible. The results of the experiments, as the accompanying table shows, are in entire harmony with the theory I have put forward—in every case the theoretical and actual results are the same. Experiment No. 14 might be thought to be an exception, but when we remember the extremely low stimulation efficiency of KNO_3, and that its effect might be very easily neutralised by small quantities of salts with negative stimulation efficiencies introduced with the rectal contents we see that the organisms, in this case, were very probably isotactic. It will also be observed that the re-action always takes place quickly when media with a high stimulation efficiency were employed; and delay, as in experiment No. 9, only occurred when the stimulation efficiency of the medium was low. As there were generally individuals of more than one species in the cell, some of the results were obtained simultaneously, *e.g.*, experiment No. 3 gave results for *Spirostomum*, *Opalina*, and species B.

No. of Experiment.	Organism.	Medium.	Tested with	Re-Action.	Remarks.
1	*Spirostomum*	$\frac{N}{10}$KI	$\frac{N}{50}$HCl and $\frac{N}{50}$BaCl$_2$	Attraction to HCl and repulsion from BaCl$_2$	The specimens were washed in $\frac{N}{10}$NaCl and then placed in $\frac{N}{10}$KI for a few minutes—they formed a thick cluster in the HCl capillary almost at once, the space about the BaCl$_2$ capillary being left free.
2	*Spirostomum*	$\frac{N}{10}$KI	$\frac{N}{50}$HCl and $\frac{N}{50}$BaCl$_2$	Attraction to HCl	The specimens were placed in $\frac{N}{10}$KI and left for 1 hr. 5 min., then tested with $\frac{N}{50}$HCl and $\frac{N}{50}$BaCl$_2$, the organisms formed a thick semicircular cluster some distance from the BaCl$_2$ tube, some entered the HCl tube. Left the capillaries in the chemotaxis cell for 1 hour. The infusorians had formed a thick cluster in the acid tube, and a few had entered the BaCl$_2$ tube. On testing with litmus the contents of both tubes were acid, but those of the HCl tube much more acid than those of the BaCl$_2$ tube.

3	*Spirostomum*	$\frac{N}{10}$KCl	$\frac{N}{10}$HCl and $\frac{N}{10}$BaCl$_2$	Attraction to HCl and repulsion from BaCl$_2$	A small portion of the rectal contents was placed in $\frac{N}{10}$KCl and left for half an hour, then tested with $\frac{N}{10}$HCl and $\frac{N}{10}$BaCl$_2$. The organisms were uniformly and thickly distributed through the cell at the beginning of the experiment Within 5 mins. the half of the cell into which the acid capillary was inserted was distinctly more thickly populated than the half into which the BaCl$_2$ capillary was inserted. In a quarter of an hour the whole of the BaCl$_2$ half of the cell was deserted, and in half an hour the organisms had formed a thick mass immediately in front of the HCl capillary. In three-quarters of an hour the acid tube was completely choked with infusoria for an inch of its length. Temperature, 27° C.
4	*Spirostomum*	$\frac{N}{10}$NaCl	$\frac{N}{10}$HCl and $\frac{N}{10}$BaCl$_2$	Repulsion from acid—no marked attraction to BaCl$_2$	A portion of the contents of the same rectum as in the last experiment was placed in $\frac{N}{10}$NaCl and left for 1 hr. 10 mins. Then tested with $\frac{N}{10}$HCl and $\frac{N}{10}$BaCl$_2$. The space round the mouth of the HCl tube remained clear even after 40 minutes. The space round the BaCl$_2$ tube was not markedly affected; the organisms swam freely round the mouth of the tube, and a few entered it, but they were not markedly thicker in this locality than in other parts. Temperature, 27° C.

No. of Experiment.	Organism.	Medium.	Tested with	Re-Action.	Remarks.
5	*Spirostomum*	$\frac{N}{10}BaCl_2$	$\frac{N}{10}HCl$ and $\frac{N}{10}BaCl_2$	Repulsion from acid	Some of contents of rectum placed in $\frac{N}{10}BaCl_2$ for 40 minutes, then tested with $\frac{N}{10}HCl$ and $\frac{N}{10}BaCl_2$, marked repulsion from the acid at once. After half an hour the organisms had distinctly moved over to the $BaCl_2$ half of the cell, and the acid half contained only scattered individuals. At the end of 50 minutes a large area in front of the acid tube was completely clear of organisms and there was a thick cluster round the $BaCl_2$ capillary. Temperature, 27° C.
6	*Spirostomum*	$\frac{N}{10}KNO_3$	$\frac{N}{10}HCl$ and $\frac{N}{10}BaCl_2$	Attraction to acid and repulsion from $BaCl_2$	Some of contents of same rectum as in the previous experiment placed in $\frac{N}{10}KNO_3$, and left for 50 minutes, then tested with $\frac{N}{10}HCl$ and $\frac{N}{10}BaCl_2$. In 10 minutes the infusoria had crowded up the acid tube; in half an hour the $BaCl_2$ half of the cell was almost deserted, and the acid tube was choked up with infusoria. Temperature, 27° C.

7	*Spirostomum*	$\frac{N}{10}$ KCl	$\frac{N}{10}$ HCl and $\frac{N}{10}$ KOH	Attraction to acid and repulsion from alkali	Some of contents of rectum placed in $\frac{N}{10}$ KCl and left for half an hour, tested with $\frac{N}{10}$ KOH and $\frac{N}{10}$ HCl. After 5 minutes no infusoria were near the mouth of the alkali tube, and several had entered the acid tube, in front of which a number of infusoria had congregated. In quarter of an hour there was a marked clearance-area round the mouth of the alkali tube, and the infusoria were thickly congregated round the acid tube. After three-quarters of an hour the alkali half of the cell was absolutely deserted, while the acid half was thickly populated, the acid tube being choked up with *Spirostomum* and *Opalina* for about an inch. Temperature, 21° C.
8	*Spirostomum*	$\frac{N}{10}$ $CaCl_2$	$\frac{N}{10}$ HCl and $\frac{N}{10}$ KOH	Attraction to alkali and repulsion from acid	Some of contents of rectum placed in $\frac{N}{10}$ $CaCl_2$ and left for three-quarters of an hour, tested with $\frac{N}{10}$ HCl and $\frac{N}{10}$ KOH. The organisms were initially scanty, but active, and spread uniformly over the cell. In 10 minutes the space for some distance round the acid tube was quite clear, and there was a small cluster round the alkali tube, which was being continually added to by freshly arriving individuals. In 20 minutes the whole cell was deserted, except immediately in front of the alkali tube, where there was a thick cluster. Temperature, 21° C.

No. of Experiment.	Organism	Medium.	Tested with	Re-Action.	Remarks.
3	*Opalina*	$\frac{N}{10}$KCl	$\frac{N}{10}$HCl and $\frac{N}{10}$BaCl$_2$	Attraction to acid and repulsion from BaCl$_2$	Contents of rectum in $\frac{N}{10}$KCl for half an hour, then tested. The organisms were initially scanty but uniformly spread over the cell. In quarter of an hour none were left in the BaCl$_2$ half of the cell, and the organisms had formed a cluster round the mouth of the acid tube. In half an hour this cluster contained all the specimens of *Opalina* in the cell, and several had entered the tube. Temperature, 27° C.
6	*Opalina*	$\frac{N}{10}$KNO$_3$	$\frac{N}{10}$HCl and $\frac{N}{10}$BaCl$_2$	Attraction to acid and repulsion from BaCl$_2$	Contents of rectum in $\frac{N}{10}$KNO$_3$ for 50 minutes, then tested. The *Opalina* were numerous but sluggish. In 10 minutes the organisms had crowded up the acid tube, and in half an hour the BaCl$_2$ half of the cell was deserted except for a few inert, apparently dead, individuals. Temperature, 27° C.
7	*Opalina*	$\frac{N}{10}$KCl	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Attraction to acid and repulsion from alkali	Contents of rectum in $\frac{N}{10}$KCl for half an hour, then tested. After 5 minutes a clearance-area had been formed in front of the alkali tube, and there was a cluster in front of the acid tube. After three-quarters of an hour the alkali half of the cell was absolutely deserted, and there was a thick cluster round the mouth of the acid tube, into which many of the infusoria had entered. Temperature, 21° C.

9	*Opalina*	$\frac{N}{10}$KI	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Repulsion from alkali—no marked attraction to acid	Rectum of frog left in tap-water overnight; some of contents then placed in $\frac{N}{10}$KI and left three-quarters of an hour, then tested. *Opalina* very sluggish—at first no marked re-action, but after 20 minutes the space in front of the alkali tube was for some distance clear of *Opalina*, except for a few inert, apparently dead, individuals. Temperature, 20° C.
10	*Opalina*	$\frac{N}{10}$NaCl	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Attraction to alkali and repulsion from acid	Some of contents of same rectum as in previous experiment. Left in $\frac{N}{10}$NaCl for 55 minutes, then tested. Organisms numerous and fairly active. In 5 minutes there was a marked cluster round the alkali tube, and there was a clear space round the acid tube. In half an hour the acid half of the cell was deserted, and the alkali half thickly populated, especially just in front of the mouth of the alkali tube. Temperature, 20° C.
11	*Opalina*	$\frac{N}{40}$$Na_2CO_3$	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Attraction to acid and repulsion from alkali	Rectum left 24 hours in tap-water; some of contents placed in $\frac{N}{40}$$Na_2CO_3$ which did not affect *Opalina* injuriously. Left for 10 minutes, then tested. The organisms immediately swam towards the acid tube, and within 2 minutes had formed a thick cluster in the mouth of the tube, while a dense cluster was formed just outside. The space round the alkali tube was almost clear, and the few individuals left there appeared dead, being motionless, and many of them contracted into a spherical form.

No. of Experiment.	Organism.	Medium.	Tested with	Re-Action.	Remarks.
12	*Opalina*	$\frac{N}{40}\mathrm{BaCl}_2$	$\frac{N}{10}\mathrm{HCl}$ and $\frac{N}{10}\mathrm{KOH}$	Attraction to alkali and repulsion from acid	Some of contents of same rectum used in previous experiment placed in $\frac{N}{40}\mathrm{BaCl}_2$, which did not affect *Opalina* injuriously. Tested in 10 minutes. Marked attraction to the alkali tube. Within 2 minutes several had entered the tube, and stopped there motionless, while a cluster of very active individuals had been formed in front of the tube. The acid tube was clear, and one or two individuals in its vicinity were motionless.
9	Species A	$\frac{N}{10}\mathrm{KI}$	$\frac{N}{10}\mathrm{HCl}$ and $\frac{N}{10}\mathrm{KOH}$	Attraction to acid and repulsion from alkali	Rectum left in tap-water overnight; some of contents placed in $\frac{N}{10}\mathrm{KI}$ and left three-quarters of an hour, then tested. Organisms of this species scanty. At first no marked re-action, but after 20 minutes there was a small cluster of this species round the mouth of the acid tube, and five minutes later a number of individuals had entered the tube. The space in front of the alkali was quite clear. Temperature, 20° C.

10	Species A	$\frac{N}{10}NaCl$	$\frac{N}{10}HCl$ and $\frac{N}{10}KOH$	Attraction to alkali and repulsion from acid	Some of contents of same rectum used in above experiment placed in $\frac{N}{10}NaCl$ for 55 minutes, then tested. Organisms of this species were scanty. In five minutes several had gathered round the mouth of the alkali tube ; in quarter of an hour the acid half of the cell was deserted, and there was a small cluster of this species round the mouth of the alkali tube which comprised all the individuals in the cell. Temperature, 20° C.
3	Species B	$\frac{N}{10}KCl$	$\frac{N}{10}HCl$ and $\frac{N}{10}BaCl_2$	Attraction to acid and repulsion from $BaCl_2$	Some of contents of rectum placed in $\frac{N}{10}KCl$ and left for half an hour, then tested. Organisms numerous. In a quarter of an hour the half of the cell into which the $BaCl_2$ tube was inserted was deserted and a thick cluster had formed in front of the acid tube. This cluster in half an hour contained all the individuals of this species in the cell, but none of them entered the tube. Temperature, 27° C.
6	Species B	$\frac{N}{10}KNO_3$	$\frac{N}{10}HCl$ and $\frac{N}{10}BaCl_2$	Attraction to acid and repulsion from $BaCl_2$	Some of contents of rectum placed in $\frac{N}{10}KNO_3$ and left for 50 minutes, then tested. In 10 minutes all the infusoria of this species had gathered in front of the acid tube, the alkali tube being clear. Temperature, 27° C.

No. of Experiment.	Organism.	Medium.	Tested with	Re-Action.	Remarks.
7	Species B	$\frac{N}{10}$KCl	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Attraction to acid and repulsion from alkali	Some of contents of rectum placed in $\frac{N}{10}$KCl and left for half an hour, then tested. In five minutes the space round the mouth of the alkali tube was deserted and the organisms formed a small cluster in front of the acid tube; in three-quarters of an hour this cluster contained all the individuals of this species in the cell and was much larger. Temperature, 21° C.
9	Species B	$\frac{N}{10}$KI	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Attraction to acid and repulsion from alkali	Rectum left in tap-water overnight. Some of contents placed in $\frac{N}{10}$KI and left three-quarters of an hour, then tested. No marked reaction at first – but in about 20 minutes there was a small cluster of this species round the acid tube, while the space round the alkali tube was free from them. A quarter of an hour later a number of individuals had entered the acid tube. Temperature, 20° C.
10	Species B	$\frac{N}{10}$NaCl	$\frac{N}{10}$HCl and $\frac{N}{10}$KOH	Attraction to alkali and repulsion from acid	Some of contents of same rectum used in above experiment placed in $\frac{N}{10}$NaCl for 55 minutes, then tested. In five minutes the space round the acid tube was clear. In quarter of an hour there was a thick cluster round the mouth of the alkali tube. Temperature, 20° C.

13	Species B	$\frac{N}{10}Na_2CO_3$	$\frac{N}{10}HCl$ and $\frac{N}{10}KOH$	Attraction to acid and repulsion from alkali	Rectum left 24 hours in tap-water; some of contents placed in $\frac{N}{10}Na_2CO_3$ and tested in 10 minutes. Marked attraction to acid. In five minutes a cluster round acid containing all the individuals in the cell. Alkali free.
14	Species B	$\frac{N}{10}KNO_3$	$\frac{N}{10}HCl$ and $\frac{N}{10}KOH$	No reaction	Rectum left 24 hours in tap-water; some of contents placed in $\frac{N}{10}KNO_3$, and tested in 10 minutes. No marked attraction for either tube, even after half an hour.
15	Species B	$\frac{N}{10}CaCl_2$	$\frac{N}{10}HCl$ and $\frac{N}{10}KOH$	Attraction to alkali and repulsion from acid	Some of contents of same rectum used in above experiment placed in $\frac{N}{10}CaCl_2$ and tested after 10 minutes. Marked attraction to alkali; in five minutes a small cluster had formed round the mouth of the alkali tube, while the space in front of the acid tube was clear.

It was found that *Spirostomum sp.* was an ideal species for these investigations, as it was not injuriously affected by the solutions, and was very active and sensitive to the test solutions. Species A and B were also uninjured by the solutions, but did not, as a rule, re-act quite so quickly as *Spirostomum sp.* *Opalina* was very liable to injury by decinormal solutions—the action of KCl and of NaCl in this respect was capricious—sometimes decinormal solutions appeared to kill the organisms, sometimes not. Decinormal solutions of Na_2CO_3, $CaCl_2$, and $BaCl_2$, were very injurious to *Opalina*, the two latter causing almost immediate disintegration, doubtless owing to their high stimulation efficiency causing excessive lowering of the surface tension. Decinormal KOH killed all the species and caused disintegration, doubtless, again, on account of its high stimulation efficiency.

The galvanotaxis of these organisms was also tested. The ordinary stimulation trough, with parallel sides of porous clay, described by Verworn,* was employed, and non-polarisable brush electrodes were used to lead in the current. The following results were obtained :—

1. Rectum of a frog left in tap water overnight. Some of contents placed in $\frac{N}{10}$ KCl in the stimulation trough and left for a quarter of an hour. Then tested with three two-volt storage cells. *Opalina* all dead. Species B numerous, their rotatory movements became slower and tended towards the kathode. In ten minutes the anodic half of the trough was deserted, and the kathodic half well populated, especially near the kathode.

2. Some of contents of same rectum placed in $\frac{N}{10}CaCl_2$ for a quarter of an hour. *Opalina* all dead. Species B numerous. Tested with three two-volt storage cells. Organisms proceeded with an irregular, wavy motion towards the anode, and in a few minutes had formed a small cluster there, which remained unaltered. Several individuals, however, remained in the kathodic half of the cell.

3. Rectum left forty-eight hours in tap water. Some of contents placed in $\frac{N}{40}Na_2CO_3$, and left for half an hour. Tested with ten two-volt storage cells. Organisms scanty, consisting of *Opalina* and species B. Both to kathode, the attraction of species B being hampered by its rotatory movements. In half an hour a small cluster had formed at the kathode.

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* **Verworn: General Physiology: Trans. by Frederic S. Lee, page 416.**

4. Some of contents of same rectum placed in $\frac{N}{40}$KI, and left for half an hour. Tested with ten two-volt storage cells. *Opalina* and species B, both to kathode. After half an hour still at kathode, where they had formed a small cluster.

Thus the results of these experiments on galvanotaxis in different media also go to support the theory I have put forward. In addition, it may be mentioned that the results of Dale's experiments in galvanotaxis go generally to support this theory.* Thus, *Balantidium duodeni* shaken into solutions of increasing acidity collected closely at the kathode when the solution contained ·02 per cent. HCl, the current being six pint bichromate cells. The same species in pure ·6 per cent. NaCl went to anode with moderate currents, and to kathode with twelve cells. The latter result I believe to be due to the acid liberated at the anode causing the organisms to become "positive." Dale also found that *Opalina* in ·6 per cent. saline and ·01 per cent. NaOH collected at the anode, and that *Nyctotherus* did the same when left in the solution for a sufficient time (ten minutes), and other instances, in which he used only specified inorganic solutions, will be noticed on referring to Dale's paper.

4. THE STRUCTURE OF STRIATED MUSCLE.

The following is extracted from Schäfer's "Essentials of Histology," sixth edition, page 102 :—"The sarcostyles are subdivided at regular intervals by thin transverse disks (membranes of Krause) into successive portions, which may be termed *sarcomeres;* each sarcomere is occupied by a portion of the dark stria of the whole fibre (sarcous element). The sarcous element is really double, and in the stretched fibre separates into two at the line of Hensen. At either end of the sarcous element is a clear substance (probably fluid or semi-fluid), separating it from the membrane of Krause. This clear substance is more evident the more the fibril is extended, but diminishes to complete disappearance in the contracted muscle. The cause of the change is explained when we study more minutely the structure of the sarcous element. For each sarcous element is pervaded with longitudinal canals or pores, which are open in the direction of Krause's membrane, but closed at the middle of the sarcous element. In the contracted muscle the clear part of the muscle substance has disappeared from view, but the sarcous element is swollen and the sarcomere is thus shortened ; in the uncontracted muscle,

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* H. H. Dale: Galvanotaxis and Chemotaxis of Ciliate Infusoria. Journal of Physiology, 1901, page 291.

on the other hand, the clear part occupies a considerable interval between the sarcous element and the membrane of Krause, the sarcomere being lengthened and narrowed. The sarcous element does not lie free in the middle of the sarcomere, but is attached at either end to Krause's membrane by very fine lines, which may represent fine septa, running through the clear substance: on the other hand, Krause's membrane appears to be attached laterally to a fine membrane, which limits the fibril externally." Page 105:—"Comparing the structure of the sarcomere with that of the protoplasm of an amœboid cell, we find in both a framework (spongioplasm, substance of sarcous element), which tends to stain with haematoxylin and similar re-agents, which encloses in its meshes or pores a clear, probably semi-fluid, substance (hyaloplasm, clear substance of sarcomere), which remains unstained by these re-agents. In both instances, also, the clear substance or hyaloplasm, when the tissue is subjected to stimulation, passes into the pores of the porous subtance, or spongioplasm (contraction), whilst in the absence of such stimulation it tends to pass out from the spongioplasm (formation of pseudopodia, resting condition of muscle). Thus, both the movements of cell-protoplasm and those of muscle seem brought about by similar means, although at first sight the structure of muscle is so dissimilar from that of protoplasm. We have already noticed that the movements of cilia are susceptible of a similar explanation."

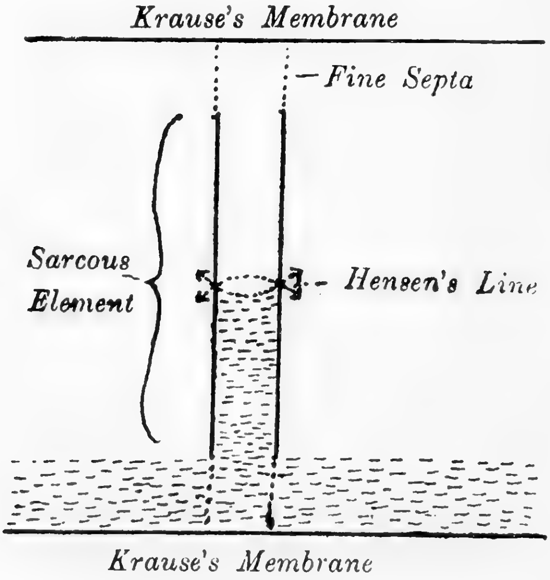

FIGURE 6.

It would thus appear that the structure of the sarcomere may be regarded as that represented in the diagram. If the walls of the sarcous element be elastic, it is obvious that the surface tension (T) of the fluid hyaloplasm would pull them in at all points along their surface of contact, while on diminution of the surface tension the sarcous element would swell in order to increase the surface of contact, and, since nothing but hyaloplasm is available to fill up the space thus created, hyaloplasm will flow *into* the sarcous element. If the surface tension is increased the operations would be reversed.

I am aware that histologists are not unanimous in adopting this theory of the structure of striated muscle, but it enables us to obtain a clear view of the influence of the surface tension of the hyaloplasm upon the contraction of muscle.

5.—The Contraction of Striated Muscle.

In order to explain the contraction of striated muscle we must assume *that there is a contact difference of potential between the spongioplasm and hyaloplasm, due to the presence of kation-proteid in the muscle.* That kation-proteid is present in striated muscle is demonstrated by the second part of Hermann's law, namely, that muscle becomes negative when dying, that is, that within the muscle there is an E.M.F. tending to produce a current *from* the dying points *to* the other points in the muscle.* If "when dying" be taken to mean "when injury of such a nature as to set up katabolism is applied" we may at once state that this is due to the liberation of kations by the decomposing ion-proteid.

Similarly, muscle becomes "negative" when excited to activity, because the excitation sets up katabolism, and kations are set free. We shall go more fully into the influence of the electric current upon the kation-proteid in the sequel; but, in passing, we may note Biedermann's statement that if the passage of a weak "polarising" current through muscle be continued, its excitability is first augmented and then diminished.† We can easily see that while the katabolic processes are being hurried up by the polarising current, any additional excitation will precipitate them the more easily because the ion-proteid is already partly decomposed, while, as the constant excitation and consequent katabolism continue the supply of kations becomes so diminished that it can no longer respond to the demands of additional excitation. That

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* For an explanation of this confusion in physiological terminology, *vide* Waller: Human Physiology, 1896, page 388.

† Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 283.

such *continuous* excitation does take place during the passage of the polarising current is a conclusion definitely arrived at by Biedermann. He says:—"The electrical current sets up a process of excitation in striated, as in smooth, muscle throughout the duration of its passage."* Assuming, for the moment, what is about to be proved, namely, that the setting free of kations by the current is the *cause* of contraction, we see that the fact that maximal twitches are much higher with a constant than with an induced current† is due to the greater amount of decomposition of kation-proteid by the current which acts the longer time.

As to the nature of the kations which form the ion-proteid in the hyaloplasm of striated muscle, we can say very little. The effects of chemical re-agents on muscle show, as we shall see later, that simple metallic ions are capable of forming ion-proteids in muscle just as in unicellular organisms. Probably K and H ions play an important part—as it is well known that KH_2PO_4 is always formed when muscle becomes rigored—and, moreover, K salts predominate in the ash of muscle, Ca and Mg only being present in traces.‡

Now, it is evident that, since hyaloplasm is laden with kation-proteid, the result of its katabolism or dissociation must be the formation of an electrical double layer at the contact surface of the hyaloplasm and spongioplasm by the deposition of ions, just as in the case of the contact surface between the mercury and sulphuric acid solution in the capillary electrometer.

The action of a stimulus, such as an electric current, on muscle, is to set up katabolism at certain points in the muscle (*e.g.*, the kathode on make), and the consequence of this is, as we have seen, to cause "negativity" at such points in consequence of the kations set free. This "negativity" is transmitted, practically unaltered, § along the muscle, and its mode of transmission will be discussed in detail in the sequel.

It remains to consider the effect of the progress of this area of high potential along the muscle. It will be, as expressed by Bernstein's "wave of excitation," || to uninterrup-

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 185.

† *Ibid.*, vol. i., page 176.

‡ Starling: Elements of Human Physiology, fifth edition, page 130.

§ Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 395.

|| *Ibid.*, vol. i., page 374.

tedly raise the potential at each point in the muscle and uninterruptedly let it fall again. The effect of this will be (just as in the capillary electrometer when the potential on one side of the meniscus is raised) to diminish the surface tension at the contact surface of the spongioplasm and hyaloplasm owing to the increase in the P.D. between them.

Now, if we suppose the walls of the sarcous element to be elastic—the effect of the surface tension of the hyaloplasm will be to exert a pull inwards upon the wall—and therefore the walls are pulled in. To this pull the wall will offer a resistance owing to its elasticity. If these two forces are in equilibrium, increasing the surface tension will narrow the tube, while diminishing the surface tension will widen it. But widening this elastic tube must shorten it, just as an indiarubber tube when stretched longitudinally grows narrower, and when stretched laterally grows shorter. The sarcous element, in shortening, must exert a pull on the fine fibrils which, it is conjectured, attach them to Krause's membrane; hence, the two membranes of Krause are pulled together and the muscle contracts. Hence, since the "wave of negativity" must diminish the surface tension—*not* by deposition of ions, for in that case it would undergo excessive decrement, which it does not*—but by simply raising the P.D. between the hyaloplasm and spongioplasm it must give rise to a contraction.

6.—ON THE PROPAGATION OF EXCITATION IN NERVE AND MUSCLE.

We have seen that the hyaloplasm of striated muscle contains a kation-proteid owing to the presence and metabolism of which the surface of contact between the spongioplasmic sarcous elements and the hyaloplasm is always positively charged on the hyaloplasmic side, or, in physiological terminology, the surface of the hyaloplasm is always "negative" to that of the spongioplasm. When any breaking up of the kation-proteid takes place, kations must therefore be set free. Now, I have previously pointed out that the fundamental property of ion-proteid is that it is very unstable in the presence of ions, tending to form new ion-proteid compounds with any ions which may be present in excess; and, indeed, it is upon this property of the ion-proteid that the phenomena of contraction and irritability in living tissues depend. I may now throw this assertion into a more definite form, and state that when a certain minimal number of free ions (the number varying in different tissues) is present at any point in an excit-

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 395.

able tissue, the mass influence of these ions will be sufficient to displace the ions already holding the proteid molecule, and to take their place. Hence the kations set free in one section of an excitable tissue by excitation may in turn displace others in the next section of ion-proteid material, which again may set free ions in the following section, and so on, so that a wave of excitation is propagated through the tissue. Thus we conclude that the "wave of negativity" does not progress so much by diffusion as by a process of successive displacement.

The evidence for this fact will come out more clearly in the sequel, but we may allude to some of the facts supporting it now. Just as in muscle, we consider that there is present in the axis cylinder of nerve a kation-proteid which, by its katabolism under stimulation, gives rise to a wave of negativity, only, as in this case there is no elastic surface for ions to be deposited on, no contraction is evoked. Now, the excitatory state evoked in nerve by an intense stimulus is propagated more rapidly than that caused by a weaker one.* We can easily see that this must be due to the greater mass of kations set free initially; they would more easily and quickly set free other ions in each section (for it is the principle of mass action that the rate of chemical change depends upon the masses of the re-acting substances). This will be seen more easily when we come to consider the genesis of the discharge in the heart; but it is obvious that if the wave of negativity were propagated by mere diffusion, since the number of ions set free in no wise affects their velocity, the intensity of the stimulus could not affect the velocity of the excitatory wave.

Of a similar nature may possibly be the explanation of the fact that nerve cells conduct more slowly than nerve fibres.† The cross-section of a nerve cell is much greater than that of its fibre; hence at any moment the same number of ions would have very many more ion-proteid molecules to cope with than they had during their course in the fibre.

Another line of evidence supporting the theory we have put forward is the influence of various solutions of salts upon the transmission of excitation. If a portion of a conducting excitable tissue were immersed in a solution with a negative stimulation efficiency, and a wave of negativity initiated elsewhere, on passing through the immersed portion (if it travels by displacement) should either be diminished, abolished, or converted into a wave of positivity, according as little or

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* Gotch: Schäfer's Textbook of Physiology, vol. ii., page 458.

† Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 69.

much of the muscle-proteid was taken up by the anions of the solution. Of course, the wave of positivity thus produced, on issuing from the region immersed, would be converted into a wave of negativity again, owing to the anions displacing kations; but it would probably be reduced owing to some of the anions combining directly with kations. This idea receives support from the fact that nerves which have been immersed for a long time in salt solution, and are repeatedly stimulated, give a wave of positivity.* Still more suggestive is the fact that the excitatory state is often diminished when passing through a portion of nerve treated with NaCl—absolutely with a 6·1 per cent. NaI solution—though excitability is still present.† Thus the wave of negativity is, in the second instance, suppressed, as we have said it may be, though a wave may be started from the point affected by direct action of the current. The reason why the wave is so absolutely suppressed in the case of NaI is probably the high stimulation efficiency of NaI causing a great predominance of anions; as we shall see, the number of kations in a normal wave of negativity in medullated nerve is small.

It will be obvious that there is a difficulty in proving this point in nerve, because the wave of positivity in the affected region is converted into a wave of negativity directly it emerges. But our previous investigations into the contraction of muscle show that a wave of positivity cannot cause a contraction until it be converted into a wave of negativity, because a wave of positivity would only *diminish*, not *increase*, the P.D. between the hyaloplasm and spongioplasm, and, therefore, the surface tension at their contact surface would not be diminished, and no contraction would ensue; hence, a portion of a muscle which has been treated with a solution which has a sufficiently great negative stimulation efficiency ought to act as a motor nerve to the rest.

This can be very easily demonstrated in the intestine of a fly. In insects the walls of the intestine contain "striated (uninuclear) muscle cells, which by contraction set up the normal peristaltic movements of the digestive tract." ‡ The species I used for experiments was *Callophora villosa*, Desv., which is the Australian representative of the English bluebottle. If the last posterior segment of one of these flies is torn away with forceps, the end of the intestine is usually left hanging from it, and, if the operation be performed carefully, nearly half an inch of intestine can sometimes be

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* Gotch: Schäfer's Textbook of Physiology, vol. ii., page 538.

† Gotch: Schäfer's Textbook of Physiology, vol. ii., page 490.

‡ Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 164.

obtained. If this be placed on a slide which has been slightly wetted with a decinormal solution of NaCl, and the superfluous fluid taken up by filter paper, on examining the intestine under the miscroscope peristaltic waves of contraction are seen travelling down the intestine towards the rectum at an easily followed, uniform velocity, with moderate frequency. On now touching the intestine at about its middle point with a fine pointed camel's hair brush, which has been just wetted with a decinormal solution of $CaCl_2$, a remarkable effect is observed:—If one of the peristaltic waves starting at the end of the intestine furthest from the rectum be followed with the eye, it is observed to completely disappear on entering the region which has been treated with $CaCl_2$; but if we continue to move the eye along the intestine at the same rate as the wave of contraction was formerly moving, on reaching the other end of the affected area the wave will be seen to emerge from it as vigorous as before, and to be travelling at the same rate. Thus, *contraction* has been abolished by the $CaCl_2$, while *conduction* continues to take place at the same rate as before. The suppression of the wave of contraction in the area affected is not due to any apparent change in form in the intestine in that area, for if the $CaCl_2$ be properly applied, no apparent change in form takes place. If, however, too much $CaCl_2$ is applied—so that it is not sufficiently diluted by the NaCl present (*e.g.*, a small drop)—the intestine at that part is thrown into corrugations which represent fixed contractions; that is, the intestine at that part acquires "tone" (the cause of this will be considered later), but this does not alter the effect of the $CaCl_2$ upon incoming waves of contraction, which enter, and are suppressed, and re-appear at the other end of the affected region as before. Care must be taken in these experiments not to have the intestine too wet, otherwise it is difficult to confine the effect of the $CaCl_3$ to a given region, as the $CaCl_2$ is carried about by currents in the water. I repeated this experiment a number of times, and, when the above-mentioned precautions had been taken I never failed to get the effect described. I also obtained the same effect using a decinormal solution of $BaCl_2$ instead of $CaCl_2$. On glancing at the table of stimulation efficiencies in section 4, it will be seen that both $CaCl_2$ and $BaCl_2$ have high negative stimulation efficiencies, so that our theoretical deduction is confirmed by these experiments. The action of $CaCl_2$ and $BaCl_2$, when applied to a limited region of the intestine, may be contrasted with that of a decinormal solution of KCl when similarly applied, although no more apparent change of form is produced in the intestine by the KCl than by $CaCl_2$; yet not only is the wave of contraction suppressed in the region treated with KCl, but also the wave of excitation, inasmuch as no wave of contraction issues below the part affected—all parts of the intestine below that treated with KCl remain motionless, while those above that part are in vigorous peristalsis. This action of KCl in abolishing both contractility and excitability in the intestine of the fly is only an instance of its general effect upon contractile tissues, the cause of which will be discussed later.

7.—On the Normal Presence of Anion-Proteid in Certain Tissues, and their Sensibility.

A fact which it is important to realise is the normal presence of a certain amount of *anion-proteid* in irritable tissues. It is easy to see that this is *à priori* probable, for, since the blood and lymph contain ions of both kinds, it is to be expected that some anions would be taken up and formed into anion-proteid. But confirmatory evidence is not far to seek: the cardiac inhibitory vagus fibres, when excited, produce a *positive* variation of the muscle current; this can only be due to anions released by the nervous impulse, and since "as regards their galvanic re-action to excitation they differ in no respect from other nerve fibres,"[*] these anions must be displaced from anion-proteid in the muscle itself, or in the nerve endings. The "staircase" phenomenon, that is, the improvement of each of the first few contractions of a muscle by the one that precedes it, which is specially noticeable in the heart, and in the swimming bell of medusæ,[†] is direct evidence of the fact that the wave of negativity is not propagated by mere diffusion; for some chemical change evidently takes place wherever the wave passes, since the improvement is not confined to the point stimulated, but occurs at all points traversed by the wave of negativity.[‡] I attribute the "staircase" to the presence of a small amount of unstable anion-proteid, which tends to accumulate, and is mostly removed by the first few waves of negativity, the kations of which displace the anions. We should note that the "staircase" is not always comparable with the cumulative effect of sub-minimal stimuli on many tissues, so that they eventually become capable of causing discharge and evoking contraction. In this case, no doubt, the kations accumulate, being added

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[*] Biedermann: Electro-physiology, vol. ii., page 257.

[†] *Vide* Romanes: Jellyfish, Starfish, and Sea-urchins. Int. sc. ser., page 56.

[‡] Romanes: Jellyfish, Starfish, and Sea-urchins. Int. sc. ser., page 57.

to by each stimulus until at last they reach the necessary minimum required to displace ions from the ion-proteid. The same principle explains idio-muscular swellings—fixed waves of contraction of small extent; these are due to the kations set free not being sufficient to cause a discharge by displacement, but sufficient to augment the P.D. between hyaloplasm and spongioplasm, and so cause local contraction —while the same principle, together with the presence of anions, explains the local extension at the anode seen in some muscles;[*] anions are liberated, as in ordinary electrolysis, at the anode—the P.D. between the hyaloplasm and spongioplasm is diminished, and the muscle extends; but, as kations are predominant, the anions are not strong enough to cause displacement, and so the excitation does not travel. Sometimes the P.D. is so far reduced that the muscle extends so much as to break at the anode;[†] such a result could not, of course, take place unless the muscle had, normally, a good deal of "tone"—that is, there is considerable room for extension and free kations are numerous.

This leads us directly to the consideration of the "*threshold number*" of a tissue—that is, the number of ions necessary to cause a discharge in a given tissue (the inverse of which is proportional to the "*sensibility*" of the tissue). If we call this number per unit cross-section β, it is evident that β must vary considerably in different tissues, and that the greater β is the slower will be conduction of excitation, for at each successive point more time must be allowed for the ions to gather. Since in non-medullated nerves the rate of conduction is much lower than in medullated nerves (8 metres per sec. in the former, 27 per sec. in the latter[‡]) we may state provisionally that β is greater in non-medullated nerves than in medullated. This is confirmed by the fact that non-medullated nerve re-acts better to stimuli of prolonged duration than to short induction shocks,[§] for more time is required by the electric current to liberate β ions in non-medullated nerves than in medullated, in which extremely short current duration is sufficient.[||] The conductivity of medullated nerve, and, indeed, of all excitable tissues, is lower-

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[*] Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 236.

[†] *Ibid.*, vol. ii., page 239.

[‡] Gotch: Schäfer's Textbook of Physiology, vol. ii., pages 455 and 482.

[§] *Ibid.*, vol. ii., page 284.

[||] *Ibid.*, vol. ii., page 475; and Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., pages 121 and 122.

ed by lowering the temperature.* This means that β is raised, therefore the excitability to short-duration stimuli is lowered.† Since conduction is much slower in smooth than in striated muscle, β must be greater in the former, and the minimal duration of excitation, in order to cause contraction, is therefore greater in smooth than in striated muscle. And, indeed, Biedermann states generally that the excitation of more sluggish excitable tissues depends on the duration of the stimulus.‡ The conductivity of muscle is lowered by lowering the temperature, but the height of the contractions is augmented ;§ this is because of the greater value of β causing a greater P.D. on excitation. Since the rate of propagation in the heart is less than in striated skeletal muscle (1·5 metres per sec., as against 3 metres per sec.)‖ β is probably greater in heart muscle than in ordinary striated muscle.

8.—POLAR EXCITATION IN MUSCLE AND NERVE AND ELECTROTANUS.

One of the most striking facts in the electrical stimulation of muscle is that the make contraction starts at the kathode, and the break contraction at the anode. From my theory, however, it seems to obtain a sufficiently simple explanation. On the passage of the electric current the ion-proteid undergoes decomposition, and, in accordance with the laws of electrolysis, kations collect at the kathode. As soon, however, as the kations at the kathode reach the "threshold number" they displace the kations from the adjacent section of ion-proteid material; these, in turn, displace the kations from the next section, and so the wave of negativity is propagated through the tissue. This view of the nature of the "wave of negativity" obtains further support from the fact that "the responsitivity of the kathodic points of fibres in a muscle traversed by a current increases, up to a certain limit, with the intensity of the polarising current. This limit, however, is very low . . . beyond this limit excitability diminishes, as has been shown, in proportion with the strength of the polarising current."¶ Suppose a

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* Gotch: Schäfer's Textbook of Physiology, vol. ii., pages 486 and 534.

† *Ibid.*, vol. ii., page 485.

‡ Biedermann: Electro-physiology, vol. ii., page 106

§ *Ibid.*, vol. i., page 98.

‖ Burdon Sanderson: Schäfer's Textbook of Physiology, vol. ii., pages 383 and 443.

¶ Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 285.

certain amount of kation-proteid to be on the point of breaking down at points which are about to be made kathodic by the polarising current, then, if the strength of the polarising current be insufficient to decompose the whole, an additional excitation will be aided by the effect already present. If, however, the polarising current has decomposed all the ion-proteid most immediately available, irritability at kathodic points will decrease.

We now touch upon the curious fact, that during the closure of a constant current, after the make twitch, no perceptible effect is usually produced in striated muscle until the current is broken.

This depends upon two factors: the superior stimulation efficiency of rapid variation of current density (to be considered later); and, secondly, the comparative exhaustion of ion-proteid material at the kathode after make. It is obvious that such exhaustion must take place sooner or later, and we need not be surprised at its taking place immediately after the initial twitch, for, as we have seen, the duration of the current has an effect upon the height of the make twitch, inasmuch as it augments it;* that is to say, the constant current decomposes a large amount of ion-proteid material initially, to produce the make twitch.

We can account for the fact that persistent closure contraction takes place more usually, and to a greater degree, in smooth than in striated muscle, by the higher value in the former of the "threshold number"—for an excess of free kations might be liberated by the current, sufficient to cause a considerable increase in tone of the muscle, and yet insufficient to cause displacement, and so initiate a wave of negativity. Not only is variation of current density ordinarily of importance, but the comparative exhaustion of ion-proteid material after the make greatly increases the necessity for such variation in a way that will be explained shortly. Hence we cannot wonder that in such highly sensitive contractile material as striated muscle persistent closure contractions are not usually seen in a marked degree.

Biedermann† states that a wave of contraction, initiated in an extra-polar tract, cannot pass the kathode of a polarising current of certain intensity, while it can the anode. This is not due to the persistent closure contraction, because "inhibition is most pronounced when a persistent descending current in the upper half of the muscle has reduced the original persistent closure contraction to a minimum." I can account

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 176.

† *Ibid.*, vol i., page 296.

for this in the following way:—The cause of the extra-polar wave of contraction is the accompanying "wave of negativity," which means that (in the first instance) when the wave of negativity approaches the kathode a number of kations are there set free. These kations will, however, be attracted by the kathode, and, moreover, there will be very little undecomposed ion-proteid from which they can displace the ions; hence, the wave of negativity will be seriously hindered, and the proteid residues at the kathode will tend to retain some of the kations. At the anode, on the contrary, undecomposed kation-proteid is abundant, and the kations are not retarded by the action of the current itself, so that the wave of negativity passes this region without hindrance.

We have seen that a certain amount of anion-proteid is present in muscle and nerve, consequently, on electrolysis taking place, anions are liberated at the anode; but, since kations are predominant, their number is not sufficient to cause displacement, and therefore a discharge; while at the kathode the proteid residues cannot take up kations, for they are immediately dissociated; but when the passage of the current ceases, the proteid residues at the kathode immediately pick up kations; hence the concentration of free kations falls at this point, and kations diffuse in from other points, including the anode; hence the mass influence of kations at the anode is diminished, the anions get the upper hand and create a discharge, which immediately, as we have seen, becomes a wave of negativity by displacement of kations. The concentration of kations at the physiological anode may, possibly, fall on break for other reasons; thus some of the proteid residue at the kathode may, when the current is broken, take up the ions from the adjacent ion-proteid; this may in turn recoup itself from the next section, and so the area of diminished kation concentration would travel to the anode.

The question immediately arises: Have we any other evidence of the liberation of anions at the anode? The answer is that we have ample in the phenomena of electrotonus.

The effect of anions at the anode would be to lower *excitability*, because, in order to obtain a sufficient excess of kations over anions to create a discharge the influence of the free anions has to be neutralised; it will be to lower *conductivity*, because the anions will tend to prevent the incoming kations from displacing ions from the ion-proteid by lowering their mass influence: and it will be to cause "positivity" in the region of the anode. These are the well-known phenomena of anelectrotonus.*

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* *Vide* Gotch: Schäfer's Textbook of Physiology, vol. ii., pages 494 and 502; and Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 268.

The magnitude of the katelectrotonic effects will depend upon the magnitude of the threshold number (β). If only a part of the kations liberated at the kathode by a current is discharged, there will be improvement in excitability, conductivity, and "negativity" at the kathode, owing to the influence of the free kations; this will be the case when β is small, and occurs, as we should expect, in medullated nerve.* But where β is large, and the ion-proteid therefore more stable, a very large proportion of the electrolysable portion of the ion-proteid is used up in initiating the discharge, and therefore the proteid residues at the kathode, after discharge, are great in proportion to the free kations, and their delaying effect neutralises the improving effect of the kations, as is the case in non-medullated nerve, where, as we have seen, β is greater than in medullated nerve, and there is no katelectrotonus.†. If β be larger still the effect of the proteid residues is to reverse the improving effect that would otherwise be produced by the kations. This is the case in muscle, as we have seen, and in muscle β is greater than in nerve.‡ The magnitude of the anelectrotonic effect depends on the amount of anion-proteid, but since no anions are discharged until break it should, in general, be greater than the katelectrotonic effect, and this is, in fact, the case.§ In further support of our theory of katelectrotonus, we may allude to the fact that with strong currents of long duration conductivity is retarded at the kathode even in medullated nerve‖ owing to the greater amount of electrolysis and the gradual diffusion of kations from the kathodic points, leaving behind the indiffusible proteid residues.

Since there is less anion-proteid than kation-proteid anelectrotonus develops more slowly than katelectrotonus, hence "currents of moderate strength but of short duration excite only on closure, *i.e.*, at the kathode."¶ Given the facts of electrotonus, Pflüger's law of contraction follows.

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* *Vide* Gotch: Schäfer's Textbook of Physiology, vol. ii., pages 494 and 502; and Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 268.

† Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 284.

‡ *Vide* section 8, this paper.

§ Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 268.

‖ *Ibid.*, vol. ii., page 148.

¶ Gotch: Schäfer's Textbook of Physiology, vol. ii., page 506.

9.—THE INFLUENCE OF VARYING CURRENT DENSITY.

It seems probable that the reason for the importance of the steepness of increase in current density for evoking muscular contractions lies in the diffusion of the kations away from the points which form the physiological kathode. When the kations are only very slowly liberated they diffuse away from the points where they are liberated, so that they never become concentrated at any point, and their mass at any point is never appreciable in comparison with the mass of ion-proteid with which they come in contact. Hence the kations diffuse through the whole muscle without the potential having risen at any point high enough to evoke a perceptible contraction. This view is supported by Biedermann's statement that "the transmission of excitation from the seat of direct stimulation would seem, in the last resort, to be produced and conditioned by a rapid *variation* in the current."*

Persistent closure contractions, however, appear to be due to a number of kations liberated by the action of the current at the different points in the muscle forming the physiological kathode. These kations are insufficient to cause a wave of negativity from any of these points, but by raising the potential at such points they evoke a persistent contraction. If such were the case we should expect to find that persistent closure contractions were more apt to occur in muscles in which the threshold number is large: and this is the case, for "the visible manifestations of persistent excitation fall into the background, while the excitatory effects of current variation come prominently forward in proportion as the excitable protoplasm is more highly mobile,"† and we have seen that the less mobile a tissue is the greater is the threshold number (section 8). Thus we see why the discharge of the initial "wave of negativity" tends to inhibit persistent closure contraction in striated muscle.‡ Only the more stable ion-proteid compounds are left at the kathode, and these, besides being fewer in number for the current to act on, present a greater resistance to the dissociative effect of the current, so that very few ions will be liberated at any given moment, and these will diffuse into the spongioplasm before any accumulated effect is possible.

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 193.

† *Ibid.*, vol. i., page 192.

‡ *Vide* remarks on polar excitation in muscle, section 9, this paper.

10.—TETANUS AND FATIGUE.

When a second momentary current is sent into a muscle before the contraction due to the first has subsided, the effect of the second current is added to that of the first, and a new contraction appears superimposed upon the old, starting from the degree of contraction at which the latter had arrived, and proceeding much as if that were the normal condition of the muscle; with succeeding currents the process goes on until a certain limit of contraction is reached, beyond which the muscle cannot go. If the shocks follow one another quickly enough the recording lever will trace upon a travelling surface a straight line, and the muscle is said to be in tetanus, and it will, if the shocks are kept up, continue in this condition until "fatigue" sets in, and the lever gradually sinks.

Helmholtz considered that "from the point at which the second excitation becomes effective the twitch behaves as if the contracted state of the muscle at the moment was its natural state, and the second twitch, alone, induced in it." It has been found, however, that this is not true even for the second twitch; it is lower than the first and of a shorter period,* while it is obviously not applicable to the later twitches when the limit is nearly reached. The reason for this summation is, of course, the repeated discharge of ions from the seat of stimulation—the twitches will become smaller and smaller and shorter as the ion-proteid is used up—and no increase of contraction can then take place. At this period, however, since a great mass of kations have been rapidly liberated, they cannot diffuse at once into the spongioplasm so as to diminish the difference of potential at the contact surface; so that the muscle remains for some time in tetanus, and only as the kations diffuse into the spongioplasm will the lever sink and the muscle enter into "fatigue"—finally the lever sinks quite, and the muscle is isoelectric—or, only with the usual contact difference of potential between its hyaloplasmic and spongioplasmic surfaces. An objection may be raised: Why do rapidly succeeding shocks produce reiterated contractions when a constant current fails to cause persistent contraction? There are two reasons: First, that to produce complete tetanus in striated muscle the shocks must be of extremely short duration; and we have seen that such shocks do not discharge so many ions as longer ones; that is, there is a reserve left, while the muscles in which the shocks need not be so short are just those in which persistent closure con-

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 115.

tractions take place. Secondly, during the intervals, however short, the proteid residues will be able to gather more kations, though fewer as time goes on, because the supplies get used up; nevertheless they will be able to do so to some extent all the time, and this corresponds to the fact that in tetanus the muscle is really vibrating, though its vibrations are imperceptible by ordinary methods.* This is further confirmed by the fact that too rapid a succession of stimuli corresponds in effect to a persistent stimulus, even in striated muscles.† Schoenlein & Richet's observations of "rhythmically interrupted tetanus" in striated muscles are doubtless due to the hyaloplasm reclaiming kations from the spongioplasm at the point of stimulation during the intervals.‡ Another reason for the rapidly decreasing height of the summated stimuli lies in the fact that the elastic re-action of the walls of the sarcous elements becomes less and less as the muscle contracts, so that each new contraction in the series starts with less force to counteract the pull of the surface tension than the previous one; hence absolute tetanus may correspond to a state of the sarcous elements in which no pull is being exerted on the wall at all. That "fatigue" is really due to the diffusion of the kations into the spongioplasm is shown by the fact that in the ureter "each wave of contraction produces a temporary depression of excitability and conductivity in the sheet of muscle, from which it only recovers during the subsequent diastole and interval (just as in the striated muscle-nets of insect intestine)."§ This also illustrates the rapidity with which the hyaloplasm recovers itself and again gathers kations; one is also reminded of the "refractory period" in the heart. It may be frequently observed that when a frog's gastrocnemius has been tetanised through its nerve for as long as several minutes, so that the lever has almost dropped to the base line again through fatigue, if the tetanising current be opened only for a moment, and then closed again, the muscle, if it is fresh, will contract in tetanus almost to the same height as before. We should, indeed, expect that striated muscle with its low β (and consequently high sensibility), and a comparatively large surface of spongioplasm to regain kations from, would have a very much shorter "refractory period" than the heart or the smooth muscle of the ureter.

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 135.

† *Ibid.*, vol. i., page 131.

‡ *Ibid.*, vol. i., page 131.

§ *Ibid.*, vol. i., page 167.

11.—THE WORK OF MUSCLE AND THE INFLUENCE OF TENSION.

It is well known that the work done by muscle increases, up to a certain point, with the magnitude of the load, and then decreases to zero, or even becomes negative, in contraction. The reason for the initial increase in the work done, as well as the cause of the favourable effect of moderate tension upon all contractile tissues, lies in the fact that the tension *increases the surface of contact between the hyaloplasm and spongioplasm.* It is, indeed, obvious, *à priori*, that when an elastic substance is stretched in any way its surface is increased; and this is just the case with the sarcous elements. Hence, the work which has to be done against the surface tension, along the contact surface, in order to increase that surface, is diminished; and, since the same work as before will be done by the ions set free on excitation, only against a tension that has been diminished, the *output* of work will be greater.

At the same time, the longitudinal stretching of the sarcous element (spongioplasm) will have a horizontal component tending to decrease its diameter—that is, to decrease the elastic reaction outwards, and so decrease the tendency of the sarcous element to bulge on stimulation; when this unfavourable influence exactly balances the favourable, the work will be the same as with a minimal load; between these points there must be a point of maximum work output; afterwards the work falls, and, finally, becomes zero. If, now, more loading is added, when the muscle is stimulated, what happens is that the pull of the hyaloplasm upon the wall of the sarcous element is diminished; normally the horizontal reaction would cause the walls to bulge, but now, owing to the great vertical strain, the horizontal reaction is converted into a vertical one, and *the muscle elongates when it contracts:* this is known as Weber's paradox.* It is just as if one violently compressed an indiarubber tube which was being at the same time violently pulled. On releasing the compression the tube will become more stretched, and its average bore diminished; but, if the tube were not stretched its average bore would be *increased.*

12.—THE ACTION OF CHEMICAL REAGENTS UPON THE CONTRACTURE OF MUSCLE.

If the "negativity" at any point in a muscle is determined by the number of free kations in the hyaloplasm at that point, we should expect to find that when a muscle is

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* Halliburton: Handbook of Physiology, fourth edition, page 135.

dipped into an electrolyte with a positive "stimulation efficiency" it would become negative at those points which are wetted, and we find this to be the case. If one end of a sartorius that is free from current is briefly immersed in highly dilute solutions of K salts, that end becomes strongly "negative" to the rest. This is simply neutralised by washing out with physiological NaCl solution.* A glance at the table of stimulation efficiencies will show that all the salts of K used in physiology have positive "stimulation efficiencies." The antagonistic action of NaCl is simply accounted for by the fact that it has a *negative* "stimulation efficiency." That the action of NaCl in abolishing the "negativity" induced by K salts is really due to the fact of its anions diffusing faster than its kations is shown by the fact that Engelmann found that a solution of NaCl, if stronger than 6 per cent., produces a weak "positivity" at points of a muscle immersed in it.† In face of the fact that nearly all potassium salts are highly positive stimuli—as shown by the table of stimulation efficiencies—it is difficult to deny that their highly poisonous effect, when applied to muscle, must be in some way connected with the high velocity of the K ion, and I think the explanation must be this: that when a muscle is dipped into too strong a solution of KCl, suppose, the kations diffuse so rapidly into the muscle-hyaloplasm and spongioplasm that little or no contraction is evoked, for the muscle is now throughly permeated with potassium ions, and ion-proteid cannot break down at any point without kations being immediately at hand to regenerate it. Even a strong current might not be able to liberate enough kations in any one section of the muscle to overcome the mass influence of those in the next; in fact, potassium salts may be said to induce a state of "persistent anabolism" in the ion-proteid. Thus it would appear that the poisonous effect of potassium salts is primarily due to loss of conductivity in the muscle, owing to an excessive rise in the threshold number, and this view is fully borne out by my experiments on the intestine of the fly. If a section of the intestine is treated, in the manner described in Section 7, with decinormal KCl solution, a block is created at the points thus treated—no contraction can pass this area, and, moreover, the peristaltic contractions travelling down the intestine *do not reappear below the affected area*, hence the excessive rise of the threshold number at the points treated with KCl renders propagation of the wave of excitation by displacement impossible.

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* Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 354.

† *Ibid.*, vol. i., page 356.

It has been shown that potassium salts produce a prolonged contraction of the gastrocnemius muscle of a frog, while calcium salts and, to a lesser extent, sodium salts, antagonise this action of potassium salts.* We can easily see that this action of potassium salts is due to the faster diffusing kation augmenting the P.D. between the hyaloplasm and spongioplasm, and hence lowering the surface tension at the contact surface, and causing prolonged contraction, while the action of the Ca salts and Na salts is simply due to the fact that in them the anion usually moves faster than the kation.

"The excitability of certain contractile substances (spermatic filaments, ciliated cells) is considerably heightened by Na_2CO_3 in dilute solutions." "If the pelvic end of an uninjured curarised sartorius dips into a ·5—1 per cent. solution of this salt, the excitability of the muscle to the closure of weak ascending currents is seen after a short time to be extraordinarily augmented, while the descending current still works quite normally, although break excitations are discharged with such low intensity of current and brief duration of closure as would not occur in normal muscle."† This improvement of contraction and excitability on treating with the Na_2CO_3 is, I believe, owing to its low *positive* stimulation efficiency slightly increasing the threshold number, while the incoming kations enable a sufficient number to cause displacement to gather more quickly at any point. In my own experiments I have observed this improvement in the sartorious, in the semi-membranosus of the frog (fig. 7), and in the intestine of the fly. If a section of the fly's intestine be touched with decinormal Na_2CO_3, the peristaltic contractions are much augmented at that part; and, if the intestine be quiescent owing to long exposure to NaCl, peristaltic contractions will start at the point painted with Na_2CO_3. The improvement, in both cases, quickly dies away, and the intestine becomes puckered at the part affected owing to increase of tone, this part now acting as if it had been painted with KCl. This is to be explained by the effect of the natrions being, at first, partly neutralised by the chloridions already present, and then as the natrions become predominant the stimulation efficiency is too great, and the ionproteids enter into persistent anabolism.

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* W. D. Zoethout: American Journal of Physiology, May, 1902: The Effects of Potassium and Calcium Ions on Striated Muscle.

† Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. i., page 221.

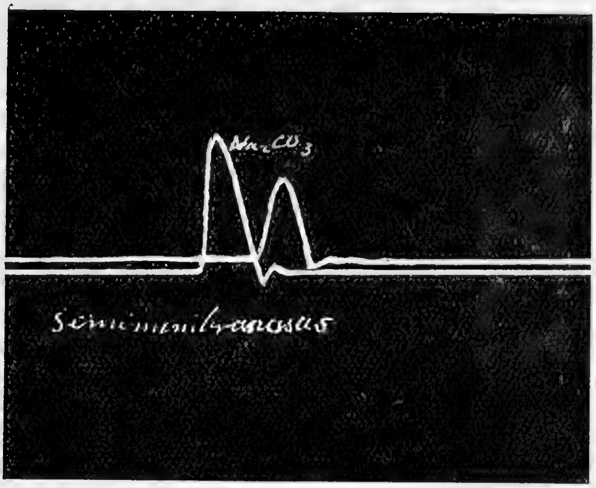

Figure 7.

13.—Rhythmicity in Muscle and the Action of Inhibitory and Augmentor Nerves.

Direct proof that the rhythm of the heart is due to the presence of electrolytes in the circulating medium is afforded by the fact that if the proteids be removed from serum which is then circulated through the heart the rhythmic contractions will continue. If the salts are removed and the serum is circulated it is ineffective.* The solutions generally used and found effective stimuli for the heart-beat have negative stimulation efficiencies, owing to the predominance of NaCl. Let us, therefore, consider the case of an excised heart through which a solution, which has a negative stimulation efficiency, is circulated. Assuming that the walls of the heart are equally permeable to both the ions in the solution—an assumption which, however, is not strictly permissible—we see that, owing to the difference of ionic concentration on the two sides of the muscle surface, ions are continually diffusing in—but at different rates—the anions more quickly than the kations. Since the time taken for the anions entering the hyaloplasm to reach a given number—the threshold number—will be inversely proportional to the velocity with which the anions enter, we may conclude that, other things being equal, the frequency of the beat is greater the greater the velocity of the anions in the solution. Also, since the driving force which causes the ions to diffuse into the muscle is dependent upon the difference in ionic concentrations on the two sides of the muscle surface, we see that, if the solu-

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* Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 226.

tion is kept sufficiently dilute to ensure complete dissociation of the salts, the frequency of the beat will be greater the greater the concentration. And, obviously, the frequency will be less the greater the threshold number.

We further notice that if the ions diffusing into the muscle gathered unchecked on the muscle side of the surface, diffusion would shortly cease because of the approximation of the concentrations on both sides—the process could not be kept up. But we know that this is not the case; a periodic discharge of anions takes place which, by releasing kations, starts waves of negativity, giving rise to the contractions, or, when the heart is bathed in a solution with a positive stimulation efficiency, the periodic discharge is one of kations starting, as before, a wave of negativity. The concentration after each contraction is, therefore, on the muscle side, kept automatically constant, as far as anions are concerned; on the fluid side it is kept absolutely constant by circulation, but during the intervals between contractions the difference between the concentrations on the two sides is not constant, but continually falls off. Another fact to be considered is that the difference between the velocities of entrance of the anions and kations will diminish progressively during the intervals between contractions owing to the electrostatic repulsion, due to the excess of one kind of ion which has entered, tending to accelerate the other kind of ion and retard the ion bearing a similar charge. Finally, we have to take into account the reciprocal influence of kations and anions in altering the threshold number—kations will augment the threshold number for anions, and anions will augment the threshold number for kations. Hence the threshold number will be greater the less the difference between the velocities of the anions and kations on entering the muscle. Also, it is possible that kations of one kind may raise the threshold number for kations of another kind (when the solution contains two or more salts). Hence the threshold number, and consequently the extent of contraction, will vary considerably in different solutions.

It is obvious that a number of conditions must be satisfied in order that a solution may be able to keep a heart beating. Thus, the threshold number must be reached on the muscle side by the faster-moving ions before their velocity has been reduced to that of the slower-moving ions, by the electrostatic force which they develop on the muscle side. This involves the difference between the velocities of the anions and kations, the influence of one sort of ion in raising the threshold number for another sort, and the difference between the concentrations of the ions on the two sides of the muscle. Then, again, if the frequency of the beat is too great the beats will merge into one another, and the heart will go into tonic contraction.

Thus, the normal rhythm of the heart is due to the ions diffusing in from the blood, and the delicate adjustment of the threshold number to the nature and concentration of the salts in the blood. Almost any point in the heart is capable, in a greater or less degree, of initiating this rhythm, *e.g.*, if the auriculo-ventricular groove be ligatured or cut through, a series of rhythmical contractions is initiated; this is soon suppressed; subsequently a more permanent series is initiated.* The "rhythm of excitation" is due to the kations released by the injury due to the cut or ligature, the "rhythm of development" to kations diffusing in from capillary spaces.

A permanent rhythm, such as we see in the normal heart, could not be maintained on a nutrient fluid whose stimulation efficiency was negative, unless the excess of anions was continually removed, for otherwise the anions would gradually convert most of the kation-proteid into anion-proteid, and contraction would become impossible. The solutions, however, which are generally used as circulating media to keep up the heartbeat have negative stimulation efficiencies owing to the predominance of NaCl. We should, therefore, expect to find, if the preceding reasoning has been correct, that the rhythm of the heart would be slowed by adding a little KCl to the solution (sufficient to reduce its stimulation efficiency without making it positive), and quickened by adding $CaCl_2$ so as to increase its stimulation efficiency (since $CaCl_2$ has a greater stimulation efficiency than NaCl.). This was found to be the case by Greene.† He found that calcium salts in isotonic solutions of NaCl stimulated a cardiac strip to increased rhythm and final permanent contracture. KCl in isotonic solutions of NaCl prevented contractions and kept the ventricular strip in a state of relaxation. If the salts $CaCl_2$ and KCl were in the proportions of ·026 per cent. $CaCl_2$ to ·03 per cent. KCl, a few good contractions at a very slow and irregular rate might result. If the ratio was changed by increasing the $CaCl_2$, or by decreasing the KCl, then the contractions were increased in frequency; but if the $CaCl_2$ was diminished or KCl increased, few contractions were developed, or none at all.‡ At first sight, these results might seem to be opposed

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* Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 175.

† C. W. Greene: American Journal of Physiology, 1899, vol. ii., page 82.

‡ *Ibid.*, vol. ii., pages 107 and 125.

to those obtained by Zoethout in experiments on the gastrocnemius,[*] but, in reality, these results are due to the action of KCl and $CaCl_2$ in lowering and raising the stimulation efficiency of NaCl respectively. Pure $CaCl_2$ or KCl applied to a heart strip throws it into strong tone,[†] as might be expected from the high stimulation efficiency of both, since the frequency of contraction is greater the greater the difference between the ionic velocities. Hence the two sets of results are, by this theory, brought into entire harmony.

With regard to the influence of the threshold number in lowering the rate of rhythm, it is obvious that the height of contraction depends upon the magnitude of the threshold number, for the greater the potential of the wave of negativity the greater is the maximum P.D. produced between the hyaloplasm and spongioplasm; hence we should expect that the slower the rhythm the greater the height of contraction, other things being equal. This has been experimentally proved for smooth muscle by Woodworth.[‡] As β grows greater in excitable tissues we find that the "refractory period" grows greater. During this period the tissue will not respond to stimuli, and it is greater in cardiac than in striated skeletal muscle.[§] The reason is that, β being greater, a greater time must be allowed for the amount of ion-proteid corresponding to β to become unstable; of course, the moment at which the kations at the point of initiation are sufficient to cause a contraction will coincide with the moment at which the ion-proteid is in a certain minimal state of instability. This is the same as saying that immediately after a wave of negativity has passed a point, β is great at that point, and the amount of decomposable material small; the amount of decomposable material grows, and β diminishes until a certain point is reached at which excitation by a given stimulus is possible. Thus the *slowing* of a wave of negativity travelling too soon after a contraction is due to the greater magnitude of the threshold number.[||] Since the frequency of contraction is greater the greater the difference between the ionic velocities, any solution in which the ions move at very different rates will cause tonic contraction. Hence alkalies cause tonic contraction.[¶]

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[*] *Vide* section 12.

[†] C. W. Greene: American Journal of Physiology, 1899, vol. ii., page 101.

[‡] R. S. Woodworth: American Journal of Physiology, 1899.

[§] Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 189.

[||] *Ibid.*, vol. ii., page 195.

[¶] *Ibid.*, vol. ii., page 195.

In general, *inhibition* must be due to an income of anions large enough to neutralise the kations present, but not strong enough to cause a discharge in addition. If inhibition in the heart were due to the refractory period after a subminimal discharge of kations it could not last 252 seconds after stimulation of the vagus, as it may do.* We should expect the anions to cause a relaxation, and this takes place.† We should expect excitation of the inhibitory nerve, if it sets free anions in the muscle, to cause "positivity" at the points affected, and this is the case.‡ All doubt as to the action of the inhibitory fibres of the vagus being comparable to the effect of free anions at the parts affected—that is, to anelectrotonus—is removed by the fact that "a crystal of salt applied to the sinus will produce the same electrical variation as stimulation of the vagus nerve," § since in NaCl the stimulation efficiency is negative. In some animals the contractions of the ventricle are not diminished by vagus stimulation, hence there must be few or no anions at the vagus nerve-endings in the ventricles of these animals, and a most remarkable confirmation of my theory as to the nature of the "staircase"|| and of inhibition is that "another somewhat unexpected coincidence is brought out by the comparison of ventricular muscle, whose contractions are diminished by vagus stimulation and ventricular muscle, whose contractions are not so diminished, namely, that the staircase phenomenon obtains only in the former case, and not in the latter." ¶ The effect of the anions liberated by the inhibitory nerve in the heart will be to depress the *rate* of the contractions, because a greater number of kations will have to gather at each point to overcome the mass influence of the anions. To depress the conductivity owing to the state of anelectrotonus induced, and to diminish the force of contractions owing to the diminished tonicity: all these are known effects of stimulation of the inhibitory nerve. ** The auriculo-ventricular ring always specially tends to block contractions—we may assume that

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* Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 207.

† *Ibid.*, page 210.

‡ Biedermann: Electro-physiology, vol. ii., page 257.

§ Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 223.

|| *Vide* section 7, this paper.

¶ Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 214.

** *Ibid.*, vol. ii., page 209.

this is due to an abundance of anions in this part—hence if we cut off the supply of kations, by ligaturing the coronary arteries, a block takes place,[*] because the anions have now got the upper hand.

The *augmentor* nerves increase the rate of rhythm, because kations are more abundant, and therefore at the initial points of contraction they more quickly reach the threshold number. The force of contractions increases because of increased tonicity. Conductivity increases because the inhibitory action of the anion-proteid normally present is overcome by the free kations; that is, presuming that the augmentor nerves end in spots where anion-proteid is scarce, and that the impulse therefore sets free kations; and all these are known effects of stimulating the augmentor nerve fibres.[†] The alteration in tone and the negative variation produced by stimulating the augmentor fibres is slight.[‡] This is to be expected, otherwise a discharge would be initiated at the nerve endings, and the refractory period would diminish conductivity. The discharge by the augmentor fibres must be less than the threshold number.

The after-effect of inhibitory nerves in improving conductivity[§] is probably due to increased instability of the ion-proteid, the after-effect of the augmentors to the reverse.

The facts we have considered throw light on the whole action of antagonistic nerves in the many cases where there is a double nerve supply.

14.—RHYTHMICITY IN NERVES.

One of the best examples of rhythmicity in nerves is that of *Ritter's opening tetanus.* "An indirectly excited muscle may, after prolonged closure of a powerful battery current, fall, on breaking the circuit, into a state of persistent tetanic excitation."[‖] It specially occurs in "cooled frogs," when, as we saw in section 7, the threshold number is great, and the nervous impulse which gives rise to the tetanus is rhythmic.[¶] There can be little doubt that this is a rhythmic discharge due to a collection of anions at the anode, just as a rhythmic

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[*] Gaskell: Schäfer's Textbook of Physiology, vol. ii., page 193.

[†] *Ibid.*, vol. ii., page 216.

[‡] *Ibid.*, vol. ii., page 218.

[§] *Ibid.*, vol. ii., page 220.

[‖] Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 117.

[¶] *Ibid.*, vol. ii., page 119.

discharge is caused in the heart by the anions in a circulating fluid. The long closure of a powerful current allows plenty of time for a large number of anions to be liberated at the anode, and, what is more important, a large amount of kation-proteid to be decomposed at the kathode, so that although the excess of anions liberated at the anode may not be equal to the threshold number while the current is closed, yet, on opening, the sudden rush of kations to the former kathode causes a sudden fall in the value of the threshold number, for anions, at the anode, so that the number of free anions may now be many times the value of the threshold number. The fact that it occurs best when the threshold number is great (cooled nerves)—when the decomposition at the kathode is most marked*—favours this view. The fact that the "opening tetanus" is removed by immersion of the nerve in KNO_3 shows that it is due to anions, since it is removed by an excess of kations.

15.—The Movements of Plants.

This theory of the influence of the ion-proteid upon the surface tension of protoplasm gives a simple explanation of the movements, and especially the heliotropism, of plants. It is a well-known fact that, in the presence of chlorophyll, green plants, under the influence of light, decompose carbon dioxide, retaining the carbon and giving off the oxygen — this carbon is built up into carbo-hydrates and proteid.† Hence, it is evident that the rapidity with which the synthesis of proteid (and therefore of ion-proteid) goes on is dependent upon the supply of carbon; that is, upon the presence and intensity of illumination. Supposing a contact difference of potential, due to free ions, exists between the protoplasm of plant cells and the cell walls, it is readily seen that at the point where the assimilation of free ions into ion-proteid is going on most rapidly, this contact difference of potential will be diminished, and therefore, as we have repeatedly pointed out, the surface tension along the contact surface will be increased. This will mean decrease of surface at such points, and comparative increase of surface at other points; therefore, a cylindrical stem, in which assimilation is going on more rapidly on one side than on the other, will bend towards the *former* side.

But, we have seen that if one side of a growing plant stem is more strongly illuminated than the other, assimilation will be going on more quickly on the illuminated side; there-

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* *Vide* discussion of electrotonus, this paper, section 8.

† *Vide* Vine's Physiology of Plants, 1886, pages 140-148.

fore, we should expect growing plants, with slender mobile stems, to bend *towards* the light. And such is, in fact, the case. I quote from Darwin: The Movements of Plants, page 465:—"In our various experiments we were often struck with the accuracy with which seedlings pointed to a light, although of small size. To test this, many seedlings of *Phalaris*, which had germinated in darkness in a very narrow box several feet in length, were placed in a darkened room near to and in front of a lamp bearing a small cylindrical wick. The cotyledons at the two ends and in the central part of the box would, therefore, have to bend in widely different directions in order to point to the light. After they had become rectangularly bent, a long white thread was stretched by two persons, close over and parallel, first to one and then to another cotyledon; and the thread was found in almost every case actually to intersect the small circular wick of the now extinguished lamp. The deviation from accuracy never exceeded, as far as we could judge, a degree or two."

Of course, in such cases, it may be objected that chlorophyll is not yet fully formed; but, inasmuch as chlorophyll is very quickly developed in the light, it may be supposed that the process of its formation, and the consequent accelerated synthesis of proteid, begins at once; while plenty of time was allowed for the reaction, since, in the experiment just before the one quoted, eight hours was allowed for seedlings of *Brassica* and *Phalaris* to bend "rectangularly towards the light."

In order to see how intimately the bending of plants towards the light depends upon the illumination of the chlorophyll, it is only necessary to refer to Darwin's "Movements of Plants," page 449 to page 468.

The few exceptions nearly all admit of some other explanation. Thus, Darwin shows that heliotropism may be much modified in some plants owing to their habit of climbing; in other cases apheliotropism may be induced because too intense illumination injures the chlorophyll,* and therefore reverses the effect we have described. Further, in time, the preponderating *growth* of the illuminated side will tend to reverse the effect. In the rare cases where plants containing little or no chlorophyll are heliotropic we may assume that light aids assimilation in some other way. The tendency for leaves to place themselves perpendicular to any not too strong illumination† is easily understood when we consider the influence of illumination upon the leaf stalk; illumination of its upper surface will cause a diminution of that surface—as we have

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* Darwin: The Movements of Plants, page 446.

† *Ibid.*, page 449.

seen—and this will counteract the effect of gravity tending to make the leaf hang downwards.

The importance of sudden change in illumination[*] is due to two factors: one the tendency of growth to counteract heliotropism if illumination is carried on for some time, and the other the tendency the ions from the unilluminated side will have to diffuse faster into the illuminated side, as the ions there are assimilated, a tendency which would slightly increase the P.D. at first lowered by the assimilation. It is evident that in normal growing plants these factors of heliotropism, growth, gravity, etc., will eventually reach a state of more or less settled equilibrium, which will determine the permanent form of woody parts.

That differences of potential, such as we have described, *do* exist in plants is well known. Thus, Biedermann[†] mentions that Kunkel found the veins of a leaf "positive" to the green surface (translating this physiological terminology this means that internally to the leaf there was an E.M.F. tending to promote a current *from* the green parts *to* the veins). There can be no doubt, I think, that this is due to the kations of the salts, brought up by the transpiration current, diffusing more rapidly through the walls of the vessels in the veins than the anions. The salts brought up are mainly KNO_3 and KCl, in which the kation has a greater velocity than the anion.[‡] The same explanation applies to the "negativity" of the roots of a seedling towards the cotyledon, and higher parts,[§] for the roots would have a large supply of kations due to diffusion from the moisture in the soil which diminishes progressively as the transpiration current mounts up the stem and the kations are assimilated.

Hermann[||] found that cross sections of the stem of a plant were "negative" to normal parts. This is doubtless due to decomposition of kation-proteid at the point of injury liberating kations.

Burdon-Sanderson finds that when the leaf of Dionea closes, the lower surface becomes "negative" to the upper.[¶] This affords an explanation of its closure, since kations are liberated on the under side the surface tension on that side is

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[*] Darwin: The Movements of Plants, page 457.

[†] Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 2.

[‡] *Vide* Table of Stimulation Efficiencies, this paper, section 3.

[§] Biedermann: Electro-physiology: Trans. by F. A. Welby, vol. ii., page 5.

[||] *Ibid.*, vol. ii., page 2.

[¶] *Ibid.*, vol. ii., page 23.

reduced; that is, the under surface tends to increase, and the upper to decrease, hence the leaf closes.

16.—SUMMARY.

It has been proved by Loeb and others that proteid takes up ions to form a loose compound, which they call ion-proteid.

Since these ion-proteid molecules must always be breaking down, there must be, for this reason, if not for others, a number of free ions in any protoplasmic body, and therefore, in general, a difference of potential between it and the medium in which it lives.

It is acknowledged by many physiologists* that the movements of unicellular organisms are due to changes in surface tension, while others, as Schäfer,† consider it probable that the movements of muscles may be due to the same cause. It is, indeed, obvious from the structure of amœba, cilia, muscle, etc., that, if changes in surface tension take place, movements must follow.

But since, for obvious reasons, the number of free ions in a protoplasmic body must always be changing or subject to change, it follows from known physical laws that the surface tension must also change.

We have shown that this mode of accounting for the movements of organisms enables us to explain the galvanotaxis and chemotaxis of unicellular organisms—the contraction of muscle—the electro-motive and other phenomena accompanying muscular contraction and the nervous impulse—the rhythmicity of certain muscles and nerves and the variations in their rhythm—the action of inhibitory and augmentor nerves, and the movements and electro-motive phenomena of plants.

It seems, therefore, certain that this explanation of the genesis of movement in living bodies is, in the main, true, and that it is probably capable of explaining the whole of that vast complex of facts which have been gathered together under the head of phenomena of contractility and irritability.

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* *Vide* Bütschli: Protoplasm and Microscopic Foams: Trans. by E. A. Minchin, 1894, page 289: and Verworn: General Physiology: Trans. by Frederic S. Lee, page 561.

† Schäfer: Essentials of Histology, sixth edition, page 56.

GEOLOGICAL REPORT[*] ON THE COUNTRY TRAVERSED BY THE SOUTH AUSTRALIAN GOVERNMENT NORTH-WEST PROSPECTING EXPEDITION, 1903.

By HERBERT BASEDOW, Prospector to the Expedition.

[Read October 4, 1904.]

PLATES XIII. TO XX.

CONTENTS.

Pre-Cambrian:—

Cambrian:—

Ordovician:—

Supra-Cretaceous:—

Appendix:—

THE RANGES OF NORTH-WESTERN SOUTH AUSTRALIA.

Although maps represent these ranges as separate entities, they must, on geological and lithological grounds, be regarded as belonging to one and the same grand system, the intervening tracts of country which now separate the individual ranges being, for the most part, superficial deposits of comparatively recent sands and sandhills, or supra-cretaceous deposits, known as the "desert sandstone."

Rising abruptly[†] from the surrounding sandy country,

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[*] This paper, which has been slightly abridged, was the successful Tate Memorial Medal Thesis, 1904.

[†] Compare J. Forrest, Explorations in Australia, III., page 248:—"The whole country is level, the ranges rising abruptly out of the plains, . . ." Also the general statement by James Geikie, in Earth Sculpture, page 202: -"Rising boldly above the general level, they exhibit no trace of talus or debris. . . ."

they extend in an easterly and westerly direction as huge, intrusive masses within crystalline schists and gneisses, mostly devoid of vegetation, though the intruded rocks bear "mulga," pine tree, and undergrowth of bush and grass. Fertile sandy loams, carrying mulga scrub of variable extent, surround them; while beyond this belt sandhills with "porcupine grass," "desert oak," "quondong," etc., prevail.

Their main bulk consists of plutonic masses, which form the cores of anticlinal folds of metamorphic rocks. Owing to the intense metamorphism induced not only in the intruded rocks, but also at the outskirts of the igneous intrusions themselves, it is often impossible to determine the actual plane of contact.* This factor has further been the cause of the contact rocks assuming a distinctive character by re-crystallisation of the original constituents *(Hornfelsstructur).* In this process the production of epidote has been greater than that of all other minerals, it being by far the most generally distributed near intrusions.

The following section is a diagrammatic representation of the mode of occurrence of the igneous and metamorphic series.

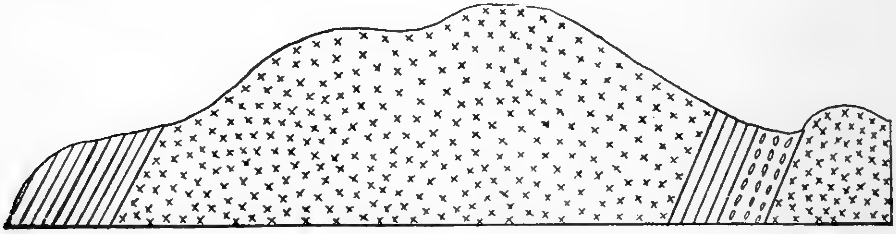

Fig. 1.—Diagrammatic Section through Portion of the Musgrave Ranges, East of Mitchell's Knob.

Owing to the absence of representatives of the Cambrian system in proximity to the ranges, the age of the igneous intrusions could not be definitely determined, but they certainly took place before the Ordovician period, as examples may be seen in the low-lying outskirts, as, for instance, Indulkana, of rocks of the Ordovician period overlying the intruded fundamentals, and not being themselves penetrated by the eruptives.

The Musgrave Ranges comprise an extensive series, ranging from acid to basic; the Mann principally acid and inter-

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* Mons. Michél-Levy has described similar features in the gneisses of the Central Plateau of France. He points out that whenever it is the case that the granite is massive and intrudes rocks of acid character the plane of contact is not sharp, but the intruded and intrusive rocks are connected by a contact zone.—Bull. Soc. Géol., France, Ser. 3, tome vii. pages 852 et 853.

mediate; while in the Tomkinson Ranges members of the basic and intermediate families are typical. The intermediate group is represented throughout by numerous diorite dykes, which are usually of no great thickness, but their frequent appearance within short distances of one another is in cases marked. Their plane of contact with the intruded rock is always well defined.* The diorite intrusions have occurred later than the main granitic injections of the district. This is evident from the fact that often the diorite can be found penetrating the granite.† Yet the diorite in places does not appear to have been much subsequent in time, for magmatic intergrowths may be observed between diorite and granite rock that have been produced during a state of semi-plasticity of the latter. On the other hand, magmatic inclusions of granite rock within the diorite occur. These have been torn from the walls of the fissure, into which the diorite was injected, and embedded in the mass.

The intruded rocks, where they appear in considerable and persistent thickness *(Mächtigkeit)*, may be included generally under the headings of "gneissic quartzite"‡ or "gneiss" proper; yet other crystalline schists are not wanting, although they are not represented to the same extent. The great variations in readings of the compass needle, produced by the magnetic minerals contained in the different granitic rocks that compose these ranges, have already been noted by various explorers.

THE MUSGRAVE RANGES.

General Remarks.—The Musgrave Ranges (Gosse, 1873) lie almost wholly in the State of South Australia, only two minor offshoots passing northward to beyond the boundary, in the localities of Opparinna and Fraser Hill. They rise from the plains as a compact chain that continues in an easterly and westerly direction for a distance of over one hundred miles. They are, however, cut in several places by valleys of denudation that are now occupied by vast deposits of sand, the upper surfaces of which form elevated plains (such as Glen Ferdinand), that permit the ranges being crossed with no great difficulty transversely to their long axis. Their breadth varies, the maximum being about thirty-five miles,

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* Compare Michél-Levy, *op. cit.*, pages 845 et 872.

† See also H. Y. L. Brown, Report Journey from Warrina to Musgrave Ranges, page 2 (Adelaide: by authority, 1889); and V. Streich, Scien. Res. Elder Expl. Exp., Trans. Roy. Soc., S.A., vol. xvi., pp. 77 and 83.

‡ An altered (clastic) sandstone in which only a very faint indication of foliation has been brought about by the production of secondary minerals.

and the altitude is considerable. Mount Woodroffe, the highest peak, is estimated to be over 5,000 feet above sea level, and more than 3,000 feet above the level of the adjoining desert. Hence this chain of mountains is by far the most massive of the series seen during the expedition.

Igneous intrusions on a grand scale have produced the upheaval and form the inner mass of the several folds into which the intruded metamorphic beds have been thrown.

Mr. W. C. Gosse, in 1874, pointed out that the Musgrave Ranges "are composed chiefly of granite,"* and later Mr. H. Y. L. Brown † (1889) that they "are composed of eruptive granite and metamorphic granite rocks of various kinds, chiefly hornblendic, and seldom containing mica," comprising "ordinary granite, porphyritic granite, hornblendic granite, graphic granite, granulite, pegmatite, syenite, quartz syenite, and epidosite, gneiss, both hornblendic and micaceous, and siliceous and felspathic crystalline rocks of various kinds," and that they are intruded by diorite and dolerite. Mr. J. Carruthers stated:—‡ "The Musgrave Ranges are composed principally of red granite rocks, and covered with spinifex and few scattered pines; the flats between the hills, which are principally formed by large creeks coming out of the ranges, are beautifully grassed, . . . the soils being a rich, red, sandy alluvial, and firm red loam."

Igneous Rocks.—The intrusives vary in character from highly acidic to basic, the differences, however, between the members of one and the same family being slight. The acid rocks are principally granitic, the greater bulk consisting of a rather coarse-grained porphyritic variety, with large corroded crystals of a bluish felspar (orthoclase). Ernest Giles was the first to mention§ this type of granite, and assigned to it the expressive term of "granite-conglomerate," making thereby particular reference to Mount Carnarvon, which is the eastern limit of the Musgrave Ranges. Mr. W. C. Gosse, moreover, in describing Mount Morris, wrote ‖ "that this portion of the range is composed of very coarse granite. At the entrance to Jacky's Pass, on the south, this class of granite flanks the chain, but further east the southern slopes

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* Parliamentary Paper, No. 48, House Assembly, page 18.

† Report on Journey from Warrina to Musgrave Ranges. By authority: 1889.

‡ Report to Surveyor General (*Adelaide Observer*, January 16, 1892).

§ Geogr. Travels in Centr. Austr., 1872-1873, Part ii., page 84.

‖ Parliamentary Paper, No. 48, House Assembly, 1874, page 16.

consist of fine-grained gneiss, the granitic outcrops being in the heart of the range. The main intrusion thus extends east of the pass towards Mount Woodroffe, thence taking a more northerly turn in direction of Mount Carnarvon; it has its greatest development east of Harries' Spring, while on the eastern borders of the range gneisses predominate. In this respect the Musgrave resemble the Mann Ranges

A subsidiary arm of the main injection of the igneous rock produces a prominence in the neighbourhood of Mitchell's Knob, the major and minor veins of the same enclosing clastic (?) gneisses. (See fig. 1.)

The ranges on the northern flanks, north of Mount Ferdinand, present a picturesque appearance, produced by grotesquely shaped, isolated, bare, granitic masses *(Sekundäre Kuppen)*.

The granite, particularly that of the porphyritic variety, is characterised in the field by its strong tendency towards concentric weathering, large shells of rock exfoliating concentrically to the present contour of the rock surface. This feature is deserving of particular notice.

In the valley of the Ferdinand, west of the mount bearing a similar name, the character of the granite changes to a more even-grained, white variety, with irregular aggregates of hornblende and biotite distributed through its mass. Where this granite has been cut by diorite the contact is marked by a development of large idiomorphic crystals of hornblende. In the same locality minor veins of epidote granite, with a red orthoclase felspar, and graphic granite traverse the main granitic mass in a westerly course.

East of Lungley's Gully an intrusion of red aplite is delicately veined with crystalline epidote, and the planes of slickensiding, that cut the rock, are lined with a "*harnish*" of secondary mica and rhombohedral calcite. The rock is conspicuously jointed in two planes, the first of which strikes W., 20° N., and dips northerly 73°, the second striking N., 45° E., and dipping 23° S.E.; a third plane is less regular. Rocks belonging to the peridotite family were found in the form of pebbles among the wash of a small watercourse south of Mount Morris, but the rock was not observed *in situ*. Diorite dykes are very plentiful. The diorite rock is normal, quartzless, and moderately fine-grained. It is usually micaceous. Dolerite dykes are less numerous. They consist of a finely crystalline groundmass with porphyritic crystals of felspar and pseudomorphous (?) epidote. Dykes of a peculiar volcanic rock are rare. Fluidal structure is typical when viewed under the microscope, it being marked by ores of iron in a glassy groundmass. Corroded phenocrysts of olivine are plentiful.

Metamorphic Rocks.—The gneisses of the Musgrave Ranges, derived both from the alteration of sedimentary and igneous rocks, with few exceptions, skirt the chain on either side; they also form the intermediate flanks of folds produced by the intrusion of the eruptives. They do not extend to the same altitude as the igneous rocks, and, as is the case in the Mann Ranges, they appear more extensive on the eastern than on the western limits of the range.

A natural section along the course of Whittell's Creek presented a variety of schists within small range of country. The section showed a gradation from a compact gneiss through a series of beds, as follows:—Quartzite, quartz schist (laminated), schists of various kinds (mica, chlorite, epidote, and garnetiferous, with numerous perfect dodecahedral crystals of garnet in a dark quartzitic, schistose matrix); thence quartzite, jointed regularly in two directions at right angles. The strike varies from almost due north and south to east and west; the latter is, however, the general strike of the beds of this section. East of Mount Woodward the gneisses are in parts compact, in parts fissile. They are jointed vertically in direction north, few degrees east, and at right angles to this plane. The planes of foliation dip south. North of here it is distinctly granitic in character, and separated into more or less horizontal (lenticular) layers by planes of division; these layers thickening appreciably as the depth increases *(Bankförmige Absonderung).* At the contact with a diorite dyke it has assumed a remarkable, closely foliated character; the folia, produced by a very dark coloured biotite and stringlets of quartz running parallel with the direction of intrusion.

The gorge cut by the Opparinna Creek affords another section within the gneisses that skirt the watercourse in the form of scarped, shattered walls. They show signs of earth - movement and folding, and are replaced in parts by smaller bands of chloritic and sericite schists, often traversed by small seams of epidote at the zone of contact with diorite dykes. At Opparinna Spring the country consists of a compact, dark bluish-black gneiss, vertically jointed in directions W., 20° N., and N., 10° E. (less perfectly), and in planes dipping S. 5°. Along the last-mentioned plane the rock parts readily into layers about twelve inches thick. North of the spring the metamorphic series changes to a compact brown gneiss, weathering massive granitic, and showing a regular cubic jointing. The texture, in parts, approaches the "graphic" intergrowth of some granites, the quartz occurring as rounded and elongated inclusions *(quartz de corrosion)* in the felspar.[*] The optically-continuous character of the quartz and felspar can readily be detected in hand specimens by suitably reflecting the light from a freshly fractured surface. The planes of foliation of the true gneiss strike W., 20° S., and dip northerly 11°.

South of Opparinna Spring the gneissic quartzites[†] composing the ranges are thrown into a great overthrust fold which can be observed on the eastern face of the gorge cut by Moffat Creek, by following up the exposure of two prominent parallel layers of the rock. These, on the south, dip at a low angle of about 30°, and on the north the same bands are seen dipping in the same direction at a high angle, with an inward curve at the top. The crest of the fold has been removed by denudation; yet the outline of the original contortion of the beds, upon reconstruction, was evidently as represented in the figure. Within the fold exists a zone of extensive dioritic intrusion, while the country is severely fractured.

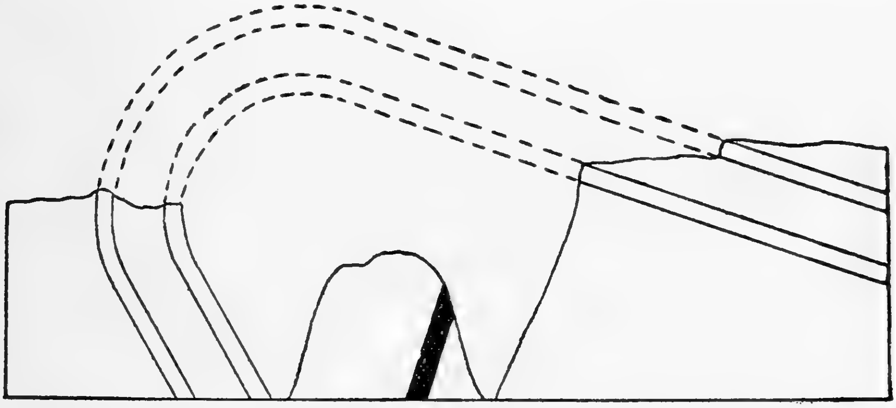

FIG. 2.—AN OVERTHRUST FOLD IN BEDS OF GNEISSIC QUARTZITE. MOFFAT CREEK, SOUTH OF OPPARINNA SPRING, MUSGRAVE RANGES.

A similar feature, though on a smaller scale, was encountered in Jacky's Pass. Beds of gneiss are in this case bent to a considerable degree; a diorite intrusion within the fold accompanied the earth-movement.

Several island-like masses of gneiss rise above the sands to the west and south-west of the group of hills termed the Kelly Hills. One of such occurs close to a native soakage

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[*] Lacroix has described a somewhat similar type of gneiss from Southern India.—Record Geol. Survey, India, xxiv., page 157 (1891).

[†] No doubt equivalent to the "granitoid quartzites" of this locality mentioned by R. W. Murray. Extracts Journals of Explorations, by R. T. Maurice (by authority: 1904, page 29).

well, known to the natives as Tarrawaitarratarra, and it has been conditioned by the intrusion, within a series of schists, of pegmatite and greisen. The muscovite of the pegmatite is remarkable for its peculiar reddish-violet tint, closely resembling that of lepidolite, but failing to give the characteristic flame test of the latter. The mica, moreover, of one of the schists is similar to that of the true igneous rock, though it occurs as smaller individuals. The schist is usually a closely laminated, quartz-mica rock, often "knotted" by secondary mineral development; while at the contact with a diorite dyke on the summit of the hill a finely foliated gneiss has been produced. The planes of schistosity strike N., 12° E., and dip 40° E. The height above sea level of the exposure is 2,100 feet, and it stands 140 feet above the sand plains. The beds have suffered local displacements; planes of shear are thickly lined with a glossy layer of secondary minerals.

Outcrops some miles to the north of this exposure were presumably observed to be overlaid by conspicuous beds of quartzite. Opportunity was not afforded to determine whether these beds form part of the fundamental series or whether they are unconformable to the schists.

The hills further south are composed of rock of the compact granitic character already discussed. In parts they are of the "fluxion" type of gneiss, and they are characterised by weathering concentrically.

OUTLIERS OF THE MUSGRAVE RANGES.

The Musgrave Ranges are bordered on the south by numerous outliers of granitic rock, many of which are of considerable magnitude, and have consequently received separate names. A few of these outliers will be briefly discussed: —

Mount Caroline.—South of that portion of the Musgrave Ranges known as Lungley's Gully, about eight miles, stands a bold, isolated mount, over 1,000 feet above the level of the sands. It is known as Mount Caroline. Its mass is composed of biotite granite, with a slight tendency to foliation on the part of the mica. Large porphyritic, corroded crystals of orthoclase predominate, the quartz being subordinate to the felspar. The rock at the surface is decomposed. It is cut by a diorite dyke that can be distinguished on the western front from a distance as a black wall running up the entire height of the mount. Smaller portions of graphic and epidote granite are included within the mass.

The hill bears porcupine grass, pine and fig tree, and a light-coloured lichen covers the massive exposures of the granite.

Low outcrops of gneiss trending in a north-easterly direction lie not far to the north of Mount Caroline.

Mount Crombie.—Still further south, and about twenty miles from the above, another conspicuous outcrop of granitic rock, bearing the name of Mount Crombie, is situated. The northern outskirts only of this exposure were visited. They consist of gneiss, whose dark planes of biotite strike roughly east and west. The rock exfoliates concentrically at the surface into large shells, which subsequently break up regularly into cubical blocks in well-defined rows, corresponding to a latent system of planes of weakness brought into prominence by weathering. A diorite dyke intrudes the gneiss in direction W., 42° N.

Mount Kintore.—Mount Kintore rises from beneath the desert south of the gap that separates the Mann from the Musgrave Ranges. It is built up principally of metamorphic beds intruded by diorite dykes. The beds, comprising gneisses and quartzite, have been thrown into a series of simple folds, which is well recognisable on the northern face of the mount. Gross shattering and crumbling of the rock have accompanied the folding. The strike of the beds varies slightly, about south-east, and it is made prominent by the weathering of the rock into ridges conforming in direction with that of anticlinal axes.

At the western end of the outcrop the gneiss is replaced by a development of graphic granite; and diorite intrusions traverse the hill in several localities.

Echo Hill.—Echo Hill lies south of the eastern extremities of the Musgrave Ranges. It is one of many minor outcrops of granitic rock occurring in this neighbourhood, and is composed of gneiss neatly "lined" with biotite. Is is cut by veins of coarse pegmatite, with large felspathic constituents, while local developments of epidote are frequent. The rock is jointed in planes striking S. 40° W., and dipping 40° N.W. The height of the hill is 2,270 feet above sea level (by aneroid determination).

THE MANN RANGES.

General Remarks.—The Mann Ranges, discovered and named by Gosse in 1873, lie to the west of the Musgrave, and are separated from them by a desert tract of sandhills bearing *Triodia* and *Casuarina*. They extend as a more or less compact chain in a westerly direction, with a slight trend to the north, across the border of South Australia and the Northern Territory, a distance of some eighty miles. Isolated hillocks can be traced to beyond the border line of Western Australia, culminating to the westward in a more pronounced development, known as the Mount Gosse group of hills. The trend of the Mann Ranges, if produced in an easterly direction across the intervening tract of sandhills, is in the same straight line as the axis of the Musgrave Ranges.

Both ranges consist of igneous intrusions* and altered sedimentary and igneous rocks. The western portion of the Mann Ranges, of no great width at this end, consists almost wholly of igneous exposures. In the centre the core of igneous intrusion is flanked on either side, namely, its northern and southern boundaries, by complexes of gneiss, schist, and gneissic quartzite; whereas on the eastern limits of the range, by far the widest portion, the main intrusion lies hidden beneath the metamorphic series, into which it was injected, to appear once more at the surface to the eastward, in the Musgrave Ranges.

A ground plan of the metamorphic exposures of the Mann Ranges gives roughly a U-shaped form, the flanks that skirt the middle of the ranges forming the straight arms of the U, the curved base of the letter being represented by the thicker mass of crystalline schists at the eastern end.

As a rule, the trend of the ranges coincides with the strike of the rock, except in a few instances, where irregularity of stress produced by igneous intrusion has interfered, and where a local bulging out of the mass, no doubt the result of an igneous offshoot, has produced a spur, the axis of which does not conform with the general direction of the range.

Though mineralogically not as rich as the Musgrave Ranges, the Mann Ranges are geologically of particular interest, as they exhibit many examples of rock movements and fracture that accompanied igneous intrusion. †

Igneous Rocks.—An intrusion of granite has been by far the greatest, it continuing uninterruptedly as the backbone of the whole range, to disappear under superincumbent gneisses on the east, and occurring as isolated outliers for a considerable distance to the west. The character of the rock varies, passing from a true granite (in portions porphyritic), to various metapyrigen gneisses. ‡

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* Compare J. Forrest, Explorations in Australia, III., page 243:—"The Mann Ranges are composed of reddish granite." Also J. Carruthers:—"The Mann Ranges are covered with pines, bloodwood, a few scattered gums, dense spinifex, and scattered patches of coarse grass, the formation being red and grey granite."—(*Adelaide Observer*, January 16, 1892, page 9.)

† Compare the statement:—". . . hills and mountains of the Mann Ranges, some few of the Musgrave chain, and all west of the Mann Ranges have been shivered into fragments by volcanic force, . . ."—E. Giles, Geogr. Travels in Centr. Austr., 1872-1873, Part ii., page 103.

‡ The term as employed by Dr. J. W. Gregory.

The plane of contact with the primary gneisses is mostly imperceptible. A contact zone is not infrequently found gradually merging into granite on the one side, and granitic gneiss on the other. In other cases the contact has been so fractured and dislocated for a considerable distance that the junction cannot be traced.

Large "floating" masses of bedrock were noted at several localities, as, for instance, north-west of Mount Whinham and south of Mount Edwin.

The granite in general occurs as bare, rounded, dome-shaped masses,* several chains' length of rock often appearing without the least fracture in the mass, though subsequent weathering produces large exfoliating shells, which detach themselves from the body of rock (concentric weathering). This feature is more usually presented by the porphyritic varieties, while a more typical granitic aspect is brought about by the natural systematic jointing of the fine-grained, uniformly crystalline rock. Frequently the mass shows neither of these physical features, but is grossly shattered throughout by the intense stress produced during the process of solidification of the crystallizing rock magma. Such instances were found south of Mount Cockburn, and on a splendid scale south-east of Hector's Pass, where the planes of fracture have assumed regular, contorted, and curved outlines, as though produced during the last stages of solidification of the magma, the more rapidly contracting envelope of the rock having caused the enclosed mass to part along certain curves of stress by virtue of the extreme pressure from without.

Diorite dykes are very numerous, forming a fairly regular system, usually, though not invariably, trending east and west. The best noted example of excessive intrusion by this rock was observed in the hills east of Mount Whinham, on the eastern extremity of the ranges. At this locality no less than fourteen diorite dykes can be counted traversing the gneissic hills in a distance of less than a quarter-mile, and can be clearly seen continued through a similar gneissic exposure a mile or two further west.

Metamorphic Rocks.—As stated above, crystalline schists and gneisses appear more extensively developed at the eastern end of the chain. Near the north-western limit of the main

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* Giles *(op. cit.)* continues his statement:—". . . most of the higher points of all these heights are composed of frowning masses of black-looking or intensely red ironstone or granite, coated with iron. *Triodia* grows as far up the sides as it is possible to obtain any soil, but even this plant cannot exist upon solid rock, therefore all the summits of these hills are bare."

range, the metamorphosed rock, close to the intrusive, occurs as a fine-grained, compact quartzite, passing further from the contact into a garnetiferous gneiss, with large lenticular crystals of felspar (a variety of adularia, or moonstone), having a satin-like lustre, and which, even to the naked eye, can be seen to be locally surrounded by a layer of finely crushed material derived from the grinding down of the felspar itself *(Morter structure)*.

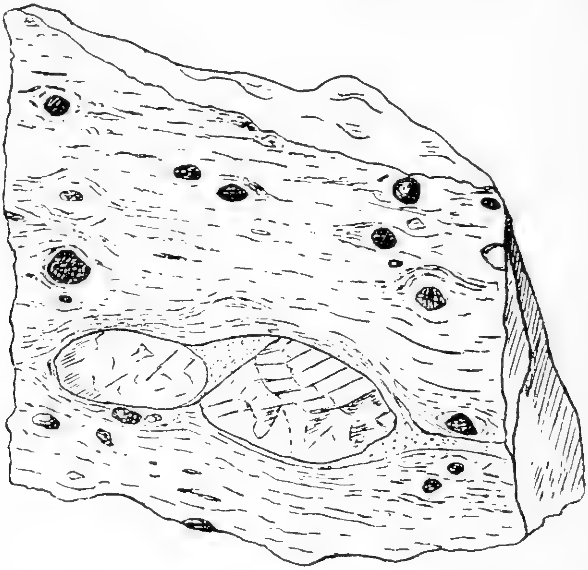

Fig. 3.—Augen Gneiss, Mount Cockburn, Mann Ranges.

In the former instance the altered rock was no doubt originally a somewhat massive, siliceous sandstone; in the latter a finely laminated rock has probably been altered by minor injection of igneous matter between the planes of lamination (injection gneiss).

South of Mount Cockburn, however, garnet-schist* and fissile gneiss occur at the zone of contact, while gneissic quartzites overlie the gneiss. It is in this locality that a natural section affords opportunity of studying the relative positions of these altered rocks. (Section on Plate xix.) A granitic intrusion appears in the form of a central axial-core,

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* W. C. Gosse writes that Mount Charles is "composed of grey granite and slate." Report and Diary of Central and Western Exploring Expedition, 1873. Parliamentary Paper No. 48, House Assembly, 1874, page 12. No slate was observed in this neighbourhood, and it may be that Gosse mistook the schist or fissile gneiss for the same.

trending west, which has thrown the overlying beds into a series of simple folds: an anticlinal directly conforms with the surface of the eruptive, and consists of blue garnetiferous schist and gneiss, with "eyes" of felspar, large crystals of hornblende and fractured garnets. South of this spot the overlying beds of gneissic quartzite can be traced, occurring as two perfect sigmoidal folds, the second synclinal, with a very sharp angle, thence passing to a shallow monocline that is finally lost in the zone of crushing at the contact with a second intrusive mass. The extreme southern exposures of the range occur as outlying masses of gneissic rock, the strike of which agrees with that of the country, and the dip is southerly.

At the foot of Mount Cockburn, a low outlier of the same exposures consists of quartzitic gneiss, the foliation being imperfectly developed, and large, lenticular "augen" of felspar not infrequent. The hill shows perfect parallel planes of jointing in direction N., 15° W., dipping 75° westerly. These planes are made the more conspicuous by the resulting fissures having become filled with detritus, in which a thick growth of grass and other vegetation, standing out as dark, prominent lines from the light-coloured gneiss behind, has flourished.

To the north the augen gneiss merges on the one hand into a gneiss with *linear foliation*, and on the other into a crushed rock, with large, false "pebbles" of quartz, produced from the original rock, surrounded by well-marked, concentric "lines of flow" of crushed material. Shearing and compressive stresses have certainly contributed largely to the formation of the latter, and like forces have produced the augen gneiss, while the ultimate result of rock-crushing and shearing is the finely "lined" variety of gneiss.

Striking evidence of the extreme conditions of stress that existed during the mountain-building processes is afforded at the north-eastern end of the Mann Ranges in the form of a series of *step-faults* on a fairly large scale. The country here consists of compact gneiss, with large, bluish orthoclase and folia of biotite, intruded by diorite dykes. Ten distinct, almost vertical, scarp-faces of gneiss, rising one above the other, can be seen, each surmounted by the severed portions of one and the same diorite dyke. The igneous rock, four feet in thickness, forms the floor of each step, the vertical distances between the successive steps averaging twelve feet, and each fractured mass of the diorite dyke dipping about 10° S. The several fault planes hade 10° in a direction N. 10° E.

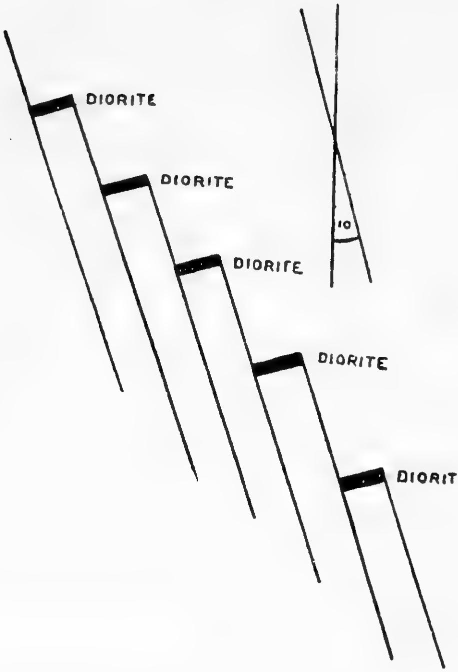

FIG. 4.—STEP-FAULTED GNEISS AND DIORITE DYKE, NORTH-EAST MANN RANGES.

An interesting phenomenon was encountered in this series of gneisses some dozen miles north-west of the western extremity of the main range, where low outcrops skirt the eastern limit of a large depression or "salt pan," the saline deposits of which rest directly upon a bed of similar gneissic rock. These outcrops have weathered by a process of *æolian erosion* into mushroom-shaped masses *(Pilzfelsen)*, with smooth central columns, narrow at the base, and gradually widening upwards to support a flat, tabular mass at the top. The stalk is abraded by deflation, the wind hurling the coarse grains of sand, which do not rise to beyond a few feet above the level of the ground, incessantly against the base of the column. (Plate xiii., fig. 2.)

Streich has reported* mushroom-like forms of sand to occur in the wind-drifted sands of the Great Victoria Desert. He states that the sand is generally loose, though somewhat consolidated by means of a clay cement, but only on the surface. When the uppermost crust has been broken through, the wind gradually blows away the underlying loose sand, leaving the upper layer unsupported around the

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* Scient. Res. Elder Expl. Exped., 1891-2, Geology. Trans. Roy Soc. S.A., vol. xvi., page 88.

border. The phenomenon is really resistance to transportation of the consolidated crust by wind rather than abrasion or erosion of the underlying loose sand by æolian agency.

A further factor that plays an important part in the weathering of rocks in the desert was noted in the outcrops of garnetiferous gneiss immediately west of the shores of Lake Wilson. This form of weathering, the *Seele der Verwitterung* of Schweinfurth, consists of the flaking off of the rock as a result of crystallisation of salt within minute fissures in the mass. Portions of the outcrops, that have been previously locally hardened by cementation (concretionary), have resisted this weathering to some extent, and consequently those portions project from the surface of the decomposing gneiss as irregular, partly serrated, ridges, the direction of which is usually consistent with that of an original constant geological feature of the rock.

Veins, etc.—Comparatively few true fissure veins or lodes were noticed in the Mann Ranges. At the salt pan just mentioned an exposure of a "quartz reef" occurs in combination with a coarse pegmatite (*i.e.*, secondary quartz, in the intrusive). The quartz of the "reef" is very coarsely crystalline, the faces of the prisms exhibiting oscillatory combination to a marked degree. The felspar of the pegmatite occurs as large pink idiomorphic crystals of orthoclase. The lode is non-metalliferous.

A common method of formation of so-called "quartz blows" in the ranges is nothing more than metamorphism by igneous intrusion into the bedrock, the ultimate product consisting of a highly altered quartz schist. The best example of this phenomenon was met with south-east of Mount Edwin. The quartzose outcrop there consists of three parallel ridges of metamorphic quartz schist and granular quartz, the planes of schistosity of the former being visible either as thin layers of secondary mica or the direct products of decomposition of the same. The outcrop trends W. 40° S., and is jointed in directions: (a) N.E., dipping 70° S.E., the rock being finely laminated in this direction, and the planes of lamination a fraction of an inch in thickness; (b) N.W., in well-defined, parallel planes, few inches apart; (c) W. 10° N., and N. 20° W., in less perfect partings. This quartzitic exposure is, beyond doubt, a true product of contact metamorphism, and the difference between its strike and that of the country is explained by parallel outcrops of garnetiferous diorite dykes between the separate ridges of the formation; for these have been the cause of the metamorphism of the original schistose beds lying directly in contact with them.

Owl and Bat Guano.—In the Mann, Musgrave, and Ayers Ranges caves were found containing a considerable floor deposit of so-called guano, the droppings of owls and bats. These caverns have been produced in the granitic rock masses by the denudation and subsequent removal of included softer portions or by the more rapid weathering of the material along planes of parting in the rock. In the former case they were usually observed opening out on to the bare, more or less vertical, joint faces. Owls (principally *Strix delicatula)* appear to be frequent inhabitants of such caves at the present time. Similar deposits were discovered in the Fraser Range by the Elder Expedition.[*]

The "guano" consists of a faintly yellowish to dirty white, compact to flaky, or lamellar mass, with a peculiar, penetrating odour resembling that characteristic of the excrement of flesh-eating birds. The bottom and oldest layers of the deposit have assumed, not invariably, a more or less elastic character when in mass, making it somewhat difficult to detach in small pieces with a hammer. It breaks away as distinct layers or slabs.

In April, 1902, Mr. H. Y. L. Brown reported[†] on cave deposits occurring in quartzite near Yunta. The "guano" from this locality is almost identical with that from the ranges of Central Australia. I have had opportunity of comparing hand specimens collected by Mr. Brown with those I gathered in the Mann and Ayers Ranges. An analysis of guano from the Yunta caves made by Mr. Goyder proved the presence of phosphoric acid and nitrogen in different samples in the following proportions:—Phosphoric acid (P_2O_5) : (a) ·55 ; (b) 6·00 ; (c) 2·57 per cent. ; and nitrogen : (a) 1·68 ; (b) 23·44 ; (c) ·6 per cent.[‡] It is evident from the above estimations that some of our cave deposits are equal to high-class manures, though it may hardly be expected that they will ever become of commercial value. On account of their limited extent, to say nothing of the troublesome journey to the above ranges.

Analyses of cave deposits have also been published from Victoria and New South Wales.[§]

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[*] V. Streich : Trans. Roy. Soc. S.A., vol. xvi., page 99.

[†] Report of Government Geologist to Minister of Mines, April, 1902.

[‡] See Macivor, On Australian Bat Guano, etc., *Chem. News*, May 13, 1887, page 3.

[§] Notes and Analyses of Some N S.W. Phosph. Minerals and Phosph. Deposits, by J. C. H. Mingaye, Aus. Asso. Adv. Sc., vol. vii., 1893, page 332.

MOUNT GOSSE, W.A.

Mount Gosse is situated in Western Australia, about two miles from the boundary of that State and South Australia, and ten miles north of the projected border line between the Northern Territory and South Australia. It is composed of an intrusion of granite within schistose to granitic gneiss, the foliation of which strikes west, slightly north. The rock shows cubical jointing, and the gneissic rocks are overlaid by a compact blue quartzite* possessing a perfect conchoidal fracture, the whole formation being traversed by the never-failing diorite.

A prominent hill, situated seven miles east of north of Mount Gosse, and almost on the border line, stands 2,250 feet above sea level, and 325 feet above the desert, which bears *Xanthorrhœa* and *Triodia*. It has been determined by an intrusion of granite, with porphyritic blue felspars, the trend of the intrusion being slightly north of west.

The injection lies within a linearly foliated gneiss, showing closely set veinlets of quartz. In portions the gneiss is schistose, or slightly fissile, and passes to a fine-grained, felsitoid quartzite. Minor veins of graphic granite, with a white (decomposed) felspar matrix, and epidote, are also met with.

TOMKINSON RANGES.

General Remarks.—These ranges occupy the north-western corner of the State of South Australia proper, and extend westward to beyond the border into Western Australia (Mount Hinckley). They were named by Gosse in 1873. Generally speaking, their dominant features are similar to those of the Musgrave and Mann Ranges, namely, igneous intrusions within crystalline gneisses. In the case of the Tomkinson Ranges, however, the intrusive rock consists largely of gabbro, accompanied by diorite dykes. Moreover, the ranges are not as persistent and compact as those already described.

The higher intrusive bosses bear scanty vegetation, as porcupine grass,† mallee, and pine, while the lower spurs of gneiss are covered with mulga and kangaroo grass. The intervening gullies and flats were thickly clothed with grass and herbs.

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* "The formation at Mount Gosse is a quartzite, with frequent diorite veins and dykes, . . ." W. R. Murray, Extracts from Journals of Explorations, by R. T. Maurice (by Authority: 1904), page 17.

† See also E. Giles, Geogr. Travels in Centr. Austr., 1872-1874, II., page 103; and J. Carruthers:—"These hills are covered with spinifex, . . ."—Report to Surveyor-General (*Adelaide Observer*, January 16, 1892).

The Mount Davis chain includes, among others, a large intrusion of granular olivine-gabbro, * varying in colour from dirty green, through various shades of green, to faint blue. In the last case the predominance of plagioclase felspar and the presence of only a small amount of olivine have produced the bluish tint. The intrusion trends east and west as a massive, rugged chain, flanked by less conspicuous diorite dykes.

The latter, though individually smaller, are very numerous. Their direction of intrusion possesses no regularity, often cutting one another at various angles. Upon one hill, about three miles south-east of Mount Davis, two conspicuous diorite dykes can be traced up the hill slope. These dykes gradually converge towards the summit of the hill, where they ultimately cross one another at an angle of about 30°, each continuing its own course after the point of crossing. The direction of intrusion of the diorite appears more constant (east and west) on the northern side of the ranges than is the case of the more numerous examples on the south.

Very often smaller dykes can be traced in a direction nearly at right angles to the larger, from which latter they have been injected into minor fissures of the rock. The trend of these smaller dykes, in several cases, was noticed to correspond with that of the planes of foliation of the intruded gneiss, and their outcrops can be traced down to the adjacent sandy flats, from which they stand out, by their superior weathering, as marked, low, parallel walls. † As a general rule the diorite rock of the Tomkinson Ranges is of one type only: a finely crystalline, black-looking (hornblendic) variety.

A few miles south of Mount Davis a slight exposure of graphic granite occurs. The quartz that produces the hieroglyphic markings on the surface of the rock is colourless and embedded in a red orthoclase felspar matrix. The whole rock is traversed by veinlets of crystalline epidote.

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* J. Carruthers, *op. cit.*: "The Tomkinson Ranges . . . are composed of grey and red granite, with large outcrops or dykes of basalt." No basalt was found in the neighbourhood of the Tomkinson Ranges, and it is possible that the gabbro was mistaken for basalt by Carruthers. W. C. Gosse, Report and Diary of Central and Western Exploring Expedition, 1873, Parliamentary Paper No. 48, House Assembly (1874), page 13, writes:—"Mount Davis must be at least 1,500 ft. high. This portion of the range is composed chiefly of grey granite." W. R. Murray, Extracts Journals of Explorations by R. T. Maurice (by authority: 1904, page 17).

† Which Mr. Streich compares with the "ruined walls of houses." Scient. Res. Elder Expl. Exp., Trans. Roy. Soc., S.A., vol. xvi., page 93.

Metamorphic Rocks.—The gneisses occur as broken spurs and ridges, extending far outward into the sandy plains. On the north their character is granitoid and foliated, the planes of foliation striking north-easterly. The rock is characterised by bands of quartz and the presence of secondary minerals in more or less distinct layers.

North of Mount Davis outcrops of hypersthene-bearing granulite, which trend slightly east of north, present splendid examples of spherulitic weathering *(Kugelige Absonderung)*. This rock is compact and granular, with little or no evidence of foliation on freshly fractured surfaces, though it is apparent on weathered faces. The rock has a peculiar olive-green waxy appearance.*

The most westerly exposure of the Gosse's Pile Spur† consists of gneiss, which is normal, though quartzitic, the quartz occurring in the form of elongated lenticles, and the mica as small flakes in regular layers of no great thickness. The rock is thickly studded with red garnets *(Almandine)*. This class of gneiss predominates in the Tomkinson Ranges, it being also met with south of the main range.

Veins, etc.—Non-metalliferous quartz veins of a bluish tint and a shattered glassy character are fairly plentiful. They are usually seen in direct association with diorite dykes.

The Murru Yilyah Outcrop.—This outcrop, which was stated to be auriferous, skirts the northern foot of the Mount Davis chain for some miles in a westerly direction (W. 20° N.), with a prominent escarpment facing the north. The deposit consists of a fresh-looking, highly-siliceous rock, varying from an impure siliceous ironstone through chalcedonic and semi-opaline varieties of quartz, the chalcedony often occurring, encrusting, drusy or slightly stalactitic, or pervading the rock as irregular planes of infiltration. The silica has been tinted by mineral salts in solution, the colour ranging from a rich brick-red through pale yellow to a bright green (chromium). Small, irregular cavities exist in the rock, which are either coated with a drusy form of quartz or filled with haematite, compact to cellular. The rock breaks with a conchoidal to sub-conchoidal fracture, and small fragments, the result of weathering, cover the adjacent slopes and

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* Mr. G. W. Card, of the Geological Survey of New South Wales, who examined a section of this rock for me, writes that the hypersthene is not very abundant, and is of a deep colour. Apatite is present in noticeable amount. The bulk of the rock consists of granular quartz and felspar. Granulitisation and recrystallisation are not complete in the case of the felspar, residual portions of which may still be seen.

† Compare "Gosse's Pile Hill is of grey granite, with diorite, . . ." W. R. Murray, *op. cit.*, page 17.

flats. A pseudo-brecciated appearance within the rock is produced by simultaneous precipitations of compounds of iron and chromium and chalcedony. Surface cappings of travertine and small deposits of magnesite rest upon the outcrop in places, and more frequently upon the diorite dykes in proximity to it. The deposit is of no great thickness, and can be seen on the west directly overlying diorite. Its origin is doubtful, as it can hardly be referred to the "desert sandstone," though in some respects it is not dissimilar to it. The formation has been proved to be non-auriferous.

EVERARD RANGES.

General Remarks.—The Everard Ranges lie to the south of the Tomkinson, and south-west of the Musgrave Ranges. They are the most southerly of the series of elevations in Central Australia, the other members of which have already been described. They were discovered in 1873 by Ernest Giles, and subsequently (1891) visited by the Elder Expedition.. Mr. V. Streich, the geologist to that expedition, points out* that the Everard and Birksgate Ranges consist almost entirely of eruptive granite, although representatives of a schistose series overlying the granite were observed, usually as outliers of the main range. Mr. Carruthers also pointed out that they "are chiefly composed of red granite."† Only the eastern limits of the range were visited by the North-West Expedition, although the main granitic chain, with Mount Illbillie as a prominent feature, was sighted in the distance, and therefore the following notes relate to that portion of the range only.

Igneous Rocks.—True granitic intrusions, often with large porphyritic felspars, have penetrated granitic gneiss. The granite at the borders of the intrusions has assumed a gneissic character, the apparent planes of foliation having a waved and plicated outline. These planes have, beyond doubt, been produced by movement of the rock magma after partial crystallisation of the constituent minerals. Veins of epidote and epidote granite, in which epidote replaces mica, are general, while interrupted veins of coarse acid secretions are not infrequent.

The intrusion of the granite has taken place in a direction a few degrees south of west, and the weathering of the softer portions of the rock has left huge, bare massifs, upon

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* Scient. Res. Elder Expl. Exped., Trans. Roy. Soc., S.A., vol. xvi., page 83.

† Rep. to Surveyor-General (*Adelaide Observer*, January 16, 1892).

the surface of which lie boulder-shaped tors that often rest in perilous positions.

Diorite and pegmatite dykes occur in fair number, the former more frequently than the latter.

Metamorphic Rocks.—The gneiss occurring in this locality is, without exception, granitic and largely "metapyrigen." The best exposures that came under notice are those occurring south-east of Artootinna soakage well. At this spot the planes of foliation, greatly contorted and folded, strike easterly, and the rock is vertically jointed in direction north and south. The foliation is made conspicuous by planes of dark-coloured biotite, the mica in the original intrusive mass being in parts poorly developed or absent.

Veins, etc.—Veins of barren quartz within the bedrock are not wanting. To the east of the ranges, further, small pegmatitic veins exist within the gneiss, containing irregular secretions of magnetite.

AYERS RANGES.

General Remarks.—The group of hills, situated for the most part in the southern limits of the Northern Territory and partly in South Australia proper, and generally known as Ayers Ranges, is hardly deserving of such a geographical term. In appearance the hills are similar, though smaller and more disconnected than the previously mentioned groups of elevation. Mr. Ernest Giles, describing these "ranges," which he discovered in 1872, from the summit of Mount Sir Henry, stated* that "the mount and all others connected with it rose simply like islands out of a vast ocean of scrub," and that the mount "consisted of enormous blocks and boulders of red stone, so riven and fissured that no water could lodge for an instant upon it."

The hills are of fair altitude; yet they appear comparatively low. This is because the red sands from which they rise cover their flanks to a considerable height. The highest point, Mount Cavenagh,† stands 2,200 feet above sea level, but only 300 feet above the adjoining sands. They may be divided into three groups: firstly, that comprising Mounts Cavenagh, Barrow, and Reynolds, all of which are portions of the same outcrop and in proximity to one another; secondly, Mount Sir Henry, situated about three miles south of the former; and lastly, a prominent southern ridge that extends into South Australia proper. All these prominences have been determined by igneous intrusions, the first two sets consisting of granite, the last of an extensive belt of diorite dykes.

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* Geogr. Travels in Centr. Austr., 1872-1874, I., page 78.

† Mount Cavenagh of Giles was re-named Mount Burton by Carruthers' party.

Lying between these masses, disconnected, rounded hills of metamorphic rock appear, rising, as in previous instances, from a vast expanse of sand.

Igneous Rocks.--The granite is somewhat coarsely crystalline, normal to slightly porphyritic, the felspar often occurring as porphyritic individuals. Magnetic ores of iron are plentifully developed. The rock is superficially rotten. The mass shows typical granitic features, with a regular, vertical system of jointing, which sometimes, by weathering, have formed large caves, notably north-west of Mount Cavenagh. The intrusion appears to have occurred in a direction north of west, and the Mount Cavenagh outcrop is divided by a series of parallel gullies running in a northerly direction. Outcrops of identical rock were found intermediate in position between Mount Sir Henry and Mount Carnarvon, thus geologically connecting the Musgrave and Ayers Ranges. About fifteen miles south of Mount Cavanagh a different type of granite is found adjacent to a belt of dioritic intrusion. It is a highly felspathic graphic granite, the felspar being a light red orthoclase, and in parts is pegmatitic. Further east it has suffered considerable metamorphism, and is veined by saussuritic rock and a coarsely crystalline, felspathic, acid modification.

Diorite intrusions are exceedingly plentiful. The southern extremity of the ranges is a pronounced ridge, rising about 200 feet above the plain, about a mile wide, and extending for several miles east and west. It is composed almost entirely of diorite intrusions, with the exception of a few "floating" masses of highly altered rock in the same. The dykes trend within a degree or two of due west, and are either regularly jointed into quadrangular blocks or weather into rounded masses resembling granitic tors. Between this prominent ridge and Mount Sir Henry a marked series of parallel diorite dykes, usually of no great thickness, continues for nearly the whole distance, a dyke being met with at every few chains. Their direction is east and west, with very few exceptions. A few low exposures of the bedrock were met with, consisting of various modifications of altered granite.

Metamorphic Rocks.—The gneiss has its greatest development in the east of the ranges, occurring as more or less isolated bare hillocks. It is linearly foliated, the planes of foliation striking N. 10° E., and dipping W. at Kurrekapinnya soakage. This fact seems extraordinary, as in all other cases noted the foliation of the gneiss coincided in direction with the trend of the intrusion, and this evidence, in conjunction with other physical features, has suggested a change in the direction of intrusion of the granite. The rock is jointed in well-defined planes, striking W. 25° N., with a northerly dip, and, less conspicuously, in planes striking N. 3° E., with a dip of 75° W. Secondary minerals line the walls of these joints, along which, moreover, slight faults and hitches have occurred.

THE INDULKANA OUTCROP.

About twelve miles east of Indulkana Spring, adjacent to Chambers's old wagon track, a small exposure of bedrock exists, and, whilst not many square miles in extent, indications are not wanting that the rock may be found at no great depth over a much wider area. The exposure is 1,300 feet above sea level, and is surrounded on all sides by a capping of "desert sandstone" barely exceeding 30 feet in thickness.

Igneous Rocks.—The intrusive rocks are of the acid and intermediate families. Diorite dykes predominate, though it is often difficult to determine the exact planes of contact with the intruded schists on account of the severe shattering of the rock. At least four major diorite intrusions have occurred in direction east and west, with slight variations, due possibly to subsequent earth movement. The largest measures one hundred yards in breadth. In places where the contact with the schist is visible the latter rock appears baked and highly schistose, with upturned planes of schistosity. The diorite is for the most part fine-textured, quartzless, and micaceous; on the surface the rock is usually "honeycombed" by unequal weathering of the constituent minerals, the liberated iron oxides coating the surface with a "rust."

Intrusions of graphic granite, pegmatite, and greisen have occurred previous to that of the diorite. This is evident from the fact that the diorite dykes are often found cutting the pegmatite, the latter having thereby frequently suffered lateral displacement. The mineralogical character of these acid rocks varies considerably. Their common feature is coarse crystallisation of the constituents. In some dykes quartz predominates, in others it is subordinate to felspar, while mica occurs as irregular aggregates in the greisen and occasionally as an accessory in the pegmatite—in the latter case usually in a state of partial decomposition. On the western limits of the exposure igneous intrusion is marked by dykes of graphic granite and schorlaceous greisen, the latter including large, perfect crystals of black tourmaline and a light-coloured microline. The general direction of intrusion is east and west, although dykes may be found running at right angles to this. True granite is feebly represented by a coarsely crystalline rock, with pink crystals of orthoclase, rather subordinate quartz of a bluish sub-opaline character and a greenish biotite.

Metamorphic Rocks.—In traversing the outcrop from south to north a gradual alteration in the structure of the bedrock will be noticed, the rock grading from a quartz mica schist on the south, through a highly micaceous black biotite schist, to a finely foliated quartzitic gneiss, to a typical augen gneiss on the north. The strike of the beds varies (in zones of extreme pressure considerably), though the general direction appears slightly south of west. The dip is doubtful, possibly northerly. The augen gneiss, compact and granitic, contains lenticular veinlets of quartz, which are often considerably distended as a result of lateral pressure during a state of semi-plasticity, and in addition are frequently found turned upon themselves or complex-folded. The schist can be distinguished from the gneiss in the field even at a distance by contrasting its serrated lines of outcrop with the rounded, massive, boulder-like outcrops of the gneiss. On the north-east the rock consists of a rotten biotite schist, in which planes of mica have become so aggregated that the rock appears to be almost entirely built up of the pure mineral biotite. Even in hand specimens the curved and crinkled lamellæ of the mica indicate how great a stress the beds have been subjected to. The planes of schistosity of the rock strike from 10° to 20° south of east, and dip N. 32°. The beds are further jointed in directions E. 10° S., with a dip of 60° S., N. and S., with a dip of 85° W., and irregularly by a poor vertical plane. To the south this rock becomes less persistent, and has yielded more to weathering. A small development of chlorite schist occurs in contact with the augen gneiss, and a local production of hornblende epidote schist has taken place at the contact with certain diorite dykes. Skirting the north-western limits of the outcrop a finely crystalline gneiss seems to point to a zone of crushing of an igneous rock. (See Appendix. Pages 94-5.) Outcrops of quartz schist, mica schist, and gneiss extend more or less continuously westwards to Indulkana soakage well, at which spot the gneiss contains coarse vein-segregations of felspar with a development of tourmaline and titaniferous iron ore. Repeated searching for tin ore proved fruitless.

Some miles south of the main outcrop low surface exposures of ferruginous clay slates and mud stones appear, the sharp, serrated edges of the same standing out conspicuously. In some parts the rock comes near to a phyllite, and is traversed by very many small quartz veins.

Veins, etc.—The so-called "quartz reefs" of the locality are of two kinds, namely, those forming portions of a true igneous (pegmatitic) dyke, and those formed subsequently by deposition from solution in fissures of the rock. The latter have a remarkably fresh, compact, crystalline appearance, and in no case do they extend downward to any depth, but pinch out in less than a dozen feet; they are the fillings of wedge-shaped fissures within the diorite dykes. A typical instance of a "reef" occurs one mile east of Krupp Hill. It measures four feet in width at the surface, but its walls rapidly converge to a point in depth. The fissure walls strike E. 8° S., the northern wall dipping 60° S., the southern 80° S. The quartz is either milky or glassy. The formation may be termed a "dead lode,"* although pyrites is disseminated through the vein, and in one instance a trace of grey copper ore was discovered. The pyrites crystals that impregnate the mass are decomposed near the surface, leaving small cavities containing sulphur and a little limonite, the remaining products of decomposition having stained the numerous cracks and crevices in the quartz. Slight quantities of secondary minerals (chlorite) occur locally, and the walls of small cavities are coated with drusy quartz.

Few miles west of Indulkana soakage a lode of siliceous ironstone† stands out conspicuously from a fissure in the crystalline schist. It is possible that this lode overlies a diorite dyke.

CAMBRIAN.

No representatives of the Cambrian system were discovered in the vicinity of the north-western ranges, none of the contact rocks having disclosed any trace of organic remains in any shape or form. However, limestones that must without hesitation be correlated with the Cambrian strata of the Flinders Range occur at the head of Lake Torrens. The outcrop occupies but a small area at the surface, being about three miles in length, in direction east and west, by two miles north and south. The beds are massive, though they extend to no great vertical height above the general level of the country; they stand as large, separated blocks resting upon a more compact body of rock below. The beds seem to strike westerly, although considerable variation (up to N. 25° W., and more) were observed. On the southern limits of the exposure they have the form of a slight syncline, the dips of the strata on either side of the axis of folding being low (12° and 25° respectively). They are jointed vertically in two directions at right angles to one another. The rock mass, as a

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* One sample of this rock, that was subsequently assayed, returned a mere trace of gold (accidental?).

† Mr. H. Y. L. Brown has noted a "lode outcrop of ferruginous quartzite and iron oxide" to occur in this locality, and is probably the same as that referred to.

whole, shows no signs of bedding, but the impurer portions (siliceous) exhibit faintly planes of deposition and current bedding that are rendered more apparent on partial denudation of the rock. The character of the rock varies from a bluish, sub-crystalline limestone to a granular marble, to be in parts replaced (in the upper layers) by coloured siliceous and dolomitic limestones. The crystalline limestone contains accessory minerals, as small, perfect crystals of fluorite and aggregates of ankerite, while carbonates of copper occur as locally concentrated fissure fillings and pockets of inconsiderable magnitude or quality. Chert nodules that have possibly been derived from solution of contained radiolarian tests, or enclose the spicules of Cambrian sponges,* weather from the surface of the limestone, by virtue of their superior hardness. They are flattish-ovoid in shape, and are bounded by regularly curved, smooth surfaces.

ORDOVICIAN.

Exposures of beds of the Ordovician period were met with in districts widely separated from one another, namely, at Indulkana, Mount Conner, and the Mount Kingston outcrop.

INDULKANA.—Mr. H. Y. L. Brown visited this outcrop in 1889, and reported† similar rocks to extend in a direction southward to Arcoollina Well, and for a long distance westwards. Mr. V. Streich passed the same outcrops two years later,‡ and traced the western boundary of the same formation to Townsend Ridge, over one hundred miles beyond the border line of Western Australia.

On approaching the Mount Chandler range from the north, it has the appearance of a tableland, with its surface sloping slightly westward. This is not, strictly speaking, the case, for, on entering the range, it is found to consist of a series of parallel ridges trending from east to west. The whole formation at this locality appears in the form of a shallow, synclinal trough, the axis of which pitches east and west. The strike of the beds is E. 5° S. The rock is composed principally of a

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* Since writing this paper Mr. R. Etheridge, jun., of Sydney, has kindly examined a section of one of these nodules for me. He writes that, "the micro-section of the nodule appears to consist of calcite and chalcedony, with perhaps a third undetermined mineral. I cannot distinguish any trace of organic structure."

† H. Y. L. Brown: Report on Journey from Warrina to Musgrave Ranges (by authority: Adelaide, 1889).

‡ V. Streich: Scien. Res. Elder Expl. Exped., 1891-2, Geology. Trans. Roy. Soc., S.A., vol. xvi., page 80.

hard, compact, fine-grained quartzite, merging in parts to a more friable sandstone and grit, portions being ferruginous. A prominent parting of the rock coincides with the original planes of bedding, while further two joints, not very persistent, occur: one in direction N. 20° E., dipping 65° easterly, and another at right angles to this. Planes of shear are highly polished by slickensiding, and in parts the rock has been severely fractured. Drift bedding is much in evidence, and makes the determination of strike somewhat difficult at the eastern limit of the outcrop. The rock has a tendency to cavernous weathering, one of the largest caves having been occupied as a store by the Government surveyors.

The quartzite overlies unconformably schists and clay slates, the planes of schistosity and cleavage of which stand at a high angle. The direct junction is for the most part hidden by the "waste" of rock that has accumulated at the foot of the escarpment, but in a small watercourse on the east the direct contact can be observed for a limited distance, the quartzite resting upon decomposed clay slate.

Although the underlying pre-Cambrian beds are extensively intruded by diorite, pegmatite, and other dykes, no such intrusion was observed to penetrate the overlying quartzite.* The same is true with regard to large quartz reefs occurring in the immediate neighbourhood. From Mount Chandler the quartzite extends eastward as low, disconnected ridges, and was subsequently found at Camp 7 (Krupp Hill) overlying pre-Cambrian schists, but not overlain by desert sandstone, which, however, directly overlies low outcrops of pre-Cambrian rocks in the vicinity. This fact would indicate a fair altitude of the quartzite during late Cretaceous times.

At Ewintinna soakage outcrops of the same formation take a northerly curve, the beds locally striking N. 25° E. The rock at this spot is, similarly, a quartzite, slightly banded and sub-fissile, and in parts traversed by numerous wavy veinlets of secondary quartz. The rock is parted by a prominent strike-joint, dipping about 75° westerly, and another plane dipping 85° in the direction N. 25° W. A few miles south of this soakage the quartzite was found to have its strike identical with that of the Mount Chandler outcrop.

Mount Conner.—This monolith, rising to a height of 2,600 feet above sea level, and about 800 feet above the level

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* Compare the statement:—". . . the granite and other dykes and quartz reefs do not extend into these rocks." H. Y. L. Brown, Report of Geological Examination of Country in Neighbourhood of Alice Springs (by Authority: Adelaide, 1890).

of the desert in which it stands, forms one of a remarkable series of three conspicuous landmarks situated north of the Musgrave Ranges; the other two being known as Ayers Rock and Mount Olga. Mount Conner, rising abruptly from the surrounding desert, is a huge, table-topped outlier of a once continuous extensive geological formation. The base of the mount has a circumference of about six miles, while the plateau itself is roughly two miles long by three-quarters broad. It is surrounded on all sides by a talus, having an angle of repose of from 30 to 35 degrees; above the talus an abrupt escarpment rises to the edge of the plateau, a vertical distance of about 250 to 300 feet. With the exception of one or two pine trees the escarpment is practically destitute of vegetation.

The rock is a close-grained, compact, siliceous quartzite. The beds show a pronounced horizontal parting, corresponding with the original planes of bedding, and the rock is in portions sub-fissile and fractured, the cracks and crevices affording shelter for numerous hawks and owls.

The topmost layers of the rock are composed of a glossy, white, hard quartzite, while the lower portions assume a softer, arenaceous character, and are stained red by precipitated products of decomposition. In places the quartzite contains irregular bands of well-rounded pebbles of altered sedimentary rock (banded and black quartzite), producing locally a conglomerate. Peculiar false-bedding-like markings are found, not infrequently surrounding these conglomeritic portions, and the quartzite contains segmented ferruginous segregations, which are not altogether unlike organic remains. The strike of the rock varies from west up to 30° north of west, the beds forming a shallow synclinal fold. Portions of the quartzite are shattered into small blocks, fairly regularly bounded by conchoidal surfaces, huge masses being in cases thus reduced to fragments, lying loosely together in a state of unstable equilibrium. This phenomenon is a direct result of insolation. (Plate xiv., fig. 2.) Mount Conner is surrounded by low, rugged outcrops and ridges of fissile quartzite, "covered with dense mulga" and "marked by a low cliff."* The quartzite is banded, and weathers into large flat slabs. The strike varies.

THE MOUNT KINGSTON OUTCROP.—Mount Kingston is situated west of Mount Watt, the portion of a southern Ordovician outcrop that was examined by Messrs. Tate and

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* W. H. Tietkens: Journ. Cent. Austr. Expl. Exped., 1889, page 59.

Watt on the Horn Expedition. These authors report[*] that Mount Watt is composed of a hard, dense quartzite, much fissured, and with few ferruginous bands. Fossils were obtained in the form of casts in large numbers in the quartzite.

The exposure[†] examined by us is situated about six miles south-west of Mount Kingston, and appears in the form of three or four well-defined parallel ridges trending north-easterly. The rock is a compact, fine-grained quartzite, in parts highly ferruginous. In certain zones the rock is fissile, breaking into fairly large slabs from a fraction of an inch to several inches in thickness. The strike is E. 36° N., and dip 60° north-westerly. The beds are jointed in directions N.W., dipping 60° N.E., and N. 10° W., dipping easterly at a low angle. A ferruginous coating is found covering slickensided surfaces, and bands of highly ferruginous rock occur within the rock. A concretionary structure and dendritic precipitations of iron oxide are common.

The outcrop appears in the midst of the desert sandstone tablelands, the broken outliers of which surround the quartzite on almost every side. Its physical features are, however, quite distinct from those of the table-top formation, although hand specimens of the two formations may be not altogether dissimilar.

The height of the exposure above sea level, by aneroid determination, is about 1,950 feet, and about 260 feet above the level of the sand.

MOUNT OLGA AND AYERS ROCK.—No doubt exists in my mind that Mount Olga and Ayers Rock are isolated remnants of the Ordovician system, the former consisting of a conglomerate,[‡] the latter of a coarse metamorphic grit. These features suggest that Mount Olga was probably situated close to the old Ordovician land surface, Mount Conner being distant, and Ayers Rock in a position intermediate between the two.

The geologists of the Horn Expedition[§] have already hinted at the possible Ordovician age of Mount Olga and Ayers Rock, while Mr. Brown, judging from specimens col-

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[*] Tate and Watt: Rep. Horn Exped. Centr. Austr., General Geology, page 59.

[†] Mr. Wells has erected a small pile of stones on the highest point of this exposure.

[‡] Compare W. C. Gosse, Parliamentary Paper No. 48, House Assembly, 1874, page 11:—"This range is formed of a number of round-topped masses of solid conglomerate rock (known as pudding stone), but with stony, spinifex slopes, from 100 to 300 feet rising to their foot. Each hill is a separate rock."

[§] Tate and Watt: *op. cit.*, page 59.

lected by Mr. Tietkens, was inclined to consider Mount Conner younger than the other two members.*

DESERT SANDSTONE.

The term Desert Sandstone, which was originally used by Daintree for a highly siliceous deposit that is often found overlying the fossiliferous Cretaceous of Australia, is, to a certain extent, misleading, as the formation is only to a limited extent a true sandstone. Mr. H. Y. L. Brown employed the term Super-Cretaceous, and later Professor Tate and Mr. Watt Supra-Cretaceous, for the same formation. Messrs. Jack and Etheridge regard the desert sandstone as Upper Cretaceous.

No conclusive evidence concerning the exact relationship was found, but I observed that the desert sandstone in many places, particularly at Indulkana, unconformably overlies intruded primary schists. This fact, if the formation is to be correlated with the cretaceous, would demand, as Professor Tate suggested, that the desert sandstone overlaps the latter

Beds of this formation occur along the track from Oodnadatta westward to Indulkana. Such trigonometrically-surveyed heights as Mount Mystery, Mount Alberga, and De Rose Hill are prominent members of the series. From Indulkana, the north-western limit of the formation in South Australia runs east of north in a direction west of Crown Point; beyond this line the primary and intrusive rocks of the Musgrave, Mann, Tomkinson, and Everard Ranges, no doubt, were high land surfaces during the deposition of the desert sandstone formation. Slight surface exposures only of the so-called sandstone were observed, immediately south of the Mann Ranges at Hector's Pass, in the form of a low bank of rather decomposed, friable, silicified quartzite and white, semi-opaline quartz a mile or two east of the pass. A similar semi-opaline rock was found a few miles south-east of Giles West Camp (Musgrave Ranges), and south of Ayers Ranges, in the Northern Territory. Indications of the formation exist, as rock fragments, strewn on the surface, north of the Mann Ranges.

To the south, the whole of the elevated country lying between Oodnadatta and Lake Torrens that was traversed by the Expedition, consists of desert sandstone, with the exception of comparatively few exposures of palæozoic rocks, as in the neighbourhood of Mount Woods and at the head of Lake Torrens.

The formation, as a whole, occurs either as isolated table-topped hills or as groups and ranges of the same. The

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* W. H. Tietkens: Journ. Centr. Austr. Expl. Exped.: Section by H. Y. L. Brown.

hills are almost invariably capped by an exceedingly hard, silicified layer of rock, the base being of a more friable and softer character.*

At Indulkana the top layer is composed of a compact, chalcedonic grit, with irregular, sub-angular fragments of colourless and blackish quartz scattered through the mass, with a secondary interstitial cement of a form of quartz. Though the rock may be a coarse grit, the surfaces of fracture, which are in parts sub-conchoidal, are remarkably smooth; the compactness of the rock causing the planes of fracture to pass through the included particles. Professor Tate described the desert sandstone as being composed of "sharp grains of glassy quartz, varying much in size, cemented by opaque, white siliceous matter, and more or less stained red by oxide of iron." This description would apply equally well to the Indulkana outcrops. In places the formation becomes very fine-grained, showing a laminated character or a distinct fissility, and a fairly regular system of vertical jointing, in a north-easterly direction.

A second variety of desert sandstone has been produced by an opalisation of the mass. Examples of this character were seen at Hector's Pass (Mann Ranges), south-east of Giles West Camp (Musgrave Ranges), and south of Ayers Ranges (Northern Territory). The rock is an impure form of common opal; in colour white to bluish-white; containing cellular cavities and small black inclusions of carbonaceous matter. It breaks with a true conchoidal fracture. Surface outcrops only were found of this variety.

At North Creek the formation consists of a very fine-grained, splintery, chalcedonic quartzite, the individual grains being hardly distinguishable with the naked eye. The rock is traversed by small veinlets of oxide of iron, subsequently precipitated. The colour varies considerably: white, yellow, reddish, blue, and purple. The rock is brittle and rings when subjected to the blows of the hammer.

At Yarrabollinna Waterhole the character of the rock again changes entirely. Large, bluff-shaped masses are composed of an excessively fine-grained form of silica, so fine that it shows no sign of a gritty feel when rubbed between the fingers, resembling somewhat the touch produced with kaolin, which mineral is present in small measure only. The pure forms are snow-white, others are variously tinted. Within this deposit nodular masses of a cherty form of silica occur, which are bounded by an outer concentric growth of white chert. (See Plate xv., fig. 1.)

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* See Tate and Watt: Rep. Horn Exped. Cent. Aus. Phys. Geog., page 8; General Geology, page 68.

In the same bed are found nodules of barytes, with a radiating, concretionary structure. They are more or less spheroidal in shape, being flat or concavely indented in the plane of the longer axis. Others are flatter, broadly discoidal. Their dimensions vary considerably, the largest being about four inches in diameter. The smaller forms have a tendency to slit horizontally in two.*

A more argillaceous variety of desert sandstone, spangled with tiny flakes of mica, was observed south of Stuart's Creek Cattle Station. This outcrop weathers more like a shale than the sandstone generally.

Fossilised wood was found in the desert sandstone at a few localities, notably west of William Creek, in the neighbourhood of Beltabeltana Waterhole, where it is plentiful. Other fossils were not observed in this formation.

The most picturesque and rugged range of disconnected masses of the desert sandstone formation came under notice in the locality known as the Serrated Range. This range is composed of peaks, bluffs, pillars, and tables, often of a very quaint appearance, and tinted in various shades of colour. The formation may with justice be called the Mauvaises Terres of Australia, as have been termed the Cretaceous desert formations of North America.

Owing to the porcelainised, brittle character of the rock, particularly of the overlying hard band, it gives way readily and suddenly when subjected to irregular strain. It is on this account that the sandstone, wherever met with, has been more or less broken up into fragments, often terminated by conchoidal faces; the phenomenon being the result of subjection to extremes of temperature within a short period of time (insolation). These fragments are subsequently scattered over the plains between the table-hills by the floods which occur at rare intervals, and are known as gibbers (less frequently shingle or gravel). The gibbers form

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* I have recently had opportunity of seeing identical concretions in the Sydney University Museum, which were collected by Mr. E. F. Pittman from the opal-bearing strata at White Cliffs. Through the courtesy of the Mines Department of New South Wales I have been permitted to annex the following analysis by Mr. J. C. H. Mingaye:—

ANALYSIS OF A NODULE OF BARYTES OBTAINED FROM OPAL-BEARING STRATA AT WHITE CLIFFS.

04·1666

Barium sulphate	95·35
Ferric oxide and alumina	·50
Silica	2·60
Water	·72
Lime, magnesia, and undetermined	·83
	100·00

stony plains, and have already been referred to by Sturt as the stony desert. Owing to the extensive denudation of the desert sandstone the gibbers cover a considerable area of Central Australia. The lateral transportation of the stones by water action cannot be considerable, owing to the level contour of the intervening plains; in fact, they are deposited, on the removal of the softer, underlying portions more or less vertically below their original position *in situ*. On the slopes of many of the hills in process of disappearance the stony "wash" has accumulated in rounded terraces or steps, transported by torrential floods.

The reflection of light from the smooth surfaces of these stones, when travelling towards the sun, is irritating to the eye. The glaze has been described by Mr. Brown as being "probably due to the action of siliceous water," and the effect is in small measure increased by a slight, glossy surface coating of precipitated iron oxide. The superficial polish has also been assisted, as has been suggested, by the action of wind-driven sand.

The gibbers consist mainly of different varieties of quartz —forms of agate, jasper, chalcedony, and semi-opal—while in association with them occur concretionary forms of limonite, often assuming grotesque shapes. Gypsiferous clays were met with throughout the area covered by this formation, and, in them, large slabs of transparent gypsum that have been produced by crystalline intergrowth. In addition to these, various nodules, that occur in the softer portions of the rock and resist the denudation to a greater extent, are found.

Obsidian Bombs (Volcanic).—These are widely distributed over the desert sandstone area, and have been the cause of much discussion, without any satisfactory deductions as to their origin. The phenomenon, which points to a former surface deposition, somewhere, of volcanic *ejectamenta* has given rise to various theories, such as meteoric, glacial, and of volcanic action *in situ*. Comparatively few examples were found during the Expedition, though single specimens were collected near to the Mann, Musgrave, and Ayers Ranges. I have, however, received a number of specimens from Mr. McNamara, from the neighbourhood of the Peake. Their universal distribution has, no doubt, been assisted by the agency of the native and the emu (in the form of "gizzard stones"). The natives call obsidian bombs *Pandölla* and *Kaleya korru*, the latter meaning "emu eye." They are collected by the medicine men of the tribes, and applied in the healing of sickness.

RECENT DEPOSITS.

Sand.—With the exception of the various outcrops of rock previously discussed, sandy deposits cover all the adjacent country to the north-western ranges of South Australia, and extend for many hundreds of miles north, south, and west, the tablelands on the east checking the accumulation to a slight degree in that direction.

The height above sea level of these deposits is considerable, the sand ascending to an altitude of 1,900 feet in the Ayers Ranges, and to 2,200 feet in the locality north of Opparinna Spring. It is on this account that all the larger valleys cutting the ranges have become filled up with elevated deposits, from which large, gum-lined creek beds emerge, to be subsequently "lost" in the sands adjoining the ranges. This drifting cover is embarrassing to the prospector, as the higher portions of the ranges alone can be examined, the more favourable contact-rocks being for the greater part hidden underneath the great depth of sand.

The material of the deposits consists of a moderately fine-grained, incoherent sand, the grains being usually superficially coated red by oxide of iron. In proximity to the ranges these sands are more loamy, and have been bound together by vegetation. There, also, they contain other constituents derived from the decomposition of the primary rocks, such as cleaved fragments of felspar and hornblende, flakes of mica, small nodules of limonite (iron-shot), and occasional patches of garnets. Beyond the belt influenced by the ranges, the sand is loose, incoherent, and subject to a continual drift. In these regions the sand accumulates in the form of more or less parallel undulations or sandhills, mostly incoherent throughout, but occasionally very slightly cemented superficially. The direction in which these sandhills trend, being at right angles to prevalent winds, is east and west, south of the Musgrave Ranges, although the more usual direction observed further south, in the basin of Lake Torrens, is south-west. Frequently two such parallel undulations unite to form one,* thence continuing as one in the same direction. Nuclei which had in the first place started the formation of sandhills were observed north of Mount Crombie, in the shape of low outcrops of granite, while a few miles south of Stuart's Creek a prominent "sandhill" consists of a former tablehill of desert sandstone, almost completely covered with drift sand, few exposures only of the rock being visible, and limited to one side of the hill. The source of this vast amount of sand must be attributed to the æolian waste of the desert sandstone formation.†

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* Streich states that the "sand dunes" of the Great Victoria Desert are "very seldom found confluent."—Trans. Roy. Soc., S.A., vol. xvi., page 89.

† Compare E. F. Pittman: On the Cretaceous Formation in the North-Western Portion of New South Wales. Rec. Geol. Surv. N.S.W., vol. iv., Part iv., page 146.

The wonderful capacity for binding the sand displayed by the porcupine grass *(Triodia spp.)* can be favourably compared with that of *Spinifex hirsutus* on the dunes of our sea shores.

Travertine.—Travertine was only found as small, local, surface coverings, most frequently along the banks of creek beds, where it is regarded as a valuable guide to subterranean water. Examples occur along the course of Opparinna Creek and certain creek beds in the Tomkinson Ranges.

Travertine was further noted in many instances to overlie diorite dykes, a breccia having often resulted from the cementation of originally loose rubble derived from the dykes (Opparinna). The travertine occurring at the foot of Mount Davis, in the Tomkinson Ranges, deserves notice on account of its extreme compactness and hardness, it being almost resistant to the blade of a knife. At Stuart's Creek a small deposit of banded travertine has been produced by the precipitation of successive layers differently coloured by varying magnesian and carbonaceous contents.

A thick incrustation of calc-tufa was discovered in the Musgrave Ranges. To the west of Opparinna Spring a series of rock waterholes is to be found along the bed of a rugged gorge enclosed by steep walls of gneiss. One of such holes is situated at the base of a waterfall that has been produced by the intermittent flow of a creek over a locally hardened band of blue garnetiferous gneiss, the softer rock below having become undermined. This deposit of earthy, calcareous sinter, with a fair percentage of included organic matter, occurs as regular stalactitic and mammillated masses, hanging from the under side of the indurated ledge or bank of gneiss. The formation produces an imposing aspect.

APPENDIX.

Petrological Notes on Rocks Collected on the Expedition.

GRANITE.

Locality.—Mann Ranges, outcrop fourteen miles west of Mount Samuel.

Macroscopically.—Granitic, porphyritic; the felspar occurring as large (up to 2·7 cm.), more or less lenticular, porphyritic crystals, rounded by the chemical (?) corrosion of the rock magma. Felspar dark grey, fresh, in places not unlike the greasy-looking elaeolites of syenites.

Quartz in smaller, blackish, segregations throughout the mass. Mica black, not infrequently as lenticular aggregates having their long axes indistinctly parallel, and surrounded by a border of pink secondary mineral. The rock has suffered from the effects of mountain building forces.

Microscopically.—Rock with a holocrystalline groundmass, in which the larger crystals of felspar are embedded.

In parts the quartz (appearing normal in plain light) when viewed in plane polarised light, proves to be microscopically separated into numerous contiguous particles; micrographic intergrowths with the felspar common; generally speaking it is allotriomorphic, crowded with inclusions, and its fissures stained by oxide of iron, subsequently precipitated.

The potash felspar is clouded and crowded with minute inclusions, which are frequently arranged in parallel bands, and some, on decomposition, locally stain the enclosing mineral. The felspar crystals are corroded and surrounded by a border of secondary mineral fibres, radially arranged; the cleavage cracks are filled with secondary mineral, polarising with high colours. "Strain shadows" traverse the quartz and felspar crystals on rotating the stage with crossed nicols.

The mica, a rather decomposed dark green biotite in irregular aggregates of crystals, is almost invariably surrounded by a broad band of closely set, pink garnets, which are minute (averaging ·005 millimetres in diameter). The individual grains appear rather to have been separately developed than to be crushed parts of larger garnets. Optical anomalies are general among them.

Magnetite is scarce; the rock also contains patches of an earthy form of iron oxide. Epidote as a scantily developed accessory (secondary), in small though conspicuous (on account of the high refractive index) aggregates with no definite geometrical boundaries.

GRANITE.

Locality.—Mount Sir Henry, Ayers Ranges.

Macroscopically.—A moderately coarse-textured, holocrystalline rock, considerably decomposed; the quartz and felspar appear brown from iron pigment; the black-looking mica in fairly large, irregular aggregates.

Microscopically.—Texture typically hypidiomorphic granular, the rock being composed essentially of quartz, felspar species, and biotite. The normal order of crystallisation from the rock magma has generally prevailed, although the mica occurs in parts interstitial to the felspar. A micrographic intergrowth between quartz and felspar on a very minute scale is apparent, and the former contains numerous unindividualised inclusions in parallel bands.

Felspar is of two species: orthoclase and a delicately twinned plagioclase. Decomposition has acted to a considerable extent upon many of the constituents; the felspar, being clouded when viewed by plain transmitted light, becomes brilliantly tinted in the dull portions under crossed nicols on account of the strong double refraction of the products of decomposition (kaolin). Orthoclase is somewhat subordinate to plagioclase; the cleavage cracks and borders of both are lined with oxide of iron.

The mica, a green biotite, occurs principally as aggregates of flakes, partially decayed; the whole rock section, moreover, is speckled with minute particles of biotite.

Magnetite is fairly plentiful, usually surrounded by a layer of secondary mineral.

Apatite is present as stout, prismatic individuals, with prominent cross fracture.

HORNBLENDIC GRANITE.

Plate xviii., fig. 2.

Locality.—Glen Ferdinand, Musgrave Ranges.

Macroscopically.—Rock granitic, normal; composed of white felspar, colourless quartz, dark mica, and hornblende, as largish, cystalline secretions.

Microscopically.—Texture hypidiomorphic granular; the quartz and felspar uniformly distributed over the sections; the mica and hornblende not so. A fine mosaic of microcline and quartz is characteristic.

The felspar is represented both by orthoclase and microcline, the former being occasionally crowded with numerous very slender, crystalline needles of zircon.

Mica (strongly pleochroic, brownish biotite), as irregular, curved, and twisted lamellæ, partially or wholly altered to a dark-green chlorite, more or less fibrous, and with a weak double refraction. Pink, fractured garnets of fair size are rather plentiful, usually, though not necessarily, in proximity to the mica and the altered chlorite.

Magnetite is present as irregular particles.

GRANITE.

Locality.—Everard Ranges.

Macroscopically.—A coarsely crystalline, normal granite with prominent pink felspar (orthoclase) and dark-coloured mica. The rock is deeply "honeycombed" on its surface, this being a result of the ready decomposition and removal of the felspar.

Microscopically.—Rock typically hypidiomorphic granular, consisting of clear quartz, a clouded orthoclase, and a strongly pleochroic biotite. Micrographic intergrowths between quartz and felspar are common. Magnetite scarce.

EPIDOTE ROCK (ALTERED GRANITE).

Plate xvii., fig. 4.

Locality.—Musgrave Ranges, Titania Spring.

Macroscopically.—A granular rock, composed of clear quartz and white, clouded felspar, traversed by veinlets of epidote, the small columns that build up the bulk of the epidote standing with their long axes at right angles to the bounding lines of the veins in the section.

Microscopically.—The texture of this rock, though no doubt originally holocrystalline, has been obscured by the secondary secretion of epidote; the rock has, moreover, suffered considerably from crushing.

The felspar is orthoclase, though little of its primary characteristics remains, it having yielded to metamorphism by transformation into epidote. Intermediate stages of this conversion are general.

The epidote, which is light greenish-yellow in colour, covers fully three quarter parts of the section, as aggregates of irregular, elongated, and columnar individuals. The strong relief produced by the total reflection at the border of the epidote is characteristic, and the cleavage is conspicuous in the larger individuals only.

An imperfect "cross-hatched" appearance is here and there visible on the faces of the felspar under crossed nicols. This is an extreme case of "strain shadowing" as a result of pressure.

Hematite (micaceous) is present as dark reddish-brown (by transmitted light), hexagonal plates, presenting a slight metallic lustre by reflected light. The perfect forms range up to ·27 mm. in diameter, and the adjoining minerals are invariably stained red by iron pigment for some distance around.

GNEISS.

Plate xviii, fig. 1.

Locality.—Indulkana, Krupp Hill West.

Macroscopically.—A fine-textured gneiss, consisting essentially of quartz (colourless), felspar, and biotite, the last-named being arranged in a more or less parallel manner without the production of distinct, continuous planes of foliation *(Quincuncial structure).* It is traversed by shattered veinlets of quartz. A green accessory mineral (epidote) is developed as irregular particles and patches throughout the rock, imparting a faint yellowish-green tint to the rock mass.

Microscopically.—Texture finely crystalline, granulitic, with faint parallelism in the arrangement of the constituent minerals. In parts a feeble *centric structure* is discernible.

The sections appear fresh, though a fine groundmass is here and there noticeable, connecting the individual minerals: this is the result of crushing.

The quartz occurs as small grains, with irregular or rounded boundaries, with numerous fluid pores arranged in parallel bands or scattered.

Felspar predominates; microcline crowded with inclusions (unindividualised) more or less grouped: a very small amount of plagioclase is present. "Strain shadows" are much in evidence.

Mica occurs as a dark, brownish-green biotite, with prism axes roughly parallel; some flakes have undergone partial decomposition peripherally, with the production of a green, fibrous mineral.

Magnetite, as opaque particles, with no definite boundary, rarely idiomorphic, elongate, frequently enclosed by biotite.

Zircon is fairly well represented as inclusions in the microline appearing with the rather rare elongated prismatic habit. The prisms polarise with red and green interference colours under crossed nicols; they are not surrounded by a pleochroic halo.

Epidote produced at the expense of the felspar, as colourless or faintly yellowish individuals, without definite form. Some of the felspar individuals can be observed to be partially converted into epidote, the latter appearing (with crossed nicols) as very numerous brilliantly coloured specks, almost entirely obliterating the characteristics of the felspar.

The gneiss in many respects resembles a granulite, though garnets, usually characteristic of granulites, are entirely absent.

The rock seems beyond doubt a "metapyrigen gneiss."

GNEISS.

Plate xvi., fig. 2.

Locality.—Mann Ranges, south-west of Mount Samuel.

Macroscopically.—A compact granitic rock, with a tendency to foliation, the mica in elongated patches, whose major axes point in one direction: advanced in decomposition superficially.

Microscopically.—Texture granular with a quartz-orthoclase mosaic, and larger felspars embedded in a crushed groundmass.

Quartz clear, with gaseous and liquid inclusions, arranged more or less distinctly in streaks; also few individualised inclusions of elongate-rounded form, the largest measuring ·03 mm., with a high refractive index and double refraction (zircon).

Felspars essentially orthoclase and microcline; plagioclase very subordinate, irregular, and finely twinned; crystal outlines generally corroded, and the mineral clouded by partial decomposition; the cleavage cracks tinted by subsequently deposited iron ores. Twinning after the Karlsbad law is observed in the orthoclase. Microline subordinate. A micrographic (granophyric) intergrowth between quartz and felspar on a small scale is visible in parts of the section.

Biotite strongly pleochroic, from light greenish-brown to almost black.

Magnetite as small, angular individuals.

GARNET GNEISS.

Plate xvii., fig. 2.

Locality.—Mount Davis (two miles north), Tomkinson Ranges.

Macroscopically.—A fine-grained quarzitic gneiss, with a rich, red-garnet development; foliated, the biotite in regular planes, the quartz and felspar foliations often wedging out. Portions of the rock appear very quartzose, compact, with largish fragments of smoky quartz.

Microscopically.—A quartz orthoclase mosaic. The foliaated character, though clearly visible in hand specimens, is not apparent under the microscope.

The quartz contains minute liquid inclusions, and aggregates of black particles disseminated through its mass, which appear to be carbonaceous, the former not infrequently grouped centrally. A fair amount of isotropic mineral is also present

Felspar: large clouded crystals of orthoclase and smaller subordinate plagioclase.

Biotite strongly pleochroic, in shades of brown to almost black, when the rays vibrate parallel to the cleavage; elongated or irregular, and is in parts decomposed, the resulting iron oxides staining the adjoining minerals reddish-brown; often enclosing magnetite and felspar.

Magentite as fine dust and larger individuals, sometimes filling fissures between the felspar.

Shattered crystals of red garnet, the largest of which are a millimetre in diameter, are plentiful. They behave completely isotropically under crossed nicols, though the quartz and felspar exhibit undulose extinction rather markedly.

This rock appears to be a "clastic gneiss."

CONTACT GNEISS.

Locality.—Opparinna, Musgrave Ranges.

Macroscopically.—A closely foliated, fine-grained gneiss, with prominent dark planes of mica *(linear foliation)*, and narrow lenticles of quartz and felspar. The rock occurs in direct contact with a diorite dyke, and its planes of foliation have the same strike as the walls of the dyke.

Microscopically.—The distinct gneissic foliation remains prominent even under a high power objective; the mica in regular parallel stringlets. The fine state of crushing of the rock appears to be an ultimate stage of metamorphism.

The quartz occurs as excessively crushed particles that display marked "shadowy extinction" when viewed under crossed nicols. It is comparatively fresh-looking, and free from interpositions except the minutest.

The felspar, orthoclase, as small, irregular individuals, showing shearage on a microscopic scale, with few individualised inclusions.

Microperthite is developed to a limited extent, and displays a very delicate lamination under crossed nicols.

The biotite is clear, strongly pleochroic, and appears in the form of elongated flakes.

SCHISTOSE QUARTZ ROCK (so-called "Quartz Blow").

Locality.—Mann Ranges, south-east of Mount Edwin.

Macroscopically.—A fine-grained, white quartzose rock, schistose, with well-defined planes of brown secondary mica, in parts decomposed and brown.

Microscopically.—Essentially composed of closely aggregated, allotriomorphic grains of quartz, the boundaries of which are usually sharp, and the grains in direct contact with one another. A fair amount of amorphous silica is present. The quartz is fresh, but contains numerous unindividualised fluid inclusions, with stationary and mobile gas bubbles, usually arranged in fairly broad parallel bands, crossing in a continuous line several adjacent grains. It, therefore, appears that the inclusions are to a certain extent not original, but have subsequently been produced by the metamorphism of the rock by igneous intrusion. Individualised inclusions occur in the form of elongated prisms of colourless apatite, with indistinct, rounded prism-terminals and transverse fracturing.

The decomposed mica flakes do not exhibit any striking tendency to parallel orientation. Dark strain shadows crossing the quartz on rotation of stage between crossed nicols give ample evidence of stress to which the rock has been subjected.

OLIVINE GABBRO.

Plate xvii., fig. 1.

Locality.—Mount Davies, Tomkinson Ranges.

Macroscopically.—Dark green, coarse-grained, heavy rock, apparently composed essentially of a pyroxene. Fracture very rough.

Microscopically.—Texture hypidiomorphic to allotriomorphic granular, of medium-sized grain; composed principally of diallage, olivine, and plagioclase. The diallage varies in colour from very faint green to colourless, and shows the basal striation to perfection. Well-defined, irregular cross-partings are prominent. Alteration to serpentine is seen in different stages of progress.

Olivine greenish to colourless, darkened by granular iron ores by decomposition. Crystal boundary rounded, and the cleavage (010) is distinct in a few examples. The crystals of olivine are altered to serpentine, sometimes completely, with deposition of a ferruginous "dust."

The plagioclase (labradorite) is scanty, and occurs chiefly in aggregates. The albite twin lamellæ frequently "wedge out." Undulatory extinction, produced by pressure, common. The scarcity of this mineral gives a decided basic character.

Ores of chromium were not observed in the rocks examined, although the Murru Yilyah outcrop, adjoining the gabbro, contains a secondary siliceous infiltration which is stained by chromium.

DIORITE.

Plate xvii., fig. 3.

Locality.—Indulkana.

Macroscopically—Heavy, compact, dark-coloured, finely crystalline rock, coated on the surface with a rusty brown product of weathering.

Microscopically.—Fine-textured, holocrystalline rock. In the sections examined quartz is absent.

A slight amount of orthoclase occurs as irregularly bounded individuals, often squeezed in between idiomorphic crystals of plagioclase. The plagioclase felspar is twinned according to the Albite and Karlsbad laws, the former being often accompanied by Pericline. From determinations on sections from the zone at right angles to (010) the felspar appears a slightly basic Andesine. Zoning comparatively scarce. The felspar is clouded (more so along the central portions) by kaolin and possibly calcite.

Hornblende light brown, enlarged in certain directions by an outgrowth of secondary, often fibrous, green mineral (hornblende); crystals not infrequently twinned, decomposing with a large deposition of red oxide of iron. Mica scarce as well-defined flakes of strongly pleochroic brown biotite.

Magnetite plentiful, arranged in groups, the individual constituents of which have a strong tendency to parallel arrangement, as though conforming with some pre-existent crystal constant. Hornblende has, no doubt, yielded to its formation.

The absence of quartz, feeble development of orthoclase, and the brown tint of the hornblende indicate a basic type of diorite.

DOLERITE.

Locality.—Mount Olga.

Macroscopically.—Slate-coloured, uniformly crystalline rock of fine grain. The minute needles of felspar are dimly recognisable, and here and there larger secretions of a green mineral are apparent (olivine). The rock decomposes to a richly coloured ochreous powder.

Microscopically.—Holocrystalline; of fine texture. The lath-shaped felspars, on an average about ·2 mm. in length, are clouded; on that account they exhibit twin lamination and cleavage cracks very imperfectly, and are variously tinted in polarised light. The arrangement of the laths produces a poor *fluxion structure.*

The augite in the sections examined has been almost completely altered to a scaly, green, chloritic mineral, possessing a very faint double refraction.

Between the felspars a subsequent crystalline segregation has taken place radially to small granules of magnetite. These aggregates show the characteristic black cross under crossed nicols, having its arms parallel to the cross wires of the microscope.

Olivine as greenish, irregularly bounded individuals.

Magnetite is distributed generally through the mass as small granules and cubes; or it darkens the constituent minerals in the form of a very fine dust.

A secondary serpentinous, fibrous mineral present is probably another product of the decomposition of the augite.

ORDOVICIAN QUARTZITE.

Locality.—Mount Chandler.

Macroscopically.—A highly compact, fine-grained, white, siliceous quartzite, breaking with a splintery fracture.

Microscopically.—Consists of closely set, rolled grains of clear quartz, so compacted by pressure as to have left but little space for interstitial cement, which is also of silica. The interstices are slightly stained by iron salts. The average dimensions of the quartz grains of this particular specimen are ·5 mm., although elsewhere the rock passes into a coarse grit and conglomerate. The quartz is either perfectly clear or encloses interpositions, either central, scattered, or arranged in bands. They are mainly unindividualised. Undulose extinction is apparent under crossed nicols.

Felspar is very subordinate, or practically absent.

The orginal planes of bedding are indistinctly discernible by a general tendency of the longer axes of the separate grains to arrange themselves in parallel lines.

No trace of any organism has been preserved in the sections observed, but a similar rock at Mount Watt is highly fossiliferous.

METAMORPHIC GRIT (Ordovician).

Locality.—Ayers Rock, Northern Territory.

Macroscopically.—A dark, metamorphic grit,* which on casual observation may be, and has been, mistaken for an eruptive rock, the large felspars showing up conspicuously from the mass with their surfaces of cleavage. The quartz grains are clearly recognised as derivative *("clastic")*. A black mica, ores of iron, and other foreign minerals are among the grains. The rock may be termed a *greywacke (Grauwacke)* or *arkose*. The aggregation of waterworn grains of quartz and felspar (one single grain of the rock, moreover, often consisting partly of quartz and partly of felspar, still in juxtaposition as orginally in an igneous rock) suggests the disintegration of granite.

Microscopically.—The rock† is compact and composed essentially of quartz and felspar *(allothigenous)*, with additional fragments and flakes of ores of iron and mica *(authigenous)*.

The quartz occurs as more or less irregularly rounded and rolled grains, containing numerous gaseous inclusions in bands and streaks, or scattered. Some of the grains, moreover, exhibit a microscopic intergrowth between quartz and felspar.

The felspar is of several species. A typical microcline predominates, and is often traversed by narrow parallel streaks of strongly doubly refracting altered mineral (kaolin). Micrographic intergrowths of this felspar, with quartz, appear to be prominent, although the effect is masked. "Strain shadows" under crossed nicols.

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* "The rock is a very indurated, and, to some extent, altered, arkose sandstone, decidedly gritty in parts."—Tate and Watt: Rep. Horn Exped. Centr. Austr., Phys. Geog., page 8.

† A description of a similar rock, by Messrs. Smeeth and Watt, has appeared in the report of the Horn Expedition, Petrology. "Arkose"; No. 213, page 83.

Orthoclase is clouded and strongly illuminated under crossed nicols as a result of its alteration.

Plagioclase is subordinately represented, the fragments being comparatively small. A dark mica (biotite), in aggregates of curved flakes, is plentiful. It is very probably secondary,* and occurs interstitially. Its decomposition has produced hematite. Few tiny flakes, apparently white mica, are also present.

Ores of iron are plentiful. Ilmenite occurs as asymmetrical masses, opaque, and (by incident light) shows the imperfect system of striation and characteristic brownish tinge. Moreover, this form is replaced in parts by a semi-transparent variety, "with a clove-brown colour,"† suggestive of micaceous titanic iron. Magnetite is also represented as irregular patches.

With regard to the constituents of this rock being essentially of grains of quartz, orthoclase, and microcline, it is interesting to note that Dr. C. Chewings has described‡ a granite from Mount Olga (a sister outcrop to Ayers Rock), which is composed almost essentially of quartz, orthoclase, and microcline. The constituent grains of the rock from Ayers Rock, therefore, have in all probability been derived from the same granite as the specimen from Mount Olga. Mount Olga consists for the most part of a metamorphic conglomerate.

EXPLANATIONS OF PLATES.

PLATE XIII.

F)fi. 1.—Mount Conner: an outlier of Ordovician quartzite, surrounded by saltbush flats.

FIG. 2.—Æolian erosion; mushroom-shaped outcrops of gneiss in the desert north-west of the Mann Ranges.

PLATE XIV.

FIG. 1.—Intrusion of porphyritic granite within hornblendic garnetiferous schist, south of Mount Cockburn, Mann Ranges.

FIG. 2.—Ordovician quartzite, shattered by insolation, Mount Conner.

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* Compare Tate and Watt: *op. cit.*, page 8—"Although once a sedimentary rock, it has been to some extent altered by metamorphic agencies, a small amount of mica, perhaps of secondary origin, having been formed."

† Rosenbusch: Microsc. Phys. of Rockmaking Minerals (Iddings), 1900, page 167.

‡ Chas. Chewings: Beiträge zur Kenntnis der Geologie Süd- und Central Australiens, Heidelberg, 1894—"Ein Granit von Mount Olga (Central-Australien) besteht fast ganz aus Quarz, Orthoklas, und Mikroklin."

PLATE XV.

FIG. 1.—Range of desert sandstone at Yarrabollinna Waterhole. The bluff consists of excessively fine-grained arenaceous material, with nodules of chert and barytes.

FIG. 2.—Krupp Hill; a table-hill of desert sandstone unconformably overlying primary schists.

PLATE XVI.

FIG. 1.—Table-hills of the desert sandstone formation east of Indulkana.

FIG. 2.—Talus blocks of gneiss in Garnet Glen, south of Mount Edwin, Mann Ranges. This rock is described in the text on page 95.

PLATE XVII.

FIG. 1.—Olivine gabbro, Mount Davies, Tomkinson Ranges.

FIG. 2.—Garnetiferous gneiss, north of Mount Davies, Tomkinson Ranges.

FIG. 3.—Diorite, Indulkana.

FIG. 4.—Epidote rock, Titania Spring, Musgrave Ranges.

PLATE XVIII.

FIG. 1.—Gneiss, Indulkana, west of Krupp Hill.

FIG. 2.—Hornblendic granite, Glen Ferdinand, Musgrave Ranges.

FIG. 3.—Hypersthene-bearing granulite, north of Mount Davies, Tomkinson Ranges.

FIG. 4.—Altered augite granite, south of Giles' West Camp, Musgrave Ranges.

PLATE XIX.

Sketch section across the Mann Ranges, extending south from Mount Cockburn. Distance, about 2½ miles.

PLATE XX.

Geological sketch map of the Ayers Ranges.

NEW AUSTRALIAN LEPIDOPTERA.
NO. 22.

By OSWALD B. LOWER, F.E.S. (Lond.), etc.

[Read April 4, 1905.]

PYRALIDINA.

GALLERIANÆ.

MELISSOBLAPTES DISEMA, n. sp.

Female, 18 mm. Head, face, and antennæ dark fuscous, head sprinkled with whitish. Thorax whitish-grey, patagia fuscous. Abdomen and middle legs fuscous, tibiæ and tarsi ringed with whitish, posterior pair suffusedly whitish. Abdomen dark fuscous. Forewings elongate, moderate, costa nearly straight, arched towards apex, greyish-white, minutely and irregularly irrorated wth black scales; markings blackish; a narrow line along costal edge, from base to first line; a nearly straight, waved, narrow line from costa beyond one-third to dorsum at one-third; a similar line, gently curved throughout, from costa at three-quarters to dorsum, before anal angle; a row of spots along termen and apical fourth of costa; cilia blackish, with a median line of black scales. Hindwings somewhat transparent; pale greyish-fuscous, paler on basal half; cilia greyish.

Birchip, Victoria. One specimen; received from Mr. D. Goudie.

CRAMBINÆ.

TALIS CYCLOSEMA, Low.

(*Talis cyclosema*, Low. Tr.R.S.S.A., p. 158, 1896;
T. diacentra, Meyr. Tr.E.S., Lond., p. 379, 1897.)

I have received this species from Balaklava, South Australia, and Birchip (D. Goudie), Victoria.

SURATTHA HEDYSCOPA, n. sp.

Male, female, 18, 24 mm. Head, palpi, and thorax ochreous-brown, palpi short. Abdomen ochreous-grey. Antennæ strongly bipectinated throughout. Legs white, tibiæ and tarsi infuscated above, tarsi banded with white; thorax and abdomen white beneath. Forewings elongate, moderate, costa gently arched, termen obliquely rounded; vein 6 absent, coincident with 7; 4 and 5 stalked; 8 and 9 stalked; ochreous, somewhat irrorated with ferruginous and fuscous; a thick, rather indistinct, irregular, fuscous fascia, from costa at one-fifth to dorsum at one-quarter, more prominent on lower half; between this and base the ground colour is mixed with whitish; a rather obscure, strongly waved, oblique, fuscous fascia, from before middle of costa to middle of dorsum; a very broad fuscous band, mixed with bluish-white scales, and containing a small, clear, white spot, somewhat triangular in shape, near its anterior edge above middle; anterior edge somewhat waved, from beyond middle of costa to beyond middle of dorsum; posterior edge dentate, from five-sixths costa to five-sixths dorsum, projecting somewhat below costa: a fine dentate fuscous line along termen; cilia whitish, mixed with some blackish scales. Hindwings, with vein 5 present, fuscous grey, paler and becoming grey on basal half; cilia white, with a fuscous sub-basal line.

Somewhat allied to *termia*, Meyr., but apart from the very much shorter palpi and the neural characters it differs in markings; it would be possible to form a new genus to receive it. One specimen has vein 5 absent in hindwings, in the remainder, four in number, it is present; but the whole of the specimens before me have vein 6 of the forewings absent. The peculiarity with reference to the absence or presence of vein 5 of hindwings is also noticeable in *bathrotricha*, Low., vein 6, however, in the forewings of that species is present.

Broken Hill, New South Wales. Five specimens; in February, at light. These were all taken at the same time and place, but I have never since met with the species, although continually collecting in the same locality.

PLATYTES POLIOPEPLA, n. sp.

Female, 16 mm. Head, palpi, thorax, and antennæ dark fuscous, palpi very long, darker beneath, abdomen broken, legs dark fuscous. Forewings elongate, moderate, costa hardly arched, termen oblique, hardly rounded; fuscous, mixed with dark fuscous; some scattered, short, black streaks and spots in disc; a small, clear white spot at two-thirds from base in middle, more or less surrounded by blackish; an obscure row of black scales along termen; cilia fuscous. Hindwings light fuscous; cilia greyish-fuscous.

An obscure species, but may be known by the long palpi and white spot of forewings.

Melbourne, Victoria. One specimen; probably taken in April.

PHYCITINÆ.

EUZOPHERODES POLIOCRANA, n. sp.

Female, 18 mm. Head, thorax, and antennæ ashy-grey-whitish, palpi dark fuscous, mixed with whitish beneath. Abdomen dark fuscous, whitish beneath. Legs fuscous, strongly suffused with white. Forewings elongate, rather narrow; ashy-grey-whitish, mixed with dark fuscous and blackish; whole of cell filled in with blackish and with a black bar at posterior extremity; a strongly waved, fine, black line from costa towards dorsum at three-quarters, but not quite reaching it; a row of short, elongate fuscous along termen, more or less preceded by black inter-neural streaks; cilia fuscous, with two darker fuscous lines. Hindwings semi-transparent; pale greyish, mixed with fuscous around margins; cilia grey, with a fuscous basal line.

Broken Hill, New South Wales. Two specimens; in March.

METALLOSTICHA METALLICA, n. sp.

Female, 10 mm. Head and antennæ ochreous-fuscous. Palpi and thorax purplish-fuscous, thorax shining metallic. Abdomen greyish-fuscous. Legs dark purplish-fuscous, posterior pair greyish. Forewings elongate, moderate, termen gently rounded; shining metallic-purplish fuscous; cilia purplish-fuscous. Hindwings greyish-fuscous, paler towards base; cilia greyish-fuscous, with a darker fuscous line at base.

Mackay and Townsville (Dodd), Queensland. Two specimens; in December.

HYPHANTIDIUM HYPOSCOPA, n. sp.

Female, 10 mm. Head, palpi, thorax, antennæ, and abdomen dark fuscous. Legs dark fuscous, posterior pair yellow. Forewings elongate, moderately dilated posteriorly, termen oblique; dark fuscous, crossed by several irregular, waved, spot-like, blackish strigulæ; a broad, slightly curved, dull whitish fascia, from three-quarters costa to anal angle, clearest on upper half; indications of the blackish strigulæ crossing the fascia, but more pronounced on costa, where they form three or four cuneiform spots; ground colour beyond this fuscous, with several black spots irregularly placed, cilia dark fuscous. Hindwings orange, slightly tinged with fuscous around apex; cilia dull orange, becoming fuscous towards apex, and with an obscure, fuscous sub-basal line throughout.

At once recognised by the orange hindwings.

Melbourne, Victoria. One specimen; in October.

NEPHOPTERYX HABROSTOLA, n. sp.

Male, 18 mm. Head, palpi, thorax, and antennæ ferruginous red, face slightly white. Legs deep ferruginous red, strongly mixed with fuscous, tibiæ and tarsi more or less banded with whitish. Abdomen blackish, reddish beneath anteriorly. Forewings elongate, moderate, costa gently arched, termen nearly straight; deep reddish, somewhat purplish and slightly shining; a narrow, oblique, white fascia, from costa at one-quarter to dorsum at one-quarter, more or less edged on either side with deep reddish; a dark reddish waved line from costa at about two-thirds to just above dorsum at three-quarters, with a somewhat lunate white mark on anterior edge of lower extremity; an obscure narrow white sub-terminal line from five-sixths costa to four-fifths dorsum, attenuated on upper half; a row of elongate, dull whitish spots along termen; cilia reddish-ferruginous. Hindwings dark fuscous, paler on basal half; cilia greyish, with a fuscous, sub-basal line.

Townsville (Dodd) and Mackay, Queensland. Four specimens; in June.

CRYPTOBLABES CENTROLEUCA, n. sp.

Male, 12 mm. Head, palpi, antennæ, and thorax dark reddish-fuscous, collar whitish. Abdomen greyish. Legs fuscous, strongly irrorated with whitish. Forewings elongate, rather narrow, reddish-fuscous, purplish tinged; a moderate, oblique, white fascia from costa at one-third to beyond one-third of dorsum, edged posteriorly by twice its own width of deeper ground colour; a somewhat waved, oblique, whitish line from costa at five-sixths to dorsum at four-fifths; space between this and first fascia finely irrorated with white, and with an obscure fuscous dot in middle, nearer to posterior fascia; a fine, obscure whitish line before termen; a waved fuscous line along termen; cilia reddish-purple mixed with whitish. Hindwings greyish, slightly fuscous-tinged; cilia greyish, with a fuscous line.

Broken Hill, New South Wales. One specimen; in November.

EPHESTIOPSIS POLIELLA, n. sp.

Male, 14 mm. Head and thorax ashy-grey-whitish. Antennæ and palpi fuscous, palpi beneath mixed with whitish. Abdomen silvery-grey. Legs suffusedly white, tarsi banded with fuscous. Forewings elongate, rather narrow; ashy-grey-whitish, costal half broadly suffused with white; a rather obscure, oblique, fuscous fascia, from beneath one-third of costa to just beyond one-third dorsum, but not reaching it; an obscure, waved, fine, fuscous line from five-sixths costa to just before anal angle, followed by a narrow, parallel reddish shade, not entire; a fine, interrupted black line along termen; cilia greyish, with a fuscous, sub-terminal line Hindwings greyish, slightly infuscated along termen; cilia greyish, with a fine, fuscous, sub-basal line.

Townsville, Queensland. One specimen; received from Mr. F. P. Dodd. I have also seen specimens from Cooktown, Queensland. Taken in December.

HYDROCAMPINÆ.

Clupeosoma rhodea, n. sp.

Female, 18 mm. Head, palpi, antennæ, thorax, and abdomen reddish-carmine, somewhat coppery-tinged, basal half of palpi beneath snow-white. Middle and posterior legs ochreous, middle tibiæ and tarsi fuscous, banded with white. Abdomen beneath ochreous. Forewings elongate-triangular, termen oblique, hardly rounded; reddish-carmine, tinged with coppery metallic scales, especially along costa; markings deep reddish-fuscous; a waved, somewhat dentate, line from two-thirds of costa to two-thirds dorsum; an oblique, fine, waved line from costa at four-fifths to dorsum, before anal angle, with a strong sinuation outwards in middle; a discal dot above middle, midway between first and second lines; termen suffused with pale fuscous-purple, thicker on upper half; cilia orange-yellow, basal half light reddish-carmine. Hindwings pale yellow, suffused with reddish-carmine on terminal third, except along dorsum; first line and discal dot absent; second line nearly straight, reddish-carmine, from beneath costa at about four-fifths to three-quarters across wing; a suffused, moderate, reddish-carmine line along termen; ground colour between the two lines suffused with light reddish-carmine; cilia as in forewings.

Mackay, Queensland. One specimen; in December.

SCOPARIANÆ.

Scoparia platymera, n. sp.

Male, 20 mm. Head, palpi, antennæ, thorax, and abdomen fuscous, palpi and thorax beneath white. Abdomen more or less ringed with silvery white, especially beneath. Legs fuscous, strongly infuscated with white, middle tibiæ and tarsi banded with white. Forewings elongate, moderate, termen obliquely rounded; whitish, with fuscous markings; a basal patch, outer edge waved from one-sixth costa to one-sixth dorsum; a very broad fascia occupying median third of wing, constricted on lower third, edges waved, anterior from about two-fifths of costa to one-third dorsum, posterior edge from three-quarters costa to two-thirds dorsum, with a somewhat rounded projection about middle; a fuscous discal dot in fascia near posterior edge above middle; an irregular band along termen, narrowed on lower half, with a projection above middle; a row of blackish elongate streaks along termen; cilia grey-whitish, barred with fuscous. Hindwings pale greyish, thinly scaled, tinged with fuscous along termen on upper half. Closely allied to *eumeles*, Meyr., but differently coloured.

Hobart, Tasmania. One specimen.

TINEINA.

ŒCOPHORIDÆ.

PLEUROTA XIPHOCHRYSA, n. sp.

Male, 14 mm. Head ochreous. (Palpi broken.) Thorax and abdomen dark fuscous. Antennæ fuscous. Legs dark fuscous, posterior pair obscurely banded with ochreous. Forewings elongate, moderate, costa gently arched, termen obliquely rounded; pale yellow, darker along costa, more or less mixed with fuscous; an obscure fuscous sub-costal streak near base; a moderately thick, well-defined, blackish streak along dorsum, edged above throughout by a streak of brighter orange-yellow, from base to anal angle; faint indications of a narrow streak, near and parallel to termen; cilia fuscous. Hindwings and cilia dark fuscous.

Perhaps nearest *callizona*, Meyr., but amongst the yellow-winged species it is easily separated by the dark fuscous cilia of both wings.

Stawell, Victoria. One specimen; (? in October).

PLEUROTA PERISEMA, n. sp.

Female, 14 mm. Head and palpi ochreous-yellow, second joint of palpi externally fuscous, terminal joint fuscous. Thorax light fuscous. Abdomen greyish-fuscous, segmental margins whitish. Legs greyish, anterior pair slightly infuscated. Forewings elongate, moderate, costa gently arched, termen obliquely rounded; pale yellow; a moderately thick, fuscous streak along dorsum, from base to near anal angle, alternated towards base, but gradually becoming dilated posteriorly, and with a projecting tooth on upper edge at about three-fifths; an inwardly oblique ferruginous fascia from just beneath costa at about two-thirds to termen immediately above anal angle, leaving a space of ground at anal angle; space between the ferruginous fascia and termen more or less wholly irrorated with pale ferruginous, except beneath costa; cilia yellowish (imperfect).

Distinct, by the outwardly oblique ferruginous fascia; in most of the other described species the markings are inwardly oblique.

Tasmania (? Hobart). One specimen; in January.

BORKHAUSENIA ZOPHOSEMA, n. sp.

Male, 18 mm. Head, palpi, antennæ, and thorax fuscous, palpi mixed with grey-whitish beneath, except at base; antennal ciliations, 1, with strong pecten. Abdomen fuscous. Legs greyish, banded with fuscous, posterior pair greyish, mixed with blackish. Forewings elongate, moderate, costa gently arched, termen obliquely rounded; 2 and 3 stalked, from just before angle; 7 and 8 stalked, 7 to costa; dark fuscous, with blackish markings; a moderate, well-defined, rather suffused spot at base, reaching dorsum; a suffused spot in middle at one-fifth from base; a second, just below, joining first; a spot in middle of cell, and one or two others at end of cell: an obscure curved series of small dots from beneath costa at three-quarters to dorsum before anal angle; cilia dark fuscous, mixed with some black scales. Hindwings with 3 and 4 from a point, 5 widely remote from 4 at base; pale fuscous, paler at base; cilia grey, with a fuscous sub-basal line.

Could easily be mistaken for *Eulechria photinopis*, Low., to which it has considerable superficial resemblance, but the neural characters are very reliable points of distinction.

Broken Hill, New South Wales. One specimen; in August.

MACROBATHRA GASTROLEUCA, n. sp.

Female, 14 mm. Head, palpi, and thorax greyish, terminal joint of palpi fuscous. Antennæ white, strongly annulated with fuscous. Abdomen dark fuscous, sharply white beneath. Legs whitish, anterior and middle pair mixed with fuscous. Forewings elongate, moderate, lanceolate; white, dorsal half greyish-tinged; termen more or less thickly strewn with ferruginous scales, more pronounced at apex and anal angle, where they become suffused into dorsal colour; cilia greyish-fuscous. Hindwings fuscous; cilia greyish, becoming ochreous on costa and upper half of termen.

This species departs from the general colouring and markings of the group previously described, and is easily determined by the white ground colour and ferruginous scales along termen.

Broken Hill, New South Wales. One specimen; in November.

PARATHETA CYCLOZONA, n. sp.

Male, 14 mm. Head ochreous-white. Thorax whitish, anteriorly fuscous. Palpi and antennæ fuscous, second joint of palpi with a fuscous apical ring. Abdomen and legs greyish, tarsi obscurely banded with fuscous. Forewings elongate, moderate, costa gently arched, termen strongly oblique; white, very minutely irrorated with fuscous around the margins; the irroration tends to accumulate more densely along costa from base to two-thirds, and forms a more or less developed costal streak: a well-defined, moderate, slightly outwardly curved dark fuscous transverse fascia, from about two-thirds of costa to two-thirds dorsum, but not reaching it;

a small fuscous dot on fold, above anal angle, and another obscure, at end of cell; cilia ashy-grey-whitish. Hindwings light fuscous; cilia fuscous, at base greyish.

At once known by the curved fuscous fascia.

Duaringa, Queensland. One specimen; in January.

XYLORYCTIDÆ.

CRYPTOPHAGA AGLAODES, Low.

(Tr.R.S.S.A., p. 171, 1893.)

Male, 38 mm. I have received from Mr. S. Angel the male of this species. In colour and markings it does not differ from the female; the antennal pectinations are about 1½; this is a similar character to that observed in *sarcinota*, Meyr. (to which this species is mostly allied), but is easily separated from that species by the totally different colouring, shorter terminal joint of palpi, and absence of double black dot on forewing, which is conspicuous in *sarcinota*.

The male was taken by Mr. Field at Tennant's Creek, Central South Australia, and the female (type) at Arthurton, Yorke's Peninsula, South Australia.

CRYPTOPHAGA BLACKBURNII, Low.

(Tr.R.S.S.A., p. 15, 1892; *Xylorycta neomorpha*, Turn, Ann. Queens. Mus., p. 13, 1897.)

I have recently taken the male of this species at Broken Hill, which is precisely in accordance with Dr. Turner's description of *neomorpha*. The type (female) was taken at Port Lincoln, South Australia.

HYPERTRICHA STENADELPHA, n. sp.

Female, 20 mm. Head, palpi, and thorax cinerous grey-whitish, second joint of palpi fuscous at apex, terminal joint nearly half of second, acute. Antennæ fuscous, obscurely annulated with white. Abdomen dull silvery-grey, segmental margins dull reddish. Legs cinerous-grey-whitish, anterior coxæ whitish, posterior legs greyish. Forewings elongate, moderate, costa gently arched, termen strongly oblique; 7 and 8 coincident; cinerous-grey-whitish; a streak of white along fold from base to end of cell, containing an oblique fuscous patch in middle, and two or three fuscous dots on upper half at and near extremity; cilia cinerous-grey-whitish, terminal half grey-whitish; hindwings pale grey-whitish, somewhat fuscous tinged around apex; cilia grey, with a fuscous basal line.

Bears a striking resemblance to *Procometis tetraspora* Low., but the resemblance is superficial only; the neuration of the forewings is a specific distinction. Although the terminal joint of palpi is somewhat longer than the characters of *Hypertricha*, that is, one-quarter of second, I scarcely consider it necessary to erect a new genus for its reception, but should the male show additional characters there may be some justification for doing so.

Broken Hill, New South Wales. One specimen; in March.

ELACHISTIDÆ.

COLEOPHORA, Hb.

Antennæ four-fifths, porrected in repose, often thickened with scales towards base, in male simple, basal joint long, usually with rough scales or projecting tuft. Labial palpi, long, recurved, second joint more or less roughened or tufted towards apex beneath, terminal shorter, acute. Posterior tibiæ rough-haired. Forewings with costa often long-haired beneath; 1b furcate, 4 sometimes, 5 absent, 6 and 7 connate or stalked, 7 to costa, 8 absent. Hindwings two-thirds, linear-lanceolate; cilia 3-4 transverse veins sometimes partly absent, 4 usually absent, 6 and 7 closely approximated or stalked.

COLEOPHORA OCHRONEURA, Low.

(*Plutella ochroneura*, Low., Tr.R.S.S.A., p. 59, 1897.)

Semaphore, South Australia.

COLEOPHORA PUDICA, n. sp.

Male, 16, 18 mm. Head, palpi, thorax, antennæ, legs, and abdomen snow-white; base of palpi, antennæ, and thorax beneath faintly ochreous-tinged. Forewings elongate-lanceolate; snow-white, veins very faintly outlined with pale fuscous, not perceptible in some species; cilia white. Hindwings and cilia snow-white.

Differs from *ochroneura* by its smaller size, white ground colour, and absence of ochreous streaks. This genus has not been previously recorded from Australia, but is numerously represented in Europe, Asia, and North America. Mr. Meyrick, to whom specimens were submitted, mentions that the different species are very difficult to distinguish unless the larval habits are known; the larvæ when very young are leaf miners, but afterwards inhabit a portable case; attaching this to the leaf or seed vessel on which it feeds, it bores into the interior; in leaves a pale blotch is usually produced, with a round hole in one membrane, which distinguishes the mines of this genus from all others. I know nothing of the larval habits of either of the above species; they were taken at light.

Broken Hill, New South Wales. Nine specimens; in April.

PLUTELLIDÆ.

Glyphipteryx calliscopa, n. sp.

Male, 12 mm. Head and thorax brownish-fuscous. Palpi, antennæ, and abdomen fuscous, palpi ringed with white. Abdomen beneath ochreous-white. Legs fuscous, ringed with white. Forewings elongate, moderate, costa gently arched, termen rounded, sinuate beneath apex; brownish-ochreous, with greenish-metallic markings: a moderate, oblique fascia from one-third costa to before middle of dorsum, and other similar fasciæ between this and two-thirds, all more or less interrupted, first reaching to fold, broken in middle, blackish posteriorly; second reaching half across wing, becoming black at extremity, and there almost meeting first; third curved outwards, reaching dorsum, more or less broken in middle; a similar fascia starting from an ochreous spot on costa at three-quarters to anal angle; below this and previous fascia are about six strongly defined black longitudinal streaks, the middle one smallest: a similar fascia starting from an ochreous spot and ending on sinuation on termen; cilia ochreous-white, at apex fuscous, with a blackish basal line throughout. Hindwings and cilia dark fuscous.

Melbourne, Victoria. One specimen; in November.

Glyphipteryx perimetalla, n. sp.

Female, 12 mm. Head and thorax ochreous-fuscous. Antennæ and palpi fuscous. Legs ochreous, posterior pair grey. Abdomen grey-whitish. Forewings elongate, moderate, costa gently arched, termen rounded; ochreous, with golden-metallic markings, very slightly edged with fuscous: a narrow, somewhat cuneiform sub-costal streak, frm base to one-third, narrowed towards base: a second similar streak along fold, terminating below first costal streak: three somewhat oblique nearly equi-distant moderate costal streaks: first from costa beyond one-third to just above fold; second from middle of costa to middle of dorsum: third from about two-thirds costa to anal angle: a narrow streak from apex, continued along termen, but not reaching anal angle; a short streak on costa, between third and last mentioned streak, all streaks more or less ochreous, whitish on costa; cilia ochreous, terminal half greyish, with a fuscous median line. Hindwings and cilia whitish-grey.

Somewhat allied to *cyanochalca*, Meyr., but differs from that and the allied species by the absence of any black markings.

Stawell, Victoria. One specimen; in November.

PHRYGANOSTOLA MACRANTHA, n. sp.

Male, 11 mm. Head, palpi, thorax, antennæ, abdomen, and legs dark fuscous, face white, palpi tufted, mixed with whitish beneath. Legs ringed with whitish. Forewings elongate, moderate, costa gently arched, apex somewhat pointed, termen very oblique; dark fuscous, with ochreous-whitish and metallic markings, more or less blackish margined; a well-marked streak along fold from base to just before anal angle; six outwardly oblique fascia, becoming metallic below costa; first, from before costa at one-third, reaching one-third across wing; second, from costa at two-fifths, reaching nearly half across wing; third from before two-thirds to just beyond termination of dorsal streak, with an extra metallic dot below extremity; a small sub-costal dot just beyond; fourth, from three-quarters costa reaching more than half across wing; fifth and sixth short, close together and similar, on costa at five-sixths; an interrupted metallic streak along termen; a round black dot at apex, containing a metallic spot on lower edge; cilia whitish, basal half blackish, and with an elongate black apical tooth. Hindwings and cilia dark fuscous.

Gisborne, Victoria. One specimen; in October.

SIMAETHIS HYPOCALLA, n. sp.

Female, 10 mm. Head, palpi, thorax, antennæ, legs, and abdomen fuscous, palpi ringed with white, antennæ ringed with whitish, and whitish beneath, abdomen whitish beneath, coxæ whitish, tibiæ and tarsi ringed with whitish. Forewings rather broad, costa gently arched, termen rounded; dark fuscous, minutely irrorated obscurely with whitish, which forms about five transverse, fascia-like series; four large black spots along termen, lower two larger and occupying lower two-thirds, each with a purplish-metallic spot in middle; cilia fuscous, basal third darker. Hindwings dark fuscous; a large dull whitish black-centred spot in cell; a narrow, transverse, dull whitish line from five-sixths costa to anal angle; a narrow, bright violet-metallic line just below; cilia dark fuscous, basal half darker. terminal half white, irregularly chequered with fuscous.

Recalls *Choreutis* in appearance, but the palpi being without a tuft I prefer to place it in *Simaethis*. Probably the male may show some additional characters sufficient to warrant forming a new genus for its reception. The violet-metallic line of hindwings is a special character.

Mareeba, Queensland. One specimen; in April. I have seen a specimen from New Guinea.

TINEIDÆ.

Comodica decaspila, n. sp.

Male, female, 12, 20 mm. Head, palpi, and thorax snow-white, palpi blackish at base, externally and beneath, thorax with a narrow blackish anterior band, antennæ fuscous, basal joint white, fuscous beneath. Abdomen greyish. Legs white, broadly banded with black, anterior pair wholly blackish beneath. Forewings elongate, moderate, costa gently arched, termen oblique; an elongate, transparent patch near base; snow-white, with black markings; ten spots, arranged as follows:—Four oblique, equi-distant, on costa, first basal; four at five-sixths, reaching one-quarter across wing; four others, similar, on dorsum, apices pointed, first at base; fourth at anal angle, the second one hardly traceable and hardly reaching dorsum; two in middle of wing, ovoid, before and beyond middle; indications of another on termen beneath apex; cilia white, becoming blackish at base on markings. Hindwings pale fuscous; cilia grey, becoming white around apex.

Cooktown, Queensland. Two specimens; in December.

Comodica epispora, n. sp.

Female, 18 mm. Head and palpi whitish, faintly ochreous tinged, palpi at base beneath dark fuscous. Antennæ fuscous. Thorax dark ferruginous-ochreous, patagia paler. Abdomen ochreous, banded with dark fuscous. Legs ochreous, irregularly banded with fuscous. Forewings elongate, moderate, costa gently arched, termen obliquely rounded; 3 and 4 coincident, 7 and 8 coincident, to costa, lower fork of vein 1 obsolete; deep ferruginous-ochreous, with whitish markings; a rather broad, transverse fascia, from near base of costa to base of dorsum, slightly angulated below costa; a rather large spot on costa beyond middle, and a smaller one midway between fascia and last mentioned spot; a large spot on middle of dorsum; a small spot on dorsum before anal angle; a suffused spot below middle of termen; cilia yellowish-orange, basal half ferruginous-fuscous. Hindwings with veins 5 and 6 stalked, 6 to costa; dark fuscous; cilia yellowish-orange.

Mackay, Queensland. One specimen; taken on a fence in December.

Comodica citrinopa, n. sp.

Male, female, 12, 14 mm. Head, palpi, and thorax white, palpi mixed with ochreous and fuscous beneath, thorax with a narrow orange anterior margin. Antennæ fuscous. Abdomen greyish, beneath ochreous. Legs ochreous, banded above with fuscous. Forewings elongate, moderate, termen obliquely rounded; bright orange-ochreous; markings whitish, rather obscure; four equi-distant fuscous spots on costa between one-sixth and three-quarters; two oblique fasciæ from one-quarter and middle, reaching two-thirds across wing, and thence meeting a thick streak along dorsum from base to two-thirds; a moderate spot on costa before three-quarters; an obscure spot on costa near apex; cilia citron-yellow, mixed with light ferruginous. Hindwings fuscous; cilia fuscous, around apex and upper half of termen greyish-ochreous.

Mackay, Queensland. Two specimens; in November. Mr. Dodd has sent me several specimens taken at Townsville, Queensland.

This may prove to be a variety of the previous species, but it presents such a different appearance as to justify me in giving it a distinctive name.

TINEA TETRASPILA, n. sp.

Male, 8 mm. Head ochreous. Thorax, palpi, antennæ, abdomen, and legs dark fuscous. Forewings elongate, moderate, costa gently arched, termen obliquely rounded; dark fuscous, coppery tinged and somewhat shining; markings ochreous-yellow; a moderate quadrate spot on dorsum at one-third; a second, similar, but smaller, on dorsum before anal angle; a third, obscure, on costa at two-thirds; a fourth, obscure and small, on costa near apex; cilia dark fuscous. Hindwings elongate-lanceolate; fuscous, somewhat coppery shining; cilia fuscous.

Probably nearest *tetropa*, Meyr., but widely distinct.

Parkside, South Australia. Gisborne, Victoria. Three specimens; in October and November.

EREUNETIS STREPTOGRAMMA, n. sp.

Female, 8 mm. Head, palpi, antennæ, thorax, and legs pale whitish-ochreous. Abdomen greyish-ochreous. Forewings elongate, rather narrow, termen obliquely rounded; pale ochreous, with fuscous markings; six outwardly oblique streaks from costa; first at base, spot-like; second at one-sixth, larger; third before middle, very oblique, hardly reaching one-third across wing; fourth beyond middle, similar; fifth and sixth small, between five-sixths and apex; last three more or less connected by a thick, longitudinal streak, which is continued to below apex; a moderately thick streak along dorsum from base to three-quarters, with about five projections on upper edge, third anteriorly oblique and nearly reaching second costal spot; a fine line along termen, not quite connected with dorsal streak; cilia ochreous. Hindwings fuscous; cilia fuscous.

Duaringa, Queensland. One specimen; in December.

NOTES ON SOUTH AUSTRALIAN DECAPOD CRUSTACEA.
PART II.

By W. H. Baker.

[Read May 2, 1905.]

Plates XXI. to XXIV.

The following paper is a study of a group of Maioid crabs or *Oxyrhyncha*. The first four species and one variety belong to the genus *Halimus*, found on our coast, two of which, *H. lævis*, Haswell, and *H. truncatipes*, Miers, are important on account of their usual large size and frequency of occurrence, and which, as far as my knowledge goes, have never been figured; one, *H. tumidus*, Dana, a figure of which is to be found in another connection, in Kongl. Svenska Vetenskaps Akademiens Handlingar, Band 23, Plate ii., fig. 6, a notable variety of this species, which I have described in detail; and another which is here described for the first time. The others belong to different genera.

In Professor Haswell's catalogue of Australian crustacea the first three species are described; but there are several points of difference which I would like to set forth which are scarcely mentioned by the above authors.

The definition of the genus given by Miers in his classification of Maioid crustacea, Jnl. Lin. Soc. vol. xiv. p. 646, runs thus:—"Carapace sub-triangular, with lateral marginal spines. Three spines above the eye. Merus joint of the outer maxillipeds somewhat auriculated and produced at its antero-external angle. Anterior legs in the male enlarged, palm slightly compressed. Ambulatory legs, with the penultimate joint more or less flattened and dilated towards its distal end. Type, *Halimus auritus*, Latreille. This genus establishes a transition to the Maiidæ."

In the species of this genus under consideration the structure of the orbital region may first attract attention as of importance, especially when compared with the corresponding parts of some members of other genera of the family Maiidæ, with which the relationship of *Halimus* is undoubted; to mention some genera, viz., *Maia*, *Chlorinodes*, *Micippa*, *Schizophrys*, *Paramithrax*, and others, in which, while the lower margin of the orbit is usually very incomplete, being partially formed by the basal joint of the antenna, the upper is divided into, first, a short, usually thickened arcuate portion immediately above the socket of the eye peduncle, and posteriorly to this usually two spines—or more or less spiniform processes—the more posterior one of which is on a slightly lower level. This I take to be the true post-ocular spine, representing the posterior or outer angle of the orbit; the preceding one I have called the intermediate spine of the upper orbital margin. In *Paramithrax*, *Schizophrys*, etc., these parts are well shown, but have become, as it were, squeezed together to form a more complete orbit; but in the species of *Halimus* under consideration the spines are distant, the posterior portion of the orbit being a widely open space.

Within the genus itself the arrangement of these parts is useful for classification, the anterior arcuate portion being spiniform, dentiform, tuberculate, or merely rounded at the anterior or posterior end, and the two succeeding spines in different degrees of development and relationship.

If *Chlorinodes coppingeri*, Haswell, be examined, these parts will be seen to be much exaggerated in shape.

Also, in the interocular space on each side, near the orbital margin above, there is in these species of *Halimus* a tubercle with a more or less distinct ridge extending from it on to the rostral horn; these elevations are supplied plentifully with the curled corneous bristles so much in evidence amongst these crabs. In the same species of *Chlorinodes* mentioned above this ridge is very distinct; it is also shown in *Paramithrax* and others.

Again, in the species of *Halimus* under consideration a more or less papilliform tubercle is situated on the subhepatic region; in *H. truncatipes* this is somewhat anvil-shaped and very distinctive.

In the cardiac region of *Halimus* are usually seen a pair of tubercles showing a tendency to coalesce, represented in the species of *Chlorinodes* again by a lamellar, bifid structure which is very prominent.

Lastly, in these allied species, the chelipeds of the males are subject to great variation as to size, their enlargement apparently taking place well on in the life of the animal, as in some specimens they scarcely exceed those of the female. I would instance the case of *Leptomithrax spinulosus*, Haswell, where certain males—doubtless adults, on account of size and being covered by much of the usual foreign matter—have the chelipeds little if at all exceeding in size and shape those of the female, while in others they are massive, with the fingers very unsymmetrical. In *Schizophrys aspera* somewhat similar conditions obtain.

In these four species of *Halimus* the normal chelipeds scarcely differ; in all, the hands become slightly narrower distally in the vertical direction, and are more or less provided with scattered punctations, from which fasciculi of hairs arise.

The following points, therefore, are common to the four species:—The carapace is sub-pyriform, more or less acutely pointed medianly on the posterior border, convex, usually more depressed anteriorly than posteriorly; the rostral horns are well developed and divergent and usually curved outwards; the posterior part of the orbit is widely open, the upper margin consists of, first, an anterior portion forming an arch over the socket of the eye-peduncle, spined or projecting each end; second, an intermediate spine more or less distant from the posterior end; and third, a strong, post-ocular spine, usually pointing forwards, and distant from the intermediate spine at a lower level.

The lateral spines of the carapace are, viz., one on the hepatic region, and three on the branchial, the most posterior of which approaches nearer the middle of the carapace.

The basal antennal joint has a strong spine at the external distal angle, and usually a small one at the internal angle. There is a small conical tubercle close to the base of this joint, on the outer side, usually tipped with hairs.

The external maxillipeds have the ischium joint with its internal distal angle very much produced above the transverse line. The merus joint, inverted-triangular in shape, is rounded and produced at its external distal angle partially covering the end of the exopod, truncate, and the margin insinuate at the internal angle; the ends of the margin thus defined are acute or spined, the following joint originating close to the outer (or upper) end of this margin.

Sub-hepatic and pterygostomial regions each with a more or less conical tubercle.

Chelipeds usually rather weak in the females and in some males, in others much enlarged, with the fingers widely gaping, but not unsymmetrical. The merus has a spine at the distal end above. The carpus is strongly keeled in the males.

Ambulatory legs long, becoming successively shorter behind, the joints mainly cylindrical, the ischium joints each with a small conical tubercle below at the distal end, the penultimate joints more or less expanded towards their distal ends, the expansions usually becoming wider on the more posterior legs. The dactyli curved, sharp, with two rows of small teeth.

Pleon seven-jointed in the males, the fourth, fifth, and sixth coalesced in the females.

The species of this genus are, as in other Maioid genera, well supplied with more or less curved corneous bristles springing in groups usually from the tubercles, rostral horns, etc., and also from the ambulatory legs. These are used for the attachment of foreign substances for purposes of obscuration.

The genus may be briefly characterised in the following manner:- -

Family Maiidæ.

Genus **Halimus,** *Latreille.*

Carapace sub-pyriform, more or less acutely pointed medianly on the posterior border.

Rostral horns divergent, and sometimes depressed.

Orbits incomplete, especially below.

A large lateral spine on the hepatic region.

Three lateral spines on the branchial region.

The basal antennal joint with a spine on its external distal angle.

The external maxillipeds with the ischium joint much produced at its internal distal angle, the merus joint rounded and produced at its external distal angle, truncate at the internal angle.

Sub-hepatic and pterygostomial regions each with a more or less conical tubercle.

Chelipeds usually weak in the females and some males; in other males much enlarged.

Ambulatory legs long, the joints cylindrical, except the propodi, which are more or less expanded towards their distal ends.

Pleon seven-jointed in the males.

Halimus lœvis, *Haswell.* Pl. xxi., figs. 1, 1*a.*

(Pr. L.S., N.S.W., Ser. i., vol. iv., p. 435.)

This species is very variable, especially as to size. The chelipeds of the males are sometimes normal, sometimes massive.

The following characteristics, in addition to those given by Professor Haswell, are tolerably constant in a moderate series of examples noted.

The rostral horns project horizontally. The anterior portion of the carapace is well depressed from the middle of the gastric region forwards, and with a less curve behind. The inter-ocular tubercles are large. There is one well-marked but low tubercle on each epibranchial region, two more faintly marked on the mid-branchial, obliquely placed. A pair of transverse, separate tubercles on the cardiac region, one median conical tubercle on the intestinal region, and between this and the cardiac pair a faint indication of a pair of transverse tubercles: these are more pronounced in some specimens. The tubercles have a tendency in old specimens to become worn away. The branchial regions are marked off from the urogastric and cardiac by a row of pits lying in the grooves which separate these regions. The posterior margin is more or less pointed medianly, in some examples broad, thick, and polished, in others almost or quite spiniform.

The supra-ocular border is anteriorly thrown into a prominent acute spine; posteriorly there is a smaller one. The intermediate spine is well developed, projecting nearly horizontally, and further than the preceding one; it is situated slightly nearer this than to the post-ocular. The post-ocular sine is long, and is inclined in a forward direction. The hepatic region has a spine about the same size. The three lateral spines of the branchial region successively shorten.

The sub-hepatic tubercle is papilliform, as also is that of the pterygostomial region.

The basal antennal joint has a broad, oblique sulcation, extending from near the external distal angle. The external distal spine is rather small, and is only slightly pressed upward. The remainder of the peduncle is not covered by the rostral horn.

The normal chelipeds have the fingers rather long, approximating nearly their whole length, slightly curved, and minutely dentate.

The segments of the pleon in the male are moderately prominent in the median line.

Length of medium-sized specimen, 45 mm.
Breadth in the mid-branchial region, 33 mm.
Length of rostral horn, 7 mm.
Inter-ocular space, 11 mm.
Length of cheliped, male, 40 mm.
Length of first ambulatory leg, 54 mm.

Halimus truncatipes, *Miers*. Plate xxii., figs. 2, 2*a*.

(An. and Mag. Nat. Hist., Ser. v., vol. iv., p. 3.)

My specimens agree well with Miers' description. The species attains to as large a size as *H. lævis*. The chelipeds of the male also are capable of assuming the larger development. The lateral spines are stronger, and the tubercles of the carapace more spiniform, also tubercles are shown where in the former species there are merely groups of bristles, the carapace itself is more convex, the rostral horns longer and a little depressed and more divergent. The inter-ocular tubercles are very distinct; there are four papilliform tubercles occupying the front of the gastric region, the two outermost smaller, and not in the same transverse line. The supra-ocular arcuate margin has the anterior spine very prominent but obtuse, the intermediate spine is large, and has a more forward direction than in *H. lævis*. Its position with regard to the one immediately preceding it is about the same as in that species. There are six tubercles of varying sizes on each branchial region—apart from the lateral spines—and the two cardiac tubercles are distinct. The cardiac and intestinal regions are marked off by sinuous rows of pits, which assume irregular groups on the sides of the intestinal region.

The eyes are rather small.

The sub-hepatic region has the anvil-shaped spine before mentioned.

The external distal spine of the basal antennal joint is large, the internal one very small. There is an oblique sulcation on this joint, as in the preceding species.

This species is common in shallow water at Port Willunga, Edithburg, and elsewhere, and Mr. Fulton has sent me specimens from Western Port, Victoria.

Length of carapace, 44 mm.
Breadth of carapace, 32 mm.
Length of rostral horn, 9 mm.
Inter-ocular space, 11 mm.
Length of first ambulatory leg, 56 mm.

Halimus tumidus, *Dana.* Plate xxii., figs. 3, 3*a*.

(U.S. Exploring Exped. Crust., 1, p. 165.)

My specimens of this species are small.

The carapace is very convex, anteriorily depressed, as are much so the rostral horns, which also are somewhat vertically compressed. The tubercles of the upper surface are not strongly marked, but are more numerous than in the preceding species. The inter-ocular tubercles are very low. There is no spine on the posterior border, an intestinal tubercle is present, as also are two on the cardiac region, with a small one tending to become double between them. The anterior portion of the upper orbital margin is merely thickened, rounded anteriorly, and posteriorly scarcely acute. The intermediate spine is nearly horizontal in position, and is near to the post-ocular. The post-ocular spine is well developed, but the remaining lateral spines poorly, especially the last.

The basal joint of the antenna has its external distal spine very large and somewhat compressed, showing well from above, spinulose on its outer margin, and strongly pressed upwards. The internal distal spine is very small, the oblique sulcation wide and shallow, the remaining peduncular joints are almost totally hidden by the rostral horn.

The pleon of the male has the segments scarcely prominent medianly except the first two. The pleon of the female ends in a distinct though obtuse point.

The chelipeds in the male are of moderate size, the hand is short and rather tumid, the fingers are short, narrow, and evenly dentate. The arm is provided with a distal tooth above, and there are faint indications of two more further back. The carpus is strongly keeled with a minute tooth at the proximal end.

The sub-hepatic tubercle is spiniform, and points forward.

The penultimate joints of the posterior pair of ambulatory legs are nearly as much expanded as in *H. truncatipes*.

This is a shallow water species, St. Vincent Gulf.

Length of carapace, 18 mm.
Breadth of carapace, 13 mm.
Length of rostral horn, 3 mm.
Inter-ocular space, 5 mm.
Length of chelipeds, 15 mm.
Length of first ambulatory leg, 17 mm.
Specimens in Adelaide Museum.

Halimus tumidus, var. **gracilipes,** *n. var.* Pl. xxiii., fig. 5.

Carapace very convex. Rostral horns rather slender, well depressed, and divergent, more so from their distal halves, but little vertically compressed. The upper orbital border is anteriorly tuberculate, but not so nearly spiniform as in *H. truncatipes*, the posterior end bears a small, acute tooth, the intermediate spine is well developed and acute, separated from the preceding tooth by a narrow V-shaped cleft, while it is separated from the post-ocular by a much wider space. The post-ocular spine is long, inclined forwards, and is slightly sigmoid in shape. The hepatic region bears a small conical spine. The three lateral spines of the branchial region are moderately developed. The inter-ocular space has two strong conical tubercles, with a smaller one in advance of each; the space between these pairs is somewhat concave, extending forwards to the base of the rostral horns. Five gastric tubercles are arranged in the usual manner, and are well marked; four or six more lateral ones less distinctly. There are two, very small, on the urogastric region. The cardiac region consists of two elevations, each bearing three small tubercles, and behind these there are three median, sub-acute, and well-defined, including one on the posterior border, which is slightly turned up at the apex and slightly bifid. The epibranchial regions are slightly tumid, each bearing two small tubercles, arranged obliquely, and there are nine or ten more on each branchial region (omitting the lateral spines) more or less developed. There are two or three very small tubercles on each hepatic region. Apart from the tubercles, the surface of the carapace is smooth. The limiting rows of pits between the branchial and cardiac regions are very faintly indicated.

The basal antennal joint is large, broadly sulcate in an oblique manner. The external distal spine is large, but not compressed, and is distant from the rostral horn. There is a small tooth at the inner distal angle. The external margin of the joint is slightly sinuate, and bears two spiniform teeth, one of which is on the distal spine. The remaining joints of the peduncle are not hidden by the rostral horn.

The eyes are well developed. There is a small tubercle tipped with hairs above the ophthalmus.

The epistome is somewhat excavate.

The external angles of the buccal frame are prominent, the margin bearing some small, ill-formed tubercles.

The pleon in the female has the fourth, fifth, and sixth segments very broad and coalesced, medianly sulcate, the groove marked with a few irregular punctations. The first three segments are very prominent medianly, especially the first. The external margin of the coalesced segments is raised. The terminal segment is broad and distally rounded.

The sub-hepatic spine is strong, acute, and points forward. The pterygostomial one is small.

The chelipeds in the female are slender, the merus joint short, not reaching as far forward as the post-ocular spine. It is sub-cylindrical, and bears externally three well-developed, forward-directed spines, the last larger and at the distal end. The carpus bears a small tooth near the proximal end on the outer side. The palm is laterally compressed. The fingers are slender, long, about two-thirds the length of the palm, with minute teeth towards their ends.

The ambulatory legs are long and rather slender. The merus joint of the first pair is cylindrical, and reaches nearly as far as the carpus of the cheliped. The carpus is sub-equal in length to the propodus. The proximal half of the propodus is cylindrical, the distal half not much expanded. The dactylus is slender.

This specimen differs from the typical *H. tumidus* in the following respects:—The tubercles and spines of the carapace are much more accentuated. The inter-orbital region has two tubercles on each side, with a broad, shallow concavity between them. The rostral horns are longer, much slenderer, and little compressed in the vertical direction. The upper orbital border has anteriorly a distinct tubercle and an acute spine posteriorly, the intermediate one being very close to this. There is a strong median tooth on the posterior margin. The second and third joints of the antennal peduncle are not hidden by the rostral horn. In the cheliped the merus joint bears two strong projecting spines, besides the one at the distal end. The ambulatory legs are longer and slenderer, the penultimate being not so much expanded. The penultimate joint is more than three times as long as broad.

Habitat, St. Vincent Gulf. Dredged by Dr. Verco.

Length of carapace, 18 mm.
Breadth of carapace, 13 mm.
Length of rostral horn, 4 mm.
Length of cheliped, 15 mm.
Length of first ambulatory leg, 24 mm.

One specimen, a female, in Adelaide Museum.

I have referred this specimen to Mr. G. M. Thomson, of Dunedin, who has been good enough to examine it, with the result that it is here recorded as a variety of *H. tumidus*, Dana.

Halimus gracilis, *n. sp.* Pl. xxiii., figs. 4, 4*a*.

Carapace elongate, shrunken, anteriorly moderately depressed. The rostral horns are long, rather slender, very divergent, especially distally, projecting forward horizontally. Tubercles of the carapace not so numerous as in the preceding species; there are two inter-ocular, well marked, two transverse, with three longitudinal behind, on the gastric region, the last of which is almost obsolete; four others laterally placed on the gastric region are also nearly obsolete, one on each epibranchial region, with one a little below and outward from each. The cardiac tubercle is single, and there is one on the intestinal, which is very close to the strong median spine of the posterior border. The rows of pits noticed in the other species are faintly marked.

The supra-orbital border is thin, without anterior tubercle, the posterior end has a small acute point, the intermediate spine is short, and is situated much further from the post-ocular than from the point which precedes it. The post-ocular is longer than the other lateral spines, and projects well forward, the following hepatic spine projects horizontally, and is situated close behind on the prominent hepatic region, behind which the carapace is strongly constricted. The three lateral spines of the branchial region are well developed, rather contiguous, each being curved forwards.

The basal antennal joint is elongate, narrow, the oblique sulcation scarcely indicated. The external distal spine is rather short, scarcely showing from above, the remaining peduncular joints are not hidden by the rostral horn; there is a small spine at the internal distal angle.

The epistome is narrow and rather long.

The anterior angles of the buccal frame are very prominent.

The sub-hepatic and pterygostomial tubercles are papilliform.

The normal chelipeds in the male have the arm subcylindrical, the distal spine well developed, and with a well-marked tooth near the proximal end above. The carpus is strongly keeled outwardly, the proximal end very prominent. The palm is compressed, narrowing in the vertical direction towards the distal end. The fingers are moderately long, slightly curved, rather slender, finely denticulate, and approximating for nearly their whole length. The enlarged cheliped sometimes occurs in this species in the males.

The ambulatory legs are long, rather slender, sparingly setose, with the merus joints cylindrical; the carpal and propodal joints nearly equal in length, the propodal little expanded distally. The dactyli are slender, curved, and acute.

The pleon of the male is narrow, the two first segments more so, the third slightly wider than the rest; their median portions are only very moderately prominent.

This species may easily be distinguished from the former ones by its shrunken appearance, by the length of the lateral spines and rostral horns, its single tubercle on the cardiac region, etc. In the position of the intestinal tubercle it resembles *H. aries*.

Length of carapace, 30 mm.
Breadth of carapace, 20 mm.
Length of rostral horn, 8 mm.
Length of cheliped, 34 mm.
Length of first ambulatory leg, 49 mm.
Inter-ocular space, 6½ mm.
Dredged by Dr. Verco, Investigator Straits, 20-30 fms.
Types in Adelaide Museum.

The next species is referred to the genus *Paramicippa*, M.-Edw. I have been able to compare it with *P. tuberculosa*, M.-Edw., and find the following characteristics common to both.

The carapace is rounded behind. The rostral horns are depressed, though not quite so much as in *P. tuberculosa*. The orbits are similar, although in *P. tuberculosa* the intermediate spine has disappeared, but is perhaps represented by the bifid, post-ocular spine. The eye peduncles are long, non-retractile, and project upwards. The basal joint of the antenna is broad and sloping outwards. The second joint of the peduncle (although not compressed) is large and prominent. The external maxillipeds resemble those of *Halimus*. The pleon segments in the female are free. The dactyli of the ambulatory legs are without spinules.

Family Maiidæ.

Genus *Paramicippa*, M.-Edw.

Paramicippa hispida, *n. sp.* Pl. xxiv., figs. 6, 6*a*.

Body thickly covered with long, bristly hairs, especially on the legs, where they are sometimes curved at the tips.

Carapace pyriform, convex, smooth beneath the hairs, most elevated in the protogastric region. The gastric region is broad in front, narrowing behind. The urogastric region is distinct, as also are the cardiac and intestinal. These are separated from the branchial by an irregular shallow groove extending longitudinally from the cervical groove to a shallow meta-branchial depression; this groove is bounded on the outer side by an obscurely marked, rounded ridge following the same direction but interrupted in the middle. The branchial regions are well rounded, moderately tumid, and without spines. The posterior margin is slightly produced medianly, and rounded.

The anterior portion of the upper margin of the orbit is slightly thickened and strongly arched; the posterior end of the arch is sub-acutely prominent and pressed down behind the eye peduncle; the intermediate spine, which is somewhat compressed and sub-acute, follows close behind with the post-ocular, which is a little longer and also sub-acute, following close after it in the same oblique line. The orbit is very widely open below.

The hepatic region is slightly tumid.

The rostral horns are short, nearly parallel, acute, and much, though not vertically, depressed. Two ridges, with a median groove between, extend from the base of the rostrum to the front of the gastric region, slightly diverging backwards.

The ocular peduncles are very long, project upwards, and are slightly curved in that direction.

The basal antennal joint is short, slightly oblique, sloping outwards, ending distally in a slightly curved, transverse ridge, which on the outer side is produced to a strong spine, projecting outwards and upwards, and but very little forwards, and on the inner side bearing a small tooth. The remaining joints of the peduncle are well clear of the rostral horn, the more proximal one is short and broad, but not compressed.

The sub-hepatic region is tumid.

The pterygostomial region has a compressed tubercle or spine.

The epistome is depressed.

There is a small, rounded swelling between the orbit and the external angle of the buccal frame.

The external maxillipeds are similar to those of *Halimus*, though the internal distal angle of the ischium and the external angle of the merus are not so much produced.

The chelipeds are very weak in both sexes, smooth, unarmed. The merus is short, cylindrical, and slightly constricted near the distal end. The carpus is narrow and rounded above. The hand is not much compressed, and narrows in the vertical direction. The fingers are nearly straight, very faintly toothed, more than half the length of the palm, nearly cylindrical, and with a proximal hiatus.

The ambulatory legs are moderately long, with the pairs not differing much in length, very hairy, the joints cylindrical, the carpal joints longitudinally grooved above. The dactyli are acute and slightly curved.

The male pleon is seven-segmented, the sides slightly insinuate from the third segment. The segments are medianly umbonate, especially at their distal margins; the third segment has a slight swelling on each side; the terminal segment is broadly triangulate. The female pleon has the seven segments distinct.

Length of carapace, 26 mm.
Breadth of carapace, 22 mm.
Inter-ocular space, 7 mm.
Length of cheliped, 23 mm.
Length of first ambulatory leg, 32 mm.

Littoral species, Port Willunga, Mr. W. J. Kimber; Port Lincoln, etc.

Types in Adelaide Museum.

This species has the habit of covering itself with extraneous materials to an excessive degree, scarcely more than the chelipeds and eyes are uncovered. The material consists of sand, calcareous matter, seaweeds, etc., very difficult of removal.

Family MAIIDÆ.

Genus *Micippa*, Leach.

Micippa mascarenica, *Kossman*, var. **nodulifera**, *n. var.*

Pl. xxiv., figs. 8, 8*a*.

The carapace is sub-oblong, broadest near the posterior border, depressed—more so in the male. The surface is granulate to tuberculate and nodular. The tubercles or nodules and the larger granules are white, many apparently formed by coalescence of granules: these are much more crowded near the posterior border. Groups have the following positions:—One on each hepatic region, one on each epi-branchial region, one on the meso-gastric, preceded in the median line by two or three large single granules, one on the urogastric and two on the cardiac region. Three well-marked, compressed tubercles, closely succeed each other on the lateral margin behind the orbit, and behind the last of these are numerous smaller tubercles, which become almost spiniform posteriorly. The median regions are slightly raised, and a strong depression exists in each hepatic region.

The upper margin of the orbit is anteriorly thin and arcuate, with a longitudinal row of granules near the edge. Its posterior end is produced to a slight prominence, the succeeding parts—representing the intermediate and post-ocular spines—are tuberculiform, compressed in the vertical direction, and separated from each other by almost closed fissures. The outer one is similar to those which succeed it on the lateral margin, and has a somewhat T-shape.

The front is strongly declivous, but not vertically deflexed, it is slightly narrower proximally, and faintly crenulate on the sides, terminating in four acute lobes or teeth, the outer ones slightly raised along with the lateral margins, projecting outwards and slightly upwards, the inner ones projecting downwards.

The basal antennal joint is broad, oblique, and much produced at its external distal angle; this is sub-acute and strongly pressed upwards, showing well when viewed from above. The outer margin of the joint is slighty crenulate, the second joint is dilated, the third less so.

The sub-hepatic and pterygostomial regions are tumid and coarsely granular.

The external maxillipeds are like those of *Halimus*. The outer distal angle of the merus is produced and broadly rounded, the distal margin not insinuated, and bearing minute teeth.

The pleon of the male is sub-oblong, proximally a little constricted, the third, fourth, fifth, and sixth segments are sub-equal in length, the terminal segment is rounded to almost semi-circular form. In the female the segments are distinct.

The chelipeds are rather weak in the male, smooth, the merus sub-cylindrical, and slightly curved, the carpus is rounded above, the palm is scarcely one and a half times as long as the carpus, the fingers are shorter than the palm, slightly curved, meeting for nearly the whole length of their opposable edges, very faintly toothed.

The ambulatory legs are rather short, the first pair scarcely exceeding the length of the chelipeds, the other pairs becoming successively shorter, the merus joints are sub-cylindrical, the distal ends of these and the carpal joints are nodular, the carpal joints are short, vertically compressed, and grooved above, the propodal joints are cylindrical, the dactyli are curved, strong, and without spinules.

Length of carapace, 10 mm.
Breadth of carapace, 8 mm.
Length of cheliped, 7 mm.
Dredged by Dr. Verco, S.A. coast, 20 fms.
Specimens in Adelaide Museum.

Family PARTHENOPIDÆ.

Genus *Thyrolambrus*, Rathbun. Pr. U.S. Mus., vol. xvii.

Thyrolambrus excavatus, *n. sp.* Pl. xxiv., fig. 7.

The whole of the body is covered with irregular granules, forming in parts jagged points, becoming more or less spiniform on the ambulatory legs.

Carapace triangular, broader between the lateral angles than long, produced to some extent over the bases of the chelipeds and first two pairs of legs. Surface much eroded, being covered with irregular granules, for the most part connected together by small ridges, forming somewhat stellate reticulations. The regions are well defined, those most in relief are the protogastric and branchial, and most depressed the meta-gastric and intestinal. The meta-gastric depression extends laterally to the margin behind the hepatic region, and posteriorly between the cardiac and branchial to join the intestinal, though becoming shallower. The branchial regions are tri-lobed, the lobes arranged in a triangular manner, the apex forming the lateral angle of the carapace. Of these three lobes the anterior one is the largest. The hepatic region is small and depressed. The epi-gastric region has a deep median excavation, between which and the front is a shallow median groove, which is continued behind the cavity, bifurcating in front of the meso-gastric region to join the meta-gastric depression. The meso-gastric region is triangular, and behind it the median portion of the carapace, after being a little depressed, becomes gradually elevated again at the cardiac region. This has on each side two or more irregular transverse ridges connecting it with the meta-branchial lobe, and posteriorly it is abrupt to the intestinal depression. The sides of the carapace are very declivous, and below the antero-branchial lobe there is a slight excavation, beneath which the margin expands to a ridge immediately above the chelipeds, bearing some spiniform tubercles and uniting anteriorly with the pterygostomial ridge. The latero-posterior and posterior margins are nearly in the same transverse line, the former slightly insinuate, bearing some obtuse points, especially at the junction with the posterior border. The posterior margin is short, slightly raised, and granulate, with a small transverse ridge, usually bearing three distinct granules close above it.

The front is almost vertically depressed, narrowing, and produced well beyond the orbits, terminating in a small rostral process, which projects downwards between the antennules.

The orbits are nearly circular, the internal sub-orbital angle slightly accentuated.

The basal antennal joint is slightly oblique, becoming narrower distally, barely reaching the sub-orbital angle; the second joint is much smaller, and just reaches the contiguous part of the front; the third joint and flagellum are very small and lie in the orbital cavity.

The epistome is sunken, but strongly bordered all around.

The sub-orbital region is rather tumid; an excavation behind divides it from the sub-hepatic lobe, and joins a large cavity, separating the sub-hepatic from the pterygostomial region.

The external maxillipeds completely close the buccal cavity. The ischium is about twice as long as the merus; its internal distal angle is slightly produced above the transverse line; it has a longitudinal groove, and strongly granulate ridge. The merus is sub-quadrate, its external distal angle slightly overlapping the end of the exopod, its inner distal angle truncated, the space filled by the succeeding joint. The exopod has a longitudinal series of strong granules.

The chelipeds are moderately robust, the merus is thicker proximally, sub-cylindrical, very rough above, with a conical, erect process near the proximal end; anteriorly there are two or three triangular processes, also proximal; the lower surface is more evenly granulate, and has two small projections about the middle; there are also one or two projections posteriorly. The carpus is somewhat flattened above. The hand is trigonous, its upper surface flattened and ascending to the base of the mobile finger, where it is very prominent and jagged. The inner margin bears three compressed processes projecting inwards, the middle one of which is much larger. The lower margin bears a series of five or six forward-projecting, compressed processes, usually acute, extending on to the immobile finger. The outer surface is slightly convex, and bears an obscure tubercle or two about the middle. The fingers are as rough as the hand, very much compressed laterally, the apices are crossed, and when in this position the opposable edges meet.

The ambulatory legs are small, covered with more or less spiniform points; the first pair does not reach as far as the carpus of the chelipeds; the dactyli are nearly straight. The posterior pair of legs are very short.

The pleon of the female covers the whole of the narrow sternum between the legs; the distal half is slightly broader and is medianly very prominent, the prominence broken by transverse, jagged ridges, which extend to the margins, and on the last segment have a radiate arrangement. In the male the pleon is very narrow, especially the distal half, the sternum showing a deep excavation between its last segment and the base of the buccal frame.

Length of carapace, 19 mm.

Breadth of carapace, 25 mm.

Length of cheliped, 30 mm.

Dredged by Dr. Verco, Investigator Straits, 20-30 fms.

Types in Adelaide Museum.

I am in doubt whether this species should not be placed in the genus *Parthenope*, Fabricius, but its complete agreement with *Thyrolambrus*, as presented by Miss Rathbun, has decided me here.

EXPLANATIONS OF PLATES.

Plate XXI.

Fig. 1 *Halimus lævis*, Haswell—Natural size.

Fig. 1a. *Halimus lævis*, Haswell—Inferior view of anterior regions. Enlarged.

Plate XXII.

Fig. 2. *Halimus truncatipes*, Miers—Natural size.

Fig. 2a. *Halimus truncatipes*, Miers—Inferior view of anterior regions. Enlarged.

Fig. 3. *Halimus tumidus*, Dana—Inferior view of anterior regions. Enlarged.

Fig. 3a. *Halimus tumidus*, Dana—Side view.

Plate XXIII.

Fig. 4. *Halimus gracilis*, n. sp.—Enlarged.

Fig. 4a. *Halimus gracilis*, n. sp.—Enlarged.

Fig. 5. *Halimus tumidus*, var. *gracilipes*, n. var.—Enlarged.

Plate XXIV.

Fig. 6. *Paramicippa hispida*, n. sp.—Enlarged.

Fig. 6a. *Paramicippa hispida*, n. sp. — Inferior view of anterior regions. Enlarged.

Fig. 7. *Thyrolambrus excavatus*, n. sp.—Slightly enlarged.

Fig. 8. *Micippa mascarenica*, Kossman, var. *nodulifera*, n. var.—Enlarged.

Fig. 8a. *Micippa mascarenica*, Kossman, n. var.—Inferior view of anterior regions. Enlarged.

ON THE ALPHA PARTICLES OF RADIUM, AND THEIR LOSS OF RANGE IN PASSING THROUGH VARIOUS ATOMS AND MOLECULES.

By W. H. Bragg, M.A., Elder Professor of Mathematics and Physics in the University of Adelaide, and R. Kleeman, B.Sc.

[Read June 6, 1905.]

Abstract.

In a previous paper laid before the Royal Society of South Australia on September 6, 1904 (see Vol. xxviii., p. 298; also *The Philosophical Magazine*, December, 1904), the authors had adduced theoretical and experimental evidence in support of the following propositions:—

1. The alpha particle moves always in a rectilinear course, spending its energy as it traverses atoms of matter, until its velocity becomes so small that it cannot ionise, and there is in consequence no further evidence of its motion.
2. Each particle possesses, therefore, a definite range in a given medium, the length of which depends on the initial velocity of the particle and the nature of the medium.
3. The alpha particles of radium which is in radio-active equilibrium can be divided into four groups, each group being produced by one of the first four radioactive changes in which alpha particles are emitted.
4. All the particles of any one group have the same initial velocity and the same range.

The present paper could be regarded as a continuation of the previous communication. Its contents were arranged under the following heads:—

1. Improvements in the apparatus used for measuring the ranges and relative strengths of the four groups of rays.

2. Results of experiments with the new apparatus, giving the following values of the ranges in air at 76 cm. pressure and 20° C.:—

Radium, 3·50.
Emanation or Radium A } 4·23
Radium A or Emanation } 4·83
Radium C, 7·06

These were probably correct to ·05 cm.

It also appeared that the four groups were alike in all respects save that of initial velocity, and that the alpha particle spent its energy at a rate proportional, approximately, to the inverse square root of its speed.

3. Determinations of the loss of range of alpha particles in consequence of their passage through various substances, from which it appeared that for all the materials examined the loss in traversing any atom was nearly proportional to the square root of the weight of the atom. The loss in the case of a complex molecule was proportional to the sum of the square roots of the weights of the constituent atoms. The results were presented in the following table:—

Table, showing "stopping power" of various atoms and molecules, as compared to air. The atomic weight of the imaginary standard atom of air is taken as 14·4, and the atomic square root as 3·79:—

Substance.	Stopping Power.	Ratio of Atomic or Molecular Square Roots.	Ratio of Atomic or Molecular Weights.
Hydrogen	·246	·265	·069
Air	1	1	1
Aluminium	1·53	1·38	1·88
Copper	2·42	2·1	4·53
Silver	3·12	2·75	7·5
Tin	3·42	2·88	8·2
Platinum	4·12	3·7	13·5
Gold	4·45	3·7	13·7
Methyl bromide ...	2·09	2·09	3·28
Ethyl chloride	2·30	2·36	2·23
Methyl iodide	2·49	2·35	4·9
Ether	3·30	3·68	2·56
Carbon tetrachloride ...	3·8	3·61	5·41

When these results were plotted, the metals and gases seemed to lie on rather different lines.

4. Discussion of these results. The authors suggested as a possible explanation that, if atoms had a disc-like form (see Meyer's Kinetic Theory of Gases, § 112), and if ions could only be produced on the edges of the discs, then the chances of ionisation by an alpha particle traversing any atom would be proportional to the square root of the atomic weight. This explanation involved the assumption that the energy required to produce a pair of ions was a constant under all conditions, as stated by Rutherford. The authors believed that this assumption was correct, in spite of the fact that in some of their experiments on gases with complex atoms the alpha particle did not produce as much total conductivity as in air, and they suggested, as an explanation of the apparent contradiction, that ions made in complex molecules sometimes re-combined before getting free of the molecules.

SOUTH AUSTRALIAN NUDIBRANCHS, AND AN ENUMERATION OF THE KNOWN AUSTRALIAN SPECIES.

By HERBERT BASEDOW AND CHARLES HEDLEY.

[Read April 4, 1905.]

PLATES I. TO XII.

HISTORICAL SKETCH.

Our earliest information of Australian Nudibranchs dates from Baudin's expedition. The untrained collectors who visited Australia previously were unlikely to trouble with objects so difficult to procure or preserve.

In the first years of the last century, those distinguished marine zoologists, Peron and Lesueur, took back with them to Paris several species, which were studied by Cuvier. These included *Scyllæa pelagica*, *Phyllirhoa lichtensteinii*, *Kentrodoris maculosa*, and *Casella atromarginata.*

The next contribution was also from a French source. Quoy and Gaimard, the famous surgeon-naturalists of the Astrolabe Expedition, dredged their *Doris violacea* and *D. aurea* in nine fathoms, in Jervis Bay, N.S.W., and took *Elysia australis* on the beach near Sydney.

Several active naturalists, Jukes, Macgillivray, Huxley, and Ince, served on H.M.S.S. Fly and Rattlesnake when those vessels were surveying the coast of Queensland. Hence the British Museum obtained much material. Gray was provided with *Sphaerodoris incii* and *Asteronotus cruenta*, and Abraham with *Platydoris coriacea*, and others.

During a brief visit to Sydney Dr. Stimpson procured there his *Doris obtusa*, *D. excavata*, *Goniodoris obscura*, and *Aeolis cacaotica.*

George French Angas resided for some years in Sydney. From 1858 to 1860 he took opportunities to make water-colour drawings from life of Sydney nudibranchs. He examined thirty species, most of which were then new. Crosse published these sketches and descriptions, with comments of his own, in the *Journal de Conchyliologie.* This important paper represents the only work done locally.

During the voyage of the Challenger several species were dredged off the coasts of Queensland and New South Wales, and were described by Dr. Bergh in the Challenger Results.

About the same time the naturalists of H.M.S. Alert collected five species in North Queensland, which were published in the Zoology of that voyage.

A period of twenty years then elapsed, during which no additions of importance were made to our knowledge.

Recently Professor Bergh has described six new species from material gathered by Miss Lodder in Tasmania.

As Angas was unacquainted with the work of his predecessors, and as Abraham did not know the species of Angas, the revision here commenced requires to be continued.

In concluding this brief sketch we wish to draw attention to the valuable assistance rendered by Dr. J. C. Verco, in allowing one of us to accompany him on his marine dredging excursion, and thus affording an opportunity of observing and sketching the forms collected in their natural state, a factor of extreme importance in the systematic study of these perishable beings.

CENSUS OF THE DESCRIBED SPECIES OF AUSTRALIA.

NUDIBRANCHIATA.*

NUDIBRANCHIATA CLADOHEPATICA.

FAMILY AEOLIDIADAE.

Genus **Aeolidiella**, Bergh, 1874.

AEOLIDIELLA FAUSTINA, Bergh.

A. faustina, Bergh, Zool. Jahrb. xiii. (3), 1900, p. 235-236, Pl. xx., f. 39-40. *Id.*, Reis. im Arch. der Phil., vi., 1904, p. 2, Pl. i., f. 27-31.

Hab.—Ulverstone, Tasmania (Miss Lodder).

Genus **Coryphella**, Gray, 1850.

CORYPHELLA FOULISI, Angas.

Aeolis foulisi, Angas, Journ. de Conch. xii., 1864, p. 64, Pl. vi., f. 3. *Coryphella foulisi*, Bergh, Reis. im Arch. der Phil. ii (2), 1892, p. 1029.

Hab.—Sydney Harbour (Angas).

CORYPHELLA (?) CACAOTICA, Stimpson.

Aeolis cacaotica, Stimpson, Proc. Acad. N. Sci. Philad vii., 1856, p. 388. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1878, p. xii.

Hab.—Sydney Harbour (Stimpson).

Obs.—This name perhaps refers to a species of Angas.

CORYPHELLA MACLEAYI, Angas.

Aeolis macleayi, Angas, Journ. de Conch. xii., 1864, p. 65, Pl. vi., f. 4. *C. macleayi*, Bergh, Reis. im Arch. der Phil. ii. (2), 1878, p. xvi.

Hab.—Sydney Harbour (Angas).

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* In the following list the sequence of the species is based on the classification proposed by Dr. Bergh in Semper's Reisen im Archipel der Philippinen.

Genus **Rizzolia**, Trinchese, 1877.

RIZZOLIA AUSTRALIS, Bergh.

R. australis, Bergh., Chall. Zool. x., 1884, p. 27, Pl. ix., f. 1-5. *Id.*, Reis. im Arch. der Phil. ii. (2), 1892, p. 1031.

Hab.—Sydney Harbour (Challenger).

Genus **Flabellina**, Cuvier, 1830.

FLABELLINA IANTHINA, Angas.

F. ianthina, Angas, Journ. de Conch. xii., 1864, p. 66, Pl. vi., f. 6. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1034.

Hab.—Sydney Harbour (Angas).

FLABELLINA ORNATA, Angas.

F. ornata, Angas, Journ. de Conch. xii., 1864, p. 67, Pl. vi., f. 7. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p 1034.

Hab.—Sydney Harbour (Angas).

FLABELLINA NEWCOMBI, Angas.

F. newcombi, Angas, Journ. de Conch. xii., 1864, p. 68, Pl. vi., f. 8. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1034.

Hab.—Coogee, near Sydney (Angas).

Genus **Fiona**, Alder & Hancock, 1853.

FIONA MARINA, Forskäl.

Limax marina, Forskäl, Descrip. Anim., 1775, p. 99. *Fiona marina*, Bergh, Chall. Zool. x., 1884, p. 9, Pl. xi., f. 1.

Hab.—Maroubra, near Sydney (Whitelegge).

Obs.—This world-wide mollusc has an extensive literature. It has been added to the Australian fauna by Hedley (Proc. Malac. Soc. i., 1895, p. 333). New Zealand specimens were described by Hutton as *Eolis plicata* (Trans. New Zealand Inst., xiv., 1882, p. 166, Pl. vi., f. 1). Plate discovered it in Chili (Bergh, Zool. Jahrb. xiii., 1900, p. 239).

Genus **Glaucus**, Forster, 1777.

GLAUCUS ATLANTICUS, Forster.

G. atlanticus, Forster, Voy. Resolution i., 1777, p. 49. *Id.*, Bergh, Chall. Zool. x., 1884, p. 16. *Id.*, Hedley, Mem. Aust. Mus. iv., 1903, p. 401.

Hab.—Off Sydney and Southport, Queensland (Hedley).

Genus **Janus**, Verany, 1844.

JANUS (?) SANGUINEUS, Angas.

J. sanguineus, Angas, Journ. de Conch. xii., 1864, p. 63, Pl. vi., f. 5. *Id.*, Bergh., Reis. im Arch. der Phil. ii. (2), 1892, p. 1036.

Hab.—Sydney Harbour (Angas).

Obs.—This species has neither the crest nor the rhinophores of *Janus* (properly *Antiopa)*, and is only retained here till a more suitable position may be found.

Genus **Janolus**, Bergh, 1884.

JANOLUS AUSTRALIS, Bergh.

J. australis, Bergh, Chall. Rep. x., 1884, p. 19, Pl. viii., f. 15-22; Pl. ix., f. 6-8.

Hab.—Arafura Sea (Challenger).

FAMILY DOTONIDÆ.

Genus **Doto**, Oken, 1812.

DOTO AUSTRALIS, Angas.

Melibœa australis, Angas, Journ. de Conch. xii., 1864, p. 62, Pl. vi., f. 2. *Melibe australis*, Bergh, Zool. Jahrb. Syst. v., 1891, p. 48. *Doto (?) australis*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1047.

Hab.—Sydney Harbour (Angas).

FAMILY BORNELLIDÆ.

Genus **Bornella**, Gray, 1850.

BORNELLA ADAMSI, Gray.

B. adamsi, Gray, Fig. Moll. Anim. iv., 1850, p. 107, Pl. cxcvi., f. 6. *Id.*, H. & A. Adams, Gen. Moll., Pl. lxv., f. 2. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1053. *B. hermanni*, Angas, Journ. de Conch. xii., 1864, p. 61., Pl. vi., f. 1.

Hab.—Sydney Harbour (Angas).

Obs.—Prof. Bergh regards (Zool. Jahrb. Syst. v., 1891, p. 59) as doubtfully distinct from the above, *B. arborescens*, Pease, *B. caledonica*, Crosse, *B. semperi*, Crosse, and *B. hancockana*, Kelaart.

BORNELLA DIGITATA, Ad. & Reeve.

B. digitata, Ad. & Rv., Voy. Samarang, 1850, Moll., p. 67, Pl. xix., f. 1. *Id.*, Ald. & Hanck., Trans. Zool. Soc. v., 1864, p. 140, Pl. xxxiii., f. 8-9. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (1), 1874, p. 301, Pl. xxxvii., f. 14-19, Pl. xxxviii.,

f. 13-22. *Id.*, Smith, Zool. Coll. Alert, 1884, p. 92. *Id.*, Eliot, Proc. Zool. Soc., 1904, ii., p. 101.

Hab.—Port Denison, Queensland (Alert).

Bornella excepta, Bergh.

B. excepta, Bergh, Chall. Zool. x., 1884, p. 36, Pl. vii., f. 13-22, Pl. viii., f. 1-13.

Hab.—Arafura Sea (Challenger).

FAMILY SCYLLAEIDÆ.

Genus **Scyllæa**, Linné, 1758.

Scyllæa pelagica, Linné.

S. pelagica, Linn. Syst. Nat. x., 1758, i., p. 644, 656. *Id.*, Cuvier, Ann. du Mus. vi., 1804, p. 424. *Id.*, Collingwood, Trans. Linn. Soc. Zool. ii., 1881, p. 137-8, Pl. x., f. 29-33. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1056. *Id.*, Hedley, Proc. Roy. Soc., Vict. vii., n.s., 1895, p. 199.

Hab.—Terre d'Edels, Western Australia (Peron), Port Phillip, Victoria (Bracebridge Wilson), St. Vincent's Gulf, South Australia (Verco).

Obs.—This world-wide species has too extensive a bibliography to insert here unabridged.

FAMILY PHYLLIROIDÆ.

Genus **Phyllirhoa**, Peron & Lesueur, 1811.

Phyllirhoa lichtensteinii, Eschscholtz.

Eurydice lichtensteinii, Eschscholtz, Isis, 1825, i., p. 737, Pl. v., f. 1. *Phylliroe punctulatum*, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1833, p. 407, Pl. xxviii., f. 15-18. *Id.*, Macdonald, Proc. Roy. Soc., Lond. vii., 1856, p. 363. *Id.*, Bergh. Reis. im Arch. der Phil. ii. (1), 1872, p. 210.

Hab.—Terre d'Edels, Western Australia (Quoy and Gaim.). Lord Howe Island (Macdonald).

Obs.—This bibliography is much abbreviated.

Nudibranchiata holohepatica.

FAMILY PLEUROPHYLLIDIADÆ.

Genus **Pleurophyllidia**, Meckel, 1810.

Pleurophyllidia cygnea, Bergh.

P. cygnea, Bergh, Malak. Blätt. xxiii., 1876, p. 9, Pl. i., f. 1-7. *Id.*, Reis. im Arch. der Phil. ii. (2), 1892, p. 1063.

Hab.—Swan River, W.A. (Cuming Coll.), St. Vincent's Gulf, S.A. (Verco), and Sydney Harbour (Hedley).

DORIDIDÆ CRYPTOBRANCHIATÆ.

FAMILY DORIDIDÆ.

Genus **Hexabranchus**, Ehrenberg, 1831.

HEXABRANCHUS FLAMMULATUS, Quoy & Gaim.

Doris flammulata, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1833, p. 257, Pl. xvii., f. 6-10. *Hexabranchus flammulatus*, Wild, Nat. Hist. Soc. Queensland i., 1894, p. 90.

Hab.—Tweed Heads, Queensland (Wild).

HEXABRANCHUS IMPERIALIS, Kent.

Doris imperialis, Kent, Naturalist in Australia, 1897, p. 151, Pl. v.

Hab.—Rat Island, Abrolhos, W.A. (Kent).

Genus **Archidoris**, Bergh, 1878.

ARCHIDORIS VARIA, Abraham.

Doris variabilis, Angas, Journ. de Conch. xii., 1864, p. 44, Pl. iv., f. 1 (not *Doris variabilis*, Kelaart, Ann. Mag. Nat. Hist. (3), iii., 1859, p. 300). *Doris varia*, Abraham, Proc. Zool. Soc., 1877, p. 209. *Doris prætenera*, Abraham, Proc. Zool. Soc., 1877, p. 258, Pl. xxx., f. 10-12.

Hab.—Sydney Harbour (Angas). St. Vincent's Gulf, S.A.

ARCHIDORIS STAMINEA, *spec. nov.*

Hab.—Backstairs Passage, S.A. (Verco).

Genus **Staurodoris**, Bergh, 1878.

STAURODORIS PUSTULATA, Abraham.

Doris pustulata, Abraham, Proc. Zool. Soc. 1877, p. 205, 256, Pl. xxix., f. 18, 19. *Staurodoris (?) pustulata*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1093.

Hab.—Australia (Abraham). St. Vincent's Gulf (Verco).

Genus **Alloiodoris**, Bergh, 1904.

ALLOIODORIS MARMORATA, Bergh.

A. marmorata, Bergh, Reis. im Arch. der Phil. vi., 1904, p. 42, Pl. iii., f. 12-19.

Hab.—Ulverstone, Tasmania (Miss Lodder). St. Vincent's Gulf (Basedow).

Genus **Discodoris**, Bergh, 1877.

DISCODORIS DUBIA. Bergh.

D. dubia, Bergh, Reis. im Arch. der Phil. vi., 1904, p. 50, Pl. iii., f. 29-30, Pl. iv., f. 1-2.

Hab.—Ulverstone, Tasmania (Miss Lodder.)

DISCODORIS EGENA, Bergh.

D. egena, Bergh, Reis. im Arch. der Phil. vi., 1904, p. 54, Pl. iv., f. 7-14.

Hab.—Ulverstone, Tasmania (Miss Lodder.)

Genus **Thordisa**, Bergh, 1877.

THORDISA CLANDESTINA, Bergh.

T. clandestina, Bergh, Chall. Zool. x., 1884, p. 106, Pl. iii., f. 21-25. *Id.*, Reis. im Arch. der Phil. ii. (2), 1892, p. 1098.

Hab.—Torres Straits (Challenger).

Genus **Halgerda**, Bergh, 1880.

HALGERDA GRAPHICA, *spec. nov.*

Hab.—St. Vincent's Gulf, S.A. (Verco).

Genus **Kentrodoris**, Bergh, 1876.

KENTRODORIS MACULOSA, Cuvier.

Doris maculosa, Cuvier, Ann. du Mus. iv., 1804, p. 466. *Id.*, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1833, p. 249, Pl. xvi., f. 3-5. *Id.*, Abraham, Proc. Zool. Soc., 1877, p. 202. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1878, p. xxx. *Kentrodoris annuligera*, Bergh, Reis. im Arch. der Phil. ii. (2), 1890. p. 922

Hab.—Sharks Bay, W.A. (Peron).

Obs.—Lack of space has excluded numerous references.

Genus **Platydoris**, Bergh, 1877.

PLATYDORIS CORIACEA, Abraham.

Doris coriacea, Abraham, Proc. Zool. Soc., 1877, p. 203, 247, Pl. xxvii., f. 1-4. *Platydoris coriacea*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1102.

Hab.—Sir C. Hardy's Isles, Queensland (? H.M.S. Fly), Green and Masthead Islands, Queensland (Hedley).

Obs.—This species seems suspiciously like *Platydoris scabra*, Cuvier.

PLATYDORIS INFRAPICTA, Smith.

Doris infrapicta, Smith, Zool. Coll. Alert, 1884, p. 91.

Hab.—Queensland (Alert).

PLATYDORIS CRUENTA, Gray.

Asteronotus cruenta (Alder MS.), Gray, Fig. Moll. Anim. iv., 1850, p. 44, 102, Pl. ccxxvi., f. 2, 2a. *Doris cruentata*, Abraham, Proc. Zool. Soc., 1877, p. 201; not *Doris cruentata*, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1833, p 260.

Hab.—Torres Straits (Ince).

Genus **Asteronotus**, Ehrenberg, 1831.

ASTERONOTUS MABILLA, Abraham.

A. mabilla, Bergh, Jahrb. Deut. Mal. Gesell. iv., 1877, p. 163 *(nom. nud.)*. *Id.*, Abraham, Proc. Zool. Soc. 1877, p. 249, Pl. xxviii., f. 1-4. *Id.*, Bergh, Reis. im Arch. der Phil. ii., 1876, p. 644, 1892, p. 1103.

Hab.—Sydney Harbour (Hedley).

Genus **Hypselodoris**, Stimpson, 1855.

Obs.—We would point out that the species which Stimpson described as *Goniodoris obscura* is obviously that which Angas afterwards found in the same place and named *G. crossei.* Stimpson saw that his species was unsuitably placed in *Goniodoris,* and proposed for its reception *Hypselodoris.* As this name, though unknown to any later writer, has nine years' precedence over Alder & Hancock's *Chromodoris,* it must certainly replace it.

HYPSELODORIS OBSCURA, Stimpson.

Goniodoris obscura, Stimpson, Proc. Acad. Nat. Sci. Philad., vii., 1855, p. 388. *G. crossei*, Angas, Journ. de Conch. xii., 1864, p. 54, Pl. v., f. 1. *Chromodoris crossei*, Bergh, Reis. im Arch. der Phil. ii. (2), 1884, p. 648-50. *Id.*, loc. cit., 1892, pp. 1109, 1110.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS LINEOLATA, van Hasselt.

Doris lineolata, van Hasselt, Bull. Sci. Nat. Zool. iii., 1824, p. 258. *Chromodoris striatella*, Bergh, Chall. Zool. x., 1884, p. 73, Pl. iii., f. 26-29, Pl. iv., f. 1-4. *Id.*, Journ. Mus. Godeff. xiv., 1879, p. 5. *Id.*, Reis. im Arch. der Phil. ii. (2), 1892, p. 1106.

Hab.—Port Denison (Dietrich) and Torres Straits (Challenger).

HYPSELODORIS RUNCINATA, Bergh.

Chromodoris runcinata, Bergh, Reis. im Arch. der Phil. ii., 1877, p. 479-481, Pl. li., f. 32, 33, Pl. liii., f. 5-12; 1892, p. 1107. *Id.*, Chall. Zool. x., 1884, p. 76, pl. vi. f. 1-4. *Id.*, Eliot, Proc. Zool. Soc. 1904, i., p. 393. *C. iris*, Collingwood, Trans. Linn Soc. Zool. ii., 1881, p. 127, Pl. ix., f. 9-14.

Hab.—Sydney Harbour (Challenger).

HYPSELODORIS VERRUCOSA, Crosse.

Goniodoris verrucosa, Crosse, Journ. de Conch. xii., 1864, p 56, Pl. v., f. 4. *Chromodoris verrucosa*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1108.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS ERINACEUS, Crosse.

Goniodoris erinaceus, Crosse, Journ. de Conch. xii., 1864, p. 57, Pl. v., f. 5. *Chromodoris erinaceus*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1108.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS BENNETTI, Angas.

Goniodoris bennetti, Angas, Journ. de Conch. xii., 1864, p. 51, Pl. iv., f. 10. *Chromodoris bennetti*, Bergh, Verhandl. k.k. zool.-bot. Ges. Wien, 1893, p. 415, Pl. iv., f. 12-17.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS FESTIVA, Angas.

Goniodoris festiva, Angas, Journ. de Conch. xii., 1864, p. 53, Pl. iv., f. 12. *Chromodoris festiva*, Bergh, Verhandl. k.k. zool.-bot. Ges. Wien, 1893, p. 417, Pl. iv., f. 18-22.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS LORINGI, Angas.

Goniodoris loringi, Angas, Journ. de Conch. xii., 1864, p. 52, Pl. iv., f. 11. *Chromodoris loringi*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1109.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS SPLENDIDA, Angas.

Goniodoris splendida, Angas, Journ. de Conch. xii., 1864, p. 55, Pl. v., f. 2. *Chromodoris splendida*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1109. *Id.*, Eliot, Proc. Zool. Soc. 1904, i., p. 390.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS DAPHNE, Angas.

Goniodoris daphne, Angas, Journ. de Conch. xii., 1864, p. 54, Pl. v., f. 3. *Chromodoris daphne*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1109.

Hab.—Sydney Harbour (Angas).

HYPSELODORIS TASMANIENSIS, Bergh.

Chromodoris tasmaniensis, Bergh, Reis. im Arch. der Phil. vi. (2), 1905, p. 69, Pl. v., f. 12-15.

Hab.—Ulverstone, Tasmania (Miss Lodder).

HYPSELODORIS EPICURIA, *spec. nov.*

Hab.—St. Vincent's Gulf (Newland).

Genus **Casella**, H. & A. Adams, 1858.

CASELLA ATROMARGINATA, Cuvier.

Doris atromarginata, Cuvier, Ann. du Mus. iv., 1804, p. 473, Pl. ii., f. 6. *Goniodoris atromarginata*, Angas, Journ. de Conch. xii., 1864, p. 51. *Casella atromarginata*, Bergh, Journ. Mus. Godeff. Heft. vi., 1874, p. 102, Pl. ii., f. 15-29, Pl. iii., f. 21-32. *Id.*, Reis. im Arch. der Phil. ii. (2), 1892, p. 1110. *Id.*, Eliot, Proc. Zool. Soc. 1904, i., p. 399. *Casella gouldii*, H. & A., Ad. Genera ii., 1857, Pl. xliii., f. 5. *Casella philippinensis*, Bergh, Reis. im Arch. der Phil. ii. (1), 1874, Pl. xxxiii., f. 1.

Hab.—Sydney Harbour (Angas).

Obs.—The above references are not exhaustive.

Genus **Albania**, Collingwood, 1881.*

ALBANIA (?) VERCONIS, *spec. nov.*

Hab.—St. Vincent Gulf, S.A. (Verco).

Genus **Ceratosoma**, Ad. & Reeve, 1848.

CERATOSOMA BREVICAUDATUM, Abraham.

C. brevicaudatum, Abraham, Ann. Mag. Nat. Hist. (4), xviii., 1876, p. 142, Pl. vii., f. 6. *C. oblongum*, Abraham, *loc. cit.*, p. 143, Pl. vii., f. 7, 7a, 7b. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1111.

Hab.—Western Australia (Abraham), St. Vincent Gulf, S.A. (Verco), Sydney Harbour (Hedley).

CERATOSOMA ADELAIDÆ, *spec. nov.*

Hab.—St. Vincent Gulf, S.A. (Basedow).

CERATOSOMA TENUE, Abraham.

C. tenue, Abraham, Ann. Mag. Nat. Hist. (4), xviii., 1876, p. 141, Pl. vii., f. 5, 5b. *Id.*, Smith, Zool. Coll. Alert, 1884, p. 90. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1111.

Hab.—Thursday Island, Torres Straits (Alert).

CERATOSOMA LIXI, Rochebrune.

C. lixi, Rochebrune, Naturaliste, 1894, p. 55. *Id.*, Arch. Mus. Paris, 3 ser., vii., p. 134, Pl. vi., f. 6.

Hab.—Dead Island, Torres Straits (Lix).

CERATOSOMA GIBBOSUM, Rochebrune.

C. gibbosum, Rochebrune, Naturaliste, 1894, p. 55. *Id.*, Arch. Mus. Paris, 3 ser., vii., p. 135, Pl. vi., f. 4.

Hab.—Dead Island, Torres Straits (Lix).

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* While these pages are going through the press, and too late to alter the title of Plate iv., we observed that Bergh (Reis. im. Arch. der Phil., ii. (2), 1894, p. 148) reduces *Albania* to a synonym of *Æthodoris*, Abraham, 1877.

Genus **Aphelodoris,** Bergh, 1879.

APHELODORIS LUCTUOSA, Bergh.

A. luctuosa, Bergh, Reis. im Arch. der Phil. vi. (2), 1905, p. 75, Pl. v., f. 26-32, Pl. vi., f. 1-2.

Hab.—Ulverstone, Tasmania (Miss Lodder).

Genus **Miamira,** Bergh, 1875.

MIAMIRA SINUATA, van Hasselt.

Doris sinuata, van Hasselt, Bull. d. Sci. Nat. and d. Geol. iii., 1824, p. 239. *Miamira nobilis*, Bergh, Journ. Mus. Godeff., Heft. vi., 1874, Pl. viii., f. 8, Heft. viii., 1875, p. 53, Pl. viii., f. 1-30, Pl. ix., f. 1-4. *Id.*, Reis. im Arch. der Phil. ii. (2), 1876, p. 411, Pl. xxxiii., f. 2, and 1892, p. 1112; vi. (2), 1905, p. 81, Pl. v., f. 33-36. *Id.*, Smith, Zool. Alert, 1884, p. 90. *Id.*, Eliot, Proc. Zool. Soc., 1904, i., p. 405.

Hab.—Port Denison, Queensland (Alert).

Genus **Sphaerodoris,** Bergh, 1877.

SPHAERODORIS INCII, Gray.

Doris incii (Alder M.S.), Gray, Fig. Moll. An. iv., 1850, Pl. ccxxvi., f. 1, p. 103. *Dictyodoris incii*, Bergh, Reis. im Arch. der Phil. ii. (2), 1880, Suppl. p. 75. *Sphaerodoris incii*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1113.

Hab.—Torres Straits (Ince).

FAMILY DORIOPSIDÆ.

Genus **Doriopsis,** Pease, 1860.

DORIOPSIS DENISONI, Angas.

Doris denisoni, Angas, Journ. de Conch. xii., 1864, p. 45, Pl. iv., f. 2. *Doridopsis gemmacea*, Ald. & Hancock, Trans. Zool. Soc. v., 1864, p. 126, Pl. xxxi., f. 4, 5, 6, 7. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1884, p. 698; 1892, p. 1120. *Doridopsis denisoni*, Eliot, Proc. Zool. Soc., 1904, ii. (1905), p. 277.

Hab.—Sydney Harbour (Angas).

Obs.—Professor Bergh reduces Angas's name to a synonym of *D. gemmacea*. It appears, however, that *D. denisoni* has about six months' priority over *D. gemmacea*.

DORIOPSIS VIOLACEA, Quoy & Gaimard.

Doris violacea, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1832, p. 264, Pl. xix., f. 1-3. *Doriopsis violacea*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1121.

Hab.—Jervis Bay, N.S.W. (Astrolabe).

DORIOPSIS AUSTRALIS, Angas.

Actinodoris australis, Angas, Journ. de Conch. xii., 1864, p. 49, Pl. iv., f. 8. *Doriopsis australis*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1122.

Hab.—New South Wales (Angas).

DORIOPSIS AUSTRALIENSIS, Abraham.

Doridopsis australiensis, Abraham, Proc. Zool. Soc., 1877, pp. 243, 263, Pl. xxx., f. 25-26. *Doriopsis australiensis*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1122.

Hab.—New South Wales.

DORIOPSIS AUREA, Quoy & Gaimard.

Doris aurea, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1832, p. 265, Pl. xix., f. 4-7. *Doriopsis aurea*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1122.

Hab.—Jervis Bay, N.S.W. (Astrolabe), St. Vincent Gulf, S.A. (Verco).

DORIOPSIS CARNEOLA, Angas.

Doris carneola, Angas, Journ. de Conch. xii., 1864, p. 48, Pl. iv., f. 6. *Doriopsis carneola*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1122.

Hab.—Sydney Harbour (Angas), St. Vincent Gulf (Basedow).

DORIOPSIS NODULOSA, Angas.

Doris nodulosa, Angas, Journ. de Conch. xii., 1864, p. 48, Pl. iv, f. 6. *Doriopsis nodulosa*, Bergh, Reis. in Arch. der Phil. ii. (2), 1892, p. 1122.

Hab.—Coogee, near Sydney (Angas).

DORIOPSIS (?) PANTHERINA, Angas.

Doris pantherina, Angas, Journ. de Conch. xii., 1864, p. 47, Pl. iv.. f. 5

Hab.—Coogee, near Sydney (Angas).

FAMILY PHYLLIADIDÆ.

Genus **Phyllidia**, Cuvier, 1798.

PHYLLIDIA VARICOSA, Lamarck.

P. varicosa, Lamarck, Syst. des An. s. vert., 1801, p. 66. *Id.*, Quoy & Gaim., Voy. Astrolabe, Zool. ii., 1832, p. 292, Pl. xxi., f. 25. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1876, p. 380, Pl. xxv., f. 7, Suppl. 1881, p. 8, 1892, p. 1128. *Id.*, Eliot, Proc. Zool. Soc., 1904, ii. (1905), p. 281.

Hab.—Dampier's Archipelago, W.A. (Gazelle).

DORIDIDÆ PHANEROBRANCHIATÆ.

FAMILY POLYCERADÆ.

Genus **Triopa**, Johnston, 1838.

TRIOPA YATESI, Angas.

T. yatesi, Angas, Journ. de Conch. xii., 1864, p. 60, Pl. v., f. 8. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1139.

Hab.—Sydney Harbour (Angas).

Genus **Palio**, Gray, 1857.

PALIO COOKI, Angas.

Polycera cooki, Angas, Journ. de Conch. xii., 1864, p. 58, Pl. v., f. 6. *Palio (?) cooki*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1142.

Hab.—Botany Bay (Angas).

Genus **Ohola**, Bergh, 1884.

OHOLA PACIFICA, Bergh.

O. pacifica, Bergh, Chall. Zool. x., 1884, p. 52, Pl. ix., f. 9-12.

Hab.—Arafura Sea (Challenger).

Genus **Angasiella**, Crosse, 1864.

ANGASIELLA EDWARDSI, Angas.

A. edwardsi, Angas, Journ. de Conch., 1864, xii., p. 49, Pl. iv., f. 9. *Nembrotha (?) edwardsi*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1145.

Hab.—Sydney Harbour (Angas).

Genus **Nembrotha**, Bergh, 1877.

NEMBROTHA VERCONIS, *spec. nov.*

Hab.—St. Vincent Gulf, S.A (Verco).

Genus **Placomopherus**, Leuckart, 1828.

PLACOMOPHERUS IMPERIALIS, Angas.

Plocamophorus imperialis, Angas, Journ. de Conch. xii., 1864, p. 59, Pl. v., f. 7. *Plocamopherus naevatus*, Abraham, Ann. Mag. Nat. Hist. (4), xviii., 1876, p. 139, Pl. vi., f. 4, 4a. *P. imperialis*, Bergh, Verh. Zool. bot. Ges. Wien, xxxiii., 1884, p. 144-9, Pl. vi., f. 10, Pl. x, f. 8-9, Reis. im Arch. der Phil. ii. (2), 1892, p. 1146.

Hab.—Sydney Harbour (Angas).

PLACOMOPHERUS INSIGNIS, Smith.

Plocamophorus insignis, Smith, Zool. Coll. Alert, 1884, p. 91, Pl. vi., f. l., li.
Hab.—Albany Island, Queensland (Alert).

Genus **Acanthodoris,** Gray, 1857.

ACANTHODORIS METULIFERA, Bergh.

A. metulifera, Bergh, Reis. im Arch. der Phil. vi. (2), 1905, p. 98, Pl. vii., f. 3-6.
Hab.—Ulverstone, Tasmania (Miss Lodder).

UNCLASSIFIED SPECIES.

DORIS ARBUTUS, Angas.

Journ. de Conch. xii., 1864, p. 47, Pl. iv., f. 4. *Id.*, Read, Proc. Linn. N.S.W., iv., 1879, p. 291, Pl. xvii.
Hab.—Coogee.

DORIS CHRYSODERMA, Angas.

Journ. de Conch. xii., 1864, p. 46, Pl. iv., f. 3.
Hab.—Sydney Harbour.

DORIS COLLATATA, Abraham.

Proc. Zool. Soc., 1877, p. 205, 255, Pl. xxix., f. 25-26.
Hab.—Port Essington.

DORIS PECULIARIS, Abraham.

Proc. Zool. Soc., 1877, p. 211, 258, Pl. xxx., f. 15-17.
Hab.—Port Lincoln, S.A.

DORIS ANALAMPULLA, Abraham.

Proc. Zool. Soc., 1877, p. 205, 254, Pl. xxix., f. 8-10.
Hab.—Australia.

DORIS OBTUSA, Stimpson.

Proc. Acad. N. Sc., Philad., vii., 1855, p. 389.
Hab.—Sydney Harbour.

DORIS EXCAVATA, Stimpson.

Proc. Acad. N. Sc., Philad., vii., 1855, p. 389 (not *D. excavata*, Pease).
Hab.—Sydney Harbour.

DORIS, sp.

W. S. Kent, Great Barrier Reef, 1893, p. 362, pl. xiii., f. 6.
Hab.—Queensland.

DORIS, sp.

W. S. Kent, Great Barrier Reef, 1893, p. 362, pl. xiii., f. 7.

Hab.—Queensland.

ANCULA, sp.

W. S. Kent, Great Barrier Reef, 1893, p. 362, pl. xiii., f. 9.

Hab.—Queensland.

NUDIBRANCHIATE MOLLUSC.

W. S. Kent, Great Barrier Reef, 1893, p. 362, pl. xiii., f. 8.

Hab.—Queensland.

Obs.—Perhaps a *Phyllidia.*

SUB-ORDER ASCOGLOSSA.

FAMILY ELYSIIDÆ.

Genus **Elysia**, Risso, 1818.

ELYSIA AUSTRALIS, Quoy & Gaimard.

Actæon australis, Quoy & Gaim., Voy. Astrolabe, Zool. 1832, p. 317, Pl. xxiv., f. 18-20. *E. coogeensis*, Angas, Journ. de Conch. xii., 1864, p. 69, Pl. iv., f. 9.

Hab.—Sydney Harbour (Astrolabe), Coogee (Angas)

TO BE EXCLUDED.

ALLPORTIA EXPANSA, Ten.-Woods.

A. expansa, Ten.-Woods, Proc. Roy. Soc., Tas., 1876, p. 28

Hab.—Southport, Tasmania.

Obs.—In a paper read (June 10, 1902) to the Royal Society, Tasmania, but still unpublished, Hedley points out that this name was based on a Planarian worm, *Polycelis australis*, Schmarda.

REMARKS ON SOUTH AUSTRALIAN SPECIES, INCLUDING DESCRIPTIONS OF NEW SPECIES

Scyllæa pelagica, Linné.

Plate ix., figs. 1 and 2.

S. pelagica, Linn. Syst. Nat. x., 1875, i., p. 644, 656. *Id.*, Cuvier, Ann. du Mus. vi., 1804, p. 424, etc., etc.

Several divergent forms lie before us, but after consulting Bergh's criticisms on the species, and its variations, we do not hesitate to include them all under the one widespread species. The main differences are in the length of the dorsal lobes and the colouration, the former feature depending largely upon the degree of contraction, and the latter, no doubt, upon the colour of the seaweed upon which the animal lived.

Dim.—The largest individual that has so far been found in South Australia measures 42 millimetres in length, the length of the lobes being 16, and height of body 21, making a total height of 37 mm.

Hab.—Dredged in 20 fathoms, off Antechamber Bay, Kangaroo Island, January, 1903 (Verco): thrown up on Port Willunga beach (Newland).

Pleurophyllidia cygnea, Bergh.

Plate x., figs. 1 and 2; Plate xi., figs. 1-3; Plate xii., figs. 1-6.

P. cygnea, Bergh, Malakol, Blätter xxiii., 1876, p. 9, Pl. i., figs. 1-7. *Id.*, Semper's Reisen im Arch. der Phil. ii. (2), 1892, p. 1063.

With some confidence we apply Bergh's name to a species which we have obtained from St. Vincent Gulf and Sydney Harbour respectively. The species appears to be rare and not to inhabit the beach zone. Since the original description of the animal from the Swan River, Western Australia (whence it takes its name), it has not been re-taken by any collector. That description was based on an old spirit specimen. We add the following account drawn from a living animal:—

Body elongate, oblong; sides nearly parallel, terminating in a blunt point posteriorly; dorsal surface flat, sloping towards the posterior extremity. Mantle (nothæum) fairly ample, slightly waved along the edge, and extending from behind the rhinophores; ornamented longitudinally, with a series of roughly parallel, black and yellowish, undulating ridges, the medial of which extending throughout the whole length, the lateral passing out at the sides, bordered with yellow. The lobe-like veil is colourless, edged with yellow, and with a few yellow spots in its centre. Foot dilated laterally in front, tapering behind; the edge waved and extending to beyond the sides of body; it is flat, grooved longitudinally along the centre posteriorly, and does not project appreciably behind the mantle. Rhinophores longitudinally laminate, pink, contractile. Branchiæ pink, on the under side of the lateral projection of the mantle. Mouth prominent. Genital orifice and anus prominent on the right side, the latter 19 mm. behind the former. The entire under-surface a uniform light crimson.

Radula pale yellow. Lateral spines numerous, about 70, of equal size, except the most central, which are smaller than the rest. Average length of lateral spines, ·27 mm. The minutely denticulated margin was not observed. Between the lateral spines and central plate, with its cuspidated edge, an irregularly triangular, plane plate.

Dim.—Length 82, breadth 34 mm.

Hab.—Dredged in 20 fathoms, off Antechamber Bay, Kangaroo Island, January, 1903.

Obs.—The mollusc was kept alive for several days in a glass of sea water, and it was still alive when transferred to the preservative. It has retained its colour remarkably well in a weak solution (3 per cent.) of formaline.

Archidoris varia, Abraham.

Plate v., figs. 1-5.

Doris variabilis, Angas, Journ. de Conch. xii., 1864, p. 44, Pl. iv., fig. 1 (not *Doris variabilis*, Kelaart, Ann. Mag. Nat. Hist. (3), iii., 1859, p. 300). *Doris varia*, Abraham, Proc. Zool. Soc., 1877, p. 209. *Doris praetenera*, Abraham, Proc. Zool. Soc., 1877, p. 258, Pl. xxx., fig. 10-12.

This species is as abundant in South Australian waters as in Sydney Harbour.

In addition to the characters indicated by Angas we note that the skin is soft, and, in preserved specimens, has a flabby appearance. In dead examples the rugosities of the back sometimes disappear. The rhinophora arise from elevated conical sheaths, and are ornamented with about 24 lamellæ. Oral tentacles, with a deep longitudinal groove on the exterior side. Branchial plumes five, tripinnate. In colour the species ranges from pale yellowish (St. Vincent Gulf) to dark reddish-brown (Port River). The wrinkles on the back are outlined and exaggerated by a mesh-work of dark lines. The sole of the foot is white, edged with rich orange, and through the thin skin the liver is visible. Along the edge of the mantle muscle-fibres are discernible as short, white, radiating lines.

Radula amber yellow. Lateral spines hamate, numerous, about 70 on either side of each transverse row, decreasing very gradually in size inwardly. Average height of spines, ·3 mm. No central spine. Twenty-three rows of spines in specimen examined. $\infty \cdot 0 \cdot \infty$.

Hab.—Dredged in 20 fathoms, St. Vincent Gulf, January, 1903, and Spencer Gulf (Verco); Port River, in 4 fathoms, April, 1902 (Field Naturalists); taken at low water, Port Noarlunga (Ashby); Port Noarlunga (Newland).

Obs.—This species has hitherto been classified in *Doris*. On account of the general form, grooved tentacles, and radula, we propose to include it in *Archidoris*.

Archidoris staminea, *spec. nov.*

Plate vi., figs. 3 and 4.

Body irregularly elliptical, very slightly narrower posteriorly, convex. Cloak ample, frilled along the border; colour, a uniform tint of yellow; roughened by very numerous small tubercular elevations and depressions, which cover the skin as separate, stellate, or radiate groups of notches; the underside of the mantle, of a similar yellow colour, is marked with vein-like threadlets, multiply dividing and branching towards the outer edge. Foot rounded anteriorly, sides almost parallel, terminating in a blunt point, slightly channelled; colour yellow, darkened somewhat in the centre by the appearance of the liver through the skin. Dorsal tentacles clavate, situated rather far anteriorly. Oral tentacles linear, prominent. Eyes visible in small examples as little black specks behind the rhinophores.

Dim.—Length 32, breadth 19 mm.

Hab.—Dredged in 20 fathoms, Backstairs Passage, January, 1903 (Verco).

Staurodoris pustulata, Abraham.

Plate ix., fig. 3.

Doris pustulata, Abraham, Proc. Zool. Soc., 1877, p. 205, Pl. xxix., figs. 18, 19. *Staurodoris (?) pustulata*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1093.

The species before us corresponds well with that described by Abraham, but as that description was taken from spirit specimens, we add the following account of the live animal:—

Body elliptical, moderately convex. Mantle ample with a slightly waved margin: of an uncommon greenish-grey ground colour, covered with numerous opaque, yellow, warty tubercles of various sizes. standing out prominently from the darker background like golden beads. Foot tapers posteriorly to a blunt point, well within the mantle-margin; colour of the entire under-surface, a light flesh-red. Rhinophores completely retractile within cavities, the openings to which are surrounded with a circlet of nodulations. Branchial plumes, seven, tripinnate, of a deeper shape of grey.

Radula straw-yellow. Lateral spines numerous, about 68 on either side, increasing in size from centre outwards, no central spine, from 25 to 30 rows in specimen examined. $\propto \cdot 0 \cdot \propto \cdot$

Dim.—Length 20, breadth 11 mm.

Hab.—Dredged in 20 fathoms, Backstairs Passage, January, 1903 (Verco).

Alloiodoris marmorata, Bergh.

Plate viii., figs. 1 and 2.

Alloiodoris marmorata, Bergh, Reis. im Arch. der Phil. vi., 1904, p. 42, Pl. iii., figs. 12-19.

The identification of an unfigured species must always be a matter of some misgiving. None of the South Australian examples attain the size given by the author for Tasmanian specimens. In other respects the description harmonises so well with the animals before us that we have preferred to use Dr. Bergh's name for them. We were unable to detect the denticules on the lateral teeth. The following account was prepared from living specimens:—

Body elliptic, symmetrically rounded at both ends, moderately convex. Colour yellowish-white to greyish-brown, covered with minute spiculose elevations on the dorsal surface, which impart to it the brownish tint; also, with less numerous, larger elevations, surrounded by irregular circles of deep brown. The latter occasionally have a centre of opaque white, surrounded by a ring of reddish-brown, the whole giving the impression of miniature craters. Ventral surface translucent, white; irregularly sprinkled over with asymmetrical brown spots, either isolated or arranged in small groups. Mantle considerably broader than the foot, with a slightly undulating margin; fairly thin along the border, so that the colour-markings of the dorsal surface are visible from the under-side. Foot white, with few scattered spots of brown. Rhinophores and branchiæ brown, the latter seven or eight in number. Larger individuals have come under our notice since this description.

Dim.—Length 22·5, breadth 10 mm.

Hab.—Dredged in four fathoms, Port River, December, 1901 (Field Naturalists); taken at low water on rocks, covered with seaweed, off Edithburg, Yorke's Peninsula, January, 1903 (Basedow).

Halgerda graphica, *spec. nov.*

Plate iii., figs. 1-4.

Body squat, of elliptic form, symmetrically rounded at both ends, strongly convex. Colour opaque white, liver faintly visible through the mantle. Ornamented in the following remarkable manner:—The surface of the mantle is divided somewhat regularly into quadrilateral figures, on either side of a distinct central line, by slightly elevated ridges of a rich orange-yellow colour; within these divisions are similar elevated curves and lines, in places semi-symmetrical with regard to a dark central spot, almost invariably present in the centre of each division, but easily detachable by slight abrasion. Under side of mantle white, sparsely dotted with large and small black spots, irregularly spaced. Foot rounded in front, sides approximately parallel and slightly frilled, ending posteriorly in an obtuse point, much narrower than mantle; colour opaque white, fringed with a deep orange-yellow border. Dorsal tentacles comparatively small, truncated, retractile within low sheaths, brown at the summit, white at the base. Oral tentacles, fairly long, linear, rounded in front. Genital aperture inconspicuous, situated about one-third the whole length from anterior end. Branchial plumes six, small, black, finely laciniated.

Radula light straw-coloured. Lateral spines numerous, about 40 on either side; hooked, smooth, rapidly increasing in size outwards, the three most lateral, however, small. Average height of spines, ·38 mm. No central spine. About 40 curved rows in specimen examined. Formula, 40·0·40.

Dim.—Total length 45, breadth 30, length of foot 42 mm.

Hab.—Dredged in 20 fathoms, off Antechamber Bay, Kangaroo Island, January, 1903 (Verco). Dr. Verco has dredged two individuals of this peculiar form on two separate occasions. In the Australian Museum, Sydney, there is a single specimen, collected on the beach at Middle Harbour after a gale, which is probably identical.

Obs.—Bergh's definition of *Halgerda* mentions that the lateral teeth of the radula are furnished with fine denticules, but as Eliot finds (Proc. Zool. Soc., 1903, p. 373) that this is not a constant feature, we have not considered the simple teeth of our species a bar to its admission in this genus.

The remarkable and artificial appearance presented by the ornamentation of this species resembles the hieroglyphic markings of primitive man, and suggests the species-name.

Hypselodoris epicuria, *spec. nov.*

Plate vii. figs 1-3.

Body elliptic, oblong, fairly convex, highest in region anterior to branchiæ. Mantle spiculose, of a rich red colour and covered with numerous silvery-white spiculose elevations, of a lighter shade, with a single row of dark red dots. Foot laterally expanded and slit in front, with a median groove, tapering behind; border waved; colour white, with a single row of largish yellow dots along the upper edge, and the upper surface of the tail with a faint tint of violet or rose. Both the rhinophoral and anal cavities are encircled with a stellate coronation of opaque white. Rhinophores surmounted on a white stalk, with 17 or 18 laminæ and non-retractile. Branchial plumes five, non-retractile, mono-pinnate, with indication of bipinnation at the summit: colour white.

Oral tentacles linear, projecting considerably beyond the mantle border when in motion.

Radula. Lateral spines numerous, about 30; hooked, the inner edge denticulated; surmounted on a strong base.

Dim.—Length 34, breadth 8 mm.

Hab.—Thrown up during a gale on Port Willunga beach (Newland).

Albania (?) verconis, *spec. nov.*

Plate iv., figs. 1-4.

Body oblong-ovate, rounded in front, moderately flattened on top; sides elevated; a strongly acute tail with a distinct central dorsal ridge, extends beyond the mantle edge when in motion; on death this tail curled up. Colour, exquisitely tinted dorsally, with faint, semi-transparent, reddish-violet near the border, fading imperceptibly to a light brown in the central region, which is further traversed by a fine network of opaque white lines, not discernible nearer the margin; ventrally of a uniform pale violet. Mantle serrated along the sides, and in parts upturned, produced frontally. Head, large, distinct. Foot acutely pointed, with a border frill. Rhinophores small, clavate, laminate, with about twelve laminæ, non-retractile. Genitalia large, situated about one-fifth the whole length from the anterior end. Branchial plumes ten, simply pinnate, completely surrounding the vent, non-retractile; colour, opaque white.

Radula. Colour, brownish-yellow, deepest in shade at the dilated end of odontophore. Lateral spines, about 22 on either side, stout, hooked, the central four or five trifidated. No rachidian. About 42 straightish rows in specimen examined. 22·0·22.

Dim.—Length 27, breadth 11, height 9 mm.

Hab.—A single individual dredged in 20 fathoms, off Antechamber Bay, Kangaroo Island, January, 1903 (Verco).

Obs.—With considerable hesitation we have referred this species to *Albania*. The general appearance, branchiæ, and serrate edge of the mantle suggest this genus. Dr. Collingwood describes a frontal veil in the type-species; this was not observed in the living animal. The only specimen that was found has so shrunk that we cannot now decide on its absence or presence.

Ceratosoma brevicaudatum, Abraham.

Plate i., figs. 1-4

Ceratosoma brevicaudatum, Abraham, Ann. Mag. Nat. Hist. (4), xviii., 1876, p. 142, Pl. viii., fig. 6. *Ceratosoma oblongum*, Abraham, *loc. cit.*, p. 143, Pl. vii., figs. 7, 7a, 7b. *Id.*, Bergh, Reis. im Arch. der Phil. ii. (2), 1892, p. 1111.

Dr. Bergh brackets this species with *C. caledonicum*, Fischer, *C. tenue*, Abraham, and *C. oblongum*, Abraham. It seems to us that Fischer's description indicates a species in which the lobes of the nothaeum are more developed: the colour scheme of the New Caledonian species is quite unlike that of the Australian. The difference between *C. brevicaudatum* and *C. oblongum* seems to us merely a matter of preservation. Out of a parcel resulting from the same dredging we have seen individuals, some of which shrunk to the shape of *oblongum* and others assumed in contraction the form of *brevicaudatum*. The following description was drawn up from living specimens:—

Body large, elongate, dorsally flat, rounded in front, sides nearly parallel, except along a slight lateral enlargement in the centre, and tapering to an obtuse point behind; sides much elevated, especially in the region of the vent. Cloak obsolete, sub-quadrangular, with an undulate margin, and ending posteriorly in a peculiar nipple-like protuberance. Colour, beautifully shaded with tints of buff to light brown, usually of a deeper colour at the border, and gradually fading inwards, leaving along the margin of the dorsal surface a series of alternate light and dark patches, there being in the centre of the former in each case a round, violet-purple spot surrounded by a uniform ring of reddish-purple. The central area of this surface is richly sprinkled with circular spots of varying size, of a light violet-purple colour, with a darker border, and delicately surrounded in some cases by a rim of light lemon-yellow; the larger spots of this series are also rendered conspicuous by being situated within the more faintly tinted patches of the cloak. The "post-branchial flesh protuberance" is neatly decorated by a series of brown circles, placed contiguously so as to produce a regular network with meshes of different dimensions. The sides are somewhat similarly marked to the cloak, being lightly tinted and richly sprinkled with three irregular, longitudinal rows of spots, the two outer rows of rich purple, the inner of a lighter violet-purple. The median row does not extend to beyond the length of the cloak, and thus leaves the dorsal portion of the tail marked with deep purple spots only. The spots are in this portion irregularly scattered, and often appear as small groups of two or three; they are more numerous and smaller in size than those upon the cloak. Foot linear, tapering posteriorly to a blunt point; colour white. Dorsal tentacles clavate, obliquely laminated; the number of lamellæ varying from 16 to 30 or more; colour rich orange yellow. Sheaths very slightly elevated. Oral tentacles stout, sub-conical, tapering towards the points. Genital aperture prominent. Branchial plumes twelve, intergrown at the base, and rather difficult to separate, incompletely surrounding the tubular anus in horseshoe shape, the posterior portion being bare; they are retractile with the anus into a common cavity; the five posterior plumes on either side terminate in the same foot stem respectively, the remaining two plumes are unequal in size. Colour, rich reddish-yellow.

Radula. Deep yellow to brown in colour. Lateral spines numerous, about 140 on either side; simply hooked, with an average length of ·2 mm.; about 80 rows in specimen examined. No central spine. The shape of the odontophore and the arrangement of the spines are similar to the corresponding features of *Doris adelaidæ*, *spec. nov.* Formula, $\propto \cdot 0 \cdot \propto$.

Dim.—Length 111, breadth 25, height 31 mm.

Hab.—Dredged in 20 fathoms, Gulf of St. Vincent, and off Antechamber Bay, Kangaroo Island, January, 1903 (Dr. Verco); taken at low water, Port Noarlunga (Dr. Torr and L Ashby); and Salt Creek Bay, Yorke Peninsula (E. H. Matthews).

Obs.—This fine species appears to be fairly plentiful and well distributed within our gulf. Dr. Verco has dredged it on various occasions. Though specifically identical, the littoral specimens are nowhere nearly as large as the deep-water forms. The specimens from Antechamber Bay, in particular, deserve mention for their large size and fine colouration.

Ceratosoma adelaidæ, *spec. nov.*

Plate x., fig. 3-4.

Body small, flattened on top, elongate, a little wider at the head than further posteriorly, terminating in a small tail. Mantle sparingly developed. Foot rounded in front, attenuated behind, projecting to no considerable extent beyond the mantle. Colour white underneath, scantily spotted with light lilac along the sides; the dorsal surface, for the most part of a pale buff colour, is bordered on either side by somewhat regularly spaced deep reddish-violet spots (about eight on either side), which are made the more pronounced by being surrounded each by a whitish space, the interspaces between these spots being of a somewhat deeper shade of brown than the rest; the central area is decorated with rows of light bluish spots. Dorsal tentacles club-shaped, obliquely laminated, orange-red in colour. Branchial plumes coherent at their base, apparently six, non-retractile, of the same tint as the rhinophores.

Dim.—Length 8, breadth 3 mm.

Hab.—Taken at low water off Marino Rocks in December, 1901; and also off Edithburg, Yorke Peninsula, in January, 1903.

Obs.—The species appears to live on the under side of rocks covered with seaweed, and partially buried in soft mud.

Doriopsis aurea, Quoy & Gaim.

Plate vii., fig. 4.

Doris aurea, Quoy & Gaim., Voy. de l'Astrolabe, Zool. ii., 1832, p. 265, Pl. xix., figs. 4-7. *Doriopsis aurea,* Bergh, Reisen im Arch. der Phil. ii. (2), 1892, p. 1122.

The type of this species was dredged in deep water in Jervis Bay, New South Wales. Except that the French authors describe their species as over two inches in length (ours is only 15 mm. long and 6 mm. broad), the original account harmonises well with that of South Australian examples. The white dots on the back are more regularly disposed in Quoy & Gaimard's figure, and the foot in South Australian specimens is white; whereas, in the figure quoted, it is red.

Examples from New South Wales are not accessible to us at present, but in view of the close correspondence between our material and Quoy & Gaimard's description we are unwilling to differentiate our form.

Hab.—Dredged in 5½ fathoms, off Orontes Shoal, Yorke Peninsula; also in 9 fathoms on weed, opposite the American River, Kangaroo Island, January, 1903 (Verco).

Doriopsis carneola, Angas.

Plate vi., figs. 1 and 2.

Doris carneola, Angas, Journ. de Conch. xii., 1864, p. 48. Plate iv., fig. 7. *Doriopsis carneola*, Bergh, Reisen im Arch. der Phil. ii. (2), 1892, p. 1122.

A species has been taken by one of us at Marino, South Australia, which, neglecting slight locality variations, must be regarded as Angas's *Doris carneola.* It measures 29 mm. in length, 17½ in breadth, as against Angas's data of 28 and 17 mm. respectively. The colouration of one South Australian example was identical with that of the Port Jackson type, while another individual from Marino had quite a different colour scheme. It was of a dirty greyish-white on the dorsal surface, speckled with silvery-white dots, which were connected by a faint network of white lines, the central space in the region of the liver appearing pinkish or brown; ventral surface white. The under side of the mantle of both individuals is marked with delicate vein-like, multiple branching lines. The mantle is ample, hard, thick, and fortified with numerous calc-spicules. The foot is large, and terminates bluntly. The rhinophores are clavate, with about 10 laminæ; situated rather far anteriorly; colour yellow or white. We do not note the projecting sheaths of these tentacles, that are apparently represented in Angas's sketch. Branchial plumes, four, tripinnate: colour, light orange or white.

Hab.—Marino, taken from under the rocks, at low water, March, 1902 (Basedow).

Nembrotha (?) verconis, *spec. nov.*

Plate ii., figs. 1-3.

Body large, linear, oblong, swollen in centre, and tapering behind. Colour, rich lemon-yellow, with large disconnected blunt tubercles of deep prussian blue arranged very indistinctly parallel to the edge of the foot. The skin is very delicate, and peels off easily on abrasion; it is noticeably wrinkled, the pits of the folds thus produced appearing of a deeper shade than the rest. Cloak almost entirely wanting. Frontal margin (veil) small, of deep prussian blue colour, composed of three semi-circular dilations, the two lateral of which arch laterally around the dorsal tentacles on either side, then gradually fading to *nil* posterior to them. Foot square in front, dilated outwardly at the anterior end, sides slightly frilled, approximately parallel, passing posteriorly to a bluntish point, colour light sea-blue, with a deep blue border; liver visible as a faint brown patch in the centre. Dorsal tentacles sub-clavate, tapering, laminated; about 30 slightly oblique laminæ, non-retractile; colour deep prussian blue, with a yellow stalk. Eyes not visible. Genital aperture prominent, situated one-fourth the whole length from the frontal margin; of a lighter (greenish) blue colour than the tubercles. Branchial plumes five, tripinnate, almost completely surrounding the anus; colour dark yellow at the base, passing into a rich blue along the stems and delicately fringed with small purple tufts.

Radula. Marginal plates four, subquadrate, curved over in front, the most remote very small or wanting; lateral spines one, large, hooked, bifidated; possessing a peculiar spiral twist. Central plate subquadrate-ovate. Colour light straw to amber yellow. About 18 rows. Formula, 4 + 1·1·1 + 4.

Dim.—Length 55, breadth 12 mm.

Hab.—Dredged in 20 fathoms, off Newland Head, Backstairs Passage, January, 1903 (Verco).

Obs.—The indications of the existence of a cloak are almost entirely wanting, beyond the slight continuation of the frontal margin past the dorsal tentacles and the somewhat linear arrangement of the tubercles. This species seems clearly separated from co-generic forms by its vivid primrose colour. A large specimen is in the Australian Museum collection; it measures 40 mm. in length, whereas the contracted body of our type barely reaches 30 mm. We have much pleasure in dedicating this beautiful species to Dr. J. C. Verco.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. Ceratosoma brevicaudatum, *Abraham*—Deep-water form. Dorsal view. Slightly enlarged.

Fig. 2. Ceratosoma brevicaudatum, *Abraham*—Deep-water form. Side view. Slightly enlarged.

Fig. 3. Ceratosoma brevicaudatum, *Abraham*—Shallow-water form. Natural size.

Fig. 4. An enlarged branchia of *C. brevicaudatum*, Abraham.

Plate II.

Fig. 1. Nembrotha verconis, *spec. nov.*—Side view. × 2.

Fig. 2. Nembrotha verconis, *spec. nov.*—Ventral view. × 2.

Fig. 3. A single row of teeth from the radula of *N. verconis, spec. nov.*

Plate III.

Fig. 1. Halgerda graphica, *spec. nov.*—Dorsal view. × 1⅓.

Fig. 2. Halgerda graphica, *spec. nov.*—Ventral view × 1⅓.

Fig. 3. Teeth from the radula of *H. graphica.*

Fig. 4. Enlarged teeth from the radula of *H. graphica.*

Plate IV.

Fig. 1. Albania verconis, *spec. nov.*—Dorsal view. × 3.

Fig. 2. Albania verconis, *spec. nov.*—Ventral view. × 3.

Fig. 3. Teeth from the radula of *A. verconis.*

Fig. 4. Radula of *A. verconis*, the cross lines representing transverse rows of teeth.

Plate V.

Fig. 1. Archidoris varia, *Abraham*—Dorsal view. × 1⅔.

Fig. 2. Archidoris varia, *Abraham*—Ventral view. × 1⅔.

Fig. 3. Teeth from the radula of *A. varia.*

Fig. 4. An enlarged branchia of *A. varia.*

Fig. 5. Radula of *A. varia.*

Plate VI.

Fig. 1. Doriopsis carneola, *Angas*—Ventral view. × 1⅘.

Fig. 2. Doriopsis carneola, *Angas*—Dorsal view. × 1⅘

Fig. 3. Archidoris staminea, *spec. nov.*—Ventral view. × 2⅓.

Fig. 4. Archidoris staminea, *spec. nov.*—Dorsal view. × 2⅓.

Plate VII.

Fig. 1. Hypselodoris epicuria, *spec. nov.*—Dorsal view. × 3.

Fig. 2. Hypselodoris epicuria, *spec. nov.*—Ventral view. × 3.

Fig. 3. An enlarged branchia of *H. epicuria.*

Fig. 4. Doriopsis aurea, *Quoy & Gaimard*—Dorsal view. × 5 3-5.

Plate VIII.

Fig. 1. Alloiodoris marmorata, *Bergh*—Dorsal view. × 3½.

Fig. 2. Alloiodoris marmorata, *Bergh*—Ventral view. × 3½.

PLATE IX

Fig. 1. SCYLLÆA PELAGICA, *Linné*—Side view. Lobes contracted. × 3½.

Fig. 2. SYCLLÆA PELAGICA, *Linné*—Side view. Lobes expanded. × 2⅗.

Fig. 3. STAURODORIS PUSTULATA, *Abraham*—Dorsal view. × 3¾.

PLATE X.

Fig. 1. PLEUROPHYLLIDIA CYGNEA, *Bergh*—Dorsal view. Animal fully extended. Slightly enlarged.

Fig. 2. PLEUROPHYLLIDIA CYGNEA, *Bergh*—Ventral view. Animal partially contracted. Slightly enlarged.

Fig. 3. CERATOSOMA ADELAIDÆ, *spec. nov.*—Dorsal view. × 10¾.

Fig. 4. CERATOSOMA ADELAIDÆ, *spec. nov.*—Dorsal view. × 3½.

PLATE XI.

Fig. 1. PLEUROPHYLLIDIA CYGNEA, *Bergh*—Side view. Animal contracted. Natural size.

Fig. 2. PLEUROPHYLLIDIA CYGNEA, *Bergh*—Front view. Animal contracted. Natural size.

Fig. 3. PLEUROPHYLLIDIA CYGNEA, *Bergh*—Ventral view Animal contracted. Natural size.

PLATE XII.

Fig. 1. Radula of *Pleurophyllidia cygnea*, Bergh, showing arrangement of transverse rows of teeth.

Fig. 2. Rachidian cusp with its denticles, of the radula of *P. cygnea*

Figs. 3 and 3a. Accessory plates connecting the rachidian with the laterals of the radula of *P. cygnea*.

Fig 4. Lingual spines of *P. cygnea*—Exterior aspect.

Fig. 5. Lingual spines of *P. cygnea*—Interior aspect.

Fig. 6. Mandible of *P. cygnea*.

REPORT ON THE MOLLUSCA COLLECTED BY MR. HERBERT BASEDOW ON THE SOUTH AUSTRALIAN GOVERNMENT NORTH-WEST EXPEDITION, 1903.

By CHARLES HEDLEY.

[Communicated by HERBERT BASEDOW.]

PLATE XXX.

[Read April 4, 1905.]

The Eremian Region has been shown by the investigations of the Horn Expedition to possess a considerable and varied snail population. Desert influence has left its stamp on the larger snail shells. Though quite unrelated to the forms that people the arid regions of Asia, Africa, or America, these Australian shells repeat in their chalky texture and rough sculpture the features of foreign species subjected to similar environment.

The collection which Mr. Basedow kindly invited me to examine has both added to the list of known forms and enlarged the range of those previously described.

I am indebted to Dr. J. C. Verco for an opportunity of examining the types of several species described by the late Professor R. Tate.

Mr. Basedow has generously deposited in the Australian Museum the collection here discussed.

Diplodon wilsonii, Lea.

For bibliography see Simpson, Proc. U.S. Nat. Museum xxii., 1900, p. 893.

Hab.—Algebuckinna Waterhole and Warrungudinna Waterhole, in the bed of the Alberga River.

Isidora newcombi, Adams & Angas.

For a discussion of this Eremian species, see Tate, Rep. Horn. Exped. ii.. Zool., 1896, p. 213.

Hab.—Day's Gully and Hector Pass, Mann Ranges; Indulkanna Creek, Warrungudinna Waterhole, on the Alberga.

Thersites basedowi, n. sp.

Plate xxx., figs. 1, 2, 3.

Shell discoidal, of thin and light substance, spire almost flat, umbilicus broad and shallow. Colour buff. Whorls four, parted by sharply impressed sutures. Last whorl acutely keeled at the periphery, rising at the last half-turn above the level of the coil, previous to plunging deeply below it, freed at the aperture from the adjoining whorl. Sculpture: irregular, distant growth lines, and close-set microscopic grains (fig. 2). Aperture very oblique, nearly horizontal; lip entire, a little curled back, broadly expanded. Maj. diam., 19 mm.; min. diam., 15 mm.; height, 6 mm.

A smaller, less sharply keeled specimen from the Mann Range is regarded for the present as a variety.

Compared with its nearest ally, *T. howardi*, Angas, the novelty is smaller, flatter, without colour bands, but with more decided granular sculpture. A specimen which I dissected containing a generative system characteristic of *Thersites*, and comparable to that of *T. setigera*, Tate, Horn Exped., Zool., p. 222, fig. **F.**

Hab.—Musgrave Ranges.

Xanthomelon sublevatum, Tate.

Plate xxx., figs. 7, 8, 9.

Thersites sublevata, Tate, Rep. Horn Exped., Zool. ii., 1896, p. 196, Pl. xvii., fig. 5.

A specimen from the Musgrave Ranges extends the known distribution of this species. It was identified by comparison with examples named by its author. As the figure quoted is unsatisfactory, others are now presented.

Xanthomelon perinflatum, Pfeiffer.

Apparently this snail is both most numerous individually and widest spread in this region. Its range is discussed by Professor Tate (*op. cit.*, p. 198).

Hab.—Musgrave Ranges.

Xanthomelon flindersi, Ad. & Angas.

Hab.—Musgrave Ranges.

Xanthomelon angasianum, Pfeiffer.

Hab.—Musgrave Ranges.

Xanthomelon clydonigerum, Tate, var.

Plate xxx., figs. 10, 11, 12.

Thersites (Glyptorhagada) clydonigera, Tate, Rep. Horn Exped., Zool. ii., 1896, p. 195, Pl. xix., fig. 24.

The type of this species, now in the possession of Dr. J. C. Verco, is bleached, and, through a malformation of the later whorls, is subscalar. Compared with Mr. Basedow's examples the unique type is, therefore, more elevated; it is also smaller and rather more coarsely sculptured. As the type is not only in poor condition, but distorted, I have hesitated in regarding the apparent difference as of specific value, and have compromised by offering a description and figures of the shell obtained by Mr. Basedow under this title.

The reproductive system, a partial dissection of which is here shown, demonstrates that the species is included in *Xanthomelon*, as opposed to *Thersites*.

Shell depressedly globose, narrowly perforate, substance rather light and thin. Colour cinnamon-brown, paler on the base. Whorls five, parted by sharply impressed sutures. Periphery rounded, but the flattening of the whorl above suggests an incipient keel. The last whorl descends at the aperture deeply and abruptly with a wavering suture. Sculpture: the first two whorls are smooth to the eye, but under the lens fine vermiculate etchings appear. The adult sculpture commences suddenly, and consists of close, fine, irregular, backwardly curved riblets, which grow lamellate near the aperture. During their traverse of the whorls the riblets sometimes unite, divide or end untimely, while fresh threads may be intercalated. At the periphery the riblets are especially prone to anastomose, on crossing the base they become finer and more regular. Umbilicus very narrow, deep, with a furrow entering spirally from under the columellar expansion. Aperture oblique ovate, outer lip broadly expanded, margins united by a callous ridge, columella partly arching over the umbilicus.

Maj. diam., 22 mm.; minor diam., 18 mm.; height, 15 mm.

Hab.—Musgrave Ranges.

Xanthomelon wilpenense, Tate.

Hadra wilpenensis, Tate, Trans. Roy. Soc., S.A., 1894, p. 193.

Hab.—Musgrave Ranges.

Xanthomelon radiatum, n. sp.

Plate xxx., figs. 4, 5, 6.

Shell lenticular, solid, narrowly perforate, spire slightly elevated. Last whorl bluntly angled at the periphery, rather swollen, and then much contracted behind the aperture. Colour uniform isabelline. Whorls four, parted by an impressed suture. Sculpture: First two whorls microscopically granose-vermiculate, remainder radiately ribbed. Ribs regular, prominent, increasing in strength with the growth of the shell, interstices deeply gouged, in breadth equalling the ribs, on the last whorl numbering about 45. Umbilicus oblong, narrow, and deep. Aperture oblique, lunate-ovate, lip expanded and reflected, margins united by a notched, callous film.

Maj. diam., 12 mm.; min. diam., 10 mm.; height, 6 mm.

The nearest relation to this seems to be *Angasella papillosa*, Tate, which is larger, with fainter radial sculpture.

Hab.—Mount Davies, Tomkinson Ranges, and Musgrave Ranges.

Xanthomelon asperrimum, n. sp.

Shell depressed, acutely carinated, narrowly perforated, thin, dull. Colour, uniform chalk white. Whorls four, flattened above, spire plane or elevated. Suture wound under the peripheral shelf of earlier whorls. Last whorl descending in front. Sculpture: The first whorl and a half finely shagreened, on the rest of the shell large and prominent grains are thickly set in anterior and posterior curves, which intersect each other at right angles. At the periphery the shell is pinched into a broad projecting keel. Base inflated. Umbilicus deep and narrow. Aperture oblique, lip sharp and thin, a little expanded, columella arching over part of the umbilicus. Margins united by a callus band.

Maj. diam., 20 mm.; min. diam., 16 mm; height, 9 mm.

The peculiar form of this species amply distinguishes it from its congeners. The influence of desert conditions on the sculpture of the shell, such as are shown by this species, has been lucidly discussed by Dr. Dall (Proc. Acad. Philad., 1896, p. 411).

Hab.—Mann Ranges.

EXPLANATION OF PLATE.

Figs. 1, 2, 3. Various aspects and magnified sculpture of *Thersites basedowi*, Hedley.

Figs. 4, 5, 6. Various aspects of *Xanthomelon radiatum*, Hedley.

Figs. 7, 8, 9. Various aspects of *Xanthomelon sublevatum*, Tate.

Figs. 10, 11, 12. Various aspects of *Xanthomelon clydonigerum*, Tate var.

NOTES ON SOUTH AUSTRALIAN MARINE MOLLUSCA, WITH DESCRIPTIONS OF NEW SPECIES.—PART II.

By Jos. C. Verco, M.D. (Lond.), F.R.C.S. (Eng.), etc.

[Read April 4, 1905.]

Plate XXXI.

Calliostoma zietzi, *spec. nov.* Pl. xxxi., figs. 1, 2, 3.

Shell small, conic, imperforate, moderately solid. Whorls 8, including protoconch of one smooth turn. First two spire whorls rounded and slightly mammillate, next three straight-sloping, last two rather convex. Suture moderately deep, slightly overhung by peripheral lira. Penultimate whorl with 6 spiral cinguli and 2 inter-liral threadlets. Body whorl with 6 cinguli, rather narrower than the interspaces, and 5 threadlets; barely angulated below its centre by a somewhat stouter cord; base rounded, with 8 concentric liræ, flat, and much wider than the interspaces. Spire and base finely obliquely incised with growth lines, which cut the liræ less than the interspaces. Aperture roundly quadrate. Columella nearly straight, slightly oblique and excavated, subtruncate below; outer lip simple crenulated by cinguli. Height, 8 mm.; diameter of base, 5; aperture, 2·5.

Ornament.—Horn-coloured, peripheral band white. Main cinguli on the spire and those on the base obscurely dotted with light chestnut; peripheral band with larger and plainer spots.

Hab.—Backstairs Passage, St. Vincent Gulf, at 12, 17, and 20 fathoms; 9 dead.

It is named after Mr. A. Zietz, F.L.S., of the Adelaide Museum.

Gena terminalis, *spec. nov.* Pl. xxxi., figs. 4, 5.

Shell minute thin oblong-oval, sides parallel. Whorls 4, spire terminal inconspicuous. Surface smooth and polished but for miscroscopic accremental lines: no spiral striæ or incisions, except microscopic, on the base of the body-whorl. Colour white, with crowded spiral bands of crescentic white and dark and reddish-brown spots and blotches. Length, 5·75 mm.; width, 3 mm. Radula, ∞.1.(5.1.5.).1.∞., 36 rows.

Hab.—Dredged alive, Wallaroo Bay, Spencer Gulf 15 fathoms; also alive and dead in deep water, St. Vincent Gulf.

Obs.—The ornament varies greatly. The shell may be blotched pink and white, and there may be numerous fine spiral, hair-like, dark lines.

Diagnosis.—From *G. strigosa*, A. Adams. It is smaller, comparatively narrower, the spire is terminal, the aperture is more oblong, the columella is straighter, the outer lip joins the columella almost at a right angle. A juvenile *G. strigosa*, equal in size to an adult *G. terminalis*, has been drawn in Plate xxxi., fig. 6, for comparison.

It very closely resembles *Gena nigra*, Quoy & Gaimard, Voy. de l'Astrolabe, Zool., Vol. iii., p. 307, Plate lxvi. (bis), figs. 10, 11, 12 : but their species, as figured, has its spire less terminal, and rests more upon its two ends, and, according to the dimensions given, is three times as large.

Astele calliston, *spec. nov.* Pl. xxxi., figs. 7, 8.

Shell conical, thin. Spire of nine whorls, including two smooth apical turns; gradated. Whorls straight-sloping, with crowded spiral liræ, about 24 on the penultimate; crossed by oblique crowded accremental striæ, producing sublenticular pitting. Suture linear, immediately beneath the prominent peripheral cord which gradates the spire. Body whorl with suture slightly descending at the aperture: spiral threadlets about 24 : crowded fine sinuous oblique accremental striæ: periphery acutely angular, with a projecting rounded carina, spirally closely engraved on its upper surface, axially crossed by rounded striæ, much more distant than the accremental striæ, provided at somewhat irregular intervals with 16 rounded invalid tubercles. Base very flatly rounded with 7 concentric narrow liræ, the inner 4 closer than the rest, which are separated by 4 to 6 inter-lirate striæ. Umbilicus narrow, minutely axially incised. Aperture oblique, roundly quadrate: outer lip slightly convex, thin, smooth within, margin sinuously convex below the suture, concave towards the periphery; basal lip convex, slightly effuse, smooth within. Columella, upper third concave, the rest straight, obliquely truncate below: callus at the base partly bordering the umbilicus and attached to the columella along a vertical groove.

Ornament.—Shell purple-brown, with somewhat oblique, axial, creamy, rhomboidal flames, extending from suture to suture, and nearly equalling the foundation colour in area. On the peripheral carina, and hence above the sutures, they are replaced by two or three creamy spots, while two or three less marked white spots occupy the intervals, and thus pick out the tubercles of the carina. Every whorl is encircled by four articulated colour bands, which in the white areas are of a more opaque white than the rest of these areas, and extend slightly beyond them, and are crossed by narrow vertical or oblique red lines, while in the purple areas they are of a deeper purple tint, and are crossed by narrow axial white lines. The base is of a lighter tint, the outer 6 cinguli of a rose pink, minutely dotted with creamy white. The columella and umbilicus are white, bordered outside with green, which tints the inner two basal cinguli, and curls around the columella into the throat. The inner edge of the outer lip is golden-brown and white, interior shining and nacreous. Operculum horny multispiral, nucleus central, a radial cellular fringe-like film over the inner three-fourths of each spiral. Height, 11·75 mm.; diameter, 9·75; aperture, 4.

Radula, ∞.1.5.1.5.1.∞. Central rachidian heart-shaped, narrow free end surmounted by small, slightly serrated denticle; the other rachidians with trilobed cusps, which gradually enlarge outwards; a single lateral with one cusp trilobed at its base; marginals many unicuspidate, not serrated.

Hab.—Spencer Gulf, 20 fathoms; 32 alive and dead.

Variations.—Some individuals are uniformly pinkish-brown, with white peripheral tubercles, and four pink cinguli on each whorl articulated with white, the larger white spots lying vertically between the supra-sutural tubercles, while narrower, oblique white spots alternate in groups with them.

Clanculus leucomphalus, *spec. nov.* Pl. xxxi , figs. 9, 10, 11.

Shell depressed conic, rather thin. Protoconch one turn and a half smooth. Whorls 6, rapidly increasing, sloping convex. Penultimate with 8 close-set spiral rows of smooth ovate granules. Body-whorls with ten spiral rows of granules above the acutely angled periphery, the granules of the infra-sutural row are much larger and placed axially, the rest spirally ovate; and ten rows on the base of flatter, more quadrate, and more close-set granules. Oblique axial striæ crowd between the granules on the spire, but are obsolete on the base.

Aperture quadrate oblique; outer lip crenulate, toothed just within the margin opposite each spiral lira, within this thickened and wrinkled, and in the throat lirate and nacreous; basal lip crenulate, thickened within with 5 teeth gradually enlarging towards the columella; columella oblique, nearly straight, ending below in a prominent, obliquely furrowed but not bifid tooth, with a large tubercle at the junction of its upper and middle third, and with a flange throughout its whole length bent towards the umbilicus. The umbilicus is wide and deep, with a funicle winding up its outer side to the tubercle on the columella. The umbilical border overhangs, and has 6 medium-sized tubercles, and is margined by a flat, axially incised, spiral lira, with a threadlet on either side.

Colour light ashen-grey, with obscure flames of deeper grey or buff, and with numerous small pink dots on the second and third whorls. The umbilicus and its margin are pure white, the throat nacreous green.

Height, 8 mm.; diameter of base, 9·75 mm.

Hab.—Backstairs Passage, St. Vincent Gulf; dredged alive in 20, 22, 23 fathoms, dead in 6 to 23 fathoms.

Diagnosis.—The type from Gray's collection of *Trochus clangulus*, Wood, in the Natural History Museum, London, differs from our species in having a more sinuous columella, due to a large tubercle at each end, and a median bulge, only 6 liræ on the penultimate whorl, stouter and fewer liræ in the throat, a less rounded periphery, its colour light pink, with pink spots on the base, and articulated deep pink just above and below the suture, and green and red tints instead of light ashen-grey with darker buff flammules.

Crassatellites ponderosus, Gmelin.

This is the name suggested by Mr. Hedley, in P.R.S. of N.S.W., 1904, Part 1, page 198, for *C. castanea*, Reeve, as also for *C. kingicola*, Lamk.; *C. donacina*, Lamk.; *C decipiens*, Reeve; *C. errones*, Reeve; *C. pulchra*, Reeve; and *C. cumingi*, A. Adams, which E. A. Smith and Brazier had previously united under the name of *C. kingicola*, Lamk. Gmelin's shell, which was first defined in pre-Linnean times by Chemnitz, is cited by von Martens in Malak. Blat. xix., 1872, page 30, as from New Guinea. In Syst. Naturæ, C. Linné, vi. Vermes, page 3280, it is given as *Venus ponderosa*, No. 54, as inhabiting the Southern Ocean.

Some 40 specimens have been dredged by me in South Australian waters, of which 26 are single values. Living individuals were found at 20 fathoms, off Normanville, at 19 fathoms off Eastern Cove, Kangaroo Island, and at 15 fathoms off Wallaroo. These form the material on which the following observations were based.

All the species above-named, except *C. castanea*, are validly corrugated by sub-distant concentric ribs. Not one of my forty examples is so corrugated. It is, therefore, least like *C. kingicola*, Lamk. But I only possess one cabinet specimen of each of them. Perhaps a large series would show examples with smooth surfaces near the umbos.

Size.—The largest measures 115 mm. antero-posteriorly, 90 mm. umbo-ventrally, and 49 mm. in section, and weighs ten ounces.

Shape.—This varies a good deal, as is noted in Conch. Cab., Band x., Abtheil i., page 2; Taf. i., fig. 1; Taf. vi., fig. 1, 1886, where two figures are given, one of a shell 88 mm. by 75 by 42, and another much produced posteriorly, 98 by 73 by 50. One from Port Lincoln, a rounded form, is 112 mm. by 93, while another very produced behind is 115 mm. by 90. This is not merely a senile tendency, for the difference in contour is found in young shells, and also in those of equal size and apparently of similar age. In the produced individuals the ventral outline, instead of being uniformly convex as far as the postero-inferior angle, may be somewhat concave in front of this.

Thickness.- It is very solid; the heaviest shell we have on our coast; it may weigh 10·75 ounces. Often growth in superficial area ceases after a time, and then the thickness greatly increases. Thus a shell only 3·7 inches long and 3·1 deep is 2·05 in section, and weighs 10·75 ounces, whereas another 4·25 inches long and 3·5 deep is only 1·9 inches in section, and weighs but 8 ounces. The volume of the contained mollusc actually diminishes, the thickening taking place at its expense. The muscular impressions appear deeply excavated then, owing to the heaping up of shelly material around the adductor muscles beneath the mantle. The ventral margin, instead of being sharp, is flattened for as much as an inch, nearly at right angles to the external surface, and is in some cases even incurved.

Periostracum.—This is very durable, and even in dead and decaying valves is frequently present, and allows very fair cabinet specimens to be prepared from very unpromising material by a little careful scraping. It disappears sometimes first at the umbos and the subjacent surface, then erodes deeply. My largest individual, taken alive, has only a little of its epidermis remaining along the ventral and posterior borders, and its face value has been thus greatly depreciated.

Interior.—This is smooth down to the pallial line, which is slightly crinkled, and thence on there are radial striæ which fade out towards the ventral margin. The older the shell the deeper is the pallial line, and wider posteriorly, and more markedly crinkled, and the more rugose become the radial striæ beyond.

Colour.—The interior is white, with a beautiful glistening chestnut or burnt-umber colouring of certain parts. The frequency and depth of tinting of these parts is in the following order:—The posterior adductor scar, the posterior part of the pallial line, the anterior portion of the anterior adductor scar, the posterior margin, the ventral margin, and the posterior part of the cartilage pit and hinge plate. Sometimes the colour is a very deep, almost blackish-brown, with a delicate flesh tint, and one is tinted a pretty purplish-pink.

Carinaria australis, Quoy & Gaimard.

Quoy & Gaimard, Voy. de l'Astrolabe, Zool., vol. ii., page 394, Pl. xxix., figs. 9, 13, 1833. The type specimen was dredged between New Holland and New Zealand in January, 1827. Mr. Hedley supplied me with the following quotation from Voy. de l'Astrolabe, Histoire du Voyage ii., 1830, page 27:—"January 2, 1827, the zoologists collected some living carinarias, the shells of which attained a length of eight to ten lines." The next day the vessel was 130 leagues from Port Jackson, on the way to Cook's Straits, New Zealand. Allowing about a hundred to a hundred and fifty miles for the day's run, we can fix the locality of the haul of *Carinarias* at about 158° E. longitude and 40° S. latitude. My single specimen was taken in January, 1905, in 104 fathoms, in sandy ooze, 35 miles south-west of the Neptune Islands, below the entrance to Spencer Gulf, in E. longitude 135·40°, and S. latitude 35·25°. So its *habitat* is extended some 22 or 23 degrees to the west. It measures 10 mm. in length and 3·75 in width. Several characters can be added to those given by the authors. The transverse ridges spreading fan-like from the posterior part to the carina increase in number by intercalation of secondary and tertiary ridges. The carina is undulated in its proximal part, where it springs from the shell, but its distal edge is straight, not corrugated, and only at the back part, where the distal border has been worn or broken away, is it actually undulated at the margin. The aperture is oval, and is about twice as wide towards the posterior part as at the anterior. From within a portion of the protoconch can be seen projecting through the posterior wall of the shell somewhat obliquely and slightly to the right of the middle line. The record of this shell adds not only a new species and a new genus to the South Australian list of marine molluscs, but a new order of Gasteropods; the Nucleobranchiata. Atlanta, another genus of this order, is also represented by an undetermined species taken in the same haul.

Gibbula lehmanni, Menke.

Turbo lehmanni, Menke, Moll. Nov. Holl., page 18; *Trochus lehmanni*, Philippi, Conchyl. Cab. Band ii., Abth. iii., page 185, t. 28, fig. 15; Fischer, Coq. Viv., page 362, t. iii., fig. 3; *Gibbula pulchra*, A. Ads. P.Z.S., 1851, page 187; *Gibbula lehmanni*, Menke, Tryon, Man. of Conch. xi., page 233, Plate xl., figs. 12, 13.

This is a fairly common species. It has been dredged alive at 14 and 25 fathoms in Spencer Gulf, and dead at 15 fathoms in Wallaroo Bay. It has hitherto been confused in South Australia with *G. Coxi*, Angas, so I give the following diagnostic characters:—*G. Coxi* is more solid, slightly less depressed, rather more concave between the carinæ, with sharper spiral liræ, and a much smaller umbilicus. This last character is the easiest diagnostic. The radial flames are much fewer, the colour elsewhere is irregularly stippled instead of spirally articulated, and there are fewer colours in the same shell. Mr. J. H. Gatliff has sent me this shell as *G. sulcosa*, A. Adams, P.Z.S., 1851, page 186, recorded in his Catalogue of the Marine Shells of Victoria, P.R. Soc. of Vict. xiv. (N.S.), Part ii., 1902, page 132. Adams's name is given in Tryon's Man. of Conch. xi., page 243, "unfigured and undetermined species," with the *habitat*, Sir C. Hardy's Island, North Australia.

Astele subcarinatum, Swainson.

Astele subcarinatum, Swns., 1854, P.R.S., Van Diemen's Land, vol. iii., page 36, Plate vi., figs. 1, 2; *Eutrochus perspectivus*, A. Adams, P.Z.S., Lond., 1863, page 506; *Calliostoma (Eutrochus) Adamsi*, Pilsbry., Man. Conch. xi., page 402.

It has been dredged alive at 16, 19, 20, 22, 23 fathoms, in Backstairs Passage, and off Newland Head.

Zizyphinus subgranularis, Dunker, Malak. Blätt, 1871, page 170, No. 56, unfigured, from Bass Straits; *C. subgranulatum*, Dunker, Man. Conch. xi., page 403, is a half-grown individual of the same species. This identification was referred to Mr. Hedley, who says he had arrived at the same conclusion.

EXPLANATION OF PLATE.

Plate XXXI.

Figs. 1, 2, and 3. *Calliostoma zietzi*, Verco—Basal and profile views, and magnified sculpture.
Figs 4 and 5. *Gena terminalis*, Verco.
Fig. 6. *Gena nigra*, Quoy & Gaimard.
Figs. 7 and 8. *Astele calliston*, Verco.
Figs. 9, 10, and 11. *Clanculus leucomphalus*, Verco.

DESCRIPTIONS OF NEW AUSTRALIAN LEPIDOPTERA WITH SYNONYMIC NOTES.—NO. XXIII.

By Oswald B. Lower, F.E.S. (Lond.), etc.

[Read August 1, 1905.]

SYNEMONIDÆ.

Synemon monodesma, n. sp.

Male, 38 mm. Head, antennæ, and legs dark fuscous; face and palpi white. Thorax and abdomen whitish beneath. Legs white, mixed with fuscous. Forewings elongate - triangular, costa gently arched, termen obliquely rounded; deep fuscous - ochreous, faintly iridescent; a moderate, very oblique white fascia from below costa in middle, extending towards anal angle, but only reaching two-thirds across wing, almost separated by ground colour in middle; a suffused, whitish, short, oblique fascia below costa at about four-fifths, about half the length of previous fascia; some whitish scales on upper half of termen; cilia fuscous-whitish. Hindwings with termen rounded; blackish-fuscous, with bright orange markings; a broad crescentic fascia at end of cell; a similar fascia, from below costa at three-fourths, running towards anal angle, but not reaching it, deeply excised on upper edge above middle; an irregular row of more or less obscure orange spots along termen; cilia whitish.

Differs from the other described species by the single fascia of forewings.

Mount Darling Range, Western Australia. In November; two specimens.

CARADRININA.

CARADRINIDÆ.

Ectopatria virginea, n. sp.

Male, 36 mm. Head, palpi, thorax, and abdomen snow-white, legs snow-white. Antennæ ochreous. Forewings elongate, moderate, costa nearly straight, termen oblique, hardly rounded; snow-white, without markings; cilia snow-white. Hindwings snow-white, slightly iridescent; cilia snow-white. A distinct species, well characterised by the wholly white colour; at first sight it is not unlike *Caradrina gypsina*, Low., but is without markings of any kind.

Adelaide, South Australia. One specimen; in October.

Euplexia signata, n. sp.

Male, 48 mm. Head, thorax, and abdomen fuscous, thorax with ochreous fuscous posterior crest, palpi ochreous.

Antennæ and legs fuscous. Forewings elongate-triangular, costa hardly arched, termen waved, oblique: light fuscous, markings dark fuscous: posterior two-thirds of cell filled in with dark fuscous: a moderately large sub-triangular blotch below posterior edge, extending beyond end of cell, only separated from cell by intersecting vein; an elongate patch above dorsum, from base to just beyond one-third: a somewhat quadrate spot beyond posterior extremity of cell, indented on posterior edge; an irregular, triangular blotch on costa at five-sixths: orbicular indistinct; reniform in middle of dark fuscous patch in cell, light fuscous, well defined; a row of small lunate marks along termen, hairs of dorsum reddish-fuscous throughout; cilia fuscous, with an ochreous line at base. Hindwings with the termen waved; dark fuscous; cilia as in forewings.

Hobart, Tasmania. One specimen; in October.

CATOCALINÆ.

Niguza anisogramma, n. sp.

Male, 30 mm. Head, palpi, and antennæ ochreous. Thorax fuscous. Legs ochreous. Abdomen greyish, segmental margins ochreous. Forewings elongate; triangular, costa faintly sinuate, termen rather strongly and obliquely rounded; fuscous; a broad, nearly straight, white fascia from one-fourth costa to one-fourth dorsum; a similar fascia, gently curved inwards, from costa at four-fifths to dorsum at three-fourths, edged posteriorly by a line of darker ground colour; a large black ring at two-thirds of wing, edged externally by a line of yellow, and containing two blue metallic spots, one above the other, and externally by an incomplete ring of white: a somewhat elongate oviform ring, below and considerably before the ring, filled in with yellow, and edged above with yellow; a transverse row of somewhat triangular yellow spots, parallel to limiting line of second white fascia, and again followed by a small and more indistinct parallel row of similar spots; a dentate black line along termen, anteriorly edged by a whitish line of similar shape; cilia fuscous, imperfect. Hindwings with termen slightly waved; whitish: a suffused fuscous ante-median band, containing a darker fuscous whitish centred ring below costa: a moderately broad fuscous band along termen, containing the yellow spots, etc., as in forewings; (cilia imperfect).

A pretty insect, not like any other Australian species known to me.

Alice Springs, South (Central) Australia. One specimen, received from Mr. S. Angel.

ACRONYCTINÆ.

Sesamia albicostata, n. sp.

Male, 28 mm. Head, palpi, thorax, and legs light ochreous-grey, antennæ whitish, pectinations ochreous. Abdomen shining grey Forewings elongate, moderate, costa slightly arched towards base, apex somewhat rounded, termen obliquely rounded; pale ochreous; veins somewhat outlined with white; a rather suffused broad white costal streak throughout, edged below by darker ground colour; cilia greyish-ochreous. Hindwings and cilia white.

Ocean Grange, near Sale, Victoria. One specimen, taken in January.

LYMANTRIADÆ.

Anthela niphomacula, n. sp.

Male, 46 mm. Head, palpi, thorax, abdomen, and legs dull reddish-carmine. Antennæ carmine-whitish, pectinations 10, dark fuscous. Forewings elongate-triangular, termen nearly straight; dull carmine-pink; a moderate white spot in cell at one-third from base of wing; a similar spot at end of cell, both faintly edged with fuscous; cilia reddish-ochreous. Hindwings with colour as in forewings, basal two-thirds lighter and somewhat ochreous-tinged; cilia as in forewings. Underside of hindwings with a single white fuscous-edged spot at end of cell.

Allied to *Rubescens*, Walk., but distinguished at once by the white spots.

Duaringa, Queensland. One specimen; in November.

Anthela callispila, n. sp.

Male, 46 mm. Head and thorax ochreous-fuscous, face ochreous, palpi ochreous beneath, fuscous above. Antennæ whitish, pectinations 10, dark fuscous. Abdomen ochreous-fuscous, anal tuft ochreous. Legs ochreous-fuscous. Forewings elongate-triangular, termen rounded; dark ochreous-fuscous, irrorated with fine ochreous hair scales along costa; markings snow-white, very distinct; a moderately large elliptic spot at anterior end of cell; a large one, rounded, at posterior end of cell; cilia ochreous-yellow. Hindwings with termen moderately straight; colour as in forewings; a moderately defined whitish spot at posterior end of cell; cilia as in forewings. Forewings beneath more ochreous, especially in cell; spots as above reproduced. Hindwings similar in colour, but an additional round white spot in cell at one-sixth from base.

A very distinct species, easily recognised by the white spots on the ochreous ground colour.

Broken Hill, New South Wales. One specimen; in April.

Anthela pyromacula, n. sp.

Male, 48 mm. Head, thorax, abdomen, and antennæ dark fuscous, antennal pectinations, 10; dark fuscous. Forewings shaped as in *Callispila;* dark fuscous, very minutely irrorated with obscure whitish scales, and more or less appearing to be streaked with dark fuscous along veins towards termen; a moderate black line along vein 2; a somewhat cuneiform orange-red, black-edged spot at anterior end of cell; a rather large, round, similar coloured spot in cell, at posterior extremity; cilia dark fuscous, faintly barred with darker. Hindwings with termen moderately straight; colour and cilia as in forewings; basal half of wing clothed with long fuscous hairs. Forewings beneath with spot at posterior end of cell reproduced in dull white. Hindwings with a dull whitish spot at posterior end of cell.

Not very near any other, probably allied to *Clementi*, Swin., but widely distinct.

Broken Hill, New South Wales. One specimen: in September.

Orgyia hemicalla, n. sp.

Male, 20 mm. Head, thorax, and antennæ blackish, antennal pectinations, 8. Face, palpi, and legs orange. Abdomen blackish, anal tuft orange. Forewings elongate-moderate, costa nearly straight, termen strongly rounded, oblique; dark fuscous; costal edge from two-thirds to apex narrowly orange; cilia orange. Hindwings bright orange; basal half dark fuscous, suffused and irregular; cilia orange.

Melbourne, Victoria. One specimen; in November.

Orgyia retinopepla, n. sp.

Male, 24 mm. Head, antennæ, and legs dull white, face and legs mixed with ochreous-fuscous; antennal pectinations, fuscous, 8. Thorax and abdomen ochreous-fuscous, beneath grey-whitish. Forewings elongate-triangular, costa slightly arched, termen gently rounded; light ochreous-fuscous; markings somewhat darker fuscous; two suffused fascia; first from one-third costa to one-third dorsum, curved outwards, anterior edge moderately defined; second from costa at three-fourths to dorsum at three-fourths, becoming triangular on costa, curved inwards below middle, and edged throughout by a narrow dull whitish line; a moderate discal spot above middle, midway between the two fascia; cilia light ochreous-fuscous, with a darker basal line. Hindwings light ochreous-fuscous, paler towards base, dorsal hairs whitish-ochreous; cilia as in forewings.

Broken Hill, New South Wales. One specimen; in October.

SPHINGIDÆ.

Hopliocnena brachycera, Low.

Coemotriche brachycera, Low., T.R.S.S.A., page 50, 1897.
Hopliocnena melanoleuca, Roths. (1902).

I have taken this species at Broken Hill, New South Wales, and have seen specimens from Roeburne, Western Australia, and Alice Springs, (Central) South Australia.

NOTODONTIDÆ.

Cerura (?) melanoglypta, n. sp.

Female, 40 mm. Head, palpi, and thorax cinerous-grey. Antennæ fuscous. Abdomen silver-grey-whitish. Forewings elongate, moderate, termen slightly waved, rounded, oblique; cinerous-grey, minutely irrorated with black scales; a well-marked, narrow, waved, black line starting on costa at one-sixth, thence becoming sub-costal for a short distance, thence curved and becoming thrice sinuate, and terminating on dorsum at about one-third; a second, nearly straight waved black line from costa at three-fourths to dorsum about anal angle, gently curved inwards below, and with a short outward angulation immediately above dorsum; a moderate, well-defined, somewhat reniform discal spot above middle; midway between the two lines; cilia cinerous-grey, faintly barred with fuscous at extremities of veins. Hindwings with termen gently waved; white; a broad black band along termen, mixed with obscure whitish spots along edge of termen, better defined beneath: cilia whitish.

Mount Pleasant, South Australia. One specimen; in October.

GEOMETRIDÆ.

BOARMIANÆ.

Amelora anthracica, n. sp.

Male, 30 mm. Head, palpi, and thorax black, face rounded, prominent. Antennæ ochreous, pectinations 5. Abdomen grey-whitish. Legs grey-whitish, anterior and middle tarsi infuscated. Forewings elongate-triangular, costa nearly straight, termen gently bowed, oblique: black, with blacker markings; markings thick, well defined; a basal fascia: a dentate fascia from one-fourth costa to one-fourth dorsum; a more strongly dentate fascia from costa at five-sixths to dorsum at five-sixths, more pronounced and somewhat angulated in middle; a large linear discal spot; cilia black. Hindwings with termen gently waved, rounded; whitish, becoming fuscous on posterior two-thirds; discal dot and second line as in forewings, fuscous; cilia dark fuscous.

Probably nearest *Milvaria*, Gin., but abundantly distinct from any other described species.

Mount Darling, Western Australia. One specimen; in November.

Orsonoba (?) euryscopa, n. sp.

Male, 44 mm. Head, thorax, palpi, and abdomen yellow, abdomen speckled with fine fuscous scales. Antennæ fuscous, bipectinated, pectinations 2. Legs ochreous-yellowish, posterior pair spotted with fuscous. Forewings elongate-triangular, costa gently arched, apex acute, termen faintly waved, strongly bowed in middle; sinuate beneath apex; yellow-ochreous, becoming broadly paler along costa, from one-third to apex; a narrow blackish waved line from costa before one-third to just above dorsum at two-fifths; a well-defined, oblique, fuscous line, edged posteriorly by its own width of white, which colour is again edged suffusedly by a similar width of dull purple, from apex to dorsum in middle; a round pale whitish-yellow spot lying on upper edge of fuscous line, just below middle; cilia ochreous. Hindwings faintly waved, more or less strongly near angle; colour and cilia as in forewings; a moderate waved fuscous streak, from one-fifth costa to one-fifth dorsum; a similar parallel streak before middle of costa to before middle of dorsum; a fine waved fuscous line from costa at three-fourths to dorsum before anal angle, obscure on lower half. Wings beneath pale yellowish, finely irrorated with fuscous, all markings, except streak of forewings from apex, obscurely reproduced.

Mackay, Queensland. One specimen; in November.

MONOCTENIANÆ.

Homospora rhodoscopa, Low.

Onychodes (?) rhodoscopa, Low., Tr. Roy. Soc., page 228, 1902.

Homospora procrita, Turn., *l.c.*, page 229, 1904.

I am sorry that Dr. Turner has re-named this species, as I pointed out to him when in Brisbane that I had already given it a MS.S. name. However, the discovery of the male has made it necessary to erect a new genus to receive it, and has borne out my conclusions that it is allied to *Onychodes*, Gin., the female of both genera having the antennæ very shortly pectinated; it differs, however, from that genus, as Dr. Turner points out, by the frontal projection of head and different neuration.

Systatica xanthastis, Low.

Dr. Turner has formed this new genus (Tr. Roy. Soc., S.A., page 231, 1904), to receive this species; but I am strongly of opinion that my type is a female: the antennæ are unipectinated, the pectinations being 1. Should my surmise prove correct, the character of the new genus will require to be altered in accordance with the above character.

DREPANIDÆ.

Oreta hypocalla, n. sp.

Male, 32 mm. Head, face, and palpi scarlet. Thorax and abdomen fleshy-ochreous, paler anteriorly. Antennæ and abdomen dull ochreous, fillet reddish. Abdomen beneath scarlet. Legs scarlet, anterior coxæ more brilliant. Forewings elongate-triangular, costa slightly sinuate, arched on posterior third; termen nearly straight, slightly sinuate beneath apex: dull ochreous-fuscous, finely and obscurely strigulated with darker, especially on median third, where it forms a broad, transverse fascia, anterior edge curved inwards from middle of costa to one-fifth dorsum; posterior edge oblique, from just before apex to two-thirds dorsum; faintly edged with whitish on upper third; cilia chestnut. Hindwings with termen gently rounded; colour and cilia as in forewings, the central fascia faintly indicated. Forewings beneath reddish-orange, suffused with fuscous; posterior edge of fascia reproduced in blackish. Hindwings beneath brilliant scarlet. Allied to *Miltodes*, Low, but differs in shape of forewings and other details.

Mackay, Queensland. One specimen; in November.

ADDENDA.

Deilephila euphorbiæ, Linn.

I recently received a living specimen of this beautiful Sphinx from Mr. J. Fairhead, who caught the insect in the sorting room of the post-office at Broken Hill in April. I feel pretty confident that up to the present it has not been recorded from Australia, and I am very pleased to be able to add it to our fauna. I have also taken in Broken Hill the following *Sphingidæ*:—

Hemaris hylas, Linn.
Hemaris kingii, Macl.
Chærocampa scrofa, Bdv.
Chærocampa celerio, Linn.
* *Chærocampa erotus*, Cr.

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* A single poor specimen.

Protoparce { *abadonna*, Fab.
distincta, Lucas.
Protoparce convolvuli, Linn.
lineata, Fab.
Deilephila { *livornica*, Esp.
livornicoides, Lucas.

CARADRINIDÆ.

Amaloptila ptilomela, Low.

Metaptila (?) ptilomela, Low, T.R.S.S.A., page 31, 1900; *Amaloptila triorbis*, Turn., T.R.S.S.A., page 6, 1903.

ERASTRIANÆ.

Homodes erizesta, Turn.

(P.L.S.N.S.W., page 110, 1902.)

I have seen this species standing in some collections as *Homodes gemmifera*, Moore, but can find no reference to this in Coates & Swinhoe's Catalogue of the Indian Moths, 1889.

PYRALIDINA.

ENDOTRICHINA.

Endotricha baryptera, n. sp.

Male, 16 mm. Head, thorax, palpi, antennæ, legs, and abdomen dark fuscous; thorax ochreous-whitish in middle; legs more or less banded and ringed with whitish. Forewings elongate, moderately dilated posteriorly, costa nearly straight, termen oblique, slightly bowed; dark fuscous-chocolate; a broad transverse whitish fascia, anterior edge sharply defined, from just before middle of costa to middle of dorsum, with a sharp curve inwards on lower one-third, posterior edge moderately straight, suffused into ground colour; a fine undulating, whitish, sub-terminal line, with a projection outwards, just beneath costa; a few small white spots on costa between fascia and line; a dark fuscous discal spot at end of cell; a few obscure black dots along termen; cilia dark fuscous. Hindwings with colour as in forewings; a fine, well-defined, dentate whitish line from one-third costa to one-third dorsum; a similar line from costa, just beyond middle, to dorsum near anal angle, with a sharp projection outwards in middle; ground colour between the two lines much lighter; cilia as in forewings.

Mackay and Brisbane, Queensland. Two specimens; in January.

ON NATICOID GENERA LAMELLARIA AND CALEDONIELLA FROM SOUTH AUSTRALIA.

By HERBERT BASEDOW.

[Read April 4, 1905.]

PLATES XXVI. to XXIX.

The NATICIDÆ include a sub-family known as the *Lamellariinæ*, the members of which are characterised by possessing a thick dorsal shield (reminding of the mantle of the *Doridæ*), partly or wholly enclosing a fragile shell. Five genera have now been established, and of these two have their shell completely enveloped by the animal. They are *Lamellaria* and *Caledoniella*.

The genus *Caledoniella* was founded in 1869 by Souverbie on the shell of an unknown animal It was consequently very doubtfully placed among the *Naticidæ*, and has maintained its uncertain position ever since.

Among other genera that came under my notice on Dr. J. C. Verco's marine dredging excursion were included a number of molluscs with internal shells, and of these I have separated several forms which I unhesitatingly refer to this little-known genus.

After an examination of the dentition and general structure of the animal I am fully convinced that *Caledoniella* is correctly included under the *Naticidæ*, in the sub-family *Lamellariinæ*.

An unfigured species of *Lamellaria*, the internal shell of which was originally described in 1849 from New Zealand, by Gray,* has been reported to occur in South Australia. It goes by the name of *L. ophione*. Dr. Verco has dredged a shell, measuring 8 mm., in Backstairs Passage, in 22 fathoms, which, as near as determination will permit, is *L. ophione*. An additional new species is described in this paper.

GENUS LAMELLARIA, Montagu, 1815.

Lamellaria australis, *spec. nov*

Animal.—Dorsal shield elliptic, with a waved outline and notched in front; soft, smooth, or minutely granular; appreciably broader than the foot, over the sides of which it folds very loosely and imperfectly (differing in this respect considerably from *Caledoniella*): under side obliquely striated (muscle fibres), around the foot. Body depressed, more con-

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* Proc. Zool. Soc., Lond., 849, p. 169.

vex over the shell. Foot flat, straight and dilated in front, sides approximately parallel, terminating in a blunt point, the free tail nearly one-half the whole length : projects beyond the mantle border anteriorly when in motion ; it is horizontally slit in front. Eyes, distinctly discernible as little black beads on the outer bases of tentacles, which are not retractile. Genitalia, situated far anteriorly on the right, immediately adjacent to the trunk of the head. Colour: The dorsal shield of the unique specimen is of a uniform, dull, brick-red or vermilion colour, with an imperfectly stellate, four-lobed, opaque white crown in its centre, and three additional white blotches on the right side, all of the white markings being easily removed by abrasion ; its under surface is yellow at the border, grading to vermilion, thence to an impure white in the region adjoining the foot. Head and foot shaded brownish yellow. Dentition: Formula 1:1:1 : central plate sub-trigonal ; laterals large, their spines overlapping in the central line. Dimensions: Length, 33 ; breadth, 25 ; height, 12 mm.

Shell.— Auriform, moderately convex, about three and a half whorls : margin of lip with a shallow concavity anteriorly ; ornamented with distinct incremental striae and very faint spiral incisions, the latter hardly recognisable with the unaided eye : open underneath, exposing the whorls : invested with a thin, transparent yellowish epidermis. Colour shining white, spire and inside nacreous. Dimensions: Major axis, $21\frac{1}{2}$; minor axis, $16\frac{1}{2}$; height, 9 mm.

Hab.—Backstairs Passage, St. Vincent Gulf. Dredged in 25 fathoms.

Obs.—The shell of *L. ophione*, Gray, is much like that of *L. australis*, though smaller, with its body whorl more convex, spire smaller and apex less central ; no authentic description or figure of the animal has, however, come to hand. Professor F. W. Hutton has taken a mollusc in New Zealand which he considers in all probability to be *L. ophione*, of Gray.* It clearly differs in one respect from my species. Whereas the dorsal shield of *L. australis* is smooth or minutely granulated, that of the specimen taken by Profesor Hutton is smooth, but much wrinkled, resembling convolutions of the brain.

GENUS CALEDONIELLA, Souverbie, 1869.

Animal.—Body ovoid. Dorsal shield thick, ample, verrucose, with its edges tucked in along the sides, and, in a contracted state, completely enclosing the foot : notched anteriorly and produced to an imperfectly closing siphon, re-

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* Manual New Zealand Mollusca, p. 59.

ceiving the inhalent current. Head differentiated; eyes distinct, on outer bases of tentacles, which are flattish cylindrical. Foot truncated, horizontally slit, and dilated laterally in front; bluntly pointed behind; tail free. Renal aperture on the right, the mantle-border slightly grooved outward from this spot. Dentition, 2·1·1·1·2. Mandibles corneous, strong.

Shell.—Internal, "heliciform, imperforate oval, orbicular, thin, invested by a thin epidermis, which extends beyond the lip;* spire much depressed, sub-lateral; whorls few, rapidly increasing; aperture oblique, rather large, the extremities of the simple lip united by a callus extending widely upon the whorl."

Hab.—New Caledonia and South Australia.

Caledoniella contusiformis, *spec. nov.*

Plate xxviii., fig. 1, and Plate xxix., figs. 1 to 8.

Animal.—Body ovoid, large. Dorsal shield soft, verrucose, and wrinkled; drawn in along the sides, the head and foot being unprotected when in motion, but capable of being retracted under the shield, which closes over them securely. Foot flat; extended laterally, and slit horizontally in front; the tail and head being free to move, and connected to the main body by a comparatively narrow trunk. Mouth large, from underneath the strong muscular rim of which the serrated edges of the jaws are visible. Dentition, formula 2·1·1·1·2.; central tooth sub-quadrangular, minutely and multicuspidated, laterals at least bicuspid, marginals noticeably narrower than the laterals, strongly hamate. Mandibles strong, elongate, wing-shaped, horny; obliquely striate; outer edge sharply serrate; a prominent ridge marking off the serration, beneath which a narrow band of setæ. Colour: The wrinkled dorsal shield is of an impure white to light brown ground-colour, which in the valleys of the wrinkles appears of a deeper hue. Large black, easily detachable blotches cover the surface, without system in their arrangement: they are each surrounded by a rim of deeper brown, and, at some distance from their edge, by a ring of similar colour; the underside of the shield is light flesh-red. Foot and head brownish-red, the edge of the dilated front of the former, and the tips of the tentacles of the latter, black. Dimensions: Length, 40; breadth, 30; height, 25 mm.; length of foot, 25 mm.

Shell.—Very thin, globose, ellipsoid, heliciform; about three whorls, rapidly increasing in size; spire small, depressed;

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* As a generic character I do not attach much importance to this feature.

covered by a colourless epidermis, which projects beyond the shell-lip; suture channelled; aperture oblique, border with a wide, shallow depression in the anterior; widely open so as to display the winding columella up to the apex. Ornamented by faint accremental striæ; the epidermis has raised, branching lines, radiating from the apex. Colour white, semi-translucent. Dimensions: Major diameter, 28; minor diameter, 17 mm.

Hab.—Backstairs Passage, St. Vincent Gulf; in 25 fathoms.

Obs.—I have not been able to trace the existence of a callus over the body whorl of the shell, between the inner and outer lip, although such was described of the only species hitherto known, viz., *C. montrouzieri*, Souverb. The remaining features of that shell correspond so closely with those of my type that a new genus can hardly be proposed, especially as the animal has not been previously seen; but the differences are considered sufficient to warrant the creation of a new species.

The calcareous matter does not completely infiltrate the shell, which in parts is only membranous (see var. *labyrinthina*, below), especially in the earlier and posterior portion of the last whorl. I will, however, point out that, prior to my examination of the shells, the molluscs had been kept in a weak solution of formalin, and it is just possible that this chemical may have had some deteriorating influence on their delicate tests.

Mr. E. A. Smith has described* a mollusc from Port Phillip Bay, closely allied to my new species. No figure of the living animal is given, and it is not a fair criterion to make a comparison from the description of a contracted spirit specimen with the living animals. Mr. Smith's figure of the internal shell is more elongate-bulimoid, and the spire more elevated, than is the case in my specimens.

Varieties of **Caledoniella contusiformis**, *spec. nov.*

I have before me a number of smaller specimens of *Caledoniella*, which in the outer colouration and design of the dorsal shield differ markedly from one another and the type. The head and foot are coloured the same in each case, and the measurements about one-half that of the form described above. The similarity in shape of the internal shells and other features is so close that I feel indisposed for the present to separate them specifically from *C. contusiformis*, for it is a matter of opinion whether, in this strange genus, specific dis-

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* Ann. and Mag. Nat. Hist., V. Series, 1886, Vol. xviii., p. 270.

tinction can with justice be made on colour variation alone. For the time being I enumerate them as varieties.

Var. **testudinis.**

Plate xxviii., fig. 2.

This comes nearest to the described type. The dorsal shield is more closely wrinkled, of an earthy-brown colour, with more numerous black blotches, in the centre of the crests produced by the wrinkles; each crest does not necessarily carry a blotch.

Shell calcareous, as described in type above.

Hab.—St. Vincent Gulf; in 25 fathoms.

Var. **pulchra.**

Plate xxviii.; fig. 3.

Dorsal shield comparatively smooth; of a rich yellow ground-colour, with large, circular, or oval lighter blotches surrounded by wreaths of black.

Shell calcareous, as described in type above.

Hab.—St. Vincent Gulf; in 25 fathoms.

Var. **labyrinthina.**

Plate xxviii.; fig. 4.

Dorsal shield wrinkled; of a faint yellowish ground-colour, of which very little remains visible on account of a labyrinthine structure, produced by closely set, black, partly spiral lines, usually more or less concentric to an enclosed nucleus in the form of a black dot, into which the innermost line very often passes.

The internal shell in this case is destitute of calcareous matter, consisting only of a soft, transparent membrane, with the characteristics described in the type above.

Hab.—St. Vincent Gulf; in 25 fathoms.

EXPLANATIONS OF PLATES.

PLATE XXVI.

Fig. 1. *Lamellaria australis*, Basedow—Animal; dorsal surface.

Fig. 2. *Lamellaria australis*—Animal; ventral surface.

PLATE XXVII.

Figs. 1, 2, and 3. *Lamellaria australis*, Basedow—Internal shell, various aspects.

Fig. 4. *Lamellaria australis*, Basedow—Showing position of internal shell with respect to animal.

Fig. 5. *Lamellaria australis*, Basedow—A lateral tooth.

Fig. 6. *Lamellaria australis*, Basedow—Dentition 1 : 1 : 1. A single row of teeth, unfolded.

PLATE XXVIII.

Fig. 1. *Caledoniella contusiformis*, Basedow.

Fig. 2. *Caledoniella contusiformis*, Basedow—Var. *testudinis*

Fig. 3. *Caledoniella contusiformis*, Basedow—Var. *pulchra*.

Fig. 4. *Caledoniella contusiformis*, Basedow—Var. *labyrinthina*.

PLATE XXIX.

Figs. 1, 2, and 3 *Caledoniella contusiformis*, Basedow—Various aspects of internal shell.

Fig 4. *Caledoniella contusiformis*, Basedow—Showing position of shell with respect to animal.

Fig. 5. *Caledoniella contusiformis*, Basedow—Radula.

Fig. 6. *Caledoniella contusiformis*, Basedow—A single row of teeth. Dentition 2 : 1 : 1 : 1 : 2.

Fig. 7. *Caledoniella contusiformis*, Basedow—Mandible, external aspect.

Fig. 8. *Caledoniella contusiformis*, Basedow—Mandible, internal aspect.

ON THE RECOMBINATION OF IONS IN AIR AND OTHER GASES.

By W. H. BRAGG, M.A., Elder Professor of Mathematics and Physics in The University of Adelaide; and R. D. KLEEMAN, B.Sc., Demonstrator.

[Read October 3, 1905.]

It is well known that when positive and negative ions are distributed through a given space a process of combination goes on until ions of one sign only are left. Let there be p positive ions, and n negative ions in each cubic centimetre at any instant, and suppose that the relations of any ion to all those of opposite sign are of the same character. Then the chance that an ion, say, a positive one, will enter into combination before the end of a short time δt is proportional to $n\delta t$; and generally the number of combinations taking place in that time may be denoted by $apn\delta t$ where a is the "co-efficient of recombination." This has been clearly established by the experiments of Rutherford, Townsend, McClung, Langevin, and others.

As a consequence, the current passing between two electrodes in a gas in which ions are being formed by external agents depends on the magnitude of the potential gradient or electric force. The relations between current and force have been carefully studied by many workers, and the observed facts have been compared with the results of calculation based on theory. The comparison is partly, but not completely, satisfactory.

Certain experimental results which we propose to describe in this paper seem to throw light on the reason of the discrepancy. They point to the existence of another cause, distinct from that represented by the expression anp, which prevents ions from reaching the electrodes in the gas in which they are formed. This cause appears to be a process of recombination of newly-formed ions with the atoms from which they have just been separated. The effects of it are proportional to the number of ions formed in a c.cm. in unit time, not to the product of the existing numbers of positives and negatives. They are independent of the shape of the ionisation chamber, and in this they differ from those of general recombination. They depend directly on pressure, and vary greatly from gas to gas.

In order to bring these effects into relief it is only necessary to reduce the number of ions in a c.cm. until the number of those that are lost by general recombination is negligible compared to the number of those that are formed. When this is done it is found that it is still necessary to apply a high potential in order to extract all the ions from the gas. For example, in air at atmospheric pressure an electric force of 25 volts to the cm. will only extract about 80 % of the ions which are obtained when the force is increased to 1,000. The following example will serve as an illustration:—The width of the ionisation chamber is 4 mm., the upper electrode being a metal plate, the lower a sheet of gauze. A thin layer of radium is placed 6·2 cm. below the sheet, and a particles emitted from RaC cross the chamber and ionise the air, which is at atmospheric pressure. The area of the plate on which the rays fall is about 18 cm. The capacity of the electrometer to which the upper plate is connected is about 150 cm, and a potential of ·125 volts applied direct to the electrometer causes a deflection of 722 divisions on the scale; ten divisions = 1 mm. When the lower plate is raised to 400 volts positive, so that the electric force is 1,000 volts per cm., there is a deflection of 982 divisions in 10 seconds, under the influence of the a rays. When a potential of 10 volts is applied, giving a force of 25 volts per cm., there is a deflection of 772 in 10 seconds.

In the latter case the charge Q received per sq.cm. of electrode in one second, measured in electrostatic units, is—

$$\frac{772 \times 150}{10 \times 722 \times 8 \times 300 \times 18} = 3{\cdot}5 \times 10^{-4}$$

The number of ions falling on each sq.cm. of electrode per second is therefore $1{\cdot}2 \times 10^6$ nearly.

The velocity of ions at this potential gradient is nearly $25 \times 1{\cdot}5$, or 37 cm. per second.

Thus, if n be the number of ions in a cubic centimetre, $37n = 1{\cdot}2 \times 10^6$, and therefore $n = 3{\cdot}2 \times 10^4$. Hence, the number of recombinations taking place in a second in the space between two opposing square centimetres of the electrodes is equal to $a \times {\cdot}4 \times (3{\cdot}2 \times 10^4)^2$. If we take the value of a to be $3{,}400 \times 3 \times 10^{-10}$, we find this number to be nearly 420. Finally, therefore, the number of ions recombining in each second is 420, whilst the number received is $1{\cdot}2 \times 10^6$, and thus only 1/3,000th of the ions are lost in this way.

But the current at 25 volts is only 772/982, or about 80%, of the current at 1,000 volts.

It is clear from this example that there is some cause which prevents the current attaining its full value other than general recombination between positive and negative ions.

Now, it is possible that ions newly formed might be specially liable to recombine with each other. Such a possibility has been already suggested by Rutherford ("Radioactivity," p. 33). An electron, which has just been ejected from an atom by a passing α particle, does not go far before encountering a neighbouring atom. The encounter, perhaps, results in a temporary attachment, for we know that ion-clusters are formed in this way. In any case, it is probable that the electron loses much of its velocity of projection. Now, it is still under the attraction of the atom from which it has come. Supposing this atom to have only lost one electron, the strength of the electric force which it exerts at the distance of the mean free path is equal to $e/r^2 = 3 \times 10^{-10}/10^{-10} = 3$ *E.S.U.*, or 900 volts per cm. This is large compared to the usual impressed electric forces of experiment. It is by no means improbable, therefore, that the electron may finally slip back into its old place. Such a possibility is not considered in the equations as usually formed. For all writers begin their arguments by the statement:—"Let p be the number of positive ions in a cubic centimetre, and n the number of negative." In doing so they tacitly assume that the relations of any one ion to all others of opposite sign are of the same character. But if a pair of newly-formed ions ran a special chance of recombination until they got away from each other, then the relations of either of these two to the other would be quite different from its relation to all other ions.

Let us, then, for the moment suppose that there is a special form of recombination, which we may call "initial," as distinguished from general recombination, and let us consider the nature of its effects, in order that we may find means of testing the correctness of the supposition.

Now, it is clear that the effects of initial recombination do not depend upon the shape of the ionisation chamber, and this at once differentiates them from those of general recombination. For the special or initial recombination concerns only the ion and its parent atom. But general recombination depends on the chance of an ion meeting others of the opposite sign, which chance depends on the number in a c.cm., and this, again, on the shape of the chamber. If, for example, α particles cross a chamber 3 mm. wide, and a sufficient potential gradient is applied, most of the ions will be carried to the electrodes. If the width of the chamber is increased to 6 mm. the magnitude of the stream of ions is doubled, each positive meets twice as many negatives as before, and therefore the chance that any one ion enters into recombination is twice as great. Suppose the saturation current for a 3 mm. chamber were 100, using any arbitrary system of units, and the actual current for a moderate potential were 90, then for the 6 mm. chamber, under an equal potential gradient, the current would be 160, not 180: the saturation current being 200. This is recognised in the usual formulæ. For example, Langevin finds that—

$$\frac{\epsilon Q}{\sigma} = \log\left(1 + \frac{\epsilon Q_0}{\sigma}\right)$$

where Q_0 is the saturation current per sq.cm. of electrode, and Q is the current when such a potential is applied that σ is the density thereby caused to exist on each sq.cm. of the electrode. When Q and Q_0 are both small compared to σ, it follows that:—

$$\frac{\epsilon Q}{\sigma} = \frac{\epsilon Q_0}{\sigma} - \frac{\epsilon^2 Q_0{}^2}{2\sigma^2}$$

$$\therefore \frac{Q_0 - Q}{Q_0} = \frac{\epsilon Q_0}{2\sigma}$$

Thus, the relative lack of saturation, viz. $(Q_0 - Q) / Q_0$, is proportional to Q_0, which itself depends on the depth of the chamber. Other formulæ show the same dependence.

But experiment shows that when the density of the ions is small the depth of the ionisation chamber has very little effect on the degree of saturation. This may be illustrated by the following experiments:—

Five mm.g. of radium bromide were so placed that the α rays passed upwards through an aperture in a lead plate and crossed the gauze of the ionisation chamber. The rays formed a cone whose vertical angle was about 20°. The apparatus used was the same as that of the previous experiment described, but the currents were so strong that a capacity of 1,070 cms. had to be put in parallel with the electrometer. Determinations were then made of the strengths of the current at various potentials:—(1) When the ionisation chamber was 3 mm. wide; (2) when 6 mm. wide; and (3) when 9 mm. wide. The values obtained were then reduced so that the saturation current in each case was set at the same value. Comparison then showed that the curves were almost identical except at low potentials, and this was in agreement with the hypothesis now put forward. For at all but low potentials an^2 was so small as to be negligible. When the potential was very low, one or two volts per centimetre, then the ions moved so slowly that n was larger, and an^2 was not negligible, and under those circumstances the curve showed a difference of the right kind. That is to say, the 9 mm. curve was further from being saturated than the others. The currents were specially made not too weak in order to bring out this contrast between the effects at low and at high potentials. The figures are given in the following table:—

Relation of current to potential gradient for different widths of the ionisation chamber, the currents being small: potential gradients in volts per centimetre: currents in arbitrary units, reduced to common maximum.

Width of Chamber.

3 mm.		6 mm.		9 mm.	
Potential Gradient.	Current	Potential Gradient.	Current.	Potential Gradient.	Current
1,000	400	1,000	400	1,000	400
34·8	341	35·7	335	36·0	333
11·9	308	12·7	302	16·4	300
8·65	294	9·47	292	9·83	290
6·6	285	7·47	283	7·81	283
4·66	274	5·50	272	5·83	271
2·75	252	2·75	247	3·10	244
1·92	235	1·89	224	2·23	220
1·50	221	·98	169	1·36	174
1·06	196	·51	108	·84	134
·59	147	·02	4	·04	68
·385	106				
·20	47				

These figures are plotted, as far as 36 volts per cm., in curves A, B, and C of Fig. 1. An open scale is chosen so as to show the separation of the curves at low values of the field, when n is not very small.

These figures and curves show that the ratio of the current at any particular strength of field to the saturation current is almost independent of the shape of the ionisation chamber, when the current is small. As this seems an important point, we have made many experimental tests of it. We give below the details of one such test, in order to illustrate the methods employed and their degree of accuracy.

The arrangements were the same as those just described, and the special object of the experiment was the determination of the degree of saturation under a certain moderate potential gradient in the case of chambers of two different depths. The depths were reckoned in turns of the screw, which raised the upper from the lower plate of the chamber: eleven turns = 1 cm. The currents were allowed to run into the electrometer for 10 seconds. The electrometer was not dead beat, and therefore the first and second resting-places on the scale were observed, and the mean taken. For example, the second line, marked †, of the subjoined table, shows that the first deflection was to 57·47 cm., and then back to 54·92, zero being 4,700. The experiment repeated gave 57·42 to 54·92, and again 57·47 to 54·93. The leak was also measured with

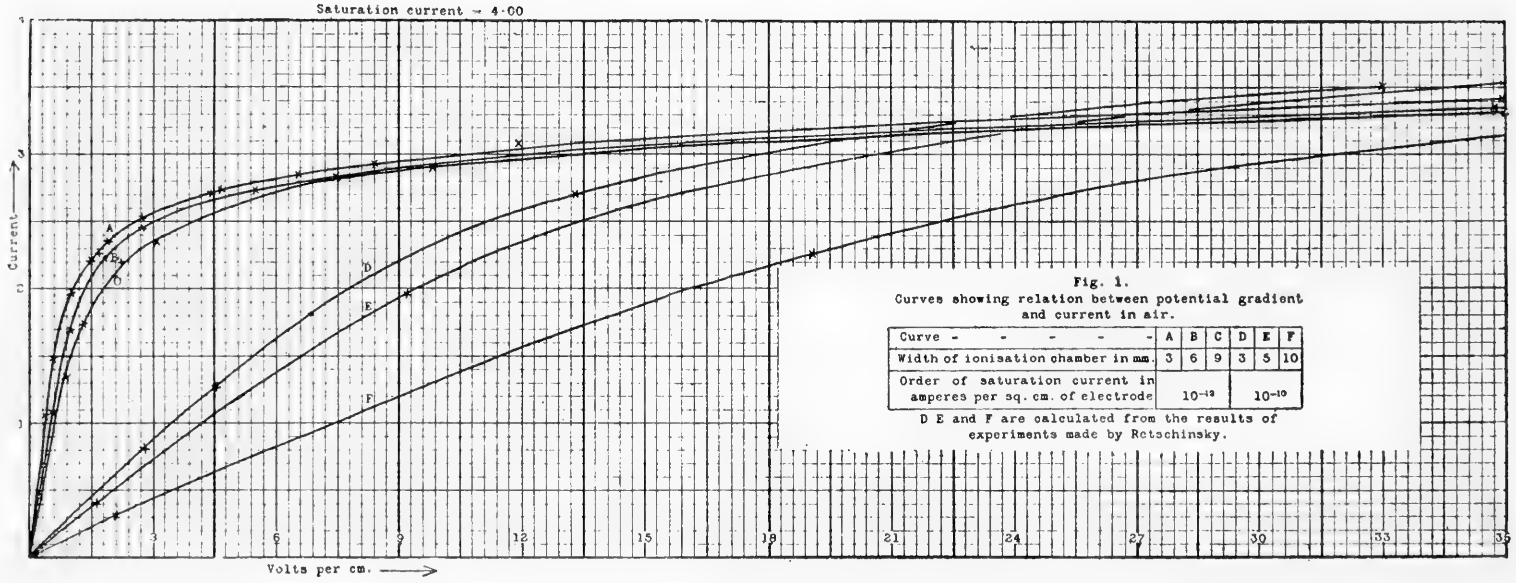

Fig. 1.
Curves showing relation between potential gradient and current in air.

Curve - - - - -	A	B	C	D	E	F
Width of ionisation chamber in mm.	3	6	9	3	5	10
Order of saturation current in amperes per sq. cm. of electrode	10^{-12}			10^{-10}		

D E and F are calculated from the results of experiments made by Retschinsky.

a metal plate over the radium, and the difference taken as the proper value of the leak for that experiment, a small proportion only being due to β rays. The first measurements relate to a chamber of depth 6 turns—(i.) under a potential gradient of 600 volts for the 6 turns: (ii.) a gradient of 20 volts for the same distance: (iii.) under 600 volts again. The difference between (i.) and (iii.), as shown in the table, was due to the variation in sensitiveness of the electrometer. In almost all our experiments this variation has been negligible: in this special case it was not so, because so large an amount of radium was used, viz., 5 mmg. The γ rays penetrated all the metal casings, and caused a leak in the charge of the needle. The leak had an exaggerated influence on the readings because the capacity of the electrometer was increased by the addition, in parallel, of a plate condenser of 1,000 cm. capacity. This disturbed the usual balance of the electrometer, in which leakage of the needle's charge had little effect on the deflection for a given quantity of electricity. To obviate any error from variation of sensibility the results of (i.) and (iii.) were averaged, and compared with the result of (ii.). It will be observed that successive determinations of the same leak were very consistent with each other. This implies that almost all the observed effect was due to the radium: extraneous influences were very small.

6 TURNS. Zero = 4700.

600 volts	47	75 69	Mean leak = 67	Nett leak = 852 = I_6 (say)
(Metal over Ra)	47	63 59		
† 600 volts	57	47 42 47	Mean = 919	
	54	92 92 93		
20 volts	47	50 54	Mean = 48	Nett leak = 695 = I'_6
(Metal over Ra)	47	40 46		
20 volts	55	49 39 49	Mean = 743	
	53	43 36 42		
600 volts	47	70 69	Mean = 64	Nett leak = 829 = I_6
(Meta over Ra)	47	61 55		
600 volts	57	19 16 13	Mean = 893	
	54	73 70 66		

∴ Mean value of $I_6 = 840$.

Value of $I'_6 = 695$.

3 Turns.

300 volts (Metal over Ra)	47 47	53 53 44 44	Mean = 49	Nett leak = 416 = I_3 (say)
300 volts	52 50	27 30 31 99 00 03	Mean = 465	
10 volts (Metal over Ra)	47 47	41 42 34 36	Mean = 38	Nett leak = 340 = I'_3
10 volts	51 50	26 31 31 23 28 27	Mean = 378	
300 volts (Metal over Ra)	47 47	52 51 45 42	Mean = 48	Nett leak = 396 = I_3
300 volts	52 50	06 07 04 83 83 83	Mean = 445	

∴ Mean value of $I_3 = 406$.

Value of $I'_3 = 340$.

Hence, $I_6/I'_6 = 1{\cdot}208$, and $I_3/I'_3 = 1{\cdot}193$. A repetition of the experiment, in different order, gave $I_6/I_3 = 1{\cdot}947$, and $I'_6/I'_3 = 1{\cdot}897$. These agree well with each other, for we find from the first set that $I_6I'_3\ I'_6I_3 = 1{\cdot}013$, and from the second that the same fraction $= 1{\cdot}025$.

The fraction I_6/I'_6 is the ratio of the saturation current in a chamber about 6 mm. wide to the current when the potential gradient is about 35 volts per cm., and I_3/I'_3 is the ratio when the chamber is 3 mm. wide, all other conditions being exactly the same. It ought, perhaps, to be mentioned that the current for the chamber of double width was not quite twice that for the other, because the widening was effected by raising the top plate, and so adding to the chamber a layer of air which was about 3 mm. further away from the radium than the original layer. As a little heap of radium bromide was used, the curve was of the form shown in Plate xviii., "Philosophical Magazine," December, 1904, so that ionisation decreased as distance from the radium increased. These results show clearly the existence of at least one effect which we should expect to find as a result of initial recombination.

Again, we ought to find that variation in current strength, caused by altering the power of the ionising agent, makes little difference to the form of the curve when the current is small. We have made several experiments in this direction also. In Fig. 2, curves A and B show the results

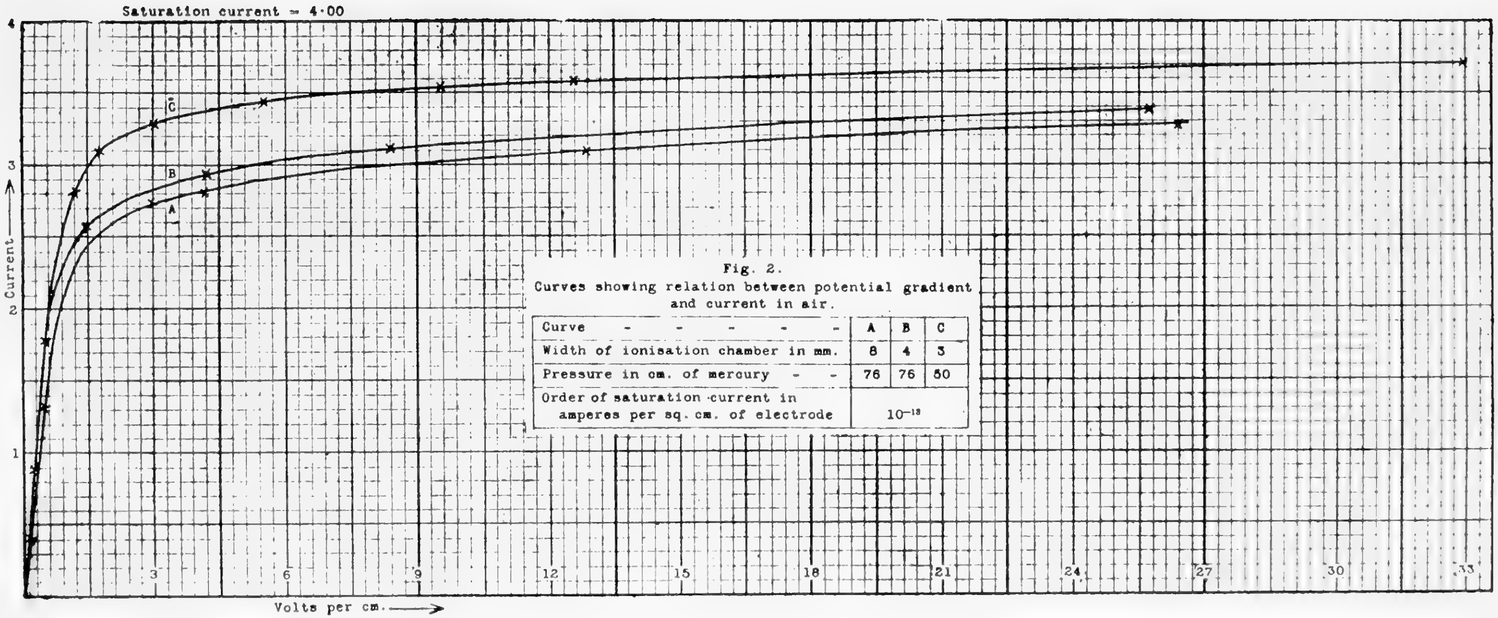

Fig. 2.
Curves showing relation between potential gradient and current in air.

Curve - - - - - -	A	B	C
Width of ionisation chamber in mm.	8	4	3
Pressure in cm. of mercury - -	76	76	50
Order of saturation current in amperes per sq. cm. of electrode	10^{-13}		

of experiments with currents which were of an order ten times smaller than those already described; yet their form is very similar. The curve A shows results with an 8 mm. ionisation chamber; curve B, 4 mm. The ionisation was due to a thin layer of radium, surmounted by a set of vertical tubes, as described by us in the "Philosophical Magazine," September, 1905. Other experimental results may be expressed in terms of I_4, the saturation current for 4 turns of the screw (rather less than 4 mm.), and I'_4 the current for a potential gradient of 25 volts per cm., and the same depth of chamber. On one occasion it was found that $I_4/I'_4 = 1·17$: $I_8/I'_8 = 1·21$; and on another $I_4/I'_4 = 1·18$: $I_8/I'_8 = 1·23$. In these experiments the radium was 5·05 cm. from the gauze. When the distance was 6·25 it was found that $I_4/I'_4 = 1·27$; $I_8/I'_8 = 1·29$; and again $I_4/I'_4 = 1·30$, $I_8/I'_8 = 1·30$. In the latter cases the a rays did not all get across the chamber: possibly the small variation of the ratios with distance may, in some way, be due to this fact.

It might be argued that we ought not to find much variation in the lack of saturation when the current is increased by shooting a greater number of a particles across the chamber in one second, on the following grounds:—Each particle as it flies across makes something like 10^5 ions in a centimetre of its path. If there are only about 10^4 or 10^5 ions in a c.cm. at any one time it is clear that these must be all the work of one particle, and that all the ions it produces are cleared away before the next one comes. Thus, the ions made by one a particle have no chance of combining with those made by another, and recombination cannot be proportional to the square of the number per c.c. But this consideration, though no doubt true, cannot furnish an explanation of the fact that the curves are little altered when the chamber is altered in depth. It was, indeed, in view of this argument that we made the experiments with the varying depths of the chamber.

It is very instructive to compare these figures with the results obtained by Retschinsky, and described by him in a paper contained in "Drude's Annalen," No. 8, 1905. Very careful measurements have been made by this observer of the relation between current and potential gradient in the case when the currents are of an order 100 to 1,000 times greater than those of the experiments described above. Curves D, E, and F, in Fig. 1, are plotted from the table on page 531 in his paper, being reduced to a saturation value 400, so as to be comparable with the other curves in the same figure. It will be seen that in this case the curves for different widths of the ionisation chamber differ very widely at low potential gradients, and this is in accordance with the present hypothesis. For, when the currents are so large, the value of an^2 is great, and the effects of general recombination must be considerable, unless the potential gradient is much increased. In fact, the general characteristic of these curves is that the larger the current the higher the potential gradient must be at the point where the effects of altering the depth of the chamber cease to be visible.

Several observers have determined the form of the curve connecting current and potential gradient, and have calculated therefrom the recombination co-efficient. Let us now consider the result of neglecting the effects of initial recombination in these calculations.

If the currents are very great, the effects of initial recombination may be small as compared to those of general recombination. But they must always be there, and their effect will be of greater relative importance when the current is made smaller, either by using a weaker source of ionisation or by lessening the width of the ionisation chamber. If both effects are ascribed to one cause, whose influence is measured by a, then a must be given a value which is fictitiously large. The smaller the chamber, the greater the apparent value of a must be; and this is actually the case, as found and remarked upon by Retschinsky. For when the chamber is very small the effects of general recombination ought to be small; and if, as is the case, there is still a considerable lack of saturation at moderate voltages, the whole of which is ascribed to general recombination, the value found for a must be very great. It is possible to find any desired value of a in this way, if only the currents are made small enough. This is especially true if we use the first formula employed by Retschinsky, and ascribed by him to Riecke. In this the determination of a depends on the difference between two current-values taken from the upper part of the curve where the slope is due rather to initial than to general recombination. To make this point clear consider the following determinations of a:—

Retschinsky gives the following form of Riecke's equation where the quantities are expressed in electrostatic units:—

$$a = 5{\cdot}52 \times 10^{-4} \frac{(C-c)\,F_0}{c^2\,l} \left(1 - {\cdot}2 \times \frac{C-c}{c}\right)$$

where C = saturation current per sq. cm. of electrode

c = current for a potential gradient F_0

l = depth of chamber.

He has found by experiment that when l is 1 cm., and F_0 is 151 volts per cm., then (in amperes)

$$C = 8{\cdot}03 \times 10^{-8}/200 \text{ (area of electrode} = 200 \text{ sq. cm.)}$$
$$= 4{\cdot}01 \times 10^{-10}$$
$$c = 3{\cdot}94 \times 10^{-10}$$

Therefore,

$$\frac{C - c}{c^2} = 4{\cdot}5 \times 10^7$$

and by substitution in the equation it can be found that

$$\alpha/e = 4434 \quad (\textit{loc. cit.}, \text{ p. } 530).$$

Now, in a similar experiment, with far smaller currents, we find that when l is 1 cm. and F_0 is 150 volts per cm.

$$C = 4{\cdot}23 \times 10^{-13}$$
$$c = 3{\cdot}90 \times 10^{-13}.$$

Therefore

$$\frac{C - c}{c^2} = 2{\cdot}2 \times 10^{11}$$

and substitution in the equation gives a value of α/e about 5,000 times greater than Retschinsky's, or about 2×10^7.

In the second formula (Stark's) the values of α are more correct, because the current values used are taken, one from the lower part of the curve, and one from the saturation values, so that their difference depends less on the effects of initial recombination. Retschinsky draws attention to these anomalies in his results, but ascribes them to absorption of ions by the electrodes. He argues that in a shallow ionisation chamber this effect must be greater than in a deeper one; and so he accounts for the lack of saturation in the small chamber, a lack which is excessive if attempt is made to explain it as wholly due to general recombination. But we think that a more reasonable explanation is to be found in the hypothesis and results described in this paper, in connection with which Retschinsky's results fall naturally into place. Retschinsky points out that McClung obtained smaller values of α than he himself obtained, and he suggests that, since McClung's apparatus consisted of a series of shallow ionisation chambers, the absorption effects would be considerable. On the hypothesis of this paper McClung's method is so far the more reliable, that it avoids the complications due to the special phenomena which occur in connection with the original forming of the ions, and deals only with a state of things in which ions have been formed and are distributed at random through the gas. All methods in which ions are formed whilst the potential gradient is in existence must be more or less affected by those phenomena, hitherto unregarded, which it is the object of this paper to explain.

When, therefore, the ionising agent is feeble, the only part of the curve which can be altered by varying the current is that where the potential gradient is small; the feebler the agent the smaller the gradient. Let us now consider whether our hypothesis makes it probable that we can alter the shape of the rest of the curve by any variation of the conditions of the experiment.

Now, if initial recombination takes place because the ejected electron does not get far enough away from its parent atom before it is stopped by encountering another atom, then diminution of pressure ought to make it much easier to saturate. But this is a well-known fact (Rutherford, "Philosophical Magazine," vol. xlvii., p. 160). In order to obtain results comparable with those we had already obtained at ordinary pressures, we made several experiments in which all the conditions were the same, except that the pressure was less than that of the atmosphere. Curve C in Fig. 2 shows the results of such an experiment. If this is compared with the other curves in the same figure it will be clear that alteration has taken place in the very portion of the curve where we should have expected it, and where change in the strength of the current has small influence, viz., all along the upper part of the curve up to the high potential end. The saturation current per sq.cm. was about 10^{-13} amp. In further support of our hypothesis it may be pointed out that it gives a ready explanation of an experiment due to Rutherford, and described by him in the "Philosophical Magazine," vol. xlvii., p. 158. He found that the saturation value of the current through a gas could be obtained for a much lower potential gradient when the gas was drawn away from the uranium which ionised it, and treated in a separate vessel. This is to be expected when it is considered that under the circumstances of the experiment initial recombination was wholly absent.

It is now convenient to consider these phenomena as they are manifested in other gases than air. It is well known that the relations between current and potential in carbon dioxide are in some way abnormal. But the peculiarities of this gas are even intensified in ethyl chloride (C_2H_5Cl). The fact is that this effect, which makes it difficult to draw all the ions to the electrodes in the case of air, is far greater in more complex gases, and thus it is extremely difficult to obtain the saturation current unless very high potentials are employed. We find it necessary to use a potential gradient of two to three thousand volts per cm. in the case of ethyl chloride at 60 cm. pressure. In the investigations which were made by us ("Philosophical Magazine," September, 1905), with regard to the ionisation curves in different gases, we found the currents to be unexpectedly small in the case of some gases. We suggested that possibly some of the ions made by the α particles did not get away from their parent atoms. We proposed to make a special investigation of the point, and it was with this purpose that the work described in this paper was undertaken.

It now appears that our suggestion was justified, but it is also clear that we should have obtained larger currents if we had used a higher potential gradient; 500 volts per cm. was insufficient.

Consider the curves in Fig. 3. In A is shown the relation between current and potential gradient up to 3,000 volts per cm. for ethyl chloride at 56 cm. pressure, the saturation current per sq.cm. being about 3×10^{-13}. B shows the same relation in the case of air at atmospheric pressure, the saturation current being rather smaller. Comparison of these two shows how much more difficult it is to obtain the full current in the more complex gas. Again, C shows the results of experiments in which the depth of the ionisation chamber was varied. The crosses refer to a 2 mm. chamber, the dots in circles to a 4 mm. chamber. The currents were of the 10^{-13} order. The two sets of observations lie on practically the same curve. This shows that general recombination is not responsible for the lack of saturation, and that the cause is probably similar to that whose effects in the case of air have been described above. Curves D and E refer to experiments in which the chamber was maintained at the same depth, 2 mm., but the currents were altered by varying the distance of the radium. In the former curve the saturation current is about 10^{-13}, in the latter six times as much. In the case of the results shown in C, D, and E the gas contained a certain proportion of air.

These results all go to show that the form of the curve for ethyl chloride is almost independent, as in the case of air, of strength of current and depth of ionisation chamber, when the ionisation is small. But also, as in the case of air, it depends greatly on the density of the gas. F represents the results of experiments at a pressure of 36 cm., and is to be compared with A. All the conditions, except as regards pressure, were the same for the two curves.

We have also carried out experiments, similar to some of those just described, for a mixture of carbon tetrachloride and air, and obtained similar results. Although there was only 5% (by pressure) of the denser gas in the mixture, yet the current at a potential gradient of 330 volts per cm. was only 82% of the saturation value, whilst in air under similar conditions it was 93%.

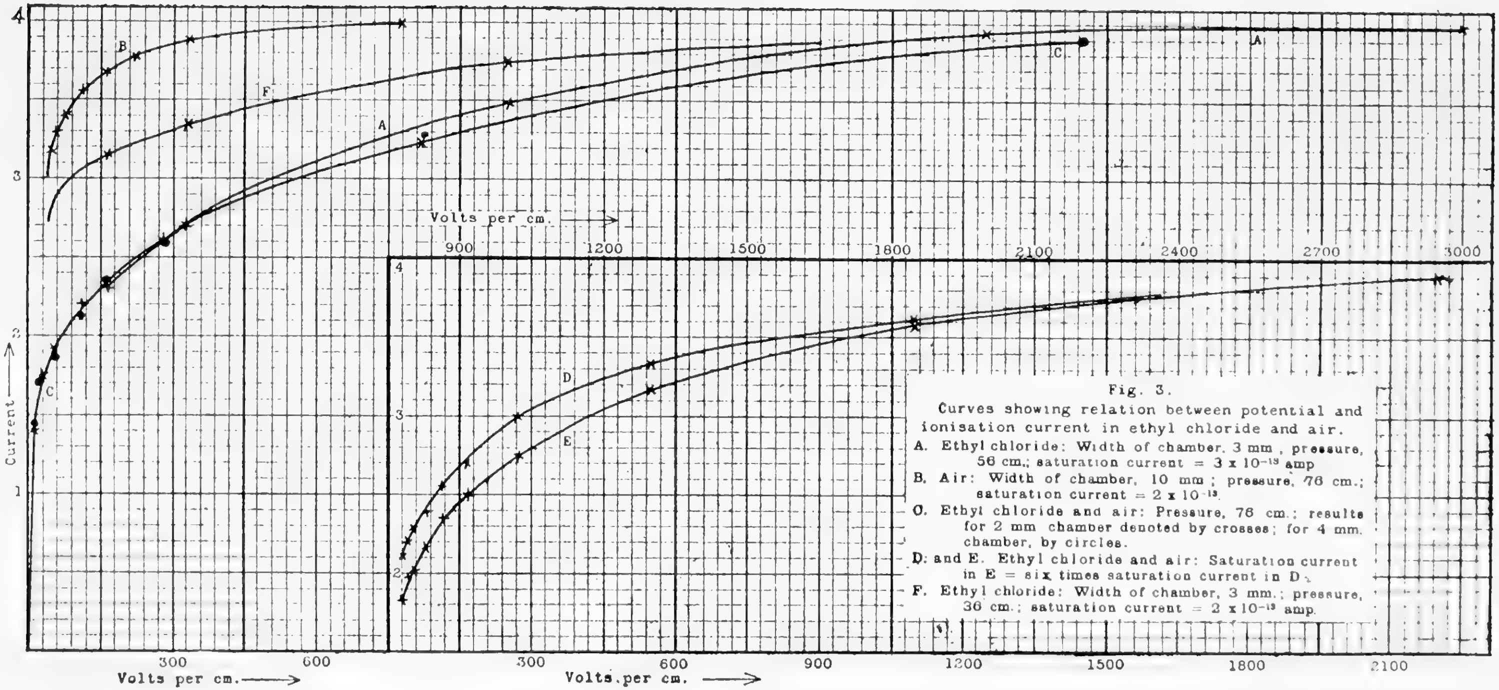

Fig. 3.

Curves showing relation between potential and ionisation current in ethyl chloride and air.

A. Ethyl chloride: Width of chamber, 3 mm., pressure, 56 cm.; saturation current = 3×10^{-13} amp

B. Air: Width of chamber, 10 mm; pressure, 76 cm.; saturation current = 2×10^{-13}.

C. Ethyl chloride and air: Pressure, 76 cm.; results for 2 mm chamber denoted by crosses; for 4 mm. chamber, by circles.

D. and E. Ethyl chloride and air: Saturation current in E = six times saturation current in D.

F. Ethyl chloride: Width of chamber, 3 mm.; pressure, 36 cm.; saturation current = 2×10^{-13} amp.

It is hardly surprising that initial recombination should be more effective in a complex gas than in air. For the molecule contains many atoms, each one of which is just as likely to lose an electron as if it were not associated with other atoms. Perhaps, therefore, the molecule as a whole loses two or three electrons, and its electric field is the more intense. Recombination of this kind must also be easier, the shorter the free path.

It will be clear from the foregoing that certain effects occur which are characteristic of a process of initial recombination, a process which is *a priori* not improbable. The question now arises as to whether any other cause could produce the same effects.

When we consider the great increase of current in a complex gas which is caused by an increase in the electric force applied, we cannot but ask whether any of it is due to the production of other ions by those actually made by the α particle. Could the electric force aid the freed electron to gather speed sufficient to ionise by collision? A process of this kind would be similar in its results to initial recombination, in that it would be independent of strength of current and depth of ionisation chamber. It seems probable, however, that its effectiveness would rather be increased than diminished by lowering the pressure; and also it would be difficult to account for the existence of a saturation value of the current. Nevertheless, it does not seem safe as yet to say that no such process occurs. Probably further light could be thrown on the subject by an investigation into the total number of ions produced in different gases under varying conditions. Some initial experiments of this kind will be described presently.

Rutherford has recently shown that the α particle of RaC has only lost 40% of its velocity when it ceases to ionise. If this fact is considered in conjunction with our investigations into the form of the ionisation curves for gaseous mixtures, it is at once clear that the α particle stops ionising in every gas when its speed has fallen to precisely the same value. For, if not, the ionisation curve for a mixture would show a superposition of simple curves, of which effect there is no trace. This and other considerations seem to show, as we have already said ("Philosophical Magazine," September, 1905), that the α particle performs the same number of acts of ionisation in every gas. If, then, we find the total saturation current to be different in different gases, we must come to the conclusion that either the ions in the gases of higher conductivity produce others by the help of the electric field, or that in the gases of lower conductivity some of the ions made by the α particle do not get free, even under conditions of saturation, from their parent atoms, or that both these effects take place. With the object of helping to a decision on this point we have begun a set of experiments, of which those now described are the first examples.

The method used is to measure the co-ordinates of some standard point on the ionisation curve of the gas investigated, under different pressures. The point chosen is that where the side of the RaC curve is struck by the top of the curve which belongs to the α particles of next velocity to those of RaC. This point in air, at 760 mm. and 20° C., is at a height of nearly 4·83 cm. It is a convenient point to choose, for the following reasons:—Being on a part of the RaC curve, where no great change in the ionisation takes place for a considerable alteration in range, the measurements there are usually pretty consonant with each other, even though they are taken quickly, and if several be taken on the RaC curve they check each other. The ordinate of this point can also be determined with great precision by measuring two or three points along the top slope of the curve of RaA (or emanation, whichever it finally proves to be). Thus, a few readings can be quickly taken in succession which determine the point accurately, and very little leakage of air into the apparatus takes place while the experiments go on. This is a desirable thing, because our apparatus leaks slowly when the pressure within is much reduced, on account of the large number of connecting tubes and mechanical arrangements. We find that this method is very satisfactory. We may mention also that to save time it is not well, in the case of gases like ethyl chloride, which are at first in the liquid form, to admit any of the liquid into the apparatus, as it takes so long to evaporate completely. It is better to let the liquid evaporate in another chamber, which can be quite small, and then to take over gas only.

Fig. 4 shows the results of some experiments with C_2H_5Cl. The curves shown are portions of the ionisation curves in this gas at different pressures. In all cases the apparatus was exhausted of air to about 10 mm. pressure, then partly filled with gas, re-exhausted, and filled again to the desired pressure. The observations were made at once, those in the neighbourhood of the standard point being made first, so that the gas might be as pure as possible whilst the important readings were being taken. A potential of 900 volts was used for the three greater pressures, and of 300 for the low pressure. The chamber was 3 mm. wide, and therefore these potential gradients were, respectively, 3,000 and 1,000 volts per cm.

The results for ethyl chloride and for air are contained

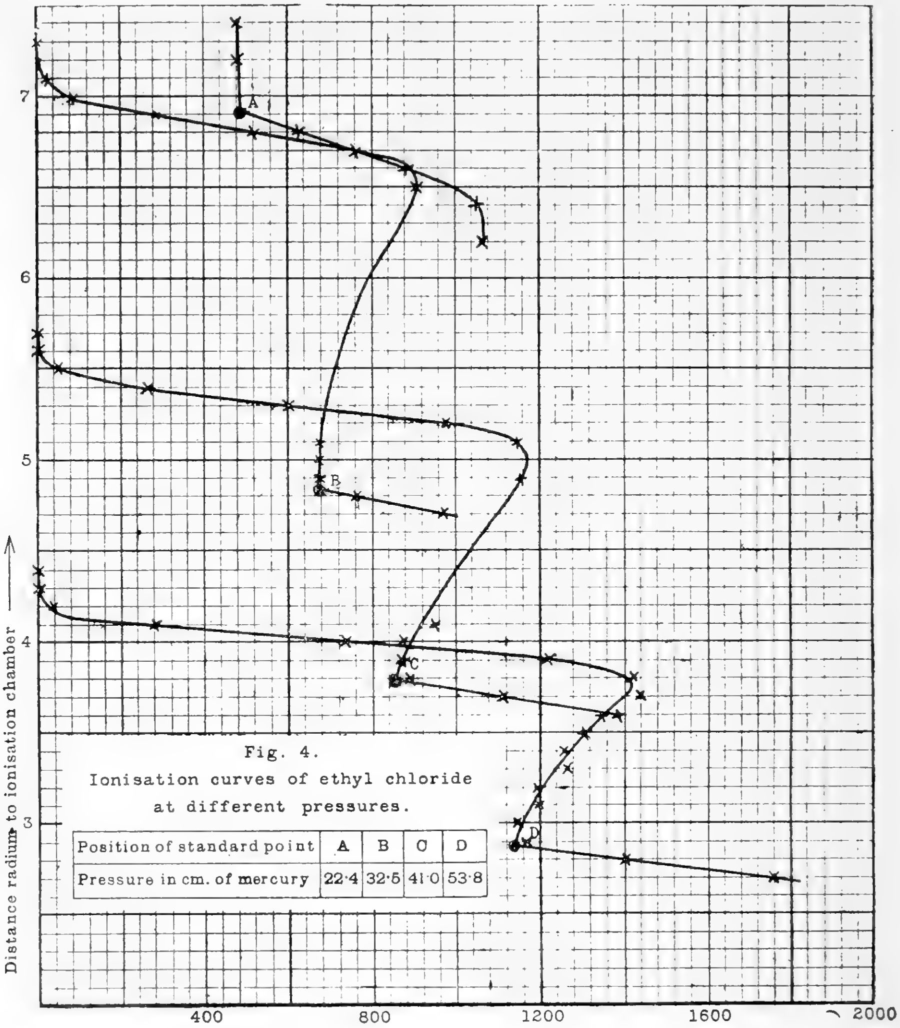

Fig. 4.
Ionisation curves of ethyl chloride
at different pressures.

Position of standard point	A	B	C	D
Pressure in cm. of mercury	22·4	32·5	41·0	53·8

in the following table, where P. denotes the pressure, R. the range, and I. the ionisation on an arbitrary scale:—

Ethyl Chloride.

P.	R.	I.	R. × I.	R. × P.
53·8	2·87	1,140	3,260	154
41·0	3·78	860	3,260	155
32·5	4·83	666	3,220	157
22·4	6·92	476	3,300	155

Air.

P.	R.	I.	R. × I.	R. × P.
75·3	4·72	546	2,570	355
57·9	6·08	432	2,620	352
46·9	7·42	340	2,520	348
38·8	9·00	283	2,540	349

These results relate to two gases only; but so far as they go they show:—(i.) That the range varies inversely as the pressure, which result might have been anticipated; (ii.) that the total number of ions set free in a gas is independent of the pressure, but is different in different gases. The total ionisation is greater in ethyl chloride than in air. This is a contrary result to that which we obtained during our experiments on absorption. We were unaware at that time of the enormous force required to saturate the complex gas.

Finally, the following experiments may be briefly described:—

We have tried the effect of reversing the field on the relation between current and potential, and found a result which was practically negative. We have found a similar result when the α particles were not shot straight across the ionisation chamber in the direction of the lines of force, but in a slanting direction. These experiments were made in the endeavour to find whether there was any relation between the direction in which electrons were projected and the direction of the applied field. We have also tried to alter the range in air by using different potential gradients, with the idea that it might be possible to obtain ions from an atom traversed by a slower α particle, if only enough electric force were applied. But the result was the same, no matter whether the force was 20 volts to the cm. or 2,000: and a variation of ·2 mm. could hardly have escaped detection.

In a paper which we had the honour to lay before this Society on June 6, 1905, we described the results of some investigations into the correct form of the ionisation curve. Assuming that the α particle had lost almost all its energy when it ceased to ionise, we showed that it spent its energy at a rate which was inversely proportional to the square root of its speed. This assumption appeared to us at the time to be reasonable, but Rutherford has shown since then ("Philosophical Magazine," July, 1905), that the α particle of RaC still retains 40% of its initial energy when it ceases to ionise the gas through which it passes. In consequence, the conclusion which we drew from our experimental results needs modification. Recalculation shows that the α particle spends energy at a rate which is inversely proportional to the square of its speed. This is interesting, since this is the rate at which any particle moving with great speed gives up energy to a particle, relatively at rest, which it passes by, it being supposed that a force acts between the two which is a function of their mutual distance (Report of the Australasian Association for the Advancement of Science, Dunedin, 1904. p. 64). Rutherford's remarkable discovery does not affect any other of our conclusions.

We have examined the loss of range of the α particle in passing through several other atoms and molecules, and found that in all cases the square root law is fulfilled at least as accurately as for the atoms and molecules of the original list. The new substances are:—Lead, iron, nickel, oxygen, carbon dioxide, carbon bisulphide, ethyl iodide, chloroform, pentane, and benzene.

During the progress of this work, one of us (R. D. Kleeman) left Australia for England. We wish to acknowledge with gratitude the assistance of Mr. H. J. Priest, B.Sc., in completing the observations.

AN AROID NEW FOR AUSTRALIA.

By J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney, Honorary Fellow.

[Read June 6, 1905.]

Amorphophallus campanulatus, Blume, Pine Creek, Northern Territory of South Australia (J. H. Niemann). Cultivated in the Botanic Gardens, Sydney, where it flowered, October, 1904. Water colour drawings of the flower (October, 1904), and of the foliage (January, 1905), have been executed by Miss Margaret Flockton, and are deposited in the National Herbarium, Sydney.

This species belongs to the section "Candarum," chiefly distinguished from the other sections by the long style.

According to Engler's Monograph of Aroideæ in DC.'s Monographiæ Phanerogarum, vol. ii., p. 308 (1879), the following three species belong to this section:—

A. campanulatus, Blume.
A. dubius, Blume.
A. hirsutus, Teysm.

The measurements of our plant are:—

Height of spathe, 10¾ inches.
Breadth of spathe, 8 inches.
Height of spadix, 8½ inches (from base to top of sterile appendage).
Sterile appendage, nearly 4 inches broad, and rather above 3 inches high.

The measurements of *A. dubius* are, according to "Bot. Mag.," t. 5187:—

Height of spathe, 6 inches.
Height of spadix, 4 inches.

It will be seen that the flower is about twice as large as those of *A. dubius*, and are sharply distinguished from that species by the wrinkled appendage of the spadix, which is smooth and almost egg-shaped in *A. dubius*.

The following are actual measurements of the plant of *A. campanulatus*:—

Height of plant, 6 feet 4 inches.
Length of petiole (trunk), 3 feet 10 inches.
Diameter of petiole, 1¾ inches.
Length of leaf, 2 feet 6 inches.
Spread of foliage, 4 feet 4 inches.

The leaf does not differ from that of the type of *A. campanulatus*.

The flower differs in colour and shape. In the typical *A. campanulatus* (as figured in "Bot. Mag.," t. 2812, and in Blume's "Rumphia," I. t. 32 and 33) the spathe is broader than high, while in the Northern Territory specimen *the spathe is higher than broad.* The Northern Territory plant is, further, darker inside and more distinctly spotted outside than the type, and the sterile expansion on the top of the spadix is considerably less wrinkled.

I do not think these differences are sufficient to warrant its description as a new species, and, in view of the amount of variation known to exist in the species, I am not altogether free from doubt as to the expediency of giving it a varietal name. But it may be a convenience to distinguish the Northern Territory form, and therefore I propose the name *A. campanulatus*, Blume, var. *australasica*, for it.

Several new species of *Amorphophallus* have been described since 1879 (the date of Engler's Monograph), but none of the species recorded in the Supplement to the "Index Kewensis" come near the Northern Territory plant, so that I have no doubt the plant is unrecorded for Australia.

Mueller mentions *A. variabilis*, Blume, as the only Australian species, and Bailey adds two more species, *A. galbra* and *A. angustiloba*, but all these three species belong to a different section of the genus, and are very different from the plant under consideration.

The geographical range of *A. campanulatus* is from Madagascar to the Malayan Archipelago and the Melanesian and Polynesian Islands, so that its occurrence in Australia is only what could have been expected.

DESCRIPTIONS OF AUSTRALIAN CURCULIONIDÆ, WITH NOTES ON PREVIOUSLY DESCRIBED SPECIES.

By Arthur M. Lea.

Part III.

[Read October 3, 1905.]

SUB-FAMILY OTIORHYNCHIDES.

Myllocerus and Allied Genera.

There is a very natural group of the *Otiorhynchides*, of which *Myllocerus* is the leading genus, that is abundantly represented in Australia. The species are all comparatively small, and live on foliage; many of them are clothed with green scales, which to the naked eye are sufficiently beautiful, but which, under the microscope, are almost dazzling; under that instrument also scales apparently the most sober greys and fawns take on a lovely appearance. The species are most numerous in the tropics, and become sparser and more soberly coloured the greater the distance from the equator; from Tasmania the group appears to be entirely absent.* Mr. Pascoe proposed a number of genera allied to *Myllocerus*, but it is very doubtful if they will all be maintained. He regarded the bisinuation of the base of the prothorax as the main distinguishing feature of *Myllocerus*, but this is a variable character, and at least two species *(ignaria* and *bicolor)* have been referred to *Titinia*, in which the base is bisinuate.

I do not know a single external character which alone is sufficient to denote the sex of a specimen; where the sexes are before one they can sometimes be distinguished by the greater size of the females: in some species also the scape is considerably stouter in one sex than in the other; the shape of the prothorax is also not always the same; but these characters are useless for ascertaining the sex of unique specimens.

The scales are usually so dense that the derm cannot be seen, and the shape and positions of the punctures are seldom traceable: consequently, before describing the new species, I have always considered it necessary to partially abrade at least one specimen. By doing this great differences can be seen to exist in the punctures of the prothorax (and to a less extent of the elytra), and of which absolutely no sign was visible before abrasion.

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* It is true that *Myllocerus speciosus* was described as from Western Australia and Tasmania, but I do not believe that it, or any other species of *Myllocerus*, occurs in Tasmania.

Practically any species with green scales, belonging to the allied genera, would fit the description of *Myllocerus australis*, Boi., so until more information is forthcoming I think this name should be regarded as non-existent.

MYLLOCERUS TREPIDUS. Pasc., and DUPLICATUS, Pasc.

There are four specimens before me, from Port Denison and Endeavour River, which evidently belong to one of these species, but as to which is very doubful if these names really appertain to distinct species. The four specimens appear to agree very well with either of the formal descriptions, but on comparing these together the following apparent discrepancies appear:—

Trepidus	*Duplicatus.*
Second joint of funicle longer than first	Second joint much longer than first
Prothorax short	Prothorax very short
Scutellum oblong	Scutellum less oblong
Elytra with irregular white setæ	Elytra with white setæ in double series.

Duplicatus is also said to be more richly coloured, and the setose scales otherwise arranged.

The four insects have the elytral setæ arranged in places in double and in places in treble series, but the apparent arrangement is subject to alteration according to the point of view. If, however, the character of the antennæ is reliable, the specimens will belong to *trepidus*, as the second joint of the funicle is but very little longer than the first.

MYLLOCERUS DARWINI, Blackb.

I have two specimens from Cairns, one of which agrees exactly with the description of this species, but in the other three very faint infuscate lines can be traced on the prothorax.

MYLLOCERUS SPECIOSUS, Blackb.

A species which appears to be common in North Queensland* agrees with the description of this insect. The dark vittæ of the prothorax are somewhat variable in shape and width, and the scales on the elytra of some specimens have a distinct golden gloss.

MYLLOCERUS LATICOLLIS, n.sp.

Dark reddish brown; appendages somewhat paler. Densely clothed with whitish-grey scales, on the upper surface obscurely mottled with brown; in addition with stout setose scales or setæ; dense on legs, dense and rather fine on antennæ, and subseriate in arrangement on elytra, on the latter they are but little elevated above the general level.

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* Cairns, Endeavour River, Cooktown, etc.

Head not impressed between eyes; these prominent and suboval. Rostrum short, broad, and slightly concave. Scrobes distant. Two basal joints of funicle subequal in length. *Prothorax* strongly transverse, sides strongly dilated to base: base strongly bisinuate and distinctly wider than elytra. *Scutellum* transverse. *Elytra* slightly dilated at shoulders, thence parallel-sided to near apex: striate-punctate. *Femora* feebly dentate. Length, 5½ mm.

Hab.—Queensland: Cairns (Henry Hacker).

The base of prothorax distinctly wider than the elytra will readily distinguish from all previously described species. On abrasion the prothorax is seen to be supplied with rather small, isolated punctures: those on the elytra are fairly large, round, and in distinct striæ, but before abrasion appear to be much smaller and narrowly oblong.

MYLLOCERUS ABUNDANS, n.sp.

Black, appendages in places obscurely diluted with red. Densely clothed with scales, usually more or less green in colour. In addition with numerous setæ, which on the elytra have a tendency to form in double rows on each interstice.

Head narrowly impressed between eyes; these oblong oval. Rostrum short, but rather narrow, slightly constricted in middle, feebly concave along middle. Scrobes deep, large, and approximating behind. Antennæ stout: scape grooved below; first joint of funicle as long as second and third, second as long as third and fourth, seventh slightly longer than sixth. *Prothorax* transverse, apex much narrower than base, and slightly incurved to middle; sides strongly rounded, base trisinuate, the median sinus small and the width of scutellum. *Scutellum* transverse. *Elytra* not much wider than and closely applied to prothorax: striate-punctate. *Femora* feebly dentate. Length, 6½ to 8½ mm.

Hab.—N.W. Australia: Roebourne (C. French).

Judging by the numerous specimens before me, the colour of the scales seems subject to alteration after death, either through improper treatment or through oily exudations. When alive the scales are probably of an uniform bright green, but in specimens before me there are patches, varying from single scales to large, irregular areas, in which the process of change appears to be as follows:—From bright green to golden green, then to bright golden, then to dull golden, and finally to ashy, in this stage all lustre having disappeared: the patches are never symmetrical (unless the whole of the scales are changed), but may be confined to one side, and appear in some instances to have been altered through contact with other insects in the bottle in which they were collected. I believe in other species of the subfamily the scales are also subject to alteration.

The elytral setæ are often indistinct, and (except to a slight extent posteriorly) do not rise above the general level, on the prothorax they are more distinct. The eyes are less prominent than in any other here recorded. The emargination of the apex of the prothorax, although of the same nature, is much less distinct than in *Bovilli*. In other species of the genus the scutellar lobe is probably emarginate, but the emargination masked. In the present species, however, it is sufficiently deep to prevent the scales entirely masking it. The scape is narrowly grooved throughout its entire lower surface, a most unusual character in any genus of weevils; there are, however, several of its congeners with traces of this feature. On abrasion, the punctures are seen to be as described in the preceding species, and the rostrum to have two fine costæ marking the inner boundaries of the scrobes.

Possibly close to *aurifex*, but differs from the description of that species in having the elytra without patches or spots of fawn, the rostrum longitudinally impressed (the impression, however, often concealed by scales), the eyes slightly oblong, elytra not much wider than base of prothorax, and the second abdominal segment (at least along middle) much shorter than the first; also in *aurifex* no mention is made of setæ. With the description of *glaucinus* it agrees fairly well, but it cannot be that species, as Pascoe tabulates it as having the "eyes round" and "form more slender," whilst the present species is the most robust of its genus I have seen.

MYLLOCERUS AMBLYRHINUS, n. sp.

Black, appendages reddish. Densely clothed with white (very lightly tinted with blue) scales, on the elytra obscurely variegated with small pale brown spots. In addition with short setæ, which on the elytra are curved and slightly elevated above the general level.

Head convex. Eyes suboval and very prominent. Rostrum very short, subquadrate, concave only at extreme apex. Scrobes distant. First joint of funicle not much longer than second. *Prothorax* strongly transverse, base moderately bisinuate and slightly narrower than apex; sides rounded. *Elytra* much wider than prothorax, striate-punctate. *Femora* minutely dentate. Length, 5½ mm.

Hab.—N.W. Australia: Roebuck Bay (C. French).

The rostrum is unusually short, and the eyes are more prominent than usual. The femoral teeth are so small as to be invisible from most directions. On abrasion the prothoracic punctures are seen to be fairly large, and more numerous than in the two preceding species, but those on the elytra are much the same.

Evidently close to the description of *nasutus*, but smaller, prothorax slightly *narrower* at base than at apex, and with distinctly rounded sides, the elytra without rows of decumbent scales, although on each interstice there is a row of larger scales, but these are nowhere elevated above the others. From the description of *torridus* it differs in the first joint of the funicle slightly longer than the second and the base of its prothorax not very strongly bisinuate.

MYLLOCERUS SORDIDUS, n. sp.

Blackish-brown, appendages in places obscurely diluted with red. Densely clothed with white or whitish scales; on the upper surface largely mottled with rusty brown. In addition with numerous setæ, which on the elytra have a tendency to form in irregular rows, and are distinctly elevated above the general level.

Head narrowly impressed between eyes; these suboval and not prominent. Rostrum not very short, feebly but regularly diminishing in width to apex, feebly concave. Scrobes rather distant. Antennæ fairly stout; apical half of scape feebly grooved beneath; first joint of funicle distinctly longer than second. *Prothorax* moderately transverse, apex feebly incurved to middle, sides rounded; base rather strongly bisinuate and not at all or but slightly wider than apex. *Elytra* considerably wider than prothorax, very feebly increasing in width to beyond the middle; striate-punctate. *Femora* edentate. Length, 5-6½ mm.

Hab.—Western Australia: Geraldton (A. M. Lea).

On abrasion the punctures of the prothorax are seen to be fairly large and rather numerous, with the minute intervening punctures* rather more distinct than usual.

MYLLOCERUS NIVEUS, n. sp.

Black, appendages reddish. Densely clothed with pure white scales. In addition with numerous stout setæ, which on the elytra are formed into irregular rows and slightly elevated above the general level.

Head narrowly impressed between eyes; these briefly elliptic and prominent. Rostrum not very short, diminishing in width from base but not to extreme apex, gently concave in front. Scrobes rather distant, distinct to eyes. Antennæ thin, all joints of funicle elongate, first slightly longer than second. *Prothorax* moderately transverse, sides rounded, extreme base slightly wider than apex, and srongly bisinuate. *Elytra* much wider than prothorax, parallel-sided to near apex; striate-punctate. *Femora* finely dentate. Length, 6-7½ mm.

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* These minute punctures are evidently for the scales, the larger ones being for the setæ; they are to be seen on all the species on abrasion, both on the prothorax and elytra.

Hab.—Queensland: Cooktown, Endeavour River (C. French).

On abrasion the punctures of the prothorax are seen to be rather large, those on the elytra (although before abrasion apparently no larger than in other species) are almost as wide as the interstices separating them.

MYLLOCERUS ELEGANS, n. sp.

Dark reddish-brown; appendages reddish. Densely clothed with pale-green, golden-green or rosy glistening scales. In addition with fine setæ, which on the elytra are formed into irregular rows, and scarcely rise above the general level. Length, 6 mm.

Hab.—N.W. Australia: Roebourne (C. French).

In structure much like the preceding species, but the eyes rather less prominent, the prothorax longer, more convex across middle, the sides more strongly rounded, and base not so strongly sinuous; the antennæ are stouter, and the first joint of the funicle is considerably longer than the second; the scales are greenish instead of dull, dead white, setæ denser, finer, and longer; the punctures (as seen after abrasion) are also larger and more irregular on the prothorax and smaller on the elytra. The setæ on the upper surface are unusually thin. It agrees fairly well with the description of *glaucinus*, but cannot be that species, which Pascoe placed in his table amongst those having "prothorax much broader at the base," whilst in the present species the base and apex are of equal width; *pudicus* (from Nicol Bay, practically the same as Roebourne) is briefly compared with *glaucinus*, and placed beside it in the table, so that it also cannot be the present species.

There are two specimens before me, one having the scales as described, the other having them almost entirely without gleam, and white, except that in places they are lightly tinged with green or gold: on this specimen the elytral setæ (although exactly as in the type) are much more distinct. The species, in fact, appears to be one in which the scales (as in *abundans*) are subject to alteration.

MYLLOCERUS RUGICOLLIS, n. sp.

Reddish-brown, appendages paler. Densely clothed with pale, greyish scales, on the elytra very slightly (or not at all) variegated with small spots of pale brown. In addition with fairly stout setæ, but on the elytra these are very sparse and indistinct.

Head feebly convex, very narrowly impressed between eyes: these briefly elliptic and rather large. Rostrum subquadrate, feebly concave. Scrobes distant. Antennæ rather stout; scape grooved on its lower surface at apex; first joint of funicle slightly longer than second, the others all slightly transverse; club rather short. *Prothorax* moderately transverse, apex slightly wider than base, sides rounded, base not very strongly bisinuate. *Elytra* much wider than prothorax, widest at their middle; striate-punctate. *Femora* distinctly dentate. Length, 5-6¼ mm.

Hab.—Queensland: Brisbane (R. Illidge, T. McGregor, and E. J. Turner).

The prothorax has an elevated ridge across its middle, with a slight depression on each side behind it, the depressions being occasionally very distinct. On abrasion the punctures of both prothorax and elytra are seen to be almost exactly as in the preceding species, but the elytral interstices are narrower and more convex.

Close to the description of *modestus*, but all the femora distinctly dentate, instead of the front femora only (at least it is so implied), prothorax no wider at base than at apex and sides quite strongly rounded; for that species also no mention is made of the transverse prothoracic impressions so conspicuous in the present species.

There are two specimens before me from the Endeavour River, which I hesitate to regard as this species, although they have a strong general resemblance to it. They differ in having thinner antennæ, none of the joints of the funicle transverse, and in having the femoral dentition stronger: the transverse impressions on the prothorax are also absent.

MYLLOCERUS ECHINATUS, n. sp.

Dark reddish-brown, appendages (except club) somewhat paler. Very densely clothed with greyish or pale fawn-coloured scales. In addition with numerous stout setæ: long, erect, or suberect on the elytra, shorter on the prothorax and head, and still shorter on the appendages.

Head with the eyes briefly elliptic and rather large. Rostrum moderately long and concave. Scrobes subapproximate. Antennæ stout; first joint of funicle slightly shorter than second. *Prothorax* as long as wide, sides scarcely rounded, and very feebly increasing in width to base, base strongly bisinuate. *Elytra* much wider than prothorax, parallel-sided to near apex; striate-punctate. *Femora* edentate. Length, 4-4½ mm.

Hab.—North Queensland: (H. J. Carter), Cairns (E. Allen).

The elytral setæ or bristles are longer and stouter than in any other species known to me, each is directed at almost or quite a right angle with the derm in which it is set. From behind they can be seen to be in quite regular rows, of which the alternate ones are slightly higher than the others. On abrasion the punctures of the prothorax are seen to be very large (they are fully twice as large as those of any here recorded), close together, and rough; those on the elytra are large (but smaller than those on prothorax), with the interstices separating them narrow and rather strongly convex. The rostrum has two very strong costæ, which are almost or quite concealed by the clothing.

MYLLOCERUS SUTURALIS, n. sp.

Dark reddish-brown, elytra and appendages paler. Densely clothed with whitish scales; on the under surface slightly tinged with blue, on the upper surface largely (and to a variable extent) mottled with rusty brown. In addition with numerous stout setæ, which on the elytra become long and suberect.

Head almost flat, and with a small impression between eyes: these fairly large and briefly elliptic. Rostrum slightly longer than wide, slightly diminishing in width to apex, feebly concave. Scrobes distant. Antennæ rather thin; first joint of funicle slightly longer than second. *Prothorax* about as long as wide, apex just perceptibly incurved to middle, sides slightly rounded, base as wide as apex and feebly bisinuate. *Elytra* much wider than prothorax, almost parallel-sided to beyond the middle; striate-punctate. *Femora* finely but acutely dentate. Length, $3\frac{2}{3}$-$4\frac{2}{3}$ mm.

Hab.—Queensland: Gayndah (Australian Museum).

The white scales clothe the sides, and form a continuous line commencing between the antennæ and terminated at the tip of elytra, they usually clothe the shoulders and form spots (sometimes condensed into more or less oblique fasciæ) between the sides and suture. On several specimens, however, the white scales do not form a median line on the prothorax, and on the elytra no distinct spots or patches are defined. The elytral setæ are almost as long as in the preceding species, but are thinner and less erect, whilst those on the prothorax and head are quite normal. On abrasion the prothoracic punctures are seen to be fairly large and dense, those on the elytra are also fairly large and close together.

Although the base of the prothorax is almost truncate, I have referred this species to *Mylloceru*s, despite Mr. Pascoe's contention that all such species should be excluded; to fall in line with Mr. Pascoe it would be necessary to propose a bewildering number of new and highly unstable genera. In general appearance, the present is close to several species of *Myllocerus*, closer still perhaps to several species of *Titinia*, but its dentate femora exclude it from that genus, from *Proxyrus* (also with dentate femora and base of prothorax subtruncate), its prothorax distinguishes it, from *Proxyrodes* it is distinguished by the scape passing the apex of the prothorax.

MYLLOCERUS TRILINEATUS, n. sp.

Dark reddish-brown; elytra and appendages paler. Densely clothed with scales; white on the lower surface, rusty-brown, variegated with dingy white on the upper. In addition with stout setæ, which on the elytra are arranged in regular rows, and scarcely rise above the general level. Length, male 5, female 7 mm.

Hab.—Queensland: Gayndah (Australian Museum).

Decidedly allied to the preceding species, and placed in *Myllocerus* for the same reasons; but differs in its feeble elytral setæ and in its larger size, the base of its prothorax is also slightly more sinuous; the rostrum slightly diminishes in width from base, but not to extreme apex, and is not concave, and the antennæ are rather thin. On abrasion the punctures are seen to be much the same, except that those on the prothorax are somewhat denser and coarser. In all other features of structure, however, the two species are almost identical.

The brown scales are almost absent from the head, form three feeble stripes of variable intensity on the prothorax (of which the median is always narrower than the others), and are condensed into numerous spots on the elytra, these spots (although never eye-like in character) frequently have their centres darker than their margins. I have two pairs pinned as having been taken *in cop.*, but except for the difference in size the sexes appear to be exactly alike.

MYLLOCERUS EXILIS, n. sp.

Brownish-red, appendages of a rather pale red. Densely clothed with white or greyish-white scales (slightly tinged with blue or not); prothorax with three very pale stripes of brown, elytra usually with very indistinct brownish spots. Setæ much as in the preceding species.

Head moderately convex; eyes briefly elliptic. Rostrum shorter than wide, feebly diminishing in width to apex. Scrobes moderately distant. First joint of funicle just perceptibly shorter than second; scape stouter in female than in male. *Prothorax* in male slightly longer than wide, in female very feebly transverse, sides feebly rounded, base the width of apex, and rather feebly bisinuate. *Elytra* much wider than prothorax, widest at about the middle; striate-punctate. *Femora* very feebly dentate. Length, 4¼-5½ mm.

Hab.—N.W. Australia: Roebourne (C. French).

A rather thin species; its clothing on the whole is much as in the preceding species, except that it is much paler (on only one specimen before me are the markings at all distinct), but the size of both sexes is distinctly less, and the prothorax is decidedly longer, and on abrasion the punctures are seen to be somewhat smaller and more regular.

The species of *Myllocerus* known to me may be tabulated as follows: —

- Prothorax at base wider than elytra ... *laticollis*, n. sp.
- Prothorax narrower than elytra.
  - Prothorax at base much wider than at apex.
    - Apex of prothorax strongly incurved ... *Bovilli*, Blackb.
    - Apex of prothorax straight, or almost so.
      - Clothing never green ... ... *cinerascens*, Pasc.
      - Clothing more or less green.
        - Prothorax with two irregular black vittæ ... ... *speciosus*, Blackb.
        - Prothorax without vittæ. ... ... *abundans*, n. sp.
  - Prothorax at base not at all or very little wider than at apex.
    - Elytra with long setæ or bristles.
      - Setæ on prothorax and head also long *echinatus*, n. sp.
      - Setæ on prothorax and head normal ... *suturalis*, n. sp.
    - Elytra never with long setæ.
      - Clothing more or less green.
        - Elytra wider at middle than at base *trepidus*, Pasc.
        - Elytra parallel-sided to beyond the middle.
          - Prothorax strongly rounded in middle ... ... *elegans*, n. sp.
          - Prothorax at most moderately rounded in middle.
            - Prothorax less than once and one half as wide as long ... *usitatus*, Lea.
            - Prothorax at least once and one half as wide as long.
              - Sutural interstice with distinct setæ throughout ... *carinatus*, Lea.
              - Sutural interstice at most setose posteriorly ... ... *Tatei*, Blackb. *Darwini*, Blackb.
      - Clothing of upper surface not at all green.
        - First joint of funicle shorter than second ... ... *exilis*, n. sp.
        - First joint of funicle longer than second.
          - Rostrum wider than long.
            - Elytra wider at middle than at base ... ... *rugicollis*, n. sp.
            - Elytra parallel-sided to beyond the middle ... ... *amblyrhinus*, n. sp.
          - Rostrum longer than wide.
            - Clothing pure white ... ... *niveus*, n. sp.
            - Clothing more or less variegated.
              - Narrowest part of rostrum its apex ... ... *sordidus*, n. sp.
              - Narrowest part of rostrum before its apex ... ... *trilineatus*, n. sp.

TITINIA.

As with many others of Mr. Pascoe's genera, there is really very little to distinguish this genus from *Myllocerus*, the sinuation at the base of the prothorax being practically one of degree only. I have referred but one new species to it, but several placed in *Myllocerus* might have been so referred, only that their femora are dentate, and this character (not that it is a very good one) I have regarded as a bar to the species belonging to *Titinia*.

TITINIA EREMITA, Blackb., and BICOLOR, Blackb.

Specimens of both of these species were sent to me by Mr. Blackburn (his 469 and 3945); the two are very closely allied, but appear to be distinct on account of the first joint of the funicle being much longer than the second in *eremita* and not much longer in *bicolor;* in the former also there is a median whitish vitta on the prothorax, and that part is more parallel-sided.

In the table Mr. Blackburn supplies* he divides the genus into two sections:—

"A. Rostrum very narrow between the scrobes."
"AA. Rostrum but little narrowed between the scrobes."

These expressions are somewhat misleading, inasmuch as the width of the rostrum *between* the scrobes is much the same in both sections;† in "A," however, the rostrum itself is almost continuously narrowed from the base to the apex, but in "AA" it is narrowed from the base, and then increases in width to the apex. But the upper surface of the rostrum between the scrobes is greatly constricted in both sections.

TITINIA IGNARIA, Pasc.
marmorata, Pasc.
læta, Blackb.

These names appear to appertain to but one species, *ignaria* having been described from a female with the markings but little pronounced; *marmorata* from a male (the male is always smaller than the female in this species, as in most, if not all, of the subfamily). *Ignaria* was described as having the "head (the rostrum presumably included) without any traces of lines or excavations"; *marmorata* as having *"capitis fronte rostroque in medio linea longitudinaliter impressa."* This apparent difference, however, was probably due to the

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* P.L.S.N.S.W., 1892, p. 121.

† At least in *læta, tenuis*, and *brevicollis* of A, and *bicolor* and *eremita* of AA; the appearance of this space, moreover, varies according to whether the scales have been abraded or not.

comparative freshness of the individuals, as when the head and rostrum are densely squamose no line can be seen, but when at all abraded a line can be traced.

The species is a variable and widely distributed one, and is common on various species of acacia. The elytra are sometimes almost entirely pallid, whilst in others they are very decidedly maculate: they always, however, have rows of semi-erect bristles. The prothorax is usually supplied with three infuscate lines, occasionally with but two (it was probably from a female of this form that Blackburn drew up his description of *læta)*, whilst a form is not at all uncommon in which the whole upper surface of the prothorax is clothed with infuscate scales. The size varies from 1⅓ to 2 mm.

In this species (as in others of the subfamily) the apparent width and shape of the joints of the funicle differ according to whether they are free or clogged with gum, and fresh or abraded.

On one specimen before me the deciduous mandibular processes are present. They are strongly curved, not half the length of the head and rostrum combined, widest and obtusely dentate in the middle, and of a reddish colour.

The species is very close to *tenuis* and *brevicollis* (if these are really distinct), but differs in having the prothorax longer and the elytra with semi-erect bristles.

Hab.—Victoria: Grampians, Ararat, Melbourne; New South Wales: Blue Mountains, Springwood, Forest Reefs; Queensland: Brisbane.

TITINIA PARVA, n. sp.

Black, appendages (except middle of femora) reddish. Densely clothed with dingy whitish and slaty-brown scales, and with sparse, stout setæ.

Head narrowly impressed in middle, the impression continued on to rostrum. Eyes large, almost round. Rostrum gradually narrowing to apex. Scrobes short, deep, and approximating behind. Scape strongly curved: first joint of funicle distinctly longer than second. *Prothorax* feebly transverse, base lightly bisinuate, sides lightly rounded in middle. *Elytra* subparallel on basal two-thirds, much wider than prothorax: striate-punctate. *Femora* edentate. Length, 2½ mm.

Hab.—Victoria (National Museum).

The smallest of the subfamily as yet recorded from Australia. From *ignaria* it differs in being smaller, in the elytra having the setæ sparse, short, and scarcely (usually not at all) rising above the general level (instead of rather dense and sub-erect): the club also is reddish. The prothorax is distinctly longer than in *tenuis* and *brevicollis*.

The white scales in places (but especially on the under surface) are slightly tinged with green, but they are nowhere shining; they clothe the head (on one specimen there is a broad median patch of brown scales extending from the base to between the antennæ), rostrum, scutellum, under surface, and legs; form four lines on the prothorax (two median and two lateral), and are distributed in irregular patches on the elytra; on the latter they cover from one-fourth to one-half of the surface, on the prothorax they cover less than half. The setæ are rather numerous on the legs and antennæ, rather sparse on the prothorax, and very sparse on the elytra; they are nowhere dark in colour. The elytra to the eye appear almost seriate-punctate, the punctures being partially visible,* but the striæ very indistinct.

SYNOMUS ÆRUGINOSUS, n. sp.

Black, appendages reddish. Densely clothed with golden-green scales; abdomen and appendages with white scales (with an occasional golden gleam) and with white setæ. Elytra with long, stiff, upright, whitish bristles, prothorax with similar but shorter bristles, and still shorter ones on head.

Head large and very feebly convex. Eyes almost round. Rostrum slightly diminishing in width from base to apex, with a narrow, impressed line, which terminates posteriorly in a narrow, ocular fovea. First joint of funicle distinctly longer than second. *Prothorax* strongly transverse, base strongly bisinuate, sides lightly rounded. *Scutellum* minute. *Elytra* ovate, widest at about the middle, at base closely applied to and no wider than prothorax; striate punctate. *Femora* minutely dentate. Length, $4\frac{3}{4}$ mm.

Hab.—Queensland: Chillagoe (C. French).

On both specimens before me several obscure patches of greyish scales are to be seen on the prothorax and elytra, but these may be due to an oily exudation. The elytra appear to be rather finely striate only, but on abrasion fairly large punctures are exposed. The green scales will readily distinguish it from *cephalotes*.

The elytra at the base no wider than the prothorax † is practically the only character Pascoe gave as distinguishing *Synomus* from *Myllocerus*, but it appears to be a very good

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* These are the only ones that are even partially visible, all the punctures on the prothorax and elsewhere being quite concealed.

† This is due to the narrowing of the elytra to the base, the prothorax being normal; in several species of *Myllocerus* the elytra at the base are no wider (in one species they are narrower) than the prothorax, but this is due to the hind margins of the prothorax being widened out to the base.

one, and, as in other genera having similar elytra, these are partially soldered together, and the wings are rudimentary.

HOMÆOTRACHELUS.

Although this genus* was referred by Faust to the *Tanymecides*, it appears to me to belong to the same subfamily as *Myllocerus*, despite its short scape; the side pieces of the meso- and meta-sternum to which (and with justice) so much importance was attached by Leconte, are identical in both genera, and, in fact, were the antennæ removed, there would be nothing to prevent the species of it being referred to *Myllocerus* itself.

HOMÆOTRACHELUS TRICARINATUS, n. sp.

Black, appendages reddish; apical sides of elytra obscurely diluted with red. Densely clothed with scales—white on the under surface and legs, greyish-white on upper surface; elytra and abdomen in addition with subsetose scales, but which do not (or but seldom) rise above the general level.

Head distinctly impressed between eyes; these large and suboval. Rostrum the length of head, sides parallel and almost vertical, sides and middle carinate, the median carina bifurcate in front, terminated posteriorly in ocular fovea.† Two basal joints of funicle of equal length, and combined slightly longer than scape. *Prothorax* moderately transverse, base not much wider than apex, sides moderately rounded. *Scutellum* subtriangular. *Elytra* much wider than prothorax, each strongly rounded at base, striate-punctate, the punctures large, subapproximate and subquadrate, but more or less concealed. *Femora* unarmed, the hind pair glabrous internally. Length, 6-6½ mm.

Hab.—Queensland: Port Denison (Macleay Museum).

The prothorax, although almost truncate at the base, appears to be rather strongly bisinuate; as in others of the genus the ocular lobes are absent, but their positions are marked by small patches of long yellowish setæ. The punctures are everywhere more or less concealed, but those on the head and prothorax are evidently rather coarse; those on the elytra appear to be large, oblong, and black, but when the scales have been abraded appear of different shape and

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* I cannot be mistaken as to its identification, as I have four specimens agreeing with the description of *H. australasiæ*, and one of which was sent to me with the name by the late Herr J. Faust himself.

† The expression "ocular fovea" refers to the impression which exists between the eyes in almost all weevils, and which appears to correspond with the clypeal suture of other beetles.

much larger. In general outline it approaches *Australasiæ*, but the clothing is more uniform, and the elytral punctures are larger.

SUB-FAMILY CRYPTORHYNCHIDES.

LYBÆBA ACUTICOSTA, n. sp.

Male. Red, club infuscate; base of rostrum, sterna, and abdomen black. Clothed with bright red, variegated with stramineous scales; on prothorax the paler scales form a short median and distinct lateral stripes, on the elytra they are condensed into numerous small spots, which become more or less fasciate in arrangement. Under surface with pale scales: head with red scales continued to near antennæ.

Eyes separated the width of rostrum at base. Rostrum long, moderately curved, thin, parallel-sided to antennæ, thence slightly (but noticeably) decreasing in width and depth to apex; rather strongly punctate, punctures behind antennæ partially concealed, but leaving three acute costæ. Scape inserted one-third from apex, shorter than funicle. *Prothorax* moderately transverse, apex more than half the width of base, with dense, partially-concealed punctures. *Scutellum* round and punctate. *Elytra* subcordate, each gently rounded at base, shoulders gently rounded; striate-punctate, punctures partially concealed: interstices regular, much wider than punctures. *Mesosternal* plate semi-circular, feebly depressed. Abdomen densely and shallowly punctate, third and fourth segments straight, their combined length more than that of second and much more than that of fifth. *Femora* acutely dentate. Length, 4: rostrum, $1\frac{1}{3}$: width, $2\frac{1}{6}$ mm.

Female differs in having the derm entirely red, the rostrum slightly longer, more noticeably curved, feebly punctate, shining, gently decreasing in width from base to apex and clothed only at base: the antennæ inserted less close to apex, and the eyes larger and less prominent.

Hab.—South Australia (Macleay Museum).

Allied to *majorina*, but the rostrum different in both sexes.

MELANTERIUS IMPOLITUS, Lea.

I have to thank the Rev. T. Blackburn for calling my attention to a mistake made by me in regard to this species. In my table it is included amongst those having "interstices raised posteriorly," and in the description I say (quite correctly), "elytra nowhere ridged."

MELANTERIUS COSTIPENNIS, n. sp.

Piceous-black: head, legs, and rostrum piceous-red, antennæ and elytra somewhat paler. Clothed with moderately elongate scales, varying on different specimens from a stramineous yellow to an ochreous red; prothorax with a basal spot and two sublateral stripes: elytra with numerous distinct spots of scales, the interspaces with small and obscure sooty scales. Metasternal episterna each with a distinct row.

Head densely punctate: ocular fovea distinct: eyes ovate, separation less than width of rostrum at base. Rostrum feebly curved, sides very feebly incurved to middle; male densely and strongly punctate, punctures leaving five irregular ridges to antennæ: female less coarsely punctate, and with only the median ridge moderately distinct. Scape the length of funicle: in male inserted one-third from apex; in female two-fifths. *Prothorax* strongly transverse, densely punctate, punctures in places feebly confluent, with or without a feeble median line. *Scutellum* oblong-ovate. *Elytra* about once and one-third the width of and more than twice the length of prothorax: shoulders oblique; seriate-punctate, punctures suboblong, feebly connected; interstices much wider than punctures, the third, fifth, and seventh acutely raised, the ridges shining. *Mesosternal plate* moderately transverse, depressed, and feebly concave. Metasternum rather densely punctate, the episterna each with a single row of punctures. Abdomen with moderately large and shallow punctures on first segment, smaller and sparser on second, smaller and dense on fifth: third and fourth combined, slightly longer than second, each with a single row of punctures. *Legs* moderately long; femora rather strongly dentate: posterior tibiæ with punctures in feeble series. Length, 6 (vix.): rostrum, $1\frac{3}{4}$; width, 3: variation in length, $4\frac{1}{5}$-$6\frac{1}{2}$ mm.

Hab.—Tasmania: Launceston (A. Simson), Hobart (H. H. D. Griffith, in *Acacia* galls; A. M. Lea, under bark).

May be distinguished from all previously described species by the alternate interstices of the elytra being triangularly raised to the base, with the ridges shining: *floridus* has the alternate interstices raised, but not triangularly, nor are they shining; *aberrans* has somewhat similar interstices, but the ridges are not continued to the base, and the antennæ are very different; *vinosus* has all the interstices raised and the eyes widely separated.

POROPTERUS NODOSUS, n. sp.

Moderately densely clothed with greyish-brown and small but moderately long scales, becoming ochreous-brown on under surface, base of head and base of prothorax. Ciliation of ocular lobes very distinct, even with head in position.

Convex. *Head* with the ocular fovea rather large and deep: eyes finely faceted. Rostrum with moderately dense subseriate punctures. Funicle slightly longer than scape, first joint slightly longer than second. *Prothorax* slightly transverse, sides rounded, constriction continued across summit, across middle a series of four moderately large and very distinct tubercles, a subobsolete one on each side of apex: with rather numerous large, glossy granules: median line without granules, but with a feeble ridge anteriorly. *Scutellum* subtriangular, distinct *Elytra* ovate, about thrice the length and at widest about once and one-half the width of prothorax; interstices with numerous small and moderately large glossy granules, and with about five or six small tubercles on each side; each side at summit of posterior declivity with a large subconical tubercle; each side of apex with a moderately distinct one. *Abdomen* with second-fourth segments scarcely depressed, and at a glance appearing almost equal in length, but the second encroaches on the first. *Legs* long and rather thin; posterior femora extending to apex of elytra; third tarsal joint wide. Length, 15; rostrum, 4; width, 7 mm.

Hab.—Tasmania (type in Mr. A. Simson's collection).

A very distinct species, belonging to the *succisus* group. Each elytron has the third interstice subtuberculate at base, and with two moderately distinct tubercles between the base and the large tubercle, this is obsoletely granulate and outwardly directed.

POROPTERUS RHYTICEPHALUS, n. sp.

Rather sparsely clothed with small scales, each puncture containing a distinct scale; tubercles feebly setose.

Strongly convex, subcylindrical. *Head* and rostrum roughly punctate; eyes finely faceted: ocular fovea rather large. Antennæ black; funicle longer than scape, its second joint longer than first. *Prothorax* moderately transverse, sides rounded; constriction irregularly continuous across summit; with numerous granules; across middle a series of four large rounded punctate granules; with a distinct median carina, which terminates before base and apex. *Scutellum* subtriangular. *Elytra* oblong-ovate, not much wider than prothorax, and more than twice as long; with moderately large, round punctures, and with numerous subtubercular elevations; second interstice with two tubercles of moderate size; one near base round and slightly larger than those on prothorax, the other just beyond middle, suboblong, and smaller; each side near summit of posterior declivity with a large, obtusely conical tubercle; apex without tubercles. *Abdomen* with third and fourth segments depressed below second and just perceptibly below fifth. *Legs* moderately long and thin: posterior femora just passing elytra. Length, 9½; rostrum, 2½; width, 4 mm.

Hab.—Queensland (Australian Museum).

A very distinct species belonging to the *succisus* group. The (two) specimens under examination are probably partially abraded, but as the species is very distinct I have not hesitated to describe them. The seventh elytral interstice is moderately distinctly ridged in middle, so that it causes an appearance of a slight epipleural fold. Compared with *succisus* it differs in being considerably narrower, the elytra with less numerous tuberosities, the subapical tubercles larger and rounded and by the conjointly rounded apex.

POROPTERUS LISTRODERES, n. sp.

Moderately densely clothed with stout brownish scales, prothorax with a very distinct complete border of paler scales, and which is continued on sides of elytra to apex, but decidedly incurved at basal third.

Flattened, subelliptic. *Head* flat; ocular fovea indistinct; eyes finely faceted. Rostrum rather short and stout, increasing in width to apex; muzzle moderately densely punctate. Funicle slightly longer than scape, second joint much longer than first. *Prothorax* flat, sides moderately round, strongly narrowed towards apex, apex feebly bifurcate. *Elytra* not much wider than prothorax, and scarcely twice as long; base strongly bisinuate; with series of large, shallow punctures, more regular on sides than on disc; the spaces between the punctures often tuberculiform, and with small, shining granules, second interstice near apex with a subconical tubercle, apex itself without tubercles. *Abdomen* with the third and fourth segments below level of second, but not of fifth. *Legs* moderately long; posterior femora extending to apex of elytra; third tarsal joint moderately wide. Length, 11; rostrum, 2½; width, 5 mm.

Hab.—Queensland: Mount Dryander (A. Simson).

The very distinct pale lateral markings of the prothorax and elytra will readily distinguish this species; it belongs to the *exitiosus* group. The tubercles on the posterior declivity are rather small, and are indistinct when viewed from above, but they are very distinct from the sides.

POROPTERUS LONGIPES, n. sp.

Moderately densely clothed with muddy-brown scales, interspersed (especially on legs) with rather long blackish setæ and with stouter scales, on the elytra these form a feeble fascicle on each side at summit of posterior declivity.

Strongly convex. *Head* with punctures concealed by clothing; ocular fovea moderately large; eyes finely faceted. Rostrum long, thin, moderately strongly curved; basal portion coarsely, elsewhere finely (very finely in female) punctate; with a feeble median ridge continued to near antennæ. Scape inserted two-fifths from apex of rostrum, almost the length of funicle; second joint of the latter almost twice the length of the first. *Prothorax* slightly transverse, subglobular; without punctures or tubercles. *Elytra* ovate-cordate, widest at about one-third from base, less than thrice the length of prothorax, without tubercles: with series of moderately large (large at sides) punctures, which are partially concealed by clothing. *Abdomen* with third and fourth segments not depressed, their combined length equal to that of second or fifth; without large punctures except for a curved row on intercoxal process, and which, around the coxæ, become compressed into a distinct groove. *Legs* unusually long and thin; posterior femora passing elytra: third tarsal joint wide. Length, 8½; rostrum, 2¾; width, 4 mm.

Hab.—Queensland: Cairns (George Masters).

Belongs to the *varicosus* group, but is, nevertheless, a distinct species, and is not close to any known to me.

Poropterus cavernosus, n. sp.

Densely clothed with stout, suberect brownish scales almost uniform in size and colour throughout, except that on the legs they are feebly variegated; on the elytra they are most numerous on the alternate interstices, but even there are less dense than on the prothorax.

Strongly convex. Punctures of *head* and rostrum entirely concealed, but evidently very coarse; eyes coarsely faceted. Rostrum noticeably incurved to middle. Scape inserted almost in exact middle of rostrum, much shorter than funicle; second joint of the latter much longer than first, third joint almost as long as two following combined, none transverse. *Prothorax* as long as wide, or slightly longer than wide, sides rounded; densely and coarsely punctate, punctures entirely concealed. *Elytra* elliptic-ovate; decidedly raised above, scarcely twice the length of and once and one-half the width of prothorax; with nine series of large, regular foveiform punctures; the interstices narrow, not much wider than the transverse ridges between puncture and puncture. *Abdomen* without distinct punctures, third and fourth segments combined slightly shorter than second. *Legs* moderately long; posterior femora extending to apex of elytra; third tarsal joint moderately wide. Length, 6¼; rostrum, 1¾; width, 3 mm.

Hab.—Queensland: Cairns (Macleay Museum).

Belongs to the *varicosus* group, and with an outline somewhat similar to that of the preceding species; from which, however, it totally differs in the punctures and legs: of the described species it is perhaps closer to *crassicornis* than to any other, but is abundantly distinct from it on account of the absence of large abdominal punctures (one specimen has been abraded to make sure of this point), and by the different punctures of elytra.

Poropterus foveatus, n. sp.

Densely clothed with ruddy brown scales, interspersed with numerous long suberect or erect spathulate scales, which are very numerous on legs, and even appear on the apex of the scape.

Strongly convex. Punctures of *head* and rostrum concealed, but evidently coarse. Scape inserted slightly nearer base than apex of rostrum, stout, subclavate, considerably shorter than funicle; the latter with the second joint very slightly (if at all) longer than first, third strongly, fourth-sixth moderately strongly, seventh feebly transverse. *Prothorax* and *elytra* much as in the preceding species, but the former with a feeble median ridge and much larger punctures, the latter with a feeble projection at base of third interstice, and with very much larger and less numerous punctures or foveæ. *Abdomen* with a few large punctures on the two basal and on the apical segments, third and fourth combined considerably shorter than second or fifth. *Legs* moderately stout; posterior femora terminated before apex of elytra; third tarsal joint moderately wide. Length, $5\frac{1}{2}$; rostrum, $1\frac{2}{3}$; width, $2\frac{1}{2}$ mm.

Hab.—New South Wales (J. Faust).

The shape is much the same as in the preceding species, but the elytral foveæ are almost twice as large as they are even in that species, and are very much larger than in any other member of the *varicosus* group. The brevity of the third joint of the funicle is very unusual. The eyes are very coarsely faceted.

Poropterus inusitatus, n. sp.

Sparsely clothed with small brown scales; prothorax with four fascicles transversely placed in middle, apex feebly bifurcate, each puncture with an elongate scale; elytra with the alternate interstices moderately densely clothed, the third with a feeble, dark fascia beyond middle, suture posteriorly with similar scales, but scarcely fasciculate. Under surface moderately densely, the legs, head, and rostrum densely squamose.

Strongly convex. *Head* and rostrum roughly punctate; eyes moderately coarsely faceted. Rostrum moderately long, noticeably increasing in width to apex. Scape inserted three-sevenths from apex, shorter than funicle; second joint of the latter considerably longer than first, the others slightly longer than wide. *Prothorax* as long as wide, sides rounded, constriction deep, and not quite continuous; with four tubercles transversely placed in middle, of which the two median only are moderately distinct; with rather large round punctures somewhat irregular in size and very irregularly distributed, but more numerous at base than elsewhere. *Elytra* ovate, moderately long, more than twice the length of prothorax, widest at basal third; with series of large punctures, becoming foveæ on sides and very small on posterior declivity: without distinct tubercles. *Abdomen* with a few large punctures (not foveate, however), on the two basal and the apical segments; third and fourth combined slightly shorter than second or fifth. *Legs* moderately long; posterior femora terminated before apex of elytra; third tarsal joint wide. Length, 8½; rostrum, 2¼; width, 4 (vix.), mm.

Hab.—E. Australia (Horace W. Brown).

Belongs to the *varicosus* group, from all the members of which it may be distinguished by the exposed and irregular prothoracic punctures. On a glance the clothing appears as if partially abraded, but I am convinced that the specimen described (which was taken at Orange, in New South Wales, or Rockhampton, in Queensland), is in perfect preservation.

POROPTERUS LISSORHINUS, n. sp.

Densely clothed with stout sooty and sooty-brown scales, rather paler on head and under surface than elsewhere; prothoracic scales stouter and less numerous than those on elytra; prothorax with six feeble fascicles; four across middle, and two at apex; elytra with eight moderately distinct fascicles (on the third and fifth interstices) forming two distinct transverse series; one near base and one at summit of posterior declivity.

Moderately convex, subelliptic. *Head* with punctures entirely concealed by clothing; eyes finely faceted. Rostrum long, thin, rather strongly convex; base and sides behind antennæ coarsely punctate; elsewhere shining and very sparsely and finely punctate. Scape inserted slightly nearer base than apex of rostrum, half the length of funicle and club combined: second joint of funicle slightly longer than first, the others transverse. *Prothorax* and *elytra* much as in *bituberculatus*, but the former without carina. *Abdomen* densely and regularly punctate, punctures indistinct, but each carrying a large scale; third and fourth segments combined slightly longer than second or fifth. *Legs* moderately long: posterior femora terminated before apex of abdomen; third tarsal joint wide. Length, 7; rostrum, 2½; width, 3¼ mm.

Hab.—New South Wales: Mount Kosciusko (J. J. Fletcher).

In appearance this species strongly resembles *bituberculatus*, and it is remarkable that the two should have exactly similar tubercles at the base of the elytra; the facets of the eye, however, are very much finer (less than half the size) than in that species, and forbid its being regarded as a variety. Many of the prothoracic and abdominal scales appear to be conical in shape.

POROPTERUS RUBUS, Pasc.

Two specimens, from Cairns, appear to represent a variety of this species. They differ from typical specimens in having the clothing longer and denser, the apex of the elytra very obtusely mucronate, and all the tubercles more obtuse; of the sutural tubercles the second is almost obsolete, being transformed into a feeble ridge.

DECILAUS APICATUS, n. sp.

Densely clothed with large soft scales, varying from a dingy white to sooty brown, and causing the upper surface to appear speckled. Under surface with longer dingy-whitish scales; pectoral canal densely squamose.

Head indistinctly but evidently coarsely punctate. Rostrum stout; coarsely punctate, punctures irregular in front of antennæ, behind them evidently in seven rows, the lateral row very distinct. Scape stout, almost the length of funicle, inserted close to apex. *Prothorax* (by measurement) slightly longer than wide, with moderately large, round, shallow punctures, which are entirely concealed. *Elytra* oblong-cordate, scarcely twice the length of prothorax, striate-punctate, both striæ and punctures entirely concealed, punctures moderately large, but not as wide as interstices, these flat and punctate. *Abdomen* with the punctures almost entirely concealed. Anterior *tibiæ* at apex with a glabrous, outwardly rounded, and obliquely flattened plate, from which the terminal hook proceeds. Length, 5; rostrum, $1\frac{1}{6}$; width, $2\frac{1}{2}$ mm.

Hab.—South Australia: Eyre's Peninsula (Rev. T. Blackburn, No. 1492).

The anterior tibiæ are very peculiar. The margins of the elytra in the vicinity of the abdomen are perfectly glabrous in the (two) specimens under examination, this character being invisible from above; it does not appear to be due to abrasion. Each puncture of the rostrum behind the antennæ contains a large scale, which entirely conceals it, but as the scales can be traced in seven rows the punctures are probably also in rows.

DECILAUS SQUAMIPENNIS, n. sp.

Prothorax with three feeble whitish lines, each puncture containing a scale, the majority of which are dingy brown, and do not rise to the general level; elytra densely clothed with soft pale brownish scales and with paler scales, giving the surface a slightly speckled appearance. Under surface and legs with brownish-grey scales; head (except between eyes), rostrum, and pectoral canal sparsely squamose.

Head transversely impressed, and with coarse punctures between eyes, with smaller (but not fine) and almost regular punctures elsewhere. Rostrum moderately long; not very coarsely punctate, punctures forming four distinct rows. Scape inserted two-fifths from apex, much shorter than funicle. *Prothorax* transverse, with dense, moderately large, round, clearly cut punctures, which are larger on flanks and smaller on apex than elsewhere; with or without a feeble median line. *Elytra* subcordate, outline almost continuous with that of prothorax; striate-punctate, punctures moderately large, subquadrate, only partially concealed; interstices feebly convex, much wider than punctures, themselves rather densely punctate. Two basal segments of *abdomen*, with punctures which are but little smaller than those on prothorax. Anterior *femora* feebly dentate. Length, 4; rostrum, $1\frac{1}{6}$; width, 2 mm.

Hab.—Australia (J. Faust); Queensland. Gaynaah (Macleay and Australian Museums).

The dentition of the femora is more of the nature of a slight lateral extension of the ridge bordering the groove (as in *moluris*), rather than distinct teeth. The difference in the clothing of the prothorax and elytra is very pronounced. Six specimens have a distinct transverse whitish spot on each side of elytra at summit of posterior declivity, on a seventh these spots are continued (running parallel with suture) almost to apex, on an eighth they are not traceable.

DECILAUS CUNICULOSUS, n. sp.

Clothed with greyish-white scales, on the prothorax long and setose, and each arising from a puncture, on the elytra softer, and rounded and densely clothing the interstices, each puncture with a thin, indistinct scale. Under surface and legs with moderately elongate, almost white scales; metasternum with very thin setose scales; pectoral canal moderately squamose; head and rostrum with similar scales to those on elytra.

Head coarsely and irregularly punctate. Rostrum moderately stout, coarsely punctate, punctures more or less seriate in arrangement, and leaving a distinct impressed median space. Scape inserted two-fifths from apex, the length of the four following joints; of these the first is longer than the second. *Prothorax* moderately transverse, with dense, coarse, round punctures. *Elytra* subcordate, seriate-punctate, punctures moderately large, oblong or suboblong, sometimes with slightly wrinkled walls; interstices not separately convex, much wider (at base not much wider) than punctures. *Abdomen* irregularly punctate, the punctures of the two basal segments never very large, and not very dense, a few larger than the others on second; third and fourth each with a single row of squamose punctures. Length, 5; rostrum, $1\frac{1}{2}$; width, $2\frac{1}{2}$ mm.

Hab.—South Australia (Rev. T. Blackburn, No. 1493).

The prothoracic punctures are fully as large as in *foraminosus*, but those on the elytra are very much smaller than in that species. The clothing of the under surface shows a slight approach to that of *auricomus* and *tibialis*. Mr. Blackburn informed me that the specimens described were probably taken near Adelaide.

DECILAUS IRRASUS, n. sp.

Sparsely and irregularly clothed with brown and whitish scales, forming in places indistinct spots. Sterna and basal segments of abdomen with elongate whitish scales; pectoral canal almost glabrous.

Head densely and coarsely punctate. Rostrum moderately stout, sides feebly incurved to middle; coarsely punctate, punctures subseriate in arrangement between antennæ and base. Scape inserted three-sevenths from apex, the length of five following joints; of these the first is noticeably longer than the second. *Prothorax* moderately transverse, basal two-thirds almost parallel sided, with rather large, round, clearly-cut punctures, which become smaller towards apex. *Elytra* oblong-cordate, base almost truncate; seriate-punctate, punctures moderately large, deep, oblong, or suboblong; interstices not separately convex, narrower than punctures and rather coarsely punctate. *Abdomen* with the two basal and the apical segment irregularly but not densely punctate; some of the punctures rather large. Length, $3\frac{1}{4}$; rostrum, $1\frac{1}{6}$; width, $1\frac{5}{6}$ mm.

Hab.—Queensland (Australian Museum).

The prothoracic punctures are about the size that they are in *distans*, but those on the elytra are considerably larger.

DECILAUS AURICOMUS, n. sp.

Clothed with pale fawn-coloured and whitish scales; prothorax with three feeble lines of rather stout elongate scales; elytra not very densely clothed with soft, almost round scales, a few of which are of an almost pearly whiteness. Middle of metasternum and two basal segments of abdomen and the four posterior coxæ with long, slightly curved, golden setæ or hair: pectoral canal almost glabrous; legs and head densely clothed, the scales feebly variegated.

Head and rostrum coarsely and irregularly punctate, punctures on the latter scarcely seriate in arrangement, but leaving a feeble, longitudinal, impunctate space. Scape inserted two-fifths from apex, slightly shorter than funicle. *Prothorax* moderately transverse, with dense, moderately large, round, clearly defined punctures, which are scarcely smaller at apex and larger on flanks than on disc. *Elytra* subcordate; seriate-punctate, punctures large, oblong, all connected together; interstices gently convex, the width of or slightly wider than punctures, with sparse punctures. *Abdomen* with dense and irregular punctures, none of which is very large, third and fourth segments each with a single row of squamose punctures. Length, 4½; rostrum, 1⅓; width, 2¼ mm.

Hab.—New South Wales: Sydney (at roots of beach-growing plants).

The clothing of the under surface is most remarkable, and, except in the following species, is dissimilar to that of any other; two specimens are under examination, and are probably both males. The colour of the derm is of a brownish-red, the elytra and legs rather less dark than elsewhere. Each prothoracic puncture contains a scale, but along middle and towards sides these scales are stouter and paler than elsewhere, and cause three feeble stripes to appear. The elytral punctures cause an appearance as of deep, continuous striæ, the walls of which are slightly waved. I know of no other species having similar punctures, although there is a slight approach to them in *spissus*.

DECILAUS TIBIALIS, n. sp.

Male. Upper surface moderately densely clothed with stout, sooty scales, interspersed with small spots of pale brownish scales. Under surface, legs, head, and rostrum with pale brownish scales, the legs feebly ringed with sooty ones: middle of metasternum and two basal segments of abdomen, and the four posterior coxæ clothed with very long recurved golden setæ or hairs.

Punctures of *head* and rostrum (except in front of antennæ, where they are moderately dense and coarse) concealed, on the latter evidently subseriate in arrangement. Scape inserted one-third from apex, the length of four following joints, two basal subequal; club elongate-ovate. *Prothorax* moderately transverse, base feebly but distinctly bisinuate, apex less than half the width of base; with (for the genus) rather small punctures, less crowded than usual, but entirely concealed (except at sides); an impunctate and slightly depressed median line. *Elytra* cordate, shoulders slightly prominent; seriate-punctate, punctures large and deep; interstices feebly convex, not at all or very slightly wider than punctures, themselves with small and rather numerous, but entirely concealed, punctures. *Abdomen* with punctures entirely concealed, but evidently dense and not very large. Terminal hook of posterior *tibiæ* strongly incurved and outwardly dentate. Length, 7; rostrum, 1½; width, 4 (vix.); variation in length, 6½-7⅓ mm.

Female. Differs in being entirely without golden hair on the under surface, the terminal hook of the posterior tibiæ simple, the rostrum squamose only at base, and antennæ inserted more distant from apex of rostrum.

Hab.—New South Wales: Armidale (D. McDonald and A. M. Lea); Tamworth (Lea).

A much less convex species than usual, the male with very remarkable clothing and posterior tibiæ. I believe the species belongs to *Decilaus*, the clothing of the under surface is almost exactly the same as in *auricomus*, an undoubted *Decilaus*. Many of the elytral punctures have a slightly triangular appearance, others are more or less rounded or ovate, each is isolated by a distinct transverse ridge, which is just below the level of the interstice, but which is more or less concealed by the clothing.

DECILAUS SPISSUS, n. sp.

Very densely clothed with soft, pale, dirty, fawn-coloured scales, which are larger and more rounded on prothorax and abdomen than elsewhere. Head and rostrum very densely clothed; pectoral canal with a few elongate scales.

Punctures of *head* and rostrum entirely concealed, but those on the latter evidently seriate in arrangement. Rostrum wider at base than apex, and much wider than between antennæ. Scape stout, inserted nearer base than apex, the length of two following joints; these subequal in length. *Prothorax* rather strongly transverse, sides not suddenly narrowed towards apex; with dense, large, round, clearly-cut punctures, which are partially concealed. *Elytra* oblong-cordate, more than twice the length of prothorax; striate-punctate, punctures rather large, subcontiguous; interstices convex, much wider than punctures, fourth widest of all. Two basal segments of abdomen with exactly similar punctures to those on prothorax. Length, 5; rostrum, 1⅔; width, 2½ mm.

The clothing is so dense that, except where abraded, the sculpture can scarcely be seen.

Hab.—South Australia (Macleay Museum).

DECILAUS NOCTIVAGUS, n. sp.

Black, antennæ and tarsi dull red. Very densely clothed with muddy brown scales, with stouter, suberect, and darker scales, rather thickly distributed, and forming feeble loose fascicles.

Head and rostrum with coarse but concealed punctures, those of the latter evidently in rows. *Rostrum* stout, the length of prothorax. Scape stout, inserted two-fifths from apex of rostrum, the length of five basal joints of funicle. *Prothorax* transverse, sides rounded; with dense but entirely concealed punctures. *Elytra* briefly subovate, not twice the length of prothorax; striate-punctate, punctures large, but entirely concealed, striæ traceable through clothing. *Abdomen* with rather dense and large but entirely concealed punctures. Length, $2\frac{3}{4}$: rostrum, $\frac{3}{5}$; width, $1\frac{2}{5}$ mm.

Hab.—New South Wales: Forest Reefs (A. M. Lea).

With the exception of *hispidus*, the smallest of the genus. I could only take it (at dusk and night time) crawling over old "cockatoo" fences, but it was rather numerous on them. The surrounding "post-and-rail" fences (although numerous other weevils were to be obtained on them at the same time) never seemed to attract specimens of this species.

A specimen from Victoria (Rev. T. Blackburn) differs in having the clothing more uniform in size and each individual scale traceable and larger. The general colour is a rather pale fawn, but with darker patches, the abdomen is sparsely clothed, and the femora are distinctly ringed. It probably represents a distinct species, or at least a very distinct variety, as I cannot find the least variation in the clothing of eighteen specimens of the typical form.

DECILAUS CORYSSOPUS, n. sp

Black, antennæ (club infuscate), and tarsi dull red. Densely clothed with dark, muddy-grey, thickly interspersed with sooty, erect scales; an obscure patch of paler scales on each side of elytra at basal third, and which is sometimes continued on to shoulder. Scales of under surface, both of body and legs, of a rather dark brown.

Punctures of *head* and basal third of rostrum entirely concealed: apical two-thirds of rostrum shining, and with round and moderately coarse punctures, not at all seriate in arrangement. Scape inserted nearer base than apex, the length of two basal joints of funicle: of these the second is slightly longer than the first. *Prothorax* distinctly transverse, sides strongly rounded: with dense, moderately large, round, clearly-cut punctures, which, however, are almost concealed by the clothing. *Elytra* subcordate, widest about middle:

striate-punctate, punctures moderately large, but almost concealed; interstices slightly rough, gently convex, much wider than punctures. *Abdomen* with dense round punctures. Anterior *femora* distinctly, the four posterior rather feebly, dentate. Length, 5; rostrum, 1½; width, 2½; variation in length, 4½-5½ mm.

Hab.—Tasmania: Hobart (H. H. D. Griffith and A. M. Lea).

The tooth on each of the anterior femora is triangular, compressed, and distinct, although not large; it is, however, of the same character as that of *moluris.*

A specimen (also from Hobart) differs in having the scales of a pale fawn, interspersed with sooty brown, and a few whitish ones; the elytra have sooty suberect scales scattered about, and in places forming feeble spots, but forming a moderately distinct fascia across middle and a distinct spot on third interstice at base: the clothing of the under surface and legs is of a uniform fawn.

DECILAUS OVATUS, n. sp.

Dark brown, antennæ (club excepted) and claw joints paler. Densely clothed with stout adpressed scales of various shades of grey, and stouter on prothorax (where three or five paler lines are sometimes traceable) than on elytra.

Head with dense concealed punctures. Rostrum rather strongly curved, comparatively (for the genus) thin, sides lightly incurved to middle; basal half with coarse punctures subseriate in arrangement, apical half with moderately large punctures. Scape inserted almost in exact middle of rostrum, the length of three basal joints of funicle; of these the first is slightly longer than the second. *Prothorax* rather strongly transverse; with dense and rather large, round, clearly-cut punctures, which, however, are almost concealed. *Elytra* not twice the length of and outline subcontinuous with that of prothorax; punctate-striate, punctures separated by feeble ridges, and becoming very small posteriorly, but everywhere concealed; interstices convex, punctate, considerably wider than striæ. *Under surface* with dense and large, but almost entirely concealed, punctures. *Femora* slightly but acutely dentate. Length, 5; rostrum, 1⅓; width, 2¾; variation in length, 3¾-5½ mm.

Hab.—Queensland: Cooktown (J. Faust).

The dentition of the femora associates this species with *moluris* and *corysopus*, from both of which it may be readily distinguished by the clothing; in general appearance it approaches *litoralis.* The rostrum is unusually thin for *Decilaus.* In one specimen (probably immature) under examination, the whole of the derm is red, the rostrum and elytral suture being reddish-brown.

INSECTS COLLECTED IN THE NORTH-WESTERN REGION OF SOUTH AUSTRALIA PROPER BY H. BASEDOW; WITH DESCRIPTIONS OF NEW SPECIES OF MANTIDÆ AND PHASMIDÆ.—NO. 2.

By J. G. O. Tepper, F.L.S., F.S.Sc., etc.

[Read October 3, 1905.]

The insects were collected incidentally during the progress of an expedition fitted out to examine the mineralogical, geological, and economic conditions of this hitherto little visited part of the State, and was engaged in that work from March to November, 1903. The Coleoptera were principally identified by the Rev. Thomas Blackburn, and the Lepidoptera by Mr. O. Lower, the author being responsible for the remainder. The collector, not having much time or adequate facilities at disposal, accounts for the comparative meagreness and not quite satisfactory state of the specimens in some cases. The latter, however, were often supplemented by such obtained previously from neighbouring regions. As it is, the collection, as the first made there, is of some importance in respect of geographical distribution, filling up a considerable gap, and has been deposited by the collector in the South Australian Public Museum.

The present list only comprises the Orthoptera, with supplementary descriptions of new species, in addition to previously published ones, and accounts for the greater part of the collection, as shown by the appended synopsis. The rest of the collection embraces the following identified species:—Hymenoptera—*Chrysis*, sp., *Camponotus testaceipes* (Smith), *Iridomyrmex glaber* (Sm.), *Bothroponera piliventris* (Sm.), *Myrmecia sanguinea* (Sauss), *Mutilla rugicollis* (Sauss), *Eumenes bicincta* (Sauss), *Megachyle Blackburni* (Frogg.), *Saropoda bambiformis* (Sm.). Odonata—*Hemianax papuensis* (Burm.), and *Lestes*, sp. The remainder of these contain species not previously represented in the Museum.

GENERAL SYNOPSIS.

Coleoptera	57 genera,	87 species,	211 specimens
Lepidoptera ...	31 ,,	39 ,,	108 ,,
Hymenoptera ...	13 ,,	20 ,,	31 ,,
Orthoptera ...	27 ,,	37 ,,	67 ,,
Odonata and Neuroptera	6 ,,	6 ,,	11 ,,
Hemiptera ...	7 ,,	15 ,,	21 ,,
Diptera	2 ,,	2 ,,	2 ,,
	143 ,,	206 ,,	451 ,,

ORTHOPTERA.

BLATTARIÆ.

Epilampra aspera, Tepper.
Epilampra notabilis (Walk.), Tepper.
Periplaneta basedowi, Tepper.
Pseudepilampra punctata, Tepper, Musgrave Ranges.
Oniscosoma castanea, Brunner.

MANTIDÆ.

Orthodera marginata, Saussure.
Orthodera prasina, Saussure. (Also an egg-case.)
Pseudomantis pulchellus, Tepper.

Fischeria quinquelobata, *spec. nov.*

Male and female. Resembling *Archimantis latistylus*, Brunner, in general aspect. Greyish-brown. Head much compressed. Eyes large, prominent. Antennæ very slender. Tips of mandibles black. Pronotum oval, minutely tuberculate, margins minutely spinulate, spines alternately black and pale. Meso- and metanotum glabrous, unarmed. Forelegs stout, *coxæ with the strong, external ridge provided with four large lobes and one small one, mucronate, and black underneath:* internal ridge minutely serrate. Fore femora with four spines preceding a fifth much longer one externally; internal ridge with numerous sub-equal spines. Middle and hind legs slender, latter long, unarmed. Tegmina much longer and wider than the wings, greyish; veins dark brown; two black, sub-rotundate spots at and before middle respectively; anal area pale. Wings about half the size of the former; all veins and veinlets of the costal area dark brown (similar to tegmina). Cerci broadly oar-shaped, apex subobtuse.

Length of body, 92-107 mm.; width, 5-9 mm.
Length of head, 2-3 mm.; width, 9-10 mm.
Length of pronotum (base), 7-8 mm.; width, 4-5 mm.
Length of mesonotum (max.), 32-37 mm.; width, 4-6 mm.
Length of metanotum, 5-7 mm.; width, 5-7 mm.
Length of abdomen, 45-52 mm.; width, 6-9 mm.
Length of ant. coxæ, 16-20 mm.
Length of ant. femora, 20-25 mm.
Length of ant. tibiæ, 8-10 mm.
Length of ant. tarsi, 10-13 mm.
Length of med. femora, 20-23 mm.
Length of med. tibiæ, 20-24 mm.
Length of med. tarsi, 12-14 mm.

Length of post. femora, 25-32 mm.
Length of post. tibiæ, 32-38 mm.
Length of post. tarsi, 12-14 mm.
Length of cerci, 9-10 mm.
Length of tegmina, 24-34 mm.
Length of wings, 13-20 mm.
Length of antennæ, 16-20 mm.

The male is similar to the female, only smaller. Besides the specimens from the North-West, there are three others in the Museum collection, viz.:—One, since 1887, from Yactoo, Far North (M. Crawford); another from Broken Hill, in 1890 (F. J. Burgess); and a third from Central Australia (R. Helms); and are comprised in the above measurements and description.

PHASMIDÆ.

Lonchodes caurus, *spec. nov.*

Male. Brownish-grey, glabrous, with more or less distinct black, or blackish, median line or markings dorsally from transverse carina at back of head to fifth abdominal segment. Head a little longer than pronotum, tumid behind antennæ, with a raised flat spot in place of the obsolete central ocellus, and two short divergent ridges lateral thereof. Eyes elliptical, small, scarcely prominent. Antennæ grey, triquetrous (terminal portion wanting). Pronotum rotundately arched above, median line slightly, lateral carina more deeply impressed, transverse carina a little anterior to middle, hind margin narrowly black. Mesonotum slightly wider than head, sides parallel throughout, median line raised, dorsum along the middle with numerous blackish, irregularly scattered dots; lateral carina rather broad, extending for three-fourths of length, brown, externally to same a blackish line extending to hind margin, and forming the crest of a low, broad ridge. Metanotum of same width, or only slightly wider, as the preceding, and of similar structure, but darker brown, and the aggregated dots forming a broad dark median stripe. Abdomen with segments, 1 to 3 subequal and of same width as thorax, 4 to 6 somewhat narrower, and much longer, tapering, next three still more slender, short (two subequal, the third scarcely more than half the length of the preceding), last joint with supra-anal lamina very short, latter with closely adpressed edges, forming a ridge, subacute, and longer than preceding segment. Subgenital lamina boat-shaped, last joint finely rugose, apex ovate, whitish. Cerci very short, concealed. Legs comparatively short and weak, unarmed, scabrous, grey.

Length of body, 70 mm.; width do., 1·5-3 mm.
Length of head, 4·5 mm.
Length of pronotum, 3·5 mm.
Length of mesonotum, 17 mm.
Length of metanotum, 11 mm.
Length of abdomen, 35 mm.
Length of ant. femora, 17 mm.
Length of ant. tibiæ, 16 mm.
Length of med. femora, 14 mm.
Length of med. tibiæ, 16 mm.
Length of post. femora, 20 mm.
Length of post. tibiæ, 16 mm.
Length of tarsi, 3·5 mm.

This species appears to approximate in general form to *Lonchodes Confucius*, Westwood, in general form, but differs from it in being much smaller and differently coloured, while also disagreeing in most of the minute characters. The specimen is fairly perfect, excepting the antennæ, of which only some 12 or 13 of the basal joints are preserved.

Cyphocrania cornuta, *spec. nov.*

Female. Body hoary grey to whitish, or brownish, where discoloured. Head with two thick, acuminate, rugose horns, almost vertical, and subparallel, and with several rows of tubercles. Tegmina small, with brown veins and veinlets. Wings perfect, but too small for flight; costal area with base pale, and adjoining a large black spot, remainder with ill-defined pale and dark bars and blotches; membranous portion deep black, with about five narrow, more or less irregular and disrupted transverse pale bars and some small isolated spots near the external margin. Pronotum tuberculate, furrowed, and ridged. Anterior femora stout, acutely triquetrous, the superior ridge with *four subequal, broad, forward-directed serrations*, terminating in acute spinelets. Mesonotum finely tuberculate in front and behind, with some scattered spinelets (two larger than the rest), on the disc. Median femora with eight spinelets along inferior internal ridge, and one near the middle of the external; internal ridge of median tibiæ with three triangular spines, and one on the external near the joint, besides the terminal spurs. Hind femora with larger spines along the central line beneath, five small spines along the inner lower ridge, and four minute ones on the external. Abdomen stout, cylindrical to fifth segment, but gradually contracted beyond. Posterior margin of fourth segment *with four short ridges*, the outer ones convergent, and the margin between them extended into a *foliate quadrilateral appendage* with rugose edges, and double mid-rib, 4 mm. long. Subgenital lamina much exceeding the next two segments in length (24 mm.), apex broad, subemarginate. Cerci very short, scarcely exceeding anal segment. Under side of abdomen with a double row of tubercles to sixth segment, 6 to 8 on each segment.

Length of body, 172 mm.
Length of head, 10 mm.; width, 7 mm.
Length of pronotum, 8 mm.; width, 6·5 mm.
Length of mesonotum, 38 mm.; width, 6·5 mm.
Length of metanotum, 15 mm.; width, 8 mm.
Length of abdomen, 103 mm.; width, 9 mm.
Length of tegmina, 22 mm.; width, 6 mm.
Length of wings, 47 mm.; width, 47 mm.
Length of ant. femora, 34 mm.
Length of ant. tibiæ, 33 mm.
Length of ant. tarsi, 11 mm.
Length of med. femora, 27 mm.
Length of med. tibiæ, 30 mm.
Length of med. tarsi, 8 mm.
Length of post. femora, 46 mm.
Length of post. tibiæ, 42 mm.
Length of post. tarsi, 10 mm.
Length of antennæ, 35 mm.

The described female is the only specimen in the S.A. Museum collection which possesses both the conspicuous cephalic and the dorsal abdominal appendages denoted, nor have I come across figures or descriptions indicating these in the form mentioned—besides other distinctions. There are, however, one or two other Central Australian species represented, which exhibit similar form and wing structure of the females. There is also in the collection a male with prominent cephalic horns, which may belong to the same species as the described female, although the horns differ in form, being very divergent and compressed laterally. There are also several other males with small tubercular spines on the head, but these appear to belong to the hornless females referred to above. The colour pattern of their ample wings is quite different from that of the described form, but the detailed descriptions, etc., have to be postponed for the present.

Acrophylla nubilosa, *spec. nov.*

Male. Pale brown; body very slender. Head glabrous; flat, with indistinct, whitish dots and lines above. Occiput with two median depressions, and curved impressed furrows on each side. Ocelli obsolete. Antennæ densely hirsute. Pronotum much shorter and narrower than the head, with some longitudinal furrows, terminated by a transverse carina near hind margin. Mesonotum cylindrical, gradually tapering to near base of elytra, then rapidly expanding to more than double between median legs, thickly beset with many small interspersed and some large spines. Metanotum stout, glabrous, with three pairs of short, oblique, white streaks underneath. Legs very long and slender, all ridges with small, distant spinelets, except those of the anterior tibiæ and of the tarsi. Tegmina short and narrow, costa and a short, oblique, discal streak whitish, remainder brown. Wings long and rather narrow; costa with some small dark spots from near middle to apex; veins and veinlets from pale to dark brown, some of the former interruptedly black towards margin; veinlets bordered with blackish-brown; outer margin broadly suffused with dull blackish, likewise the costal part of the membranous disc, with irregular blotches, the dark markings separated by translucent areas. Abdomen very slender throughout; sexual organs, including respective joint and lamina, also anal joints, very short and tumid. Cerci broad, ovate, subacute, nearly as long as the preceding three joints together.

Total length of body, exclusive of cerci, 86 mm.
Length of head, 5 mm.; width, 3 mm. (behind eyes).
Length of pronotum, 3 mm.; width, 2·3 mm.
Length of mesonotum, 15 mm.; width, 1·5-4 mm.
Length of metanotum, 13 mm.; width, 4 mm.
Length of abdomen, 50 mm.; width, 1·5-2·5 mm.
Length of ant. pedes, 61 mm.
Length of med. pedes, 44 mm.
Length of post. pedes, 62 mm.
Length of tegmina, 10 mm.; width, 4 mm.
Length of wings, 52 mm.; width, 22 mm.
Length of cerci, 8 mm.

The species is comparable with *Acrophylla tesselata*, G.R.G., from N. Australia (Westwood, Cat. Phasm. B.M., Plate xxxv., fig. 1), but is larger, and differs in the paucity of the spinulation of the legs, colouration of the wings, etc. There are a pair of similar insects in the collection from Central Australia, but appear to differ in proportions.

Acrophylla paula, *spec. nov.*

Male. Brown; in general aspect resembling the preceding, except size and wing form, in which it approximates *A. tesselata*, Westwood. Head flat, occiput, with anterior median depression (obsolete ocellus) much larger and deeper than in preceding, and other markings different. Antennæ long, slender, 16 (?) jointed, minutely hairy. Pronotum with transverse furrow in the middle. Mesonotum and metanotum similar to preceding; also abdomen. Tegmina reddish- brown, costa not whitish, but a whitish, oblique streak indicated; apex rounded. Wings rather short, obtusely rounded; costal area reddish-brown, with indistinct dark markings along the costal margin: membranous area almost colourless; veins alternately pale and dark; veinlets narrowly bordered with blackish, but no other spots or blotches present. Legs long and slender, with minute, distant spinelets along the ridges of femora and tibiæ.

Length of body without cerci, 73 mm.
Length of head, 4 mm.; width, 2·5 mm.
Length of antennæ, 22 mm.
Length of pronotum, 3 mm.; width, 2 mm.
Length of mesonotum, 10 mm.; width, 1·5 mm.
Length of metanotum, 5 mm.; width, 2·3 mm.
Length of abdomen, 51 mm.; width, 1·3 mm.
Length of tegmina, 8 mm.; width, 3 mm.
Length of wing, 38 mm.; width, 16 mm.
Length of cerci, 5 mm.

Although agreeing in size and colour patterns of the wings with Westwood's fig. 1 of Plate xxxv. (Cat. Phasm., B.M.), the specimen differs much in the minuteness and paucity of the spinelets of the femora and tibiæ of the legs, etc. The ocilli appear also to be practically replaced by mere shallow depressions. There are no other specimens in the S.A. Museum collection resembling either of the above. There is in the collection a female from Lake Aroona (N.W. from Port Augusta), and also a nymph of one, which appear to belong to the described male in general aspect, contour, and colour of wings, etc. Both were collected in December, 1900, by Mr. A. Loveday, and are differing in being larger.

Necroscia bella, *spec. nov.*

Male. Greenish to reddish-brown; very slender. Head above rounded, minutely and distantly tuberculate, occiput anteriorly with a deep oval impression, median line indistinct; sides flat. Antennæ not much longer than the anterior femora, finely and densely hairy. Pronotum narrower and much shorter than the head, with a slight longitudinal and a promiscuous transverse carina in the middle. Mesonotum scabrous, nearly twice as long as the two preceding together, and attenuated towards the middle from both ends. Metanotum stout and the widest part of the body. Abdomen slender, gradually attenuated towards and inclusive of seventh joint, remainder moderately tumid. Subgenital lamina half the length of joint, apex emarginate. Cerci short, ovate, hairy; porrected. Legs simple, very slender, moderately long; femora, tibiæ, and first joint of tarsi minutely and very densely spinulate along all three ridges. Tegmina very small, apex rotundately sinuate, elevated knob dark brown, remainder pale brown. Wings narrow, apex almost subacute; veins and veinlets of costal area from brown at the base to greenish along costa, and whitish near margin; of the remainder from bright to faintly rosy; interspaces pale green near costa, remainder very faintly rosy, transparent.

Length of body, 52 mm.; width, from 1-2·3 mm
Length of head, 3·3 mm.
Length of antennæ, 19 mm.
Length of pronotum, 2 mm.
Length of mesonotum, 9 mm.
Length of metanotum, 3·7 mm.
Length of abdomen, 34 mm.
Length of cerci, 3 mm.
Length of tegmina, 2 mm.; width, 1·5 mm.
Length of wing, 28 mm.; width, 12 mm.
Length of ant. femora, 16 mm.
Length of ant. tibiæ, 15 mm.
Length of med. femora, 10 mm.
Length of med. tibiæ, 10 mm.
Length of post. femora, 14 mm.
Length of post. tibiæ, 15 mm.
Length of tarsi, 3-4 mm.

This species appears to be nearest in affinity to *N. annulipes*, Curtis, but is considerably smaller and more slender, the proportions of antennæ and wings, besides less conspicuous characters, appear also to be sufficiently different to entitle it to specific rank. It is the first of the genus which has reached me from any part of the State of South Australia.

Bacillus peristhenellus, *spec. nov.*

Two males. Body pale ochreous to dull blackish-brown, filiform, thorax carinated. Head pale dull ochreous, with two interrupted black vittæ behind the eyes, an ovate, longitudinal impression anteriorly, on either side of which a fine distinct ridge, hind margin crenate. Eyes yellowish-grey. Antennæ as long or longer as anterior femora, first joint long, flat, next two very short and thick, remainder shorter than first, subequal, filiform. Pronotum rough, dull, same colour as head, wider behind, anterior margin subcrenate, forming a distinct ridge, median carina very fine, marginal ridges distinct, intra-marginal carina rather broad. Mesonotum with subparallel sides, raised median and submarginal ridges, dark brown. Metanotum similar, ridges much more distinct, both meso- and metanotum very minutely papillose between the raised lines, and of the same width. Abdomen very slender, apparently flat underneath, brown in the dried specimens, tapering towards apex. Legs triquetrous, with one or two carina on each face, unarmed. Supra-anal lamina very short, triangular. Cerci not exceeding apex.

Length of body, 35 mm.; width, 1-1·3 mm.
Length of head, 1·6 mm.
Length of pronotum, 1·4 mm.
Length of mesonotum, 9·5 mm.
Length of metanotum, 6·5 mm.
Length of abdomen, 16 mm.
Length of ant. femora, 11 mm.
Length of ant. tibiæ, 11 mm.
Length of med. femora, 8 mm.
Length of med. tibiæ, 8 mm.
Length of post. femora, 10 mm.
Length of post. tibiæ, 7·5 mm.

There are two specimens in the collection, one a mature one apparently, the other immature and much smaller. Although much smaller, they appear to be best comparable with *B. Peristhenes*, Westwood, in general type of form, and to this the trivial name given refers. There are also two other immature specimens, too defective for classification.

ADDITIONS TO THE CAMBRIAN FAUNA OF SOUTH AUSTRALIA.

By R. ETHERIDGE, JUNR., Hon. Fellow, Curator of the Australian Museum, Sydney.

[Read April 4, 1905.]

PLATE XXV.

Our Cambrian Fauna is, comparatively speaking, of so limited a nature at present that additions are always most welcome. Mr. W. Howchin recently forwarded to me a small collection of fossils from a new horizon, discovered by himself. Mr. Howchin describes the deposit as a "shelly band in an oolitic limestone of much inferior thickness to that carrying the great reef of Archæocyathinæ, situated in the Flinders Range, not far from Wirrialpa."

The limestone is, generally speaking, flesh-coloured, and the fossils break out on fracture in fairly good condition. The oolite grains appear under two conditions: either on a fractured surface, as small spherical or oval bodies up to one millimetre in diameter; or, on weathered faces, in natural section, when their structure, under an ordinary pocket lens, is very misleading. In this condition they present the appearance of minute corallites of a fasciculate Rugose coral, with definite septa, and are closely packed on some pieces of limestone, or sparsely distributed on others. On placing a thin slice of this pseudo-coral, prepared for the microscope, under a high-power objective, the supposed corallites at once resolve themselves into oolitic grains of a peculiar structure. These grains are wholly composed of concentric layers, or zones, of carbonate of lime, with or without a central nucleus of clear calcite, accompanied by a radial structure, and it is the latter that simulates the appearance of a septate coral. In fact, these grains when seen in natural or weathered transverse section resemble very minute Archæocyathinæ, especially when the pellicle is thin, or of small diameter, and enclosing a clear nucleus. This radial structure is not uncommon in oolitic grains, but its remarkable resemblance to a minute coral has not before come under my notice. Between crossed Nicols the black cross is clearly seen in places, indicating crystalline and not organic structure. No organic nucleus was observed in any case.

I have succeeded in determining one Trilobite, five Brachiopods, and one Pteropod, but these, with the exception of the Pteropod, bear no specific relation to the more copious fauna, described by the late Professor R. Tate,*

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* Tate—Tr.R.S.S.A., 1892, xv., part 2, p. 183.

from Parara and Curramulka, Yorke Peninsula. The chief point of interest lies in the addition of the genus *Obolella* to the fauna.

The following are descriptions of the fossils: —

TRILOBITA.

Genus Olenellus, Hall, 1862.

(Fifteenth Annual Report New York State Cabinet Nat. Hist., 1862, p. 114.)

Olenellus, *sp.*

(Plate xxv., fig. 1.)

Obs.—Two species of this characteristic Cambrian Trilobite are known already from Australian rocks: —*O. Brownii*, mihi,* and *O. Forresti*, mihi,† with a possible third, *O. (?) Pritchardi*, Tate.‡ The present specimen is very imperfect, but sufficient remains to indicate *Olenellus* rather than *Ptychoparia*. It is certainly distinct from Tate's species, and probably also from *O. Brownii*.

The cephalon, less the free cheeks, is semi-circular-saggitate. The glabella oblong, rounded in front, gently convex, slightly arched in the middle line (most so anteriorly), and with parallel lateral margins; the axial grooves are strong and undulated, to correspond with the glabella furrows; the first pair are mere indentations of the axial grooves and hardly perceptible, the three latter are all complete; the frontal lobe is large and subquadrate, the palpebral lobes obpyriform, the eye lobes large, flat, crescentic, and extend as far forwards as the palpebral, beyond the first pair of glabella furrows, and posteriorly to the fourth complete furrow. The free cheeks, neck lobe, and posterior portion of the glabella are not preserved.

There is not sufficient of this cephalon to enable comparisons to be made; suffice it so say that it certainly is not *O. (?) Pritchardi*, Tate, provided the illustration of the latter is correct, and not a mere conventional figure. The form of the palpebral lobes, and complete condition of the glabella furrows, so far as they are preserved, also forbid a reference to *O. Brownii*. It is nearest to *O. Forresti*, mihi, from the Cambrian rocks of Kimberley, North-west Australia, possessing a similarly elongate glabella, yet not so long as in *O. Forresti*, similarly long and curved eye lobes, and similar pyri-

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* Etheridge—Contrib. Pal. S.A., No. 9, S.A. Parl. Papers, No. 127, 1897, p. 13, pl. i., fig. 1.

† Foord—Geol. Mag., 1890, vii., p. 99, pl. iv. figs 2, 2a-b.

‡ Tate—Tr.R.S.S.A., 1892, xv., part 2, p. 187, pl. ii., fig. 11

form palpebral lobes, but our specimen is not sufficiently perfect to complete the comparison.

On the same piece of limestone is a small portion of another glabella, and on another hand specimen part of a frontal border of a cephalon. This lends encouragement to the belief that additional, and it is to be hoped more complete, examples will be forthcoming in the near future.

BRACHIOPODA.

Genus Obolella, Billings, 1861.

(Geol. Vermont, 1861, ii., p. 946.)

Obolella wirrialpensis, *sp. nov.*

(Plate xxv., figs. 2 and 3.)

Sp. Char.—Valve (? pedical) ovate to subquadrate, gently convex, rising dorsally into a small umbo; rounded ventrally and without emargination; lateral angles rounded. Internal muscular scars hardly at all curved, diverging from one another, extending far forward, and tapering to a fine point. Surface characters very marked and distinctive, consisting of a series of clean-cut, flat, concentric steps, the "tread" of each step practically at right angles to its "riser"; no concentric or radial striæ of any kind.

Obs.—*Obolella wirrialpensis* may be regarded as the characteristic fossil of the band of limestone lately discovered by Mr. Howchin, and adds another welcome genus to our Cambrian list of fossils. It is a more quadrate form than most of the American *Obolellæ*, with the exception of *O. cingulata*, Billings;* in fact, the outline is more that of *Obolus* than *Obolella*. On the other hand, the internal structure, so far as it is preserved, is that of the latter, and the outline is more that of the British than the American species. It is further remarkable for its size, being equal to the largest of the latter, and far surpassing the former. Three selected specimens measure as follows:—

	Dorsal to ventral.	Transverse.
a.	... ... 7 mm.	8 mm.
b.	... ... 11 mm.	10 mm.
c.	... ... 11 mm.	12 mm.

The step-like nature of the concentric laminæ is very characteristic, and cannot fail to arrest attention, even in fragments.

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* Billings—Pal. Foss. Canada, 1871, i., p. 8, figs. 8-10.

Obolella, *sp.*

(Plate xxv., figs. 4-6.)

Obs.—It is often a difficult task, in dealing with these old organisms, particularly when imperfect, to determine how far difference in outline is to be allowed to have weight in varietal significance. Associated with *Obolella wirrialpensis* are a few examples differing from the latter by their ovate flask-shaped outline, accuminating towards the umbo, and swelling out towards the front; the sculpture appears to be similar to that of *O. wirrialpensis.*

In form this rarer shell is clearly allied to the little *O. gemma*, Billings,* of the North American Middle Cambrian, but is very much larger than the latter.

I anticipate it will ultimately prove to be specifically distinct from *O. wirrialpensis*, but as the amount of material is limited I content myself by suggesting that it be called *O. wirrialpensis*, var. *calceoloides.*

Genus ORTHIS, Dolman, 1828.

(Kongl. Vet. Acad. Handlingar, 1827 (1828), p. 96.)

Orthis (?) **tatei,** *sp. nov.*

(Plate xxv., figs. 7 and 8.)

Sp. Char.—Pedicle valve, dorsal margin comparatively straight; ventral and lateral margins rounded, the former non-emarginate; umbo small, depressed; surface in the median line moderately convex, the wings rather flattened; sculpture consisting of numerous, thick, sometimes bifurcating, radating costæ, which die out, or are only faintly perceptible on the wings or towards the lateral margins of the valves, the surface on these portions being also crossed by very fine concentric lines; by the prominence of two or three costæ on each side of the middle, a flattened space, taking the place of a sulcus, is marked off.

Obs.—In the absence of internal features, I am by no means confident in the generic reference of this fossil, but in all probability it is an *Orthis.* The specimens present a very analogous appearance to one of the late Mr. Thomas Davidson's figures of *O. lenticularis,* Wahl.,† from the Dolgelly Group of the Upper Lingula Flags of Wales.

The shell is named in honour of the late Professor R. Tate, who practically laid the foundation for palæontological study in South Australia.

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* Walcott—Bull. U.S. Geol. Survey, No. 30, 1886, p. 116, t. 10, figs. 2 and 2a.

† Davidson—Mon. Brit. Foss. Brach., part vii., No. 3. 1869, pl. xxxiii., figs. 27-28a.

Orthis (*vel* **Orthisina**), *sp.*

(Plate xxv., fig. 9.)

Obs.—I regard this as distinct from *O. tatei.* The valve is a single specimen, apparently the pedicle, and is subquadrilateral, convex, the greatest convexity at about midway in the length of the valve, the sinus gradually deepening and widening towards the front, and bounded laterally by ill-defined folds, one on either side, the surface sloping away on either side rapidly to the lateral margins, and at a very much less angle within the sulcus; there are indications of costæ on the divaricating folds and in the sulcus.

The hinge features are hidden in matrix, nor is the umbo distinctly visible; it may, therefore, be either an *Orthis* or an *Orthisina.*

It is quite distinct from either *Orthis (?) peculiaris*, Tate,* or *Orthisina compacta*, Tate,† but in general appearance it resembles *Orthis (?) spiriferoides*, McCoy,‡ a Caradoc-Bala species.

In the Archæocyathinæ white limestone at Wirrialpa.

Orthis (*vel* **Orthisina**), *sp.*

(Plate xxv. fig. 10.)

Obs.—In the same white marble occurs another Brachiopod, which may belong to either of the above genera, the same disabilities rendering it impossible to arrive at a satisfactory conclusion, as in the preceding instance.

This valve, again a single example, I take to be the brachial. It is rotundato-quadrate, the cardinal margin as long as the width of the valve, the surface convex, except on the dorso-lateral alations, where it appears to be flattened. There is a central, acute, or pinched-up fold, produced forward, and expanding as it advances. There are indications of the existence of strong, distant, sub-radiating costæ.

Whether or no this is the brachial valve of the species represented by the preceding form, it is, at present, impossible to say; the two occur in the same bed, however. There is a strange resemblance in the pinched-up fold to the same portion on the brachial valve of a Caradoc species, *Orthis vespertilio*, Sby.§

In the Archæocyathinæ white limestone at Wirrialpa.

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* Tate—Tr.R.S.S.A., 1892, xv., part 2, p. 185, t. ii., fig. 5.

† Tate—*loc. cit.*, p. 185, t. ii., figs. 6, 6a.

‡ Davidson—Mon. Brit. Sil. Brach., part vii., No. 4, 1871, p. 275, t. xxxvii., fig. 3a.

§ Davidson—Mon. Brit. Sil. Brach., No. 3, t. xxx., figs. 11, 12a.

PTEROPODA.

Genus HYOLITHES, Eichwald, 1840.

(Sil. Schich. Syst. in Ehstland, 1840, p. 97.)

Hyolithes communis, Billings.

Obs.—This genus is represented by single small tubes up to twenty-five millimetres in length, but without other distinctive characters. I have not seen any trace of an operculum. The facies of the specimens is that of *H. communis*, Billings, already recorded from the Parara limestone at Curramulka by the late Professor R. Tate.

DESCRIPTION OF PLATE XXV.

OLENELLUS, sp.

Fig. 1.—Incomplete cephalon, showing the glabella, palpebral and eye lobes, etc.— × 2.

OBOLELLA WIRRIALPENSIS, *Eth. fil.*

Fig. 2.—External view of a nearly complete pedicle (?) valve — × 3.

Fig. 3.—Imperfect internal cast, exhibiting traces of muscular scars— × 3.

O. WIRRIALPENSIS, var. CALCEOLOIDES, *Eth. fil.*

Fig. 4.—External view of a flask-shaped pedicle (?) valve— × 3.

Fig. 5.—Side view of another specimen— × 3.

Fig. 6.—Umbonal view of the same— × 3.

ORTHIS (?) TATEI, *Eth. fil.*

Fig. 7.—Pedical valve with thick, radiating costæ on the median portion of the valve— × 2.

Fig. 8.—A similar specimen— × 2.

ORTHIS (*vel* ORTHISINA), sp.

Fig. 9.—Subquadrilateral pedicle (?) valve, with a moderately deep sinus, bounded by ill-defined folds— × 3.

ORTHIS (*vel* ORTHISINA), sp.

Fig. 10.—Rotundo-quadrate brachial (?) valve, with a pinched-up fold— × 3.

NOTES ON SOUTH AUSTRALIAN DECAPOD CRUSTACEA.
PART III.

By W. H. Baker.

[Read October 3, 1905.]

Plates XXXII. to XXXVI.

The following notes deal with some species of *Anomura.* The first three are true hermit crabs of the family *Paguridæ,* which are closely allied to each other, belonging to that division of the family whose chief characteristics are the possession of a pair of modified appendages on the first, and another on the second, abdominal somite in the male, and a pair on the first in the female. The female also is provided with a brood pouch, which arises from the fourth somite on the left side, and covers the unpaired biramous appendages which serve for the attachment of the eggs. These three species are referred to the genus *Paguristes.* Of the four remaining species, three belong to the *Porcellanidæ.* *Petrocheles australiensis,* Miers, is a fine species, showing well the transition to the *Galatheidæ,* and as far as I know has never been figured. Of *Polyonyx transversus,* Haswell, the same may be said; so it is here figured, and the description extended. Lastly, a *Galathea,* belonging to the group which contains *G. australiensis,* Stimpson; *G. aculeata,* Haswell; and *G. magnifica,* Haswell, is described—though provisionally—as *G. setosa,* for the first time.

Family Paguridæ, Dana.

Section I., *Pagurinæ,* Ortmann.

Genus *Paguristes,* Dana.

For latest description of genus see Alcock Cat. Ind. Decap. Crust., part 2, p. 30, 1905.

Paguristes frontalis, M.-Edw. Pl. xxxii., figs. 1-7.

Pagurus frontalis, M.-Edw., An. des Sci. Nat., 2e série, t. vi., p. 283, pl. xiii., fig. 3. Hist. Nat. Crust., t. ii., p. 234.

Paguristes frontalis, Alcock Cat. Ind. Decap. Crust., part 2, p. 155, 1905.

Eupagurus frontalis, Cat. Aust. Crust., Haswell, p. 154.

The carapace anterior to the cervical groove is only slightly convex from side to side, anteriorly depressed, rather oblong viewed from above, the sides behind the curve of anterior angles being nearly straight; its surface is smooth and polished except for some small scattered punctations, but towards the sides it becomes somewhat rough or rugose. The triangular rostriform tooth is acute, quickly accuminating to its apex, depressed and projecting between the bases of the scales of the ocular peduncles. The margin of the front is raised, and the antennal projections, which do not reach as far as the rostrum, are each tipped with a small tooth. A depression behind the rostral tooth sends off an oblique branch towards each side marking off the hepatic regions, and also a median longitudinal groove, which, however, is short. In the region of this groove the carapace is slightly rugose transversely. The hepatic regions are prominent and rounded. The antero-lateral portions of the carapace scarcely project forward as far as the tubercles of the first joints of the antennæ; their descending margins carry two or three spinules. The cervical groove is deeply marked, and the carapace behind it is membranaceous, and is marked with some faint, irregular, longitudinal lines; there is a narrow median region expanding anteriorly, and running to a depression behind. The branchial regions are moderately tumid. The carapace is sparingly hairy at the sides.

The narrow tergum of the first abdominal segment is triangular, firm, and bears a few setæ. The remainder of the abdomen is soft, except in some specimens a little leathery underneath; it is glabrous, except the margin of the oviferous sac in the female. The sixth segment is strongly calcified dorsally, and is divided into two main unequal portions by a deep, transverse, irregular furrow, the anterior portion thus divided is irregularly pitted, the posterior has a median, shallow furrow, which broadens out behind.

The ocular peduncles are long, as long as the greatest breadth of the anterior portion of the carapace, moderately robust, not expanding distally, and with a tendency to become slightly unequal in length. The basal scales are rather small, spiniform, close together, and anteriorly depressed. The eyes are rather small.

The basal joint of the antennular peduncle is flattened and hollowed above, its external margin is compressed, and each edge bears distally a minute spine (stylocerite). There is a small distal spine below also. The second and third joints and the thick portion of the upper flagellum are subequal in length; the lower flagellum is about half the length of the upper, and is naked, as is also the short distal portion of the upper flagellum.

The first joint of the antennal peduncle has a prominent tubercle below, which bears the aperture of the green gland. The second joint is produced distally on the outer side, ending in three converging spines, with a group of setæ immediately below, the inner distal angle is less produced, and ends in a downward curved spinule. The upper surface of the joint is hollowed. The third joint is produced below to a strong spine, which projects one-third the length of the fifth joint; the fourth joint is short and bears a small distal spinule above. The fifth joint is cylindrical, slightly curved, and expands slightly towards the distal end, reaching to about half the length of the ocular peduncle. The acicle is short and stout, reaching about as far as the spine on the third joint; it bears, besides the acute apex, two short, strong spines externally, and one near the base above; it also carries several fasciculi of coarse setæ. The flagellum is short, not much more than twice the length of the peduncle, and is non-ciliate.

The mandibles have the edge of the cutting plate entire; a narrow and not deep cleft separates it from the molar process; into this the terminal joint of the palp dips. The molar process is narrow. The palp is three-jointed, the second joint markedly compressed, its plane being transverse to the edge of the cutting plate; the third joint, which is about as long as the two preceding ones together, is compressed and much expanded, its plane being parallel to the same edge.

In the first maxillæ the external branch has the second joint articulated below the apex of the preceding, presenting a bifid arrangement; the distal portion is strongly reflexed. This branch bears a strong setum on the inner side near the base.

In the second maxillæ the third joint is compressed, tapering irregularly, the apex being without setæ.

In the first maxillipeds the third joint is twisted and turned aside so as to be partially hidden behind the exopod. The exopod is flagellate.

The exopods of the two succeeding maxillipeds are very robust, compressed, and flagellate. The third maxillipeds have their coxal joints contiguous, the ischium bears a row of corneous teeth on the inner side, and the merus a few spinules on the same side.

The chelipeds are large and very unequal, the left one is the larger; in it the merus is trigonous, reaching a little beyond the eyes; it bears a few small, low tubercles, which become more numerous and larger towards the distal end: some are minutely punctate at their summits. The upper surface of the carpus is strongly tuberculate, the tubercles becoming almost spiniform on the inner margin. The hand is large and swollen, whitish (in contrast to the rest of the appendages, which are red), and finely granulate, the granules becoming larger towards the inner side. The fingers open transversely, and are excavate, especially the immobile one, the contiguous surfaces having some punctations, from which a few hairs spring. The mobile finger is corneous at the tip. There is a broad, rather obscure, ridge on the outer side of the immobile finger reaching some distance on the hand; at the inner end of this ridge is a small area of well-defined, reddish granules. The hand, including the fingers, is more than twice as long as the carpus. On the outer side the fingers show no hiatus, but a prominence on the immobile one fits into a corresponding slight hollow in the mobile one. The right cheliped has the carpus and hand bearing larger tubercles and granules, and a few fasciculi of hairs on the inner margin.

The second and third pairs of legs are long, almost glabrous and robust, exceeding the chelipeds in length. The third is more robust than the second. In these the meris and propodi are very slightly serrate above and below, the carpi have a distal spine above, and two or three on the outer side, on the distal margin. The dactyli, which are longer than the penultimate joints, are moderately curved and compressed, that of the third pair is more flattened on the outer side, and bears a well-marked, spinulate ridge above: the inner side is rounded and has scattered spinules, the lower margin is acute and serrate, especially towards the end. The spinules usually arise from dark red spots. The dactyli terminate in small black claws.

The fourth pair are much shortened, the joints are setose on their anterior and posterior margins, non-chelate, the propodi becoming narrower distally. The dactyli are short, and bear some stout teeth. The fifth pair are shorter, smaller, and minutely chelate, the pad of scale-like setæ covers the whole breadth of the distal end of the propodus.

The first and second abdominal segments bear sexual appendages in the male, the rami of the first being coalesced to form a semi-cylinder, the inner ramus is provided with a tuft of brown stiff setæ, which originate about the middle of the inner side, and extend beyond its end, intermingling with those of the opposite limb, the outer ramus is thickened, compressed, rounded at the end, which is slightly recurved outwards, bearing a row of minute teeth. The second pair of abdominal appendages are long, slender, and uniramous, and are terminally slightly spatulate and setose. The three succeeding segments are each provided with a weak uniramous appendage on the left side.

The uropods, as usual, are very unequal, the external ramus of the pair of the left side is much larger than the inner, falcate, and expanded with the usual pavement of scale-like setæ.

The telson bears a few setæ in groups, and is divided dorsally into four lobes, with a small lozenge-shaped area in the middle; the two terminal lobes are unequal, with a median cleft between them. The two anterior lobes have each an ear-shaped pit.

The female has a large brood pouch.

This littoral species is one of the largest and commonest hermit crabs of our coast, and varies much in size.

Specimens in the Adelaide Museum.

Length of a medium-sized specimen, 6 cm.

Length of carapace, 26 mm.

Breadth of the anterior portion of the carapace, 10 mm.

Length of large cheliped, 4 cm.

Length of ocular peduncle, 10 mm.

Length of second ambulatory leg, 47 mm.

Paguristes brevirostris, *n. sp.* Pl. xxxiii., figs. 1, 1*a*.

The animal is somewhat hairy, especially on the chelipeds, the hairs there, however, not thick enough to hide the armature.

The anterior portion of the carapace is rather flat above, sparingly pitted, rough or rugose towards the front and sides, with a depression behind the front, marked on each side by a short, slightly oblique ruga, then another small, depressed area lies beween this and the hepatic region. The rostral tooth is very short, obtuse, and scarcely projecting farther than the prominences external to it: these are rounded, and each is tipped with a very small denticle. The hepatic regions are rounded and slightly tuberculate; they are separated from the other regions by a faintly marked, very irregular, longitudinal groove, which joins the cervical groove behind. The frontal margin is thickened. The portion of the carapace behind the cervical groove is thin, and shows some small disconnected areas of calcification. The branchial regions are moderately tumid and sparingly setose: there is a tuft of setæ on each side of the cardiac region.

The ocular peduncles are moderately robust, not as long as the breadth of the anterior portion of the carapace, and somewhat constricted towards the middle. The basal scales are rather small, and bear five or six small red denticles on each. They are well separated from each other.

The antennular peduncles reach nearly to the level of the eyes.

The outer side of the first peduncular joint of the antennæ bears one or two denticles. The second joint is hollowed above, its outer distal angle is produced, bearing four or five spinules, and there are one or two denticles at the inner angle. The acicle is moderately robust, quickly tapering to a terminal spine, with three or four others on its external border, and two on its inner border near the base: it reaches more than half the length of the fifth joint. The third joint is produced below to a prominent spine, and a small spinule terminates the fourth joint above. The fifth joint is short, reaching about two-thirds the length of the ocular peduncle. The flagellum is short, much shorter than the carapace, the internodes of the joints bearing rather long setæ.

The chelipeds are moderately robust, nearly equal. The merus reaches a little beyond the level of the eyes, its lower external border is spinulate, and it is slightly rugose on the external surface; it bears some spinules on the distal margin, and one or two also above a little removed from the distal end. The carpus is short, its anterior surface is covered with white, more or less spiniform tubercles, which become larger on the inner margin. The palm is not much longer than the carpus, and is covered anteriorly with similar spiniform tubercles, which extend on to the fingers: on a side view the joint is strongly wedge-shaped, being swollen proximally and tapering quickly to the end of the immobile finger. The fingers are slightly longer than the palm, transverse, corneous at the tips, and denticulate on their opposable margins, with a small hiatus.

The second and third pairs of legs are nearly equal in length—the carpi and propodi of the more posterior pair being slightly longer—and exceed the chelipeds by about the length of the dactyli. The more anterior pair is more spinulate, spinules being situated on the posterior edges of the meri, and on the anterior edges of the carpi and propodi. The carpi and propodi also show squamose markings, from which hairs arise; these, again, are more evident on the more anterior pair; the dactyli of both pairs are longer than the propodi; they are scarcely compressed, slightly sulcate, and end in dark, corneous claws, and are distally more or less spinulate.

In the male the pairs of appendages to the first and second abdominal segments are well developed, as also are the uniramous appendages on the left side of the third, fourth, and fifth segments; these bear very long setæ.

In the female the brood pouch is a widely open sac, springing from the fourth segment. This covers the biramous unpaired appendages of the second, third, and fourth segments, and carries the ova.

The ultimate segment is four-lobed, with minute teeth and some hairs on the margin of the terminal lobes.

Length of body, 28 mm.

Length of carapace, 11 mm.

Breadth of carapace, anterior portion, 5 mm.
Length of cheliped, 17 mm.
Length of third leg, 19 mm.
Dredged by Dr. Verco, S.A. coast, 20-30 fms.
Types in Adelaide Museum.

Paguristes sulcatus, *n. sp.* Pl. xxxiv., figs. 1, 1*a*.

The animal is very hairy, especially on the chelipeds; the hairs are plumose or pinnate.

The carapace anterior to the cervical groove is medianly smooth, except for a few scattered pits; towards the sides, however, it becomes rough and irregularly furrowed. There is a rather deep depression behind the rostral tooth, and the portion of the carapace immediately behind this dips into it rather abruptly. In this region there are a few slight, irregular furrows, which appear as branching from a median, shallow groove, which extends from the frontal depression for a short distance behind. The lateral portions of the frontal depression are marked on each side by a short, oblique ruga (more pronounced than in the preceding species), and the hepatic regions, which are full and sparingly pitted, are marked off from the rest of the carapace by irregular longitudinal grooves, which join the cervical groove behind. The rostral tooth is triangular, acute, slightly depressed, reaching nearly as far as the ophthalmic scales. The front between the two antennal projections is strongly thickened; these do not project as far as the rostral tooth, and each is tipped with a small denticle.

The abdomen is of the usual soft nature, the dorsal surface of its sixth segment is strongly calcified, and divided by a transverse groove into two unequal parts; the anterior portion is marked with three irregular pits, the posterior by a median sulcus, which is not so deep as the transverse one, and a few small pits.

The ocular peduncles are long and slender, scarcely expanding distally from about the middle; they are a little shorter than the widest part of the carapace anterior to the cervical groove. The ophthalmic scales are small, well separated, and each is tipped with three spinules, one of which is small.

The antennular peduncle reaches nearly as far as the eyes. The upper flagellum slightly exceeds the ultimate peduncular joint in length.

The first joint of the antennal peduncle bears externally two spinules. The upper surface of the second joint is slightly excavated; it is much produced externally, bearing four or five spines, the two apical ones being rather divergent; there is also a prominent spine on the inner angle, with a small spinule just below it. The acicle is robust, regularly tapering to end in two spines, with one just below them on the outer or upper side, and one on the inner side, near the base; the acicle reaches rather more than half the length of the fifth joint. The third joint is produced below to a strong spine, which reaches nearly as far as the fourth joint. The fourth joint has a small spinule above at the distal end. The fifth joint reaches about as far as the middle of the ultimate joint of the antennular peduncle. The flagellum is shorter than the carapace, and hairy.

The chelipeds are equal, and weak. The merus reaches to about the level of the acicle of the antennæ; it bears a few spines on the upper margin, near the distal end, and a few on the other two margins; the external surface is slightly rugose. The anterior surfaces of the carpus and palm are densely hairy—the hairs hiding the spines—flattened and covered with spiniform tubercles, mostly curved forwards, and many with acute, dark tips; these are larger on the inner margins. The palm is shorter than the carpus; it is not swollen behind, as in the preceding species. The fingers are longer than the palm, spinulose, corneous at their tips, and externally marked at their opposable edges with small, rather regular teeth. There is no hiatus.

The second and third pairs of legs are nearly similar, the third pair being slightly longer; they exceed the chelipeds in length by about half the length of the dactyli in the second pair. The meri are slightly rugose externally. The carpi are externally sulcate, as also are the propodi, and with them bear on their anterior margins spines similar to those on the chelipeds, which, however, are smaller and less numerous on the third pair. The propodi also are slightly squamose. The dactyli are about as long as the propodi; they are faintly sulcate and spinulate on their anterior and posterior edges, are slightly curved, and end in dark claws.

The fourth pair is short, non-chelate, the carpus and propodus nearly equal in length, the propodus distally narrowing. The dactylus is short, robust, and spinulate.

The first two pairs of abdominal appendages in the male are well developed; the single pair of the first segment in the female is weak. The other appendages are of the usual character.

The telson is four-lobed, the two anterior lobes larger than the posterior: the posterior lobes are unequal, rounded behind, and spinulate and setose on the margins.

Length of body, 37 mm.

Length of carapace, 16 mm.

Breadth of carapace anterior to the cervical groove, 7 mm.

Length of cheliped, 20 mm.

Length of third leg, 26 mm.

Length of ocular peduncle, 6 mm.

A littoral species. Port Willunga, S.A. coast.

Types in Adelaide Museum.

This species differs from *P. subpilosus*, Henderson, in the following particulars:—The ocular peduncles are longer and slenderer. The ophthalmic scales are smaller and trispinose. The rostral tooth is more acute, and there is a strong depression behind it on the carapace, and a short, median, longitudinal groove. The antennal flagellum is well ciliated. In the chelipeds the hand is not swollen behind. In the second and third pairs of legs the dactyli are not longer than the propodi, and the anterior borders of the last three joints are very spinose. Finally, the telson is quadrilobate.

Family PORCELLANIDÆ.

Genus *Porcellana*, Lamarck.

Porcellana rostrata, *n. sp.* Pl. xxxv., figs. 1, 1*a*, 1*b*.

The carapace is subpentagonal, slightly longer than broad, slightly convex behind the protogastric ridges. The surface is uneven, being marked by numerous minute transverse striæ; some of the striæ are more distinct, bearing groups of soft plumose setæ, especially in the female; two protogastric ridges are particularly thus indicated. The regions are well marked; the cervical groove distinct. The postero-lateral regions are rounded and rugose, the rugæ extending around the sides of the carapace to the pterygostomial region, but not uniting dorsally, as a nearly smooth space intervenes. The epibranchial regions are slightly tumid. A narrow, depressed area borders the antero-lateral regions. The front viewed from above shows two prominent lobes, divided by a median sulcation, which extends gradually, becoming shallower backward between the protogastric ridges; from a front view the margins of these lobes show as two arches, the outer limb of each being much shorter than the inner, the two inner limbs uniting to form an almost vertically depressed, acute, median lobe or rostrum: the outer lobes, which form part of the inner margin of the orbits, are also depressed; the edge of the front itself bears a series of small denticles, which extend to the antero-lateral margins. The antero-lateral margin is longer than the postero-lateral; it is cristate, and shows an acute prominence at the external angle of the orbit, a distinct antennal spine, and two others further back; the crest is interrupted by a notch at the anterior end of the cervical groove, and on a slight lobe behind the notch are sometimes found two other small spines. The posterior border is raised and insinuate.

The pleon is smooth, polished, and glabrous, except on the margins.

The *linea anomurica* reaches from beneath the antennal peduncle to the edge of the lateral wall of the carapace, just above the coxa of the third pair of legs, a short, oblique ridge immediately behind the marginal notch before mentioned reaches from the antero-lateral crest across to this suture.

The eyes are small, and scarcely projecting.

The first joint of the antennular peduncle has two oblique ridges, which converge and unite inwardly.

The basal joint of the peduncle of the antenna is somewhat triangular; it forms the external margin of the orbit: its upper portion reaches the margin of the carapace, its lower border bears three or four teeth towards the inner end, the innermost one of which is below the eye, is spiniform, and directed forwards, and is visible from above: the other three teeth are small, and point inward. The third joint is a little longer than the second, expanding towards the distal end, where there is an anterior projection; the fourth joint is small, and also has a slight projection. The flagellum is long.

In the external maxillipeds the ischium is moderately broad, sub-triangular, produced a little, and broadly rounded at the inner distal angle, its outer distal angle having a strong, obtuse tooth, which usually lies in a shallow groove of the exopod. The outer surface is slightly excavate, and the external margin thickened and defined by two ridges. The merus has the inner lobe marked with six or seven denticles. The carpus also has an internal lobe, with a strong tooth below, and a longitudinal lateral ridge, and its upper distal end terminates in an acute tooth. The joints are fringed with the long hairs, as is usual. The exopod is slightly curved, and tapers to an obtuse point. It reaches to more than half the length of the merus; its outer face is slightly excavate.

The chelipeds are usually equal in the female; they are rough, like the carapace. The merus is short, and bears a large anterior lobe, whch is acute, with very small denticles on its edge; there is a small spine on the distal margin underneath. The carpus, which is about as long as the palm, is slightly excavate longitudinally on the inner surface: the upper surface has two longitudinal sulcations, with a prominent ridge between them marked by oblique striæ: the outer margin bears a series of small forward directed teeth; the inner margin is divided into two acute lobes and a distal prominence, the two lobes bear marginal minute denticles; there are also a few spinules near the distal end above; the lower surface is nearly smooth. The palm is much compressed, it widens considerably from the proximal end; there is a broad ridge on the upper surface which extends to the base of the mobile finger; the inner margin is rather acute, with a small tooth near the distal end, besides a terminal one; the outer margin, which is nearly straight for most of its length, bears a series of spinules which extend to the end of the immobile finger; there are also a few spinules along with a dense mass of hair on the upper surface towards the outer margin; the under surface is nearly smooth. The fingers are very much compressed and rather unsymmetrical, meeting their whole length with some obscure longitudinal sulcations; the mobile one has a sharp ridge above, which near its distal end shows some small denticles, its apex is constricted to a hook, its inner surface is excavate. The immobile finger is excavate; its apical tooth is unsymmetrically placed. In the adult male the chelipeds are very unequal, one is often greater developed, the hairs are absent, and the asperities much reduced, the fingers do not meet except at their apices, and there is a tooth on each near the proximal end of their opposable edges. This cheliped takes a strong red colour.

The carapace of the male is much less hairy.

The three pairs of ambulatory legs are stout, rather rough, with groups of soft hairs, the propodi have a series of spines behind, the dactyli are strong, more than half as long as the propodi; they end in one strong claw, at the base of which there is a little tubercle, tipped with a small spine, and inwardly from this there are four spines.

The last pair of legs are very slender and chelate; they reach about half the length of the carapace.

Dredged by Dr. Verco, Investigator Straits, 20-30 fms.
Length of carapace, 6 mm.
Breadth of carapace, 5 mm.
Length of cheliped, female, 10 mm.
Length of cheliped, enlarged, male, 16 mm.
Types in Adelaide Museum.

Sub-genus *Polyonyx*, Stimpson.

Polyonyx transversus, Haswell. Pl. xxxvi., figs. 2, 2*a*.

Porcellana transversa, Haswell, Cat. Aust. Crust, p. 150.

The carapace is nearly smooth, much broader than long, showing from above a transversely ovate shape, very convex in the antero-posterior direction, much less so in the transverse, rather more depressed behind than in front. The regions are faintly defined; the postero-lateral strongly rugose. The protogastric lobes are slightly prominent. The front, when viewed from above, appears slightly arcuate, rather more than one-third the width of the carapace, marked by a distinct ridge or crest, the median lobe of which projects, and there are two lateral lobes very obscure. Slight insinuations mark the orbits above. Viewed from before, the front appears nearly straight, the median portion slightly depressed. The antero-lateral regions are two-lobed, the lobes separated by a wide notch of the cervical groove; they are faintly cristate, and the anterior one is depressed.

The basal antennular joint is ovate and slightly ridged above.

The eyes are small, scarcely projecting beyond the margin of the carapace.

The basal joint of the antenna is large, sub-triangular in shape; its lower margin very arcuate and prominent: a ridge runs nearly parallel to the inner margin, and there is a small tooth projecting inwards at its interior angle beneath the eye; its upper portion reaches the edge of the carapace, and both its inner and outer sides are strongly incurved. The third joint of the peduncle is narrower and longer than the second, the fourth is very short: these three joints are not crested or lobed.

The appendages are more or less iridescent.

The external maxillipeds are smooth. The internal margin of the ischium is almost semi-circular. The merus is subequal in length to the propodus, and there is on the inner side near the proximal end a prominent lobe. The carpus is a little shorter than the propodus: it is sub-triangular in shape from a side view. The joints are fringed with very long hairs. The exopod does not reach to the middle of the merus.

The chelipeds are slightly unequal—in this specimen the right is larger—they are long and well developed, and very hairy. In the right one the merus is short, its upper surface irregularly rugose; there is a small incision on the upper distal end. The carpus is nearly smooth, rounded behind, somewhat spindle-shaped viewed from above, nearly as long as the carapace; the inner and upper margin, which is a thin, very prominent ridge, bordering a deep longitudinal concavity, is entire and convex, and is clothed with very long plumose hairs, which extend to parts of the upper surface: the lower inner margin is scarcely prominent: there is a small incision at the distal end above. The palm is a little shorter than the carpus, it is compressed, rounded on its upper margin, which is marked by a longitudinal line, and bears a few spinules towards the mobile finger. The lower margin is an acute ridge, bearing a row of small teeth, which reach to the end of the immobile finger. The oblique outer surface is covered with a dense mass of plumose or ciliate hairs, which end abruptly at the ridge, the under surface being quite glabrous. The mobile finger bears a longitudinal row of well-developed teeth on the outer side, on a ridge which sharply marks the hairy portion from the glabrous. The fingers are crossed at their apices, and each has an internal large tooth.

The three pairs of ambulatory legs are short, robust, and mostly smooth, very hairy. The propodi have a series of spines behind. The dactyli are short, curved, and end in two claws; behind these there are two or three strong spines. The last pair is very slender and chelate.

The pterygostomial regions are somewhat excavate, and are crossed by a rather sigmoid ridge.

The pleon of the female is very long and partially overlaps the external maxillipeds: it is smooth or slightly punctate. The first joint is narrow at first, but soon becomes as wide as the second, these become successively broader till the fifth inclusive, the sixth is slightly concave at the sides, and bears a pair of well-developed, biramous uropods. The last segment is composed of seven plates, one median and triangular, the others lateral, the most proximal of which is very small compared with the others, the two distal plates form the termination.

Length of carapace, 8 mm.
Width of carapace, 11 mm.
Length of cheliped, 19 mm.
Length of first ambulatory leg, 10 mm.
Dredged by Dr. Verco, 17 fms., off Newland Head, S.A.
One specimen, a female, in Adelaide Museum.

Genus *Petrolisthes*, Stimpson.

Sub-genus *Petrocheles*, Miers.

Petrocheles australiensis, Miers. Pl. xxxvi., figs. 1, 1*a*.

Petrocheles australiensis, Cat. Crust., N.Z., p. 61.
Petrocheles australiensis, Cat. Aust. Crust., p. 174.

The body is nearly flat, covered with scale-like prominences, which are small on the upper surface of the carapace, but larger on the appendages. From the scales arise short, harsh hairs, which, again, are more developed on the limbs.

The carapace is obcordate, slightly convex in the transverse direction, less so in the antero-posterior. The cervical groove is well marked and wide. The protogastric region bears anteriorly just behind the orbits two low spines, followed by some scale-like tubercles, more pronounced than those of the rest of the carapace. Anterior to these spines the front is depressed, triangular, acute at the apex, each side having three strong spines, including the supra-ocular, which is large. The interocular space is more than one-fourth the width of the carapace.

The lateral margins of the carapace are strongly cristate anteriorly, furnished with eight spines, including the post-ocular: these have often a few spinules between them; these spines occupy about three-fifths the length of the lateral border, the postero-lateral remaining portion of which is rounded and marked with some oblique rugæ. The posterior border is strongly insinuate.

The pterygostomial region has a very strong oblique ridge, reaching well behind.

The pleon is broad, the segments marked with transverse, slightly elevated areas, coarsely hairy. The sixth segment is longer than the preceding ones and narrower, the lateral margins being deeply excavated to receive the peduncles of the uropods. The telson is composed of five plates, viz., one large, median, and triangular, two elongate and lateral, and two terminal ovate, with peduncle-like constrictions, and fringed with long, plumose setæ.

The eyes are moderately large, on short peduncles.

The basal joint of the antennule is strongly spined distally, as in *Galathea*.

Three joints of the antennal peduncle are distinct, the first of these is very short, and anteriorly bears a prominence tipped with two or three spines, the second, which is also short, is prominent in front, with one spine and a few spinules, the third, though scarcely shorter, is cylindrical; the flagellum is about as long as the chelipeds.

In the external maxillipeds the ischium is moderately broad, produced at the internal distal angle, and the margin broadly rounded and minutely crenulated, also a little produced at the external distal angle. The merus has the internal lobe only very slightly projecting, above it is a spine, and at the distal end a smaller one. The carpus has two longitudinal ridges on its upper surface, and is a little lobed internally and deeply hollowed below, to receive the process of the following joint. The propodus is much lobed internally, the lobe being hatchet-shaped. The joints bear the usual long, plumose setæ. The exopod is rather slender, reaching about half the length of the merus; it bears a few coarse granules on its outer border.

The chelipeds are long, well developed, very spinose to tuberculate. The merus joint reaches slightly beyond the level of the eyes, and is somewhat compressed, with two small spines on the distal margin above, and with two or three on the inner surface longitudinally placed, with a large spine at the inner distal angle. The carpus is two-thirds the length of the carapace; it is rounded on the outer side with a row of seven or eight moderately-sized spines; the upper surface, which is nearly flat, bears a median row of a similar number of spines. The upper anterior border has six large, forward-directed spines, and besides these the anterior surface, especially towards the distal end, bears some more or less spiniform, scattered tubercles. The lower anterior border is almost entire, except for the ends of scale-like ridges, which are well marked on the under surface. The propodus is much compressed, the upper or inner margin of the palm is a little shorter than the carpus; it is covered by oblique rugæ, which extend for some distance on the under side. The upper or outer surface has a longitudinal granulate to spinulate ridge nearer the inner border than the outer, and between this and the outer margin is a flat area, covered by dense but very short hairs, with some spinules intermingled. The outer margin is slightly raised, granulate to spinulate, and a little sinuate in outline to the end of the immobile finger. The mobile finger is as long as the inner margin of the palm, it bears a row of spines on the inner margin, these project forwards and a little inwards. There is another row of spines on the outer side, near the cutting edge; the immobile finger has a similar row in the corresponding position. The cutting edges of both fingers are furnished with strong teeth, which become smaller and more numerous distally; an hiatus occupies about two-thirds the length of the fingers, and the tip of the mobile finger is long and hooked, and overlaps its fellow, which is almost straight. The under surface of the propodus is covered with scale-like tubercles and is almost glabrous; it has an indistinct, broad, longitudinal ridge, which corresponds in position to the one on the upper surface.

The three pairs of legs which follow are strong, the first reaches a little further than the end of the carpus of the cheliped. They are very setose, and are covered with the scale-like markings. The meri are compressed with a few strong spines on their anterior margins, and one strong spine near the distal end of the posterior border, and another just above it. The propodi, which are scarcely compressed, have three or four small spines behind, especially one at the distal end. The dactyli are short and stout, with one terminal slightly curved claw and four spines inward from this.

The last pair much reduced in size is minutely chelate, and bears terminally many stiff hairs.

Length of carapace in the median line from tip of rostrum to the insinuation of the posterior border, 23 mm.

Breadth, 23 mm.

Length of cheliped, 56 mm.

It is impossible to look at this species without recognising its strong likeness to the family *Galatheidæ*.

Dredged by Dr. Verco, St. Vincent Gulf; also a specimen from Port MacDonnell, collected by Dr. Torr.

Family Galatheidæ.

Genus *Galathea*, Fabricius.

Galathea setosa, *n. sp* Pl. xxxv., figs. 2, *2a*, *2b*.

This species is found with *G. australiensis*, Stimpson, and though closely allied to it is, however, I believe, distinct.

The transverse striæ of the carapace, which are much less numerous than in that species, are, especially on the gastric and hepatic regions, broken up into arcuate lobes or squamæ, from which spring very long, coarse, minutely serrate setæ, along with some shorter ones; these extend on to the rostrum, where they arise from small, round tubercles, and are longer than the rostral teeth. The rostral teeth are somewhat ovato-lanceolate in shape, especially the terminal one. The armature of the surface of the carapace is insignificant; there are two very small, obtuse teeth on the gastric region, placed on the most anterior arch, which are wider apart than the two spines of *G. australiensis;* two similar teeth are placed further back and wider apart than these, while there is one on each hepatic region. The first two teeth only are constant. The lateral spines of the carapace are seven, including the post-ocular, which is small.

The three anterior segments of the pleon, except the first, have deep, transverse sulcations, the posterior margins of which, and also faint transverse ridges close to the anterior margins, are fringed with similar forward-directed setæ, as those on the carapace. The fifth segment has a strong transverse ridge about the middle, the hairs of which and also those of its anterior faint ridge are directed backwards.

The eyes are rather large; they have a fringe of strong setæ at their bases.

The spines at the ends of the antennular joints are long, being visible beyond the eyes.

The flagella of the antennæ are longer than the chelipeds and are furnished with setæ at the internodes. (Those of *G. australiensis* are nearly naked.)

The chelipeds, as compared with *G. australiensis*, are shorter and stouter; they are squamose and clothed with long, coarse hairs, the spines also are longer and not so projecting outwards. The fingers are nearly as long as the palm, elongate, and becoming more narrowed or acute at the ends; they are excavate, and have no hiatus in either sex, and are minutely serrate on their outer opposable edges. The immobile finger terminates in two strong, hooked teeth, with one more or less rudimentary on each side. The mobile finger has one hooked tooth, with a rudiment on each side.

The following three pairs of legs are very spiny and very setose. The dactyli are strong, with horny, curved claws and marginal spines.

In both species the telson of the male has on each side above the middle a group of strong, corneous bristles; these on stronger magnification appear to be hollow, and have their tips split, and in spirit specimens have a shiny appearance and golden colour. *G. australiensis* varies in colour, specimens from shallow water are greenish or bluish, those from 20-30 fms. are deep red. The present species has a remarkable colouration. The carapace is white in the middle, and towards each side is a band of colour, in which violet, orange, and brown are seen. The sternal surface is orange. The chelipeds are white, with red spots, the fingers are deep red. The legs are banded with violet, orange, and white. The antennal flagella are red.

Although the differences between these two species are small, they appear constant; a moderate series of specimens having been observed with no sign of intermediacy. In practice they are not difficult to separate.

Through the kindness of the Director of the Australian Museum, I have been able to compare this species with *G. aculeata*, Haswell, and note the following differences:—*G. aculeata* is much less setose and spinose on all parts, its rostrum is nearly smooth, and its terminal spine is much slenderer and lanceolate. The joints of the chelipeds are much less robust, the carpi being longer. The fingers are notably longer than the palm.

From *G. magnifica*, Haswell, it differs in the coarse and harsh hairs of the carapace. In the striæ of the gastric region being broken up into arcuate lobes. In the setose, rostrum, eye peduncles, and limbs. The colour markings are also different.

Length of carapace, 5 mm.

Length of cheliped, 10 mm.

Dredged by Dr. Verco, Investigator Straits, S.A., 20-30 fms.

Types in Adelaide Museum.

DESCRIPTIONS OF PLATES.

Plate XXXII.

Paguristes frontalis, M.-Edw.

Fig. 1. Antennal peduncle, side view, enlarged.
2. Mandible, enlarged.
3. First maxilla, enlarged.
4. Second maxilla, enlarged.
5. First maxilliped, enlarged.
6. Large cheliped, enlarged.
7. Appendage of first abdominal somite of male enlarged.

Plate XXXIII.

Fig. 1. *Paguristes brevirostris* n. sp., enlarged.
1*a*. ,, ,, anterior regions, enlarged.

Plate XXXIV.

Fig. 1. *Paguristes sulcatus*, n. sp., enlarged.
1*a*. ,, ,, anterior regions, enlarged.

Plate XXXV.

Fig. 1. *Porcellana rostrata*, n. sp., enlarged.
1*a*. ,, ,, anterior regions, enlarged.
1*b*. ,, ,, third maxilliped, enlarged.
2. *Galathea setosa*, n. sp., enlarged.
2*a*. ,, ,, third maxilliped, enlarged.
2*b*. ,, ,, cheliped, enlarged.

Plate XXXVI.

Fig. 1. *Petrocheles australiensis*, Miers, enlarged
1*a*. ,, ,, third maxilliped, enlarged.
2. *Polyonyx transversus*, Haswell, enlarged.
2*a*. ,, ,, anterior regions, enlarged.

FURTHER NOTES ON AUSTRALIAN COLEOPTERA, WITH DESCRIPTIONS OF NEW GENERA AND SPECIES.

By the Rev. T. BLACKBURN, B.A

[Read October 3, 1905.]

XXXV.

LAMELLICORNES LAPAROSTICTI.

TROGIDES *(continued)*.

LIPAROCHRUS.

The species of this genus, as distinguished from *Antiochrus*, are of very uniform facies, and much general resemblance, *inter se*, but differing by very satisfactory structural characters. They are easily divided into well-marked groups, distinguished by the number of striæ on the elytra and the external armature of the front tibiæ. The species of only one group—that with numerous, closely placed elytral striæ—are, so far as I know, much subject to variety, and it is just possible that in that group the forms which I regard as varieties of one species may represent a considerable number of very closely allied species. Several species, which I refer to Dr. Sharp's genus *Antiochrus*, have been attributed to *Liparochrus*, and concerning that reference I propose offering some notes below, under the heading "*Antiochrus*." Sixteen names have been proposed as names for species referred to *Liparochrus*, and one *Liparochrus* has been erroneously named as a member of the genus *Cœlodes*. Of the above-mentioned seventeen names, however, all except (at most) eight, I believe to be synonyms, or not to represent true *Liparochri*, and of the eight one name is of doubtful validity. It will be well to enumerate this synonymy before I pass on to furnish a tabular statement of the distinctive characters of the named *Liparochri* of Australia, and to describe two new species which are before me.

L. crenatulus, Fairm., *pimelioides*, Lansb., and *globuliformis*, Macl., I believe to be synonyms of *multistriatus*, Har., for reasons set forth below, under the name *multistriatus*.

L. (cœlodes) bimaculatus, Macl., is said by Harold to be *L. fossulatus*, Westw. This is probably correct. I have seen the type specimen, and it is certainly a *Liparochrus*. My note, when I examined it, is, "*Liparochrus*, probably (from memory) *fossulatus*, but there is not a specimen of the latter at hand for comparison."

L. raucus, Fairm., is evidently, I think, judged by the description, a synonym of the earlier name, *silphoides*, Har.

L. ciliboides, *Har.*, is described in terms that do not distinguish it from *sculptilis*, Westw., and is probably identical with it.

L. aberrans, Fairm., *oblongus*, Har., and *politulus*, Macl., must be referred to *Antiochrus*.

L. asperulus, Fairm. The author's description of this species does not indicate characters that would enable me to place it in the following tabulation. I conjecture that it has probably tridentate front tibiæ, and if so it certainly must stand among the four species that I have placed last in the tabulation. Fairemaire himself states that it is near one of them (*L. geminatus*, Westw.). The statement that the interstices of its elytra are rugulose seems to distinguish it from all the four species I have referred to above, and its colour being stated as "black" further indicates its distinctness from all of them except *geminatus*. I have not seen any *Liparochrus* which fits Fairemaire's description. Nevertheless, it is to be noted that the differences cited between this species and *geminatus* (in which the elytral interstices of the elytra have a decided tendency towards rugulosity) are so much of degree that there is room for doubt whether the description may not have been founded on a small, strongly sculptured example of the older species, a doubt that could be set at rest only by examination of the type or of specimens agreeing with Fairemaire's description, and emanating from Fairemaire's locality (Peak Downs, Qu.). If its front tibiæ have only two external teeth the word "nitidissimus" in its description distinguishes *L. asperulus* from its congeners of the same group.

TABULATION OF CHARACTERS.

A. Elytra with closely packed, non-geminate striæ	multistriatus, *Har.*
AA. Elytra with widely spaced striæ, which run in pairs.	
B. Front tibiæ bidentate externally.	
C. Elytra opaque, with nitid granules on the interstices	silphoides, *Har.*
CC. Elytral interstices not bearing nitid granules	sculptilis, *Westw.*
BB. Front tibiæ tridentate externally.	
C. Elytra blackish, each bearing 2 red spots	quadrimaculatus, *Har.*
CC. Elytra not bimaculate.	
D. Elytral striæ impressed with comparatively large foveiform punctures	fossulatus, *Westw.*
DD. Elytral striæ finely (or scarcely) punctulate.	
E. Expanded lateral part of pronotum closely punctulate or strigose.	

F. Clypeus not abruptly expanded in front of the eye.
  G. Colour black, or nearly so; elytral interstices somewhat closely punctulate ... ... geminatus, *Westw.*
  GG. Colour bright ferruginous; elytral interstices very sparsely punctulate rufus, *Blackb.*
FF. Clypeus strongly and abruptly expanded in front of eye ... ... dilatatifrons, *Blackb.*
EE. Expanded lateral part of pronotum punctureless, with a few setiferous granules ... nitidicollis, *Blackb.*

L. multistriatus, Har. I believe this to be an extremely variable species, widely distributed in Northern Australia, and *L. crenatulus*, Fairm., *pimelioides*, Lansb., and perhaps *globuliformis*, Macl., to be synonyms of Harold's name. I have examined a large number of specimens from numerous localities, having the closely striated elytra which distinguish the above-named forms from the other named Australian *Liparochri*, and find among them a wide range of size and many differences in the sculpture of the pronotum, all these differences being observable, *inter se*, among specimens sent in batches from a common locality (*e.g.*, in a batch of specimens from Port Darwin). According to description *crenatulus* differs from *multistriatus* in its pronotum being "sat dense punctatum," while that of *multistriatus* is "in disco parce punctatum." I have both forms, and also many intermediate, and specimens whose pronotum is devoid of puncturation except close to the lateral margin. *L. pimelioides* should be smaller, with the elytra more dilated behind, and having the front angles of the prothorax less acute. A specimen before me presents these characters except the last, but, on the other hand, I have an example with the last-named character very conspicuous, but otherwise agreeing with typical *multistriatus*. *L. globuliformis*, Macl., should be smaller than *multistriatus*, with the pronotum more sparsely punctulate. I have specimens agreeing with the latter character, but have not seen any quite so small as the size Macleay gives (long., $1\frac{3}{4}$ l., my smallest specimen being $2\frac{1}{4}$ l.), and this extremely small size perhaps suggests specific validity. If the characters named as distinguishing the three forms that have been separated from *multistriatus* are to be regarded as valid, several others of the forms before me must be treated as distinct species.

L. dilatatifrons, sp. nov. Nitidus; brunneo-rufus; convexus; latissime ovalis; sat glaber; clypeo antice late leviter emarginato, rugulose subgrosse punctulato, lateribus ante oculos subito sat fortiter dilatatis: prothorace fortiter transverso, antrorsum fortiter angustato, supra in disco sparsim subtilissime (in lateribus fortiter et strigatim) punctulato, lateribus leviter arcuatis, angulis obtusis, basi marginata; scutello sparsim subfortiter punctulato; elytris sat fortiter geminato-striatis striis vix perspicue punctulatis, interstitiis sat latis leviter subconvexis sparsim sat fortiter (nullo modo rugulose) punctulatis; tibiis anticis extus tridentatis. Long., 3½ l.: lat., 2½ l.

Among the nitid *Liparochri* having geminate non-punctulate (or nearly so) elytral striæ, this species stands alone (unless *L. asperulus*, Fairm., agrees with it) in having the part of its clypeus immediately in front of the eyes abruptly and horizontally dilated. This clypeal structure is found in some species of other groups (e.g., *multistriatus*, Har.). Australia. I am not sure of the exact locality, but believe it to be in tropical Queensland.

L. nitidicollis, sp. nov. Nitidus; brunneo-rufus; convexus; latissime ovalis; sat glaber; clypeo antice late vix emarginato, rugulose grossissime strigato, lateribus ante oculos haud dilatatis; prothorace fortiter transverso, antrorsum fortiter angustato, supra in disco subtilissime sparsissime punctulato, in lateribus haud punctulato sed granulis setiferis sparsis instructo, lateribus arcuatis, angulis anticis subacutis posticis rotundatis, basi marginata; elytris subtilius geminato-striatis, striis vix perspicue punctulatis, interstitiis planis lævibus sat latis; tibiis anticis extus tridentatis. Long., 3 l. (vix); lat., 1⅘ l.

A very distinct species, differing widely from all its congeners in the sculpture of the lateral portions of its pronotum, which are perfectly smooth and very nitid (*i.e.*, devoid of any punctures or strigosity), but bear a few very conspicuous setiferous granules.

N.W. Australia.

ANTIOCHRUS.

I have before me about a dozen specimens which I have no doubt are congeneric with *A. brunneus*, Shp. The only difficulty I feel in thus referring them consists in the absence from Dr. Sharp's diagnosis and description of any mention of the peculiar sculpture of the marginal part of the elytra, which is present in all the specimens before me. They, however, present all the characters attributed by Dr. Sharp to *Antiochrus*, and moreover are evidently very close to *Liparo-*

chrus oblongus, Har, with which its author subsequently stated that *A. brunneus*, Shp., is identical. If I am in error in referring these specimens to *Antiochrus* they must be regarded as members of an unnamed genus very near to *Liparochrus*. There can, at any rate, be no objection to placing them provisionally in *Antiochrus*. Dr. Sharp says that the only definite character he can assign to *Antiochrus*, as distinguishing it from *Liparochrus*, consists in the great dilatation and compression of the posterior tibiæ, which is certainly very conspicuous in all the specimens I am discussing; but it is unquestionably the case that the form of the tibiæ is not constant in typical *Liparochri*, some of them (*e.g.*, *L. geminatus*, Har.), having hind tibiæ very much compressed and dilated; in fact, almost as strongly as they well could be. I should, therefore, as far as that particular character is concerned, hesitate to regard it as generally satisfactory if it stood alone. I find, however, that the species I regard as *Antiochri* also differ from *Liparochrus* very considerably in facies, being (as Dr. Sharp remarks of the typical *Antiochrus*, though he does not definitely make it a generic character, probably on account of having seen only one species of the genus), in shape more like *Trox* than *Liparochrus*, *i.e.*, more elongate, narrow, and parallel than *Liparochrus*. When in addition to this marked difference in *facies* I observe that all these *Trox*-shaped allies of *Liparochrus* with exaggeratedly dilated posterior tibiæ have also a peculiar elytral sculpture, of which there is no trace in any described typical *Liparochrus*, I have no hesitation in regarding them as generically distinct from *Liparochrus*. The peculiar sculpture I refer to is the presence (on the surface of the elytra close within the hinder part of the lateral margin, and more or less extended forward, according to the species) of several very fine, parallel raised lines placed close to each other, and parallel with the actual margin. In *Liparochrus* the character of the elytral sculpture is uniform quite up to the margin.

Although it seems desirable to set forth the foregoing notes on a genus of Australian *Trogides*, which appears to me distinct from *Trox* and *Liparochrus*, and which I believe to be identical with *Antiochrus*, I regret to find myself unable to write anything satisfactory about the species. The following species are all, I have little doubt, members of this genus:—*A. brunneus*, Shp., and *Liparochrus oblongus*, Har., *aberrans*, Fairm., and *politulus*, Macl. As stated above, Harold has identified the first two of these names as representing a single species. The only one of them named in my collection is *A. politulus*, Macl., my example of which has been compared with the type. It appears to be distinct from *brunneus* and *oblongus, inter alia,* by its head not being granulate. It is also quite distinct from all the other *Antiochri* known to me by the extraordinary thickening of the hinder part of the lateral margin of its elytra. Among the remaining eleven specimens before me there are clearly at least four species, but as I am unable to point out any definite character in them as reliably specific—as one of them is certainly variable in respect of sculpture—and as any one of them might be *A. aberrans*, Fairm., I must leave the determination of the species of this genus for future study and increased material.

LAMELLICORNES PLEUROSTICTI.

The *Trogides*, which end, as far as known Australian species are concerned, with *Antiochrus (vide supra)*, form, in the Lacordairean system of classification, the sixth tribe of the first subfamily, or "legion," *(Lamellicornes laparosticti)* of the family *Lamellicornes.* The seventh tribe of that subfamily, the *Glaphyrides*, has no known representative in Australia. One Australian genus *(Phænognatha)*, through its alliance with a non-Australian genus *(Aclopus)*, which Erichson referred to the *Glaphyrides*, has been placed by some authors in the same tribe; but Lacordaire (Gen. Col., iii.; p 160; note 4) has shown that Erichson was wrong in referring *Aclopus* as he did, and that the proper place for it is in the second subfamily of *Lamellicornes.* That this is the case with *Phænognatha* is obvious to any one who examines a specimen of that genus. These remarks seem desirable because *Phænognatha* stands in Masters' catalogue as a *Glaphyrid.*

The *Lamellicornes pleurosticti* are distinguished from the first subfamily by the position of their abdominal stigmata, the hinder three of them being placed (not on the connective membrane of the dorsal and ventral surfaces, but) on the ventral surface of its segment, so that the last of them is ordinarily visible when the elytra are closed, as well as when they are set open to expose the abdomen fully.

These two subfamilies (or "legions," as Lacordaire calls them) comprise on the Lacordairean system of classification the whole of the *Lamellicornes.* The second subfamily, with which I hope to deal, in respect of its Australian species, in this and some following memoirs, is divided into four "tribes," each of which is extensively subdivided into groups, subgroups, sub-sub-groups, and so on. The four main groups or "tribes" are the *Melolonthides*, *Rutelides*, *Dynastides*, and *Cetoniides.* The first of these differs from the others in the hinder three of the abdominal stigmata being only slightly distant from the connective membrane, with the consequence that all the six stigmata are almost in a continuous line, while in the others all the hinder three stigmata are considerably removed from the connective membrane, and therefore quite out of line with the anterior three. The following table shows the characters by which these "tribes" are differentiated: —

A. The abdominal stigmata (or "spiracles") placed almost in a continuous line	Melolonthides
AA. The hinder three abdominal stigmata quite out of line with the others.	
B. The claws of the tarsi unequal	Rutelides
BB. The claws equal.	
C. The front coxæ transverse, and but little prominent	Dynastides
CC. The front coxæ evidently less transverse and more prominent	Cetoniides

Most of the information contained in the preceding remarks is, of course, familiar to students of the *Lamellicornes*, but before passing on to work in which I hope to diagnose some new genera and describe new species it seems well to furnish such a brief recapitulation as the above contains of preliminary facts, in order to start with a clear understanding of the order and plan I propose to follow.

MELOLONTHIDES.

This first tribe of the second subfamily of *Lamellicornes* is of all the tribes of the family by far the most numerously represented in Australia. Lacordaire divides it into nine subtribes, and another has since been added by Dr. Sharp. Of these ten subtribes only four are incontestably represented in Australia, while to a fifth subtribe *(Macrophyllides)* have been referred two Australian species (both very rare in collections), whose position in that subtribe appears to me open to some doubt. The following table shows the distinctive characters of these five subtribes: —

A. Labrum fixed to the front of the clypeus, and on the same plane with it	Systellopides
AA. Labrum not as in the *Systellopides*.	
B. Front coxæ prominent, and not or but little transverse.	
C. Palpi inserted very little below the plane of the clypeus	Sericides
CC. Palpi inserted considerably below the plane of the clypeus	Sericoides
BB. Front coxæ but little prominent, and strongly transverse.	
C. Ventral segments soldered together	Melolonthides (true)
CC. Ventral segments free	Macrophyllides

The above brief recapitulation of facts regarding the tribe *Melolonthides* is (excepting the tabulation) a mere summary of matters that I have already discussed at some length in a former memoir (Tr.R.S.S.A., 1898, p. 18, etc.), to which I would refer the reader. I repeat the outline merely to avoid the need of having another memoir in hand while making use of the present one. Referring to the tabulation (in which I have departed somewhat from the characters relied on by Lacordaire) I may remind those who may use it that in characterising large aggregates of species it is almost invariably impossible to find single sharply defined points of difference (such as are required for a tabular statement) that can be relied upon as strongly developed in every member of the aggregates in question. The truth of this remark is illustrated by the character assigned to the *Systellopides*, inasmuch as there are genera of the *Sericides* in which to a casual glance it certainly seems to be present. I have discussed this point before *(loc. cit.)*, and therefore merely mention it now with the added remarks that, apart from this character, I cannot see how the *Systellopides* are to be distinguished from the *Sericides* as at present constituted, and that I am unable to satisfy myself that the apparent labrum is really that organ in the *Systellopides*, and is not in such *Sericides* as *Phyllotocus*.

SYSTELLOPIDES (First subtribe of Australian *Melolonthides).*

This subtribe consists of eight species, described by Dr. Sharp, to which it seems probable that the two species of the genus *Prochelyna* ought to be added, and I have two new species now to be described. If *Prochelyna* is distinct from all Dr. Sharp's genera, these twelve species must stand divided into eight genera. They are all extremely rare in collections. Dr. Sharp has conjectured that *Metascelis flexilis*, Westw., the *habitat* of which is not known, may be a *Systellopid*, in which case it might probably be Australian. Dr. Sharp's memoir on the subtribe (Ann. Mus. Gen., ix., pp. 311, etc.), supplies an excellent tabular statement of distinctive characters of those species that can be confidently referred to it. I have no information as to the habits of these insects.

SPHYROCALLUS.

S. bicolor, sp. nov. Rufo-testaceus, clypeo obscuriori, capite postice elytrisque piceis; pronoto, scutello, sternis et femoribus pilis testaceis elongatis dense vestitis: labro lævi; clypeo creberrime sat fortiter punctulato; fronte antice sparsius (postice sparsissime) punctulata; sutura clypeali impressa; prothorace fortiter transverso, antice minus angustato, supra opaco, vix perspicue punctulato (sculptura sub pilos densos abdita), lateribus sat arcuatis, angulis obtusis; elytris subnitidis crebre subtilius minus æqualiter punctulatis, leviter minus æqualiter geminato-striatis; tibiis anticis extus tridentatis. Long., 8 l.; lat., 4 l.

This species certainly ought not to be separated generically from *S. brunneus*, Shp., of which I possess an example agreeing perfectly with Dr. Sharp's description, and taken in N.W. Australia (the original locality). Nevertheless, it differs from *S. brunneus* in respect of a character that Dr. Sharp regards as generic in having its clypeus separated from the frons by an ordinary suture, not a raised line. Also, it departs somewhat in the structure of the labrum, which is intermediate between that of *S. brunneus* and *Chilodiplus* (also in my collection), the front portion of that organ being evidently *thickened* or *tumid*, though the organ is not distinctly bipartite, as in *Chilodiplus*. Apart from these slight structural modifications the present species and *S. brunneus* are extremely close, even specifically, the principal external differences being in the darker head and elytra of the present insect, the shorter joints of its antennal flagellum, the opaque pronotum, the less depth of its elytral striæ, its more nitid and less pilose pygidium, its more densely pilose pronotum, the presence of three external teeth on its front tibiæ (my example of *S. brunneus* has only two, including the apical one), and the greater length of its ventral segments. I have no doubt that my *S. brunneus* and *S. bicolor* are male and female respectively of two allied congeneric species. The joints of the flagellum of the antennæ in *brunneus* are nearly four times as long as the preceding four joints together, in *bicolor* scarcely twice as long. Some of the distinctions between the two that I have mentioned above are probably sexual, but those of the labrum, the opacity of the pronotum, and the striation of the elytra (it is hardly likely that the deeper sculpture would be in the male), together with much colour difference and widely separated locality, point to specific distinctness.

W. Australia; near Eucla.

ENAMILLUS.

The following species must be referred to this genus according to the tabular statement of the characters of the *Systellopid* genera furnished by Dr. Sharp (Ann. Mus. Gen., ix., p. 319), though it is not unlikely that had it been before Dr. Sharp he would have found a new generic name for it. It presents all the characters indicated for *Enamillus* in the tabulation, but differs from those set out in the subsequent detailed diagnosis in respect of the antennæ, the basal joint of the flabellum not enfolding the following joints (although the apical joint enfolds the preceding ones, as in *Enamillus)*. It also differs widely as a species from the unique *Enamillus (E. striatus*, Shp.), especially in its pronotum not being pilose and its elytra not regularly striate, but it is certainly so close structurally to *Enamillus* that no confusion can result from its being assigned to that genus. Unfortunately, my specimen has lost its legs, though in all other respects it is in excellent condition. The *Systellopides* are so rare in collections that I do not like to omit the opportunity of describing this one, and the species of that subtribe are, so far as known, such isolated forms that it is unlikely any other species exists which would be capable of confusion with the present one for want of a description of the colour, etc., of its legs.

E. sharpi, sp. nov. Testaceus, antennarum flabello, palporum maxillarium articulo apicali, capite postice pronoto medio et elytris rufo-piceis (pedibus exempli typici carentibus); supra sat glaber sed prothorace piloso-fimbriato; subtus sat hirsutus; capite (labro sat lævi excepto) crebre sat rugulose punctulato; pronoto subnitido minus crebre minus fortiter punctulato, fortiter transverso, antice valde angustato, lateribus fortiter rotundatis, angulis anticis sat acutis posticis nullis; scutello transverso sparsim punctulato; elytris inæqualiter sat crebre punctulatis, subopacis nec velutinis, striis subsuturali fortiter duabus (geminatim positis) modice quatuor (geminatim positis) vix et tribus sublateralibus fortiter impressis. Long., 5½ l.; lat., 2½ l.

The elytral striæ are as follows:—A subsutural stria deeply impressed except close to the scutellum; three pairs of striæ (the two of each pair very close to each other) at wide intervals from each other and from the subsutural stria, the first pair obsolete in front, but moderately deep behind, the other two pairs scarcely distinct; three entire, fairly deep striæ close to each other and to the lateral margin. The piceous median portion of the pronotum is narrow in front and much dilated hindward, so as to be of triangular form.

W. Australia.

SERICIDES (Second subtribe of Australian *Melolonthides*).

Regarding this subtribe I have little to add to what I wrote seven years ago in the memoir already referred to, where I discussed at some length the character that Lacordaire relied on as essentially distinguishing the *Sericides* from the *Sericoides*, and, without disputing its validity, proposed a different way of determining its presence or absence, which would involve some variation from Lacordaire's classification of these *Melolonthides*. I still hold the same opinion on the matter that I did then. In the memoir mentioned, however, I omitted to refer to Lacordaire's subdivision (into smaller aggregates of genera) of this and the following subtribe—a reference which seems to be called for by the fact that my proposed different expression of the distinction between the subtribes involves a certain degree of re-arrangement of their "groups" (or sub-sub-tribes). These I ignored, provisionally, and furnished a tabulation of the genera without any intermediate subdivisions. Lacordaire subdivides the *Sericides* into five groups, two of which being non-Australian need not be discussed here; and a third *(Mœchidiides)* has the insertion of its maxillary palpi much below the plane of the clypeus, which I regard as associating them with the *Sericoides* rather than with the other Australian genera that Lacordaire places among the *Sericides*. The *Sericoides* Lacordaire subdivides into six "groups," two of whch are not known to be found in Australia. Of the remaining four groups two *(Pachytrichides* and *Aclopides*—at any rate the Australian member of the latter) have their maxillary palpi inserted close to the under surface of the clypeus (as in *Phyllotocus* etc.), and, therefore, in my judgment, should stand near *Phyllotocus*, etc., rather than among such genera as *Colpochila*, *Heteronyx*, etc. I, therefore, hold that these "groups," assuming that the non-Australian *Aclopid* genus is rightly associated with *Phænognatha)*, should be transferred to the *Sericides*, so that there will be four "groups" of Australian *Sericides* and two of Australian *Sericoides*. And here I may refer to a valuable memoir on *Pachytricha* (Ent. M.M. xi., pp. 2, etc.), in which Dr. Sharp discusses the difficulty of placing that genus in the *Melolonthid* series with all the advantage of his profound learning in anatomy, but does not state his own judgment as to what place it should occupy; although I do not find in his remarks anything inconsistent with the view I have taken of the affinities of the genus. The "groups" of the *Sericides* known as occurring in Australia may, then, in my opinion, be thus stated:—

A. Claws bidentate beneath (size very large) ... ... Pachytrichides
AA. Claws not bidentate beneath (size moderate or small).
  B. Mandibles surpassing the clypeus and embracing the labrum ... .. Aclopides
  BB. Mandibles normal.
    C. Hind coxæ very wide ... ... Phyllotocides
    CC. Hind coxæ narrow ... ... Diphucephalides.

PACHYTRICHIDES (First group of *Sericides*).

The genus *Pachytricha*, with its six described species, monopolises this group. The species are all, so far as I have observed, rare in collections, nor have any, I believe, been taken except in W. Australia. They are very fine, large insects, and are very closely allied *inter se*. They have been fully dealt with by Dr. Sharp in the memoir already mentioned, and I have nothing further to say about them.

ACLOPIDES (Second group of *Sericides*).

Represented in Australia, so far as known, by the single species, *Phænognatha erichsoni*, Hope, which is fairly common in collections, but seems to be limited, in respect of *habitat*, to the far north of the continent.

PHYLLOTOCIDES (Third group of *Sericides*).

For the present I must pass this group over with the mere remark that I am not yet prepared to deal with it more fully and confidently than I did in my former memoir (already referred to); for, although I have made some progress with a revision of that memoir, it is probable that I may be able at no distant date to examine certain types, the inspection of which will enable me to write more definitely than I could do at this time.

DIPHUCEPHALIDES (Fourth group of *Sericides*).

This last group of Australian *Sericides* contains two genera, *Diphucephala* and *Epholcis*—the former numerous in known species, and widely distributed, many of its species very abundant. The latter, so far as at present known, almost limited to tropical regions, consisting of not more than five described species, and not very frequent in collections. What I have said above concerning the *Phyllotocides* may be repeated, *mutatis mutandis*, concerning this group, and I, therefore, omit further remark on it for the present.

SERICOIDES (Third subtribe of Australian *Melolonthides*).

Having referred the *Pachytrichides* and *Aclopides* to the subtribe *Sericides*, I leave only two of the groups into which Lacordaire divided the *Sericoides*, as representing that subtribe in Australia, viz., the *Heteronycides* and *Stethaspides*. They are distinguished from each other by Lacordaire as follows:—

A. Species not having a sternal projection ...	Heteronycides
AA. Species furnished with a sternal projection	Stethaspides

The former of these is by far the most abundant in species of all the "groups" of Australian *Melolonthides*. The number of species is so overwhelming that until a much larger proportion has been carefully studied and described it would not be wise to venture an opinion as to whether they should all remain included within the limits of the one "group" or ought to be split up into several "groups," and therefore I do not propose to discuss that point at present. I have already published a revision of the enormous genus *Heteronyx*, and have now before me a great number of additional species, which I hope to deal with at no distant date. I have also furnished a revision of the extensive genus *Colpochila* and of that also have now numerous additional species. Of the more extensive genera of the "group" there still remains *Liparetrus* to be revised by me, of which, in the following pages I attempt a revision, adding some notes preparatory for more detailed work on some other genera closely connected with *Liparetrus.* I may here draw attention to my having furnished (in the previous memoir already referred to) a tabulation of the characters, together with some notes on the same, of the Australian genera known to me that can be referred to the *Sericoides*, though it should be noted that in that memoir I omitted the *Stethaspides* (probably by an oversight), and limited my remarks to the *Heteronycid* portion of the sub-tribe. That, however, is a matter of little importance, as the known species of Australian *Stethaspides* are only two in number, nor is it probable that there are many more to be added in the future; and, moreover, I do not think that they will stand permanently in the *Sericoid* series. The *Stethaspides*, however, do not call for remark here.

LIPARETRUS.

I have found the study of this very extensive genus one of the most difficult tasks that I have encountered in Australian entomology, not on account of the close alliance of its species (for most of them have exceptionally distinctive structural characters), but on account of the very unsatisfactory nature of the monograph of the genus written by Sir W. Macleay, and published in the Proceedings of the Linnean Society of New South Wales, A.D. 1886, which is rendered practically useless by the fact that no reliance can be placed upon the apportionment of the species between the two principal groups into which it divides the genus founded upon the number of joints in the antennæ. I regret to find that I have to make some corrections in my own work on *Liparetrus*, in describing, many years ago, some species as new which I now find had been previously named by Sir W. Macleay, I not having discovered at that time that Sir W. Macleay's statements of antennal structure were in many instances erroneous, so that I assumed species with eight-jointed antennæ to be distinct from those which Sir William asserted to have nine antennal joints. After many attempts to identify Macleay's species by the study of their author's descriptions I arrived at the conclusion that it was impossible to do so, and that an examination of the types (which are in the Sydney Museums) was essential. Accordingly I have recently visited Sydney for the purpose of making that examination, and am now in a position to deal with the matter authoritatively, and the result of my investigations will be found in the following pages.

The number of names that I can ascertain to have been given to species presumably of *Liparetrus*, is 130, of which 29 may be confidently regarded as synonyms, and 9 are so described that they cannot be identified without the examination of types to which I have no means of access, the number of recognisable species being, therefore, 92. To these I have now to add 20 new species, bringing the total up to 112.

As remarked above, the species of *Liparetrus* are in general distinguished by good structural characters, which on first thoughts would suggest the probability of its being easy to break the genus up into satisfactory subgenera and sections; but a prolonged and careful study has forced me to the conclusion that the structural differences are so curiously intermingled that there is not one of them by means of which anything approaching a natural group can be formed. The most striking of the structural characters that I refer to are—*(a)* nature of sexual differences; *(b)* form of clypeus; *(c)* structure of hind tarsi; *(d)* vestiture of dorsal surface; *(e)* structure of front tibiæ; *(f)* structure of antennæ

The species, however, which are associated by agreement in any one of these respects differ widely as regards the other respects, and the species which are placed together by reliance upon any of them are not naturally associated, and have their closest allies in other groups. I have, therefore, not thought it well to form any subgenera, but have made the best use I can of the structural characters for grouping, without claiming to have succeeded in accomplishing a breaking up into natural aggregates except in so far as I shall indicate in the course of this paper that one or two of the subordinate aggregates seem to be a natural association of species.

It must be noted here, however, that *Liparetrus*, as treated by Blanchard and Macleay, includes a number of species of a genus separated by Burmeister from *Liparetrus* under the name *Automolus* (which I hope to discuss in a future memoir under the heading of that name), and it is to

Liparetrus, as characterised by Burmeister, that the preceding remarks refer.

The previous authors who attempted more or less grouping of the *Liparetri* known to them were Burmeister, Blanchard, and Macleay. Burmeister characterised his main groups according to the relative length of the joints of the hind tarsi—a system fairly easy to apply, but supremely unnatural in result. Blanchard founded his groups on antennal structure alone, and this system also leads to unnatural grouping, and in some cases requires use of a microscope. Macleay took the antennal structure as the basis of his classification, with the nature of the sexual distinctions, as indicating secondary aggregates—a system which is not only open to the same objection as Blanchard's, but also is vitiated by the existence of many species of which only one sex is known. I am unable, however, to find any method of grouping the *Liparetri* which will avoid relying upon the characters that I have referred to as unsatisfactory. I hope, nevertheless, to combine them in such fashion as will furnish a tabulation by which few species will be difficult of identification, although I can make no claim for my aggregates of being more *natural* groups than those of the authors I have referred to above. I divide the genus into 19 groups, on each of which separately I append some remarks, but it seems more convenient to make the *tabulation* of the species a continuous one than to provide 19 separate tabulations.

In stating the number of the external teeth of the front tibiæ I have included the apical projection of the tibiæ as a tooth. These teeth do not, I find, as a rule, vary sexually in any marked degree, though they certainly appear to vary in size somewhat in individuals of the same sex. In some species *(e.g., discipennis*, Guér.), with bidentate front tibiæ, the upper tooth is very feeble in some specimens as compared with others, and it is usually most feeble in the males; but where it is well defined in the female it is always, as far as my observation goes, not actually *wanting* in the males. The species showing the greatest sexual disparity, known to me, in this respect is *L. discipennis*. In the closely allied *L. canescens*, Macl., I do not find any sexual difference whatever in the armature of the front tibiæ.

Before I pass to the tabulated statement of the characters of the species, a list of the names that have to be sunk as synonyms, and some brief notes on the species that I have had to omit from the tabulation, seem to be required. I place the names that must be sunk as synonyms in alphabetical order, setting against each the name of which it becomes a synonym. *Basalis*, Macl., and *glaber*, Macl., are *nom præocc.* *Convexus*, Boisd., and *obscurus*, Homb. & Jacq., I have not been able to identify, and merely place them on the authority of other authors. My reasons for the rest of the synonymy will be found detailed in the following pages. It should be noted that *obscurus*, Macl., sinks as a *nom. præocc.*, as well as for the reason noted under the name *picipennis*, Germ. The three *nom. præocc.* are additional to the 29 original names that are synonyms:—

**acutidens*, Macl. = *tridentatus*, Macl.
**Adelaidæ*, Blackb. = *comatus*, Macl.
**agrestis*, Blackb. = *lævis*, Blanch.
**basalis*, Blanch. = *sylvicola*, Burm. (? Fab.).
basalis, Macl. = *albohirtus*, Mast.
**brunneipennis*, Blackb. = *ubiquitosus*, Macl.
convexus, Boisd. = *sylvicola*, Burm (? Fab.).
**flavopilosus*, Macl. = *fulvohirtus*, Macl.
glaber, Macl. = *lævatus*, Macl.
**hirsutus*, Burm. = *marginipennis*, Blanch.
**lanaticollis*, Macl. = *Palmerstoni*, Blackb.
**latiusculus*, Macl. = *sericeus*, Macl.
**Macleayi*, Blackb. = *sylvicola*, Burm. (? Fab.).
**Mastersi*, Macl. = *Germari*, Macl.
**maurus*, Blackb. = *collaris*, Macl.
**montanus*, Macl. = *discipennis*, Guér.
**nigriceps*, Macl. = *lævis*, Blanch
**nigrohirtus*, Macl. = *marginipennis*, Blanch.
**nitidior*, Macl. = *picipennis*, Germ.
**nitidipennis*, Macl. = *ater*, Macl.
obscurus, Hombr. & Jacq. = *iridipennis*, Germ.
**obscurus*, Macl. = *picipennis*, Germ.
**parvulus*, Macl. = *lævatus*, Macl.
**perplexus*, Blackb. = *criniger*, Macl.
**propinquus*, Macl. = *rubicundus*, Macl.
**pruinosus*, Burm. = *vestitus*, Blanch.
**rugosus*, Macl. = *nigrinus*, Germ.
**salebrosus*, Macl. = *sylvicola*, Burm. (? Fab.).
**senex*, Blackb. = *iridipennis*, Germ.
**simillimus*, Macl. = *abnormalis*, Macl.
**simplex*, Blackb. = *rotundipennis*, Macl.
**spretus*, Blackb. = *asper*, Macl.

The following are the names of the species that I am unable to place in my tabulation. The type specimens of

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* This synonymy has not, I believe, been previously notified.

those of them whose names are not Macleay's are in Europe, I presume, if still in existence:—

L. uniformis, Blanch., from Eastern Australia, seems likely to be a member of my twelfth group. The description implies that its elytra are of testaceous colour, without either pilosity or dark markings. If that be so, it is probably a species that I have not seen. Its author supplies no information about the structure of its hind tarsi. Macleay suggests its possible identity with his *luridipennis*, but that is most improbable. The descriptions do not agree, and the localities are very far apart.

L. convexiusculus, Macl. Quite unrecognisable by the description. I could not find the type in either of the Sydney Museums, where it might be expected to be.

L. curtulus, Burm. I suspect this species of being identical with *ferrugineus*, Blanch., although there are discrepancies of colour which render the identity doubtful. The description of colour agrees better with *ubiquitosus*, Macl., but the clypeus of the male does not seem to agree with that of the latter species. It may be distinct from both, in which case I have not seen it.

L. glabratus, Burm. I cannot identify this species. It is probably a member of my fourth group, and seems to be nearest to *incertus*, Blackb., but, *inter alia multa*, differs extremely in colouring. If the type was a specimen from whose propygidium and pygidium the vestiture had been removed by abrasion it might be *L. ovatus*, Macl.

L. glaber, Burm. This species is scarcely described. There being no information given by its author with regard to even such important characters as the structure of the antennæ and the front tibiæ, it is useless to hazard a guess as to its proper place in the genus.

L. Lottini, Dupont. According to Macleay, this species is identical with *L. humilis*, Blanch., in which case it is an *Automolus*. I cannot see, however, that Macleay can have had any solid ground for identifying it with any insect in particular, as the description is quite worthless.

L. nigricollis, Hope. This is a mere name; it is unaccompanied by any information that would associate the species with *Liparetrus;* in fact, the scanty remarks on the elytra seem to be more consistent with a place in some other genus.

L. gagaticeps, Macl. The presumable type is in the Macleay Museum. It appertains to a species that I have not seen elsewhere. Unfortunately, the structure of its antennæ cannot be examined without manipulation that could not be resorted to. Those organs, however, I can say with confidence, have not more than eight joints. If they are eight-jointed, the insect should be placed in my tabulation with *lævatus*, Macl., from which it differs by, *inter alia*, its brightly testaceous prothorax. If the antennæ are seven-jointed the insect should be placed in my tabulation with *opacicollis*, Macl., from which it differs by, *inter alia*, its being less than half the size of that species.

L. striatus, Blanch. Without information as to the structure of the hind tarsi it is impossible to place this species in a tabulation. If the basal joint of those tarsi be shorter than the second joint it might probably be identical with *L. glaber*, Burm., and also with *ovatus*, Macl., in which case it would have priority over those two names. If its hind tarsi be not as suggested above it is a species that I have not seen.

A. Antennæ 9-jointed.
B. Front tibiæ 3-dentate externally.
C. Basal joint of hind tarsi evidently shorter than the 2nd joint.
D. Disc of pronotum bearing erect pilosity.
E. Erect pilosity largely extended on the elytra.
F. Pilosity of pronotum entirely of pale colour.
G. Front margin of clypeus very deeply emarginate (as deeply as in *abnormalis*, Macl.) Kennedyi, *Macl.*
GG. Front margin of clypeus not (or more feebly) emarginate.
H. Basal joint of front tarsi (male) produced at inner apex.
I. Elytra not closely punctulate; geminate striæ well marked ... ... comatus, *Macl.*
II. Elytra closely punctulate; geminate striæ feebly defined ... ... fulvohirtus, *Macl.*
HH. Basal joint of front tarsi (male), not, or scarcely, produced at inner apex.
I. Pygidium black ...
J. Elytra with geminate striæ not, or scarcely, traceable ... xanthotrichus, *Blanch*

JJ. Elytra with geminate striæ well marked ... ... necessarius, *Blackb.*

II. Pygidium red ... rufiventris, *Macl.*

FF. Pilosity of pronotum blackish in middle part.

G. Basal joint of front tarsi (male) keeled on inner edge.

H. Size very large (about 5 l.); geminate striæ of elytra strong ... ... ater, *Macl.*

HH. Size moderate (about 4 l.); geminate striæ of elytra feebler ... phœnicopterus, *Germ.*

GG. Basal joint of front tarsi (male) not keeled, but produced at inner apex.

H. Front of clypeus (male) bisinuately emarginate (as in *xanthotrichus*) ... Mitchelli, *Macl.*

HH. Front of clypeus (male) not bisinuate villosicollis, *Macl.*

EE. Elytra glabrous, or nearly so.

F. Clypeus of male truncate; pilosity of pronotum of pale colour.

G. Clypeus scarcely narrowed forward. Front tarsi of male much thickened ... ... Germari, *Macl.*

GG. Clypeus considerably narrowed forward. Front tarsi of male scarcely thickened ... capillatus, *Macl.*

FF. Clypeus of male rounded in front; pilosity of pronotum blackish ... dispar, *Blackb*

DD. Pronotum glabrous on disc, but frilled with erect hairs all across front.

E. Front margin of clypeus with a median tooth-like obtuse prominence in both sexes ... ... Kreusleræ, *Macl.*

EE. Front margin of clypeus not prominent in the middle.

F. Lateral angles of clypeus acute in the male.

G. All the joints of front tarsi (male) keeled internally ... ... lugens, *Blackb.*

GG. Tarsi of male not keeled internally.

H. Elytra strongly pruinose and iridescent angulatus, *Macl.*

HH. Elytra not pruinose nor iridescent ... fimbriatus, *Blackb.*

FF. Lateral angles of clypeus roundly obtuse ... concolor, *Er.*

DDD. Pronotum glabrous on disc, or with only a few hairs on the antero-external parts.

E. Clypeus conspicuously tridentate in front ... ... distans, *Blackb.*

EE. Clypeus not dentate (or scarcely so).

F. Entirely testaceous (including the head) ... aridus, *Blackb.*

FF. Some part (at least the head) dark.

G. Sides (but not middle part) of front margin of pronotum pilose ... picipennis, *Germ.*

GG. Front margin of pronotum glabrous.

H. Propygidium and pygidium clothed with coarse squamiform setæ.

I. Clypeus (at least of male) sharply truncate, with well defined angles ... lividipennis, *Blackb.*

II. Clypeus rounded off at the angles in both sexes.

J. Size fairly large (3 l. or more): tarsi and claws very long .. ovatus, *Macl.*

JJ. Size small (less than 2½ l.): tarsi and claws much shorter.

K. Median line of pronotum well impressed ... rubefactus, *Macl.*

KK. Median line of pronotum not impressed subsquamosus, *Macl.*

HH. Propygidium and pygidium devoid of squamiform setæ ...

I. Propygidium and pygidium almost without sculpture.

J. Prothorax very strongly transverse ... ... rufipennis, *Macl.*

JJ. Prothorax much more feebly transverse ... posticalis, *Blackb.*

II. Propygidium and pygidium with well defined puncturation.

J. Head sparsely punctulate ... juvenis, *Blackb.*

JJ. Head closely punctulate ...

K. Pronotum conspicuously canaliculate (at any rate near base).

L. Size moderate (3 l. or more) ... incertus, *Blackb.*

LL. Size very small (scarcely 2 l). ... insularis, *Blackb.*

KK. Pronotum not canaliculate ... vicarius, *Blackb.*

CC. Basal two joints of hind tarsi equal (or scarcely differing) in length.

D. Disc of pronotum pilose.

E. Basal joint of hind tarsi longer than apical spine of its tibia.

F. The hairs of the upper surface black, or nearly so.

G. Propygidium (at least of female) closely rugulose and subopaque ... vestitus, *Blanch.*

GG. Propygidium (at least of female) with coarse sparse punctures, and somewhat nitid ... nigro-umbratus, *Blackb.*

FF. The hairs of the dorsal surface flaxen ... ... glabripennis, *Macl.*

EE. Basal joint of hind tarsi shorter than apical spine of its tibia ... ...

F. Size large (5 l.) : geminate striæ of elytra well defined ... ... erythropterus, *Macl.* [*(?Blanch.)*]

FF. Size much smaller (less than 3 l.) : geminate striæ of elytra very feeble ... ... amabilis, *Blackb.*

*DD. Disc of pronotum not, or scarcely, pilose ; a frill of very conspicuous pilosity all across the front margin.

E. Pronotum sharply and conspicuously punctulate.

F. Size fairly large ($3\frac{3}{4}$-$4\frac{1}{2}$ l.) : pilosity of pronotum black ... ... collaris, *Macl.*

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* In *L. puer* there are a few inconspicuous hairs.

FF. Size small (scarcely 3 l.); pilosity of pronotum fulvous ... ... analis, *Blackb.*

EE. Pronotum faintly, or scarcely, punctulate.

F. Size moderate (3¼ l. or more).

G. The submarginal geminate striæ of elytra become much deeper close to apex ... ... consanguineus, *Blackb.*

GG. The submarginal geminate striæ of elytra obsolete towards apex Sedani, *Blackb.*

FF. Size small (less than 2¼ l.).

G. Disc of pronotum with a few scattered hairs puer, *Blackb.*

GG. Disc of pronotum glabrous ... ... rotundiformis, *Macl.*

DDD. Pronotum not pilose either on disc or all across front margin.

E. Front of clypeus deeply and angularly emarginate ... abnormalis, *Macl.*

EE. Front of clypeus not, or scarcely, emarginate.

F. Entirely testaceous, except infuscate head ... distinctus, *Blackb.*

FF. Entirely black (unless elytra red).

G. Propygidium and pygidium densely clothed with adpressed squamiform setæ ... ... tristis, *Blanch.*

GG. Propygidium and pygidium normal.

H. Front margin of pronotum entirely glabrous.

I. Clypeus more produced (in male strongly tridentate); lateral fringe of pronotum whitish. ... ... iridipennis, *Germ.*

II. Clypeus less produced (in male feebly tridentate); lateral fringe of pronotum brown

J. Puncturation of propygidium obsolete in front part ... ... gracilipes, *Blackb.*

JJ. Puncturation of propygidium not obsolete in front part ... ... holosericeus, *Macl.*

HH. Front margin of pronotum with a pilose frill widely interrupted in middle sericeus, *Macl.*

CCC. Basal joint of hind tarsi distinctly longer than 2nd joint.

D. Disc of pronotum pilose (in some species more conspicuously so across base and front margin than elsewhere).

E. Apex (and hind part of sides) of elytra set with short stout bristles ... asper, *Macl.*

EE. Elytra without marginal bristles.

F. Elytra black.

G. Clypeus distinctly tridentate in both sexes atratus, *Burm.*

GG. Clypeus slightly emarginate, not at all dentate ... ... ebeninus, *Macl.*

FF. Elytra red (blackish, or not, near base).

G. Front of clypeus with 3 sharp recurved teeth ... tridentatus, *Macl.*

GG. Front of clypeus feebly and obtusely tridentate.

H. Elytral puncturation strong (about as in *L. villosicollis*, Macl.) parvidens, *Macl.*

HH. Elytral puncturation notably finer ... obtusidens, *Macl.*

DD. Pronotum not pilose on disc, but having a fringe of erect hairs all across its front Rothei, *Blackb.*

DDD. Pronotum not pilose on disc, and not fringed across its front.

E. Front of clypeus having 3 strong sharp recurved teeth Perkinsi, *Blackb.*

EE. Front of clypeus distinctly tridentate; the teeth feeble, blunt, and not recurved.

F. Pronotum and pygidium dark ... ... bituberculatus, *Macl.*

FF. Pronotum and pygidium testaceous red ... ... melanocephalus, *Blackb.*

EEE. Front of clypeus not at all tridentate.

F. A curved impression on either side, on pronotum behind its middle ... impressicollis, *Macl.*

FF. Pronotum normal.

G. Size moderate (2½ l.); subopaque; colour subuniform, piceous ... convexior, *Macl.*

GG. Size very small (less than 2 l.); nitid; colour variegated, partly testaceous ... ... læticulus, *Blackb.*

BB. Front tibiæ not tridentate externally.
C. Pronotum pilose, at least with a fringe of hairs across its front margin.
D. Elytra pilose.
E. Elytra very long, quite or almost covering propygidium in both sexes ... ... alienus, *Blackb.*
EE. Elytra normal (or very short).
F. Elytra unicolorous.
G. Front tibiæ very strongly bidentate externally suavis, *Blackb.*
GG. Front tibiæ not, or scarcely, bidentate externally.
H. Elytra bearing very long and very coarse sparse white bristles diversus, *Blackb.*
HH. Elytra clothed with fine soft hairs ... rotundicollis, *Blackb.*
FF. Elytra bicolorous.
G. Front tibiæ not toothed externally above the apical projection.
H. Basal joint of hind tarsi fully half again as long as 2nd joint ventralis, *Blackb.*
HH. Basal joint of hind tarsi notably shorter in proportion to 2nd joint ... ... assimilis, *Macl.*
GG. Front tibiæ distinctly bidentate externally.
H. Basal joint of hind tarsi at least half again as long as 2nd joint ... ...
I. Pilosity of dorsal surface dark .. discipennis, *Guér.*
II. Pilosity of dorsal surface almost white ... ... albohirtus, *Mast.*
HH. Basal joint of hind tarsi very little longer than 2nd joint canescens, *Macl.*
DD. Elytra glabrous, or with only a few hairs close to base.
E. Basal joint of hind tarsi not shorter than 2nd joint.
F. Dorsal surface not uniformly dark.
G. Elytra pilose in front part ... ... gravidus, *Blackb.*
GG. Elytra glabrous.
H. Disc of pronotum clothed with erect hairs.

I. Basal two joints of hind tarsi equal, or subequal, in length.

J. Pilosity of pronotum nearly white discoidalis, *Macl.*

JJ. Pilosity of pronotum dark brown or blackish.

K. Front tibiæ conspicuously bidentate externally ... occidentalis, *Macl.*

KK. Front tibiæ with upper tooth all but non-existent ... luridipennis, *Macl.*

II. Basal joint of hind tarsi very much longer than 2nd joint ... ... sericeipennis, *Macl.*

HH. Pronotum glabrous on disc, but with a fringe of long hairs across front ... ... cinctipennis, ***Blackb.***

FF. Dorsal surface uniformly dark ... ... nudipennis, *Germ.*

EE. Basal joint of hind tarsi notably shorter than 2nd joint ... ... Palmerstoni, ***Blackb.***

CC. Pronotum glabrous, or at most fringed with hairs on lateral parts of front margin.

D. Basal joint of hind tarsi fully as long as joints 2 and 3 together ... ... caviceps, *Blackb.*

DD. Basal joint of hind tarsi much shorter.

E. Clypeus very distinctly tridentate in front ... ... minor, *Blackb.*

EE. Clypeus not tridentate in front.

F. No part of dorsal surface (unless head) black.

G. Basal joint of hind tarsi not longer than 2nd joint.

H. Front tibiæ conspicuously bidentate externally ... ... pallidus, *Macl.*

HH. Front tibiæ with no distinct tooth above the apical projection.

I. Flabellum of antennæ piceous; head confluently transversely rugulose ... ... brevipes, *Blackb.*

II. Antennæ entirely testaceous; head punctulate (not very closely) ... Blanchardi, *Blackb.*

GG. Basal joint of hind tarsi considerably longer than 2nd joint ... modestus, *Blackb.*

FF. Dorsal surface (except elytra) black.

G. Front tibiæ unarmed above the apical projection ... ... Leai, *Blackb.*

GG. Front tibiæ distinctly bidentate ... ... rotundipennis, *Macl.*

AA. Antennæ consisting of 8 joints (only).

B. Front tibiæ tridentate externally.

C. Basal joint of hind tarsi not longer than 2nd joint.

D. Pronotum pilose on disc, or at least all across front margin.

E. Pilosity largely extended to the elytra.

F. Propygidium and pygidium not coarsely vermiculate-rugulose.

G. Elytra sparsely punctulate, red (more or less black-margined).

H. Basal joint of hind tarsi notably shorter than 2nd joint ... marginipennis, *Blanch.*

HH. Basal 2 joints of hind tarsi equal ... pilosus, *Macl.*

GG. Elytra closely punctulate, black (at most reddish near apex).

H. Front angles of male clypeus acute and directed outward ... callosus, *Macl.*

HH. Front angles of male clypeus not acute and not directed forward nigrinus, *Germ.*

FF. Propygidium and pygidium coarsely vermiculate-rugulose ... ... sylvicola, *Burm.* (*?Fab.*)

EE. Elytra glabrous, or with only a few basal hairs.

F. Sculpture of elytra not transversely rugate.

G. Male clypeus strongly emarginate, with strong, sharp angles; pronotum of female glabrous on disc ... ferrugineus, *Blanch.*

GG. Male clypeus scarcely emarginate, and with feeble angles; pronotum pilose on disc in both sexes.

H. Form broadly ovate; pygidium dark in both sexes ... ... ubiquitosus, *Macl.*

HH. Form much narrower; pygidium (and pronotum) bright red in male ... ... rubicundus, *Macl.*

FF. Elytral sculpture strongly and conspicuously transversely rugate ... rugatus, *Blackb.*

DD. Pronotum glabrous (the lateral margins disregarded).

E. Head, pronotum, and elytra black ... ... erythropygus, *Blanch.*

EE. Pronotum (at least partly) and elytra testaceous.

F. Clypeus subtridentate (distinctly bisinuate) ... badius, *Macl.*

FF. Clypeus not bisinuate.

G. Hind angles of pronotum quite defined.

H. Puncturation of pronotum quite sparse... monticola, *Macl.* (*? Fab.*)

HH. Puncturation of pronotum close ... fallax, *Blackb.*

GG. Hind angles of pronotum rounded off (non-existent) ... ... atriceps, *Macl.*

EEE. Entirely black, except the elytra, which are testaceous (black bordered) ... micans, *Macl.*

CC. Basal joint of hind tarsi much longer than 2nd joint ... criniger, *Macl.*

BB. Front tibiæ with less than 3 external teeth.

C. Front tibiæ conspicuously bidentate externally ... ... lætus, *Blackb.*

CC. Front tibiæ with no distinct tooth above the apical projection ... ... lævatus, *Macl.*

AAA. Antennæ consisting of 7 joints only

B. Pronotum not confluently and asperately punctulate.

C. Pronotum nitid; its longitudinal channel deep and entire.

D. Pronotum sparsely punctulate mysticus, *Blackb.*

DD. Pronotum closely punctulate globulus, *Macl.*

CC. Pronotum not as C.

D. Surface of pronotum entirely clothed with long pilosity ... insolitus, *Blackb.*

DD. Pronotum glabrous, except on sides and across front margin.

E. Surface of propygidium even lævis, *Blanch.*

EE. Surface of propygidium strongly gibbose in middle tuberculatus, *Lea* (*?*)

DDD. Pronotum entirely glabrous (except lateral fringe) ... opacicollis, *Macl.*

BB. Pronotum confluently and asperately punctulate ... ... squamiger, *Macl.*

FIRST GROUP (A, B, C, D, E, OF TABULATION).

The species under this heading form part of a natural group with which, however, some species with very different antennal structure (AA, B, C, D, E, of tabulation) are so closely allied that they ought to be placed in it to make it complete as a natural group. Sir W. Macleay placed them all together, and attributed similar antennal structure to them all. There are strongly marked sexual characters in the clypeus of all of them, and in the front tarsi of more than half, sexual characters in the antennæ moderately strong, in the abdomen almost none, vestiture of dorsal surface and structure of hind tarsi uniform, or but slightly varying specifically, structure of front tibiæ very uniform. The following are notes on some of the species:—

L. Adelaidæ, Blackb., is *L. comatus*, Macl., although the description of *comatus* is extremely misleading, being founded on a colour var. such as I have not seen, and said to resemble *L. marginipennis*, Blanch., which is a species of the same natural group, but by no means one of the most like it superficially. Macleay had a peculiarly coloured example before him, and gave a by no means felicitous description of it under the name *comatus*.

L. flavopilosus, Macl. This species was described from Gayndah specimens, as also was *fulvohirtus*, Macl. Between the two descriptions I find absolutely not one differential character except that the pilosity of one is called "pale red" and of the other "yellowish." In the Australian Museum I find one specimen (male) of *flavopilosus* and two (female) of *fulvohirtus*, doubtless including the types. They are all from one locality (Gayndah), and do not seem to differ *inter se* except in sex.

L. xanthotrichus, Blanch. Macleay says that the basal two joints of the hind tarsi are equal. The specimens so named in the Sydney Museums—as also in my own collection—have hind tarsi with the basal joint (though longer than is usual in this group) distinctly shorter than the second joint. The author of the name does not mention the hind tarsi.

L. ater, Macl. A male (unique) in the Macleay Museum is evidently the type of this species. Excessively close to *phœnicopterus*, Germ., and attributed to the same region (S. Australia) as that species. It is notably larger than any specimen that I have seen of ordinarily coloured *phœnicopterus*, nor have I seen *phœnicopterus* (of ordinary size) with elytra dark piceous in colour as they are in *ater*. The geminate striæ of the elytra are more strongly marked than in ordinary examples of *phœnicopterus*. *L. ater* may prove to be a good species, but is possibly only an aberrant specimen of *phœnicopterus*.

L. nitidipennis, Macl. A female (unique) in the Macleay Museum is, no doubt, the type of this species. It is in bad condition, and seems to me to be certainly the female of *L. ater*, Macl. It is of the size and colouring of a typical example of *phœnicopterus*, Germ., but differs from the female of that species by the more strongly marked geminate striæ of its elytra, and the more abruptly narrowed front portion of its clypeus. Like *phœnicopterus* and *ater* it is from S. Australia.

L. Mitchelli, Macl. A male (unique) in the Macleay Museum, is, no doubt, the type of this species. I do not find any character to distinguish it from *L. villosicollis*, Macl., except the slight difference (indicated in the preceding tabulation) in the form of its clypeus. This difference, however, remoteness of locality being given due weight, seems to indicate probable specific validity.

SECOND GROUP (A, B, C, D, EE, OF TABULATION).

Differs from the preceding group only by the elytra of its members being glabrous, or with only a few hairs close to the base.

L. Mastersi, Macl. Among the specimens standing under this name and *L. Germari*, in the two Sydney museums, it is impossible to identify the actual types. The distinctions indicated in Macleay's note on *Mastersi* (it can hardly be called a description) are too slight to be seriously regarded. In *Germari* the male clypeus is said to be nearly quite truncate, the angles not very acute; in *Mastersi*, "slightly emarginate in front, and acutely angled." In *Germari* the median line of the pronotum is said to be "quite traceable," and in *Mastersi* not traceable. Slight differences in puncturation and vestiture are mentioned. Differences in the inner apical spur of the front tibiæ and the degree of dilatation of the male front tarsi are also mentioned. The last-mentioned character, if it were strongly marked and constant, would, no doubt, be of importance; but, after careful study of the specimens pinned into the two labels ("*Germari*" and "*Mastersi*"), in the Macleay Museum—among which presumably are the types—I have failed in finding two specimens that present this difference *inter se*, or even that differ *inter se*, as *Germari* and *Mastersi* should do in respect of the other slight characters. I must, therefore, regard them as but one species, and as "*Germari*" stands before "*Mastersi*" in Macleay's Monograph, and is described (while *Mastersi* is not), the species must bear the name "*Germari.*"

L. capillatus, Macl. Here, again, the identification of the type is mere guesswork. It is supposed to be in the Macleay Museum, where I find two specimens (male and female), pinned into a label bearing the name *capillatus.* The female is in very bad condition, and does not seem to be specifically identical with the male, having strongly pilose elytra, while the elytra of the male are glabrous. The specimens named *capillatus* in the Australian Museum are identical (so far as can be judged in dealing with bad specimens) with the female in the Macleay Museum. As it was a male that Macleay described, I take it that the male in the Macleay Museum is probably the real type, and I have accordingly treated it as such. It is much like *Germari*, Macl., but is very much smaller, with different male characters (*i.e.*, clypeus much narrowed from base to apex, and front tarsi only very slightly thickened). Macleay's description of *capillatus* is not definite enough to assist identification of type. It may be added that a male standing in the Australian Museum as *capillatus* differs from the male in the Macleay Museum by its elytra being pilose and with a dark basal border, and by its front tarsi being strongly thickened.

L. dispar, Blackb. I place this species in the second group only with hesitation, since the basal joint of its hind tarsi is not much shorter than the second joint, and consequently it is somewhat intermediate between this group and the fifth, from the species of which it differs in the following respects, *inter alia:*—From *vestitus*, *nigro-umbratus*, and *glabripennis*, by the basal joint of its hind tarsi, notably shorter absolutely (as well as in proportion to the second joint), from *amabilis* by much larger size and quite different colouring; and from *erythropterus* by its pronotum considerably more closely punctulate, and its elytra widely dark at the base.

THIRD GROUP (A, B, C, DD, OF TABULATION).

The front of the pronotum entirely bordered with a frill of erect hairs renders this group easily recognisable among the *Liparetri* which have three somewhat equally spaced external teeth on their front tibiæ, nine-jointed antennæ, and the basal joint of their hind tarsi decidedly shorter than the second joint. The last-named three characters are all well defined in all of them, except that in *L. lugens* the difference in the length of the joints of the hind tarsi is somewhat feeble. If that species were regarded as having those joints subequal it would be brought into the sixth group, from all the species of which (not greatly differing in size) it differs by its being devoid of iridescence, and having its pronotum subopaque and closely rugulose.

L. Kreusleræ, Macl. The pronotum of this species is stated by its author to be "free from hair except on the lateral margins." That, however, is a mistake. There are specimens in the Macleay Museum (bearing the name), no doubt including the type, and agreeing with the description in all other respects, but having the apical margin (as well as the lateral margins) of the pronotum pilose. I have, therefore, no hesitation in correcting Sir W. Macleay's description in that respect.

L. angulatus, Macl. Two specimens (male and female) are pinned into the label bearing this name in the Macleay Museum, and are doubtless the types. The species is one I have not seen elsewhere. It is near my *L. fimbriatus*, but differs from it *inter alia* by its strongly pruinose and iridescent elytra.

FOURTH GROUP (A, B, C, DDD, OF TABULATION).

This group is a somewhat heterogeneous assemblage of species, among which there is considerable variety of facies, etc. The characters that I have indicated as common to the group are well marked in all its species, with the exception that a few of them (notably the female of *L. aridus*, Blackb.), are somewhat intermediate between the fourth and seventh groups, owing to the basal joint of the hind tarsi being only a little shorter than the second joint. The use of this character in the hind tarsi is too valuable in dealing with a long series of species to be discarded on account of these doubtful cases; but it seems necessary to furnish a note on each of the latter showing how the species differs (disregarding the hind tarsi) from its allies in the seventh group.

L. aridus, Blackb. The entirely testaceous colour of this species prevents its confusion with any member of the seventh group except *distinctus*, Blackb. The basal joint of the hind tarsi in the latter is quite fully as long as the second joint, the general build is much more robust than in *aridus*, the prothorax much more narrowed in front and much less finely punctulate on its upper surface, its colour a much less pallid testaceous, etc.; also it has remarkable sexual characters on the abdomen which are wanting in *aridus*.

L. picipennis, Germ., can scarcely be confused with the seventh group, as the basal joint of its hinder tarsi is quite distinctly (though not very much) shorter than the second joint. It presents the unusual character of a row of erect hairs widely interrupted in the middle on the front margin of its pronotum. The presumable types of *L. nitidior*, Macl., and *L. obscurus*, Macl., are mere colour vars. of *picipennis.*

L. rubefactus, Macl., is in no danger of confusion with the seventh group, but it is desirable to note that its colour is extremely inconstant, the elytra propygidium and pygidium varying from a rusty testaceous, or a distinctly red, colour to black. The darker specimens are for the most part males.

L. subsquamosus, Macl. A single specimen—no doubt the type—is pinned into the label bearing this name in the Macleay Museum. It is extremely close to *L. rubefactus*, Macl., especially the dark examples of that species; but the difference in the sculpture of the pronotum, in combination with great distance of *habitat*, justify the retention (at any rate, provisionally) of a separate name for this insect. It is difficult to understand why Macleay placed *rubefactus* and *subsquamosus* in different sections of *Liparetrus*, as having the "upper surface entirely glabrous" in the case of the former, and the "body squamose" in the case of the latter. The (presumable) types of the two do not differ at all in that respect from each other.

L. rufipennis, Macl. The presumable type of this insect (in the Macleay Museum) is devoid of distinct puncturation on the propygidium and pygidium—a very unusual character in *Liparetrus.* Macleay does not mention it, unless the phrase "pygidium glabrous" is intended to refer to it.

L. ovatus, Macl. I have examined the presumable type of this species in the Macleay Museum. There are specimens in the collection of Mr. H. J. Carter with their elytra black, which I cannot distinguish otherwise from the type. They are from W. Australia (the original locality).

L. posticalis, Blackb. This species is certainly rather close to that discussed above as *L. rufipennis*, Macl., but I believe it to be distinct, although the examination of more specimens from the same locality (Port Darwin) would be desirable to settle the point finally. It is of very evidently narrower and more elongate build than any of the numerous specimens that I have seen of its ally, the prothorax especially being longer in proportion to the width. There are also differences in the puncturation of the head, the punctures of the clypeus being more coarse and sparse and those of the frons distinctly asperate, which they are not in the Queensland insect, and the tarsi are manifestly less robust than in either sex of that species. I believe the type to be a female.

L. juvenis, Blackb. In my description of this species I called the basal joint of the hind tarsi "*vix breviorem*," as compared with the second joint. It is, however, sufficiently shorter to place the species in my fourth group rather than the seventh. Apart from that character, its uniform pale colour (except on the head and sterna) distinguishes it readily from all the species placed in the seventh group.

FIFTH GROUP (A, B, CC, D, OF TABULATION).

This group differs from the second by the much greater length of the basal joint of the hind tarsi in comparison with the second joint. The following are notes on some of its species:—

L. pruinosus, Burm. Macleay did not know this species. I have found in Mr. Griffith's collection two examples (from Tasmania, the original locality), which agree very well with Burmeister's description. There appears, on first thoughts, to be a serious discrepancy from Burmeister's description, which attributes to *pruinosus* hind tarsi having the basal joint longer than the second joint, whereas I have placed the insect in a group having those joints equal, or almost equal. The fact is, Burmeister did not separately describe the hind tarsi of each species, but made his primary division of the genus into species having *(a)* the basal; or *(b)* the second joint longer than the other, and recognised no intermediate group, and by placing *pruinosus* in *(a)* he indicates the basal joint as the longer. If the basal joint of the species before me be examined (with care that the whole length of the joint be in sight) it is seen to be slightly longer than the second joint, so that in Burmeister's arrangement it would properly stand in *(a)*, but the difference is so slight between the length of the joints that they must certainly be called subequal. In the Macleay Museum there is no *Liparetrus* ticketed "*pruinosus*," but two examples (from Tasmania), of the insect referred to above are ticketed "*vestitus*, Blanch." I have no doubt of their being correctly named, and of *vestitus* and *pruinosus* being synonyms. In his monograph Macleay places *vestitus* in his section with the "body squamose," but the specimens in the Macleay Museum (presumably those Macleay described) present no such character, nor does Blanchard attribute squamosity to *vestitus*. Blanchard's figure in the "Voyage au Pôle Sud," is evidently the figure of this insect, and the *habitat* is given as "Tasmania," although in Blanchard's "Cat. Coll. Ent." it is "Nouv. Holl." There are in my collection examples of a *Liparetrus* from New South Wales that I cannot distinguish from the Tasmanian examples of *vestitus* except by their colouring, which is very variable. Unfortunately, all the Tasmanian specimens that I have seen are females, so I cannot be sure of their identity with those from New South Wales. In some females of the latter the dark marginal colouring is absent from the elytra, while the single male in my possession has elytra almost entirely piceous, with only a small area of reddish tone on the disc. The front tarsi of this male are very much longer (but scarcely thicker) than those of the female.

L. nigro-umbratus, Blackb. In my description of this species (Tr.R.S.S.A., 1887, p. 22) I mentioned the size of the upper external tooth of the front tibiæ as probably a sexual character. I am now, however, of opinion that that is not so, that in the case (at any rate of most) of the species of *Liparetrus*, differences in the robustness of the teeth on the front tibiæ are not sexual, and that I do not know the male of *L. nigro-umbratus*.

SIXTH GROUP (A, B, C, DD, EE, OF TABULATION).

The relation of this group to the third is similar to that of the fifth to the second.

L. collaris, Macl. My *L. maurus* is identical with this insect. When I described it (P.L.S.N.S.W., 1892, p. 99) I stated my reasons for considering it distinct from *collaris* (which I knew only by Macleay's description). I have now examined the presumable type (in the Macleay Museum) and find that the two are specifically identical. The structure of the hind tarsi being disregarded, *L. collaris* is distinct from all those resembling it in colour, of the third group (which has similar vestiture), by the form of its male clypeus—notably emarginate in front, and not having the front angles acute.

SEVENTH GROUP (A, B, CC, DDD, OF TABULATION).

The following are notes on species that belong (at least probably) to this group, which has characters similar to those of the fourth group, except in respect of the hind tarsi.

L. iridipennis, Germ. There is no greater difficulty in studying *Liparetrus* than the identification of this species (described A.D. 1848) without examination of the type, which, if still in existence, is, no doubt, in one of the European collections. As far as Germar's description is concerned it applies very accurately to *L. senex*, Blackb.—a common South Australian species, of which I have seen examples from, among other places, the original locality of *iridipennis*. Unfortunately, there is a very important omission in Germar's description, for it contains no reference to the structure of the hind tarsi. Burmeister redescribed *iridipennis*, and placed it in his group of *Liparetri* having the basal joint of the hind tarsi longer than the second joint. For the reason noted above (under *L. pruinosus*, Burm.), this does not seem to me absolutely incompatible with the identification of his *iridipennis* with *senex*, although in *senex* the basal two joints are all but equal—in the male the basal joint, in the female the second, being just barely shorter than the other (Germar and Burmeister both describe the female only). But, unfortunately for that identification Burmeister adds a note that Germar gives the wrong size for his insect, and that it is (not 3½ l., but) 2½ l. long. The smallest specimen that I have seen of *L. senex* is 3½ l. The question, therefore, arises as to the grounds on which Burmeister made this assertion (giving the same size for *iridipennis* that he assigned to *discipennis*, Guér., a very much smaller insect than *senex*). Without definitely asserting it, he certainly seems to imply that he had seen Germar's type. Nevertheless, I am of opinion that his *iridipennis* is identical with my *senex*, and that, if his measurement is correct, it was founded on an exceptionally dwarfed example. Burmeister's accuracy in respect of this species is certainly discounted by his having represented Blanchard's *sylvicola* as a synonym of *iridipennis*, which is far from a correct statement, Blanchard having merely placed in his descriptive catalogue *sylvicola*, Fab. (without a description, but with the mention of Tasmania as the locality of the specimens before him), and appended some synonymy, at the end of which he places "*iridescens*, Germ." (doubtless a misprint). I feel extremely confident that the Tasmanian specimens which Blanchard catalogued as *sylvicola* were not *iridipennis*. *Sylvicola* is a common species in Tasmania, and I have much negative evidence (from my own collecting, etc.), that *iridipennis* is not found on that island. It seems practically certain that Blanchard's reference to *iridipennis* expresses no more than that author's conjecture that *iridipennis* is identical with *sylvicola*, which is certainly not the case, though that is not to the point here. Macleay's treatment of *iridipennis* is most unsatisfactory. In the Macleay Museum two specimens are pinned into the label "*iridipennis*," one of which is my *senex*, the other my *caviceps* (the former with the front tibiæ tridentate and the basal two joints of the hind tarsi subequal, the latter with the front tibiæ bidentate and the basal joint of the hind tarsi very much longer than the second). Macleay's description of *iridipennis*—which has always been a puzzle to me, appearing to describe a South Australian *Liparetrus* very different from any that I have seen—is evidently a jumble of these two specimens, founded on the front tibiæ of my *senex* and the hind tarsi of my *caviceps*. I may add that my treatment of *senex* as a species distinct from *iridipennis* was founded on its wide divergence from Macleay's redescription, and that author's assurance that specimens of it which I submitted to him were certainly not *iridipennis*. The real identity of *iridipennis* cannot be settled finally without examination of Germar's type; owing to the deficiency of Germar's description, and Burmeister's statement that Germar's measurement is seriously incorrect, it is possible that *iridipennis* is my *gracilipes*, or my *caviceps*, or the species that I regard as *nigrinus*, Germ.; but as my *senex* agrees best on the whole with Germar's description, and is certainly the most plentiful in the locality where Germar's types were collected, the evidence is certainly in favour of my *senex* being the true *iridipennis*. At any rate, it is now clear that Macleay's redescription of *iridipennis* depicts a species that does not exist.

L. gracilipes, Blackb. This species is abundantly distinct from *senex*, Blackb, but it is, as stated above, not certain that it may not be the true *iridipennis*, Germ. Burmeister's *iridipennis* is, I think, certainly not *gracilipes*, as the basal joint of the hind tarsi of the latter is in both sexes a trifle shorter than the second joint. Compared with *iridipennis*, Germ. (*senex*, Blackb.), this species is very similarly coloured, except that the hairs fringing the pronotum laterally are much darker ("dark brown," however, would characterise them better than "black," the word I used in the original description), and the iridescence of the surface is less pronounced; the tarsi are less robust in both sexes; the clypeus is notably less produced in both sexes and less evidently tridentate (male) or sinuate (female), although there is some variability in this respect, some females of both having the clypeus not very far from evenly truncate; the propygidium is very differently sculptured, having the hind part in both sexes more strongly punctulate and impressed with two more or less distinct longitudinal foveæ (these, in some examples, arched so as to meet at both ends and form a ring), between which the surface is more or less gibbous, and the front part abruptly devoid of punctures and highly nitid [in *iridipennis* (*senex*, mihi) the propygidium is in front opaque, with fine, very close punctuation, which becomes continuously stronger and less close hindward, and its surface is even]. In the male of *gracilipes* the middle part of the basal two ventral segments is occupied by a very dense tuft of erect, soft, whitish hairs, which is wanting in its ally.

L. simillimus, Macl. In the Macleay Museum two specimens (one of them presumably the type) are pinned into the label bearing this name. Unfortunately, their sex cannot be confidently determined, as they have both lost their front tarsi, but, judging by the form of the abdomen, I take them to be males, and I think they are males of *abnormalis*, Macl., of which the other specimens that I have seen (including the presumable type in the Macleay Museum) are females.

L. latiusculus, Macl. The presumable type of this species (female) is in the Australian Museum. I can find no non-sexual difference whatever between it and the presumable type (male) of *L. sericeus*, Macl., also in the Australian Museum. It appears to me doubtful whether the specimen pinned into the label "*latiusculus*," is really in its proper place, as Macleay's measurements of that insect indicate a considerably smaller species, but as *latiusculus* is practically undescribed (being merely briefly compared with *picipennis*, Germ.), it is incapable of identification unless the specimen in the Australian Museum be accepted as the type.

L. holosericeus, Macl. The presumable type of this species is in the Macleay Museum. It is closely allied to *L. iridipennis*, Germ. (*senex*, Blackb.), and *gracilipes*, Blackb., but, *inter alia*, differs from both of them by its clypeus without any tendency to sinuation.

EIGHTH GROUP (A, B, CCC, D, OF TABULATION).

The following notes are on species belonging to this group, which differs from the first and fifth groups by the structure of its hind tarsi, but agrees with them in other characters, *i.e.*, vestiture, etc.

L. asper, Macl. The presumable type of this species is in the Macleay Museum, and the same species also is ticketed "*sylvicola*" in the same Museum. If the specimen pinned into the label "*asper*" is really the type, it is incorrectly described in Macleay's monograph, where the vestiture of the pronotum is stated to be "a frill of long, erect, black hairs on the base, apex, and sides." Owing to that statement I assumed that the species was not *asper*, and described it (P.L.S., N.S.W., 1891, p. 482), as *spretus*. It is very possible that the presumable type is not the real one, but nevertheless, as it now stands in the place of the type, it seems better to admit its claim, and regard *spretus* as a synonym, than to adhere to the description and regard *asper* as a species known only by a brief description, and very likely non-existent. For reasons stated under the name *sylvicola*, Fab., I am quite confident that Macleay was mistaken in ticketing *asper* (*spretus*, mihi.), as *sylvicola*.

L. atratus, Burm. In his monograph Macleay expresses doubt as to his identification of this species, and merely quotes Burmeister's description. I have specimens from Tasmania (the original locality), which agree perfectly with Burmeister's description, and are certainly this insect. In both the Sydney Museums *iridipennis*, Germ. (*senex*, Blackb.) stands as *atratus* (the same species also standing, along with *caviceps*, Blackb.), under its right name). I do not find the true *atratus* in the Macleay Museum, but in the Australian Museum an example of it (and also two of *concolor*, Er.), is labelled "*sylvicola*," which latter name (as noted above) is applied in the Macleay Museum to *asper*, Macl. Apparently it was the specimen of *atratus* labelled "*sylvicola*," which Macleay described in his monograph as *sylvicola*.

L. tridentatus, Macl. The presumable type of this species, and also that of *L. acutidens*, Macl., are in the Australian Museum. I can find no difference whatever between them. After his description of *L. acutidens*, Macleay says that it differs from *L. tridentatus*, "as the description will show, very widely." Placing the two descriptions side by side, however, I have failed to find even *one* definite difference between the two, the nearest approach to it being that the elytra of *tridentatus* are called "subsericeous red," and of *acutidens* "iridescent yellow." I do not find any conspicuous difference, even in respect of colour, between the presumable types.

L. parvidens, Macl. The presumable type of this species is in the Australian Museum. It somewhat closely resembles *obtusidens*, Macl., but is probably a valid species, as its elytral puncturation is very notably coarser than in that species, and its *habitat* (Cleveland Bay) is very far distant from that of *obtusidens*.

NINTH GROUP (A, B, CCC, DD, OF TABULATION).

This group differs from the eighth by the absence of pilosity on the disc of its pronotum, and from the tenth by the presence of a fringe of erect hairs all across the front of that segment. I know only one species (*L. Rothei*, Blackb.) which can be referred to it.

TENTH GROUP (A, B, CCC, DDD, OF TABULATION).

The following are notes on species appertaining to this group, which resembles the preceding two groups except in respect of vestiture of pronotum.

L. bituberculatus, Macl. The female is usually much darker in colour than the male.

L. convexior, Macl. Two specimens (one of them, presumably, the type) are pinned into the label bearing this name in the Macleay Museum. I have not seen the species elsewhere.

ELEVENTH GROUP (A, BB, C, D, OF TABULATION).

This group differs from all the preceding by the front tibiæ of its species not tridentate externally. The following are notes on species belonging to it.

L. assimilis, Macl. The presumable type is in the Macleay Museum. I think it a male. Its apical ventral segment does not differ materially from that of male *discipennis*, Guér.

L. discipennis, Guér. Specimens from almost all parts of southern Australia and from Tasmania stand in collections under this name. Macleay gives New South Wales and South Australia as its *habitat*. Whether the specimens from Tasmania and South Australia are specifically identical with those from Sydney I feel rather doubtful. It is too variable a species in colouring for great importance to be attached to such distinctions as greater or less width of dark margins of elytra in local races; but the opportunities I have had of examining sexual characters point to difference in the ventral characters of the male in at any rate Tasmanian examples. Unfortunately, there is only a single male among those I have from Tasmania, and I do not think it safe to found a new species on the decided (though not very great) difference between the sculpture of its apical ventral segment and the corresponding segment in the few male Sydney specimens before me. The study of a longer series might not improbably establish specific difference as constant. The species that Germar describes as *discipennis* seems, from the colour of its vestiture, to be that which Macleay named *canescens*.

L. montanus, Macl. I have examined the presumable type of this species, unique in the Australian Museum, and can find no difference whatever between it and *L. discipennis*, Guér. It seems to be a male; at any rate, its apical ventral segment is quite like that of male *discipennis*.

L. canescens, Macl. I have examined the presumable type in the Macleay Museum. It is a common South Australian insect, and very distinct from *discipennis*, Guér. Besides other differences the apical ventral segment of its male is nitid and almost punctureless, with a strong, obtuse carina placed transversely across its middle, the corresponding segment in male *discipennis*, from Sydney, having an even surface, on which there is fine puncturation, mixed with some coarse piliferous granules.

L. albohirtus, Macl. Two specimens are pinned into the label bearing this name in the Macleay Museum. One of them is obviously some very different insect—the other presumably the type. Macleay says that the front tibiæ are "scarcely bidentate," the upper tooth being "nearly obsolete." I find, however, that although the upper tooth is small (as in *discipennis*, Guér., and *canescens*, Macl.), it is perfectly well defined in the type.

TWELFTH GROUP (A, BB, C, DD, OF TABULATION).

Resembles the preceding group in respect of most of its characters, but has elytra glabrous, or with only a little pilosity near base. The following notes relate to members of this group.

L. discoidalis, Macl. This and the next two species are very distinct, *inter se*, but with few distinctive characters that lend themselves readily to tabulation. *Discoidalis* is represented in the Macleay Museum by two specimens (one of them presumably the type). Their elytra are remarkably coloured, there being only a very narrow black border, except at the apex, which is very widely of a deep black colour, so that to a casual glance they seem to have bright red elytra with a wide, apical black fascia. In one specimen the pronotum is partially red. The front tibiæ are distinctly bidentate externally.

L. occidentalis, Macl. Two specimens are pinned into the label bearing this name in the Macleay Museum. There is, however, a difficulty in accepting either of them as the true type, for Macleay says that the hind tarsi were wanting in the specimen described, which is not the case with either of those in the Museum. Nevertheless, as they are distinct from any other species that I can find to have been described, and agree with the brief description, they may fairly be regarded as correctly named. They resemble *discipennis*, Guér., in colouration, but differ from it widely by, *inter alia*, glabrous elytra and basal two joints of hind tarsi subequal. It is near *discoidalis*, Macl., undoubtedly, but with very much darker vestiture, and moreover the colouring of the elytra in the two examples of *discoidalis* is so conspicuous and unusual that there can be little doubt of its being a specific character. I think one of the specimens of this insect (as also of *discoidalis)* is a male. The apical ventral segment in both is not much different from that of male *discipennis*.

L. luridipennis. A specimen bears this name in the Australian Museum, and agrees well with the description except in the pilosity of the pronotum being somewhat darker than "fulvo-villose" would lead one to expect. Its facies is very different from that of the preceding two species, the size being notably larger and the form more robust. The head is more massive, with the clypeus wide and subsemicircular (not unlike that of *rufipennis*, Macl.)—not at all of the *discipennis* type.

L. lanaticollis, Macl. The presumable type of this species is in the Macleay Museum. It is identical with my *L. Palmerstoni*. Both names were proposed in P.L.S., N.S.W., 1888. Macleay's name is a month later than mine.

THIRTEENTH GROUP (A, BB, CC, OF TABULATION).

Distinguished from the preceding group by the absence, or nearly so, of vestiture on the pronotum. The species are all fairly recognisable, and only one remark seems called for here, viz.:-

L. simplex, Blackb. This name must become a synonym of *rotundipennis*, Macl. When I described the species I drew attention to its being near Macleay's insect, but I judged from the description of the latter that it was distinct, principally from the absence of two minute tubercles on the head, which Macleay mentions, and from the elytral puncturation being by no means "faint." Comparison with the presumable type in the Macleay Museum has, however, satisfied me that the two are identical, the tubercles on the head being either sexual or accidental, and the elytral puncturation being not quite correctly described by Macleay. Macleay's measurement, moreover, is incorrect, the length being 2½-3 l.

FOURTEENTH GROUP (AA, B, C, D, E, OF TABULATION).

Macleay places all the species of this group among *Liparetri* having nine-jointed antennæ. As a fact, they are so closely allied to the species of the first group that, so far as I have observed, the antennal structure alone distinguishes the one aggregate from the other. It seems clear that Macleay must have examined the antennæ of a few species that fall into my first group, and then assumed a similar structure in the rest of the species that, the antennæ being disregarded, would be properly associated with them. Even on that supposition, however, it is difficult to understand the positive assurance he manifests on the subject, for of *hirsutus*, Burm., he says that the description seems to refer it to the aggregate containing *phœnicopterus*, Germ., but attributes only eight joints to its antennæ, which, he adds, "seems impossible." The following are notes on the species of this group and on their synonomy:—

L. marginipennis, Blanch. There seems to me to be no doubt that Blanchard was mistaken in placing this species among those with nine-jointed antennæ. Blanchard's description (which is a fairly detailed one), and his remark on the close resemblance of *marginipennis* to his *xanthotrichus* seem to forbid any doubt that he had before him a well-known species, which is common in New South Wales, and stands in Australian collections generally under the name *marginipennis;* but there are certainly only eight joints in its antennæ. Probably Blanchard counted the joints in the antennæ of *xanthotrichus*, and assumed that a species so closely resembling it as *marginipennis* does would have similar antennæ. This species stands in the Macleay Museum as *marginipennis*, Blanch. The presumable type of *L. nigrohirtus*, Macl., in the Macleay Museum, is also *marginipennis*.

L. hirsutus, Burm. It seems clear that this species is identical with *marginipennis*, Blanch. The descriptions present no definite difference except in Burmeister stating the number of joints in the antennæ as "only eight," which, as remarked above, is correct. Burmeister's omission to identify *marginipennis* may be accounted for by his remark that he is unable to bring Blanchard's *Liparetri* into his work because their author has not described their tarsi.

L. pilosus, Macl. I have examined the presumable type in the Australian Museum. Its antennæ consist of eight joints only. It is extremely close to *L. marginipennis*, Blanch., but differs by the basal two joints of its hind tarsi being almost equal, *inter se*.

L. callosus, Macl. I have examined the presumable type in the Australian Museum, the colouring of which is very unusual in the genus. Its antennæ have only eight joints. The species seems to be variable in respect of colouring, as other specimens before me (otherwise identical) are without the red mark on the elytra.

L. (Melolontha) sylvicola, Fab. This species is one of the difficult *Liparetri* for identification. Its first assignment to *Liparetrus* seems to be in Blanchard's catalogue, where, however, it is not redescribed. Burmeister redescribed it, and I think his identification must be accepted as reliable, inasmuch as he expressly stated that he had examined the Fabrician types of *Melolonthides* in London, among which that of *sylvicola* was, no doubt, included. Then Macleay followed with a redescription, which, however, is evidently founded upon *L. atratus*, Burm. In the Australian Museum two specimens of *L. concolor*, Er., and one of *L. atratus*, Burm., are pinned into the label "*sylvicola*, Fab.," and in the Macleay Museum, *L. asper*, Macl., stands under that name as well as under the name *asper*. In his monograph, Macleay described Burmeister's *sylvicola* (incorrectly in respect of the antennæ, by placing it among the species having nine-jointed antennæ), under the name *salebrosus*, and without citing any reason for rejecting Burmeister's name. The complications, however, do not stop here, unfortunately: for *sylvicola* is an insect the sexes of which are so different that they have been treated as distinct species. *Sylvicola*, Burm., is the female, and the male was described by Blanchard as *basalis*. Here, again, Macleay has confused matters by describing a totally different species as *basalis*, Blanch. I myself in my earliest memoir on *Liparetrus* neglected to verify this determination of Macleay, and, assuming that *basalis*, Blanch., was rightly identified by Macleay, redescribed the true *basalis* as *Macleayi*.

The synonymy which I believe to be correct, then, stands thus:—

L. sylvicola, Fab., Burm. (*nec.*, Macl), fem.
salebrosus, Macl., fem.
basalis, Blanch. (*nec.*, Macl.), mas.
Macleayi, Blackb., mas.

I do not think that any one comparing Macleay's description of *salebrosus* with Burmeister's of *sylvicola* can doubt that they refer to the same insect, which is a remarkably isolated species, and very common in southern Australia. As to Macleay's "*basalis*, Blanch," it is an *Automolus*, and is found in Victoria and Tasmania. Unfortunately, Blanchard's description of *basalis* is an exceptionally meagre one, and it was perhaps not unnatural that Macleay should have referred it to the insect he did if he had not the genuine *basalis* before him. In fact, it is chiefly a matter of colourng and sculpture (although the two insects differ very widely in respect of important characters that Blanchard does not refer to). Both occur in Tasmania commonly. Blanchard says of *basalis*, "elytris fusco-rubris, basi late nigris," which exactly fits the male of *sylvicola*, Burm. Macleay says of the species that he regards as *basalis*, "elytra brownish-red, the base blackish," which aptly describes his *basalis*, but not the male of *sylvicola*, the former having a mere blackish infuscation across the base of the elytra, the other a wide basal fascia, well defined, and of deep black colour. As to sculpture, Blanchard says of basalis, "prothorace scabroso x x elytris punctato-scabrosis x x pygidio scabroso," which very correctly indicates the vermiculate-rugulose sculpture of *sylvicola* (as characterised by Burmeister, who calls it "rugoso-varioloso"), and of *salebrosus*, Macl., which its author describes as "coarsely variolose-punctate." No other *Liparetrus* known to me in nature or description has any such sculpture. *L. basalis*, Macl. (*nec.*, Blanch.), is quite differently sculptured. Macleay calls it "rugosely punctate," a term which he applies (correctly enough) to the sculpture of numerous other *Liparetri*, corresponding to the "rugoso-punctatus" which Blanchard applies to the sculpture of various *Liparetri*.

As to the identity of *L. sylvicola* (Fab.), Burm., and *basalis*, Blanch. (*Macleayi*, Blackb.), as sexes of one species, I can state that I have taken them paired in Tasmania subsequently to my describing *Macleayi*.

It is, perhaps, best to add that nothing short of Burmeister's strong implication that his description of *sylvicola* is founded on an examination of the specimen that stands as the type would justify the acceptance of his identification as correct, inasmuch as Fabricius's description says, "capite et thorace glabris." If Burmeister's *sylvicola* were regarded as distinct from that of Fabricius, the name of Burmeister's species would have to be changed to *basalis*, Blanch.

L. nigrinus, Germ. The species that stands under this name in the Macleay Museum, and that Macleay describes under this name, is a common South Australian insect, and it does not agree, in an important character, with Germar's description, inasmuch as its front tibiæ are tridentate externally, whereas Germar says, "tibiis bidentatis." I believe, however, that in Germar's description "bidentatis" must be a misprint, as in other respects that description satisfactorily enumerates the characters of the species in question. Moreover, I have not seen in any collection any species with bidentate front tibiæ that could possibly be *nigrinus*, and it is hardly likely that a collection with so many South Australian *Liparetri* as were in that which Germar described would not contain this common one. Germar does not mention the structure of the antennæ, which are eight-jointed, although Macleay's description particularly emphasises them as nine-jointed. The species in the Macleay Museum undoubtedly, however, has antennæ very easily seen to have only eight joints. Burmeister, I think, applied the name *nigrinus* to the same species, although there are difficulties in the way of that opinion. He gives the size as 2¾-3 l. (Germar says "3¼ l.," Macleay 3½ l., the smallest specimen I have measured is, long. 4 l.), and says that the clypeus of the male is "obtuse tridentato." Macleay asserts that this (and Burmeister's assertion that the antennæ are eight-jointed) cannot be consistent with Burmeister's *nigrinus* being identical with his (Macleay's). In respect of the antennæ, it was Macleay's mistake, not Burmeister's, as already noted; in respect of the clypeus (the only remaining difficulty), there unquestionably is a slight tendency to bisinuation (scarcely sufficient to deserve mention, I admit, but to which Burmeister, no doubt, referred), in the front margin of the clypeus of the male of this species; indeed, I have a specimen in my own collection in which it is quite distinct, and it is just barely traceable in the specimens that are named *nigrinus* in the Macleay Museum. My conclusion, therefore, is that *nigrinus*, Germ., was correctly identified by both Burmeister and Macleay, the only doubt being connected with what neither of them mentions as a difficulty, viz., Germar's having called the front tibiæ bidentate. It should just be added that this difficulty cannot be got rid of by the supposition that Burmeister may not have counted the apical projection of the tibiæ as an external tooth, for in the case of other species he always does so count the apical projection.

L. rugosus, Macl. The presumable type of this species is in the Macleay Museum, pinned into the label "*rugosus*, S. Australia." It is a female of the species mentioned above as labelled in the same collection, "*nigrinus*, Germ." If it should prove eventually that there is another species (not known to me) which is the true *nigrinus*, the species I believe to be *nigrinus* would, of course, have to bear the name *rugosus*.

FIFTEENTH GROUP (AA, B, C, D, EE, OF TABULATION).

Although this group is distinguished from the preceding one by an apparently slight character (the elytra glabrous or nearly so), its species differ very much in facies from all of the fourteenth group, except *sylvicola*, Burm. (Fab. ?), to which latter they bear more resemblance of a general kind.

L. ferrugineus, Blanch. This is one of the most abundant and widely distributed *Liparetri*. It is remarkable for the pronotum of its male being entirely pilose, while that of the female has only an apical (and, of course, a lateral) fringe of hairs. Blanchard described a female; Macleay's redescription is a mixture of the two sexes. Both authors overlooked the fringe of hairs on the front of the clypeus in the female. I have examined the specimens in the Macleay Museum on which Macleay's redescription was doubtless founded.

L. ubiquitosus, Macl. It is strange that this common New South Wales *Liparetrus* should have remained undescribed until Macleay published his monograph. Nevertheless, it certainly seems to have been unknown to the earlier authors. Macleay is in error in attributing nine-jointed antennæ to it. It is rather near to *ferrugineus*, Blanch., but easily distinguished by the very different sculpture of the clypeus in the male, the much more pilose pronotum of the female, the different colouring, etc. I have examined the presumable type in the Macleay Museum.

L. brunneipennis, Blackb. This name is a synonym of *ubiquitosus*, Macl. At the time when I described the insect I accepted Macleay's statement that his species has nine-jointed antennæ.

L. rubicundus, Macl. Two (presumably including the type) are pinned into the label "*rubicundus*" in the Macleay Museum. Their antennæ have only eight joints, though Macleay calls them nine-jointed.

L. propinquus, Macl. Two specimens (including the presumable type) are pinned into the label "*propinquus*" in the Macleay Museum. They have eight-jointed antennæ. This insect is, I have no doubt, the female of *rubicundus*, Macl.

SIXTEENTH GROUP (AA, B, C, DD, OF TABULATION).

This group includes the species having eight-jointed antennæ, front tibiæ tridentate externally, and pronotum without vestiture (unless along the lateral margins). The following notes are on species appertaining to it:—

L. fallax, Blackb. This species is well distinguished from *atriceps*, Macl., by the hind angles of its prothorax being distinctly defined. It also differs in colouring, its pronotum being uniformly testaceous brown, while that of *atriceps* presents the unusual character of being bicolorous (its front part black). Its pronotum, moreover, is notably less convex longitudinally, that of *atriceps* being exceptionally declivous immediately in front of the base. Also, the general dorsal sculpture of *fallax* is considerably finer and feebler than of *atriceps*. The sexual characters in both species seem to be slight, consisting in little more than an increased robustness of the front tarsi in the male.

L. badius, Macl., is referred by its author to a section of *Liparetrus*, to which he attributes nine-jointed antennæ; the antennæ nevertheless have only eight joints. I have examined the presumable type in the Macleay Museum. The clypeus of that specimen is distinctly bisinuate (or obsoletely tridentate) on its front margin, although that character is not mentioned in the description. I have examples before me of a *Liparetrus* from Beverley, W.A., which I hesitate to regard as specifically distinct from *badius;* nevertheless the front margin of its clypeus is more decidedly tridentate, its colour notably paler testaceous, and the puncturation of its elytra certainly finer and less close than in *badius*.

L. monticola, Macl. (? Fab.). In the Macleay Museum two very much broken specimens are pinned into the label bearing, "*monticola*, Fab." They are examples of two distinct species, one that which elsewhere in the same museum is labelled, "*atriceps*, Macl.," the other superficially resembling it, but different, *inter alia*, by the finer and sparser puncturation, and the well-defined hind angles of its pronotum. The latter is probably that on which Macleay's description is founded, as that description calls the pronotum "thinly punctate." I can give no opinion as to Macleay's reason for the identification with *monticola*—which seems to me doubtful in the extreme; but, as I am quite unable to identify *monticola* myself, I see no objection to allowing this species to stand as "*monticola*, Macl. (? Fab.)" provisionally.

L. atriceps, Macl. This is the species that I had formerly supposed to be *monticola*, Macl. (and have probably so named, for correspondents), on account of its having antennæ with only eight joints, whereas Macleay places *atriceps* in his section of the genus with nine-jointed antennæ. The presumable type is in the Macleay Museum bearing a label, "*atriceps*, Macl." I have mentioned others of its characters (above), under *L. fallax*, Blackb.

L. micans, Macl. Placed by Macleay in his monograph among the species with nine-jointed antennæ. I examined the presumable type, unique in the Macleay Museum, and made the following note on it:—"New to me. Antennæ eight-jointed. Near *fallax*, mihi, from which it differs, *inter alia*, by its quite different colouring, *i.e.*, dorsal and under surface entirely black except disc of elytra."

SEVENTEENTH GROUP (AA, B, CC, OF TABULATION).

This group contains only one known species—*L. criniger*, Macl.—easily recognised by its presenting the following characters in combination:—Antennæ eight-jointed, front tibiæ with three external teeth, basal joint of hind tarsi notably longer than second joint.

L. perplexus, Blackb. This name is a synonym of *L. criniger*, Macl., to which its author incorrectly attributes nine-jointed antennæ; and, owing to that error, I failed to discover the identity of the two until I recently found out that Macleay's characters are not reliable. I have examined the presumable type, in the Macleay Museum.

EIGHTEENTH GROUP (AA, BB, OF TABULATION).

A small aggregate of species presenting the unusual combination of eight-jointed antennæ, with front tibiæ having less than three external teeth.

L. lævatus, Macl. Originally described by its author as *glaber (nom. præocc.)*, and placed in Macleay's monograph among the species with nine-jointed antennæ. I have examined the presumable type, in the Australian Museum, and find that its antennæ have only eight joints.

L. parvulus, Macl. I have examined the presumable type, in the Australian Museum, and find (as Macleay says) that the difference is only in colour, which is, no doubt, either varietal or sexual. I unfortunately omitted to investigate the sex of the types. Both are from Gayndah.

NINETEENTH GROUP (AAA, OF TABULATION).

Easily distinguishable from all the other groups by the antennæ of its species having only seven joints.

L. lævis, Blanch. I have before me specimens from the Swan River (Blanchard's locality) of a species so satisfactorily agreeing with Blanchard's description of this species in every respect, except the number of joints in its antennæ, that I cannot escape the conclusion that that author was mistaken in regard to its antennæ, probably neglecting to examine the antennæ on account of the general resemblance of the insect to other *Liparetri*, which have nine-jointed antennæ. The same species stands in the Australian Museum as *L. lævis*, Blanch.

L. agrestis, Blackb. I regret to find that when I described this species I counted the joints in its antennæ incorrectly, and stated them as eight in number. There was no excuse for doing so (as the joints are evidently only seven). No *Liparetrus* had been previously described as having seven-jointed antennæ, although several species, really having such antennæ, had been described erroneously. I remember thinking that only seven joints was an impossible number, and persuading myself that I discerned a very minute additional joint. In a memoir which I published in the following year attention was first drawn to the existence of *Liparetri* having antennæ of only seven joints. Blanchard having attributed nine-jointed antennæ to his *L. lævis*, I did not take that species into account when I described *agrestis*, but I am now of opinion that the two names represent only one species.

L. nigriceps, Macl. I think there is little doubt of this being the female of *L. lævis*, Blanch. Macleay attributed nine-jointed antennæ to it. I have examined the presumable type, in the Australian Museum, and find it to be—though in very bad condition—certainly conspecific with specimens in my own collection, whch I have long regarded as *nigriceps*, Macl., and as the female of *lævis*, Blanch.

L. globulus, Macl. The presumable type is in the Macleay Museum, and I have examined it there.

L. tuberculatus, Lea. This species is practically undescribed, the structure of the antennæ not being referred to except as involved in a reference to Macleay's grouping of the genus, in which (as mentioned above) the antennal structure is about as often wrong as right. There is no reference at all to the structure of the hind tarsi. As, however, there happens to be one marked character of the insect mentioned in the description, I have selected a *Liparetrus* presenting that character (which, however, is probably sexual), to be called "*tuberculatus*, Lea (?)," and have indicated its characters by its place in the foregoing tabulation.

L. opacicollis, Macl. The presumable type in the Macleay Museum has antennæ of only seven joints. It is near

L. lævis. Disregarding the difference in the vestiture of the pronotum, it is, *inter alia*, a considerably larger insect.

L. squamiger, Macl. I have examined the presumable type, which is in the Macleay Museum.

L. necessarius, sp. nov. Ovatus; minus nitidus; totus cinereo-pilosus, elytrorum pilis nigricantibus exceptis; niger, antennis (clava excepta) palpis et elytris (his ad basin anguste plus minusve nigricantibus) rufis, pedibus plus minusve piceis vel rufescentibus; antennis 9-articulatis; clypeo nitido fortiter minus crebre punctulato; fronte crebre nec subtiliter rugulosa; prothorace fortiter transverso, antice sat fortiter angustato, supra canaliculato, fere ut frons sed paullo minus crebre punctulato, lateribus sat arcuatis; elytris perspicue geminato-striatis, interspatiis sat fortiter vix crebre punctulatis; propygidio sparsius, pygidio magis crebre, rugulosis; tibiis anticis extus tridentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulo basali quam 2^{us} sat breviori.

Maris clypeo antice sat profunde emarginato (fere ut *L. villosicollis*, Macl.), angulis sat acutis nec vel vix extrorsum directis; tarsis anticis sat incrassatis.

Feminæ clypeo truncato vix emarginato, angulis sat rotundatis. Long., 3-4 l.; lat., $1\frac{3}{5}$-$2\frac{1}{5}$ l.

The characters indicated in the tabulation satisfactorily distinguish this species from its allies; it is well, however, to remark that it is apparently identical with all the specimens pinned into the label "*capillatus*, Macl.," in the Sydney Museums (so far as the bad condition of those specimens will allow comparison) except the one male in the Macleay Museum, which is the presumable type, and which agrees well with Macleay's description. From that male it differs considerably in vestiture, and also in the form of the clypeus, which, in the present species, is strongly emarginate, and notably less narrowed forward. It should be added that the emargination of the clypeus, though quite strong, is very different from the profound excision of the clypeus of *L. Kennedyi*, Macl. The notably darker colour of the pilosity of the elytra in comparison with that of the pronotum is an unusual character.

Western Australia (Perth, Mr. Lea).

L. distans, sp. nov. Ovalis; sat nitidus; supra sat glaber (lateribus piloso-fimbriatis); subtus cinereo-pilosus; ferrugineus, antennis pallidioribus (his 9-articulatis); clypeo leviter sat grosse subsquamoso-punctulato, antice 3-vel 4-dentato; fronte sat æquali, subtiliter creberrime punctulata: prothorace valde transverso, supra vix manifeste canaliculato antice sat angustato, minus crebre minus subtiliter punctulato, lateribus leviter arcuatis; elytris sat fortiter geminato-striatis, interstitiis subfortiter minus crebre punctulatis; propygidio pygidioque coriaceis, illo vix perspicue punctulato, hoc puncturis sparsis sat magnis minus fortiter impresso et apicem versus pilis nonnullis vestito; tibiis anticis extus 3-dentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulo basali quam 2^{us} perspicue (nec valde) breviori.

Maris abdomine toto longitudinaliter sulcato.

Fem. latet. Long., 5-5$\frac{1}{2}$ l.; lat., 2$\frac{1}{2}$-2$\frac{4}{5}$ l.

One of the largest species in the genus, and with no near ally among the previously described *Liparetri*. I have three specimens before me (two of them belonging to Mr. Griffith), which appear to be of one sex, and the peculiar concavity running down the whole length of the ventral segments is certainly indicative of their being males. In one example the median projection of the clypeus is bifid, making the front of the clypeus 4-dentate.

N.W. Australia.

L. lividipennis, sp. nov. Ovatus; sat nitidus; supra sat glaber (fronte pilis erectis vestita, lateribus piloso-fimbriatis, propygidio pygidioque setis crassis brevibus subsquamiformibus vestitis); subtus cinereo-pilosus; niger, elytris lividis margine obscuro anguste cinctis; antennis 9-articulatis; clypeo antice truncato (angulis subrectis), grosse squamoso-punctulato; fronte sat æquali, crebre subtiliter punctulata: prothorace fortiter transverso, vix perspicue canaliculato, supra ut frons punctulato, antice sat angustato, lateribus leviter arcuatis, pilis lateralibus albidis; elytris vix fortiter geminato-striatis, interspatiis sat fortiter minus crebre punctulatis: propygidio crebre subtiliter, pygidio minus crebre minus subtiliter, punctulatis; tibiis anticis extus leviter 3-dentatis (dentibus intervallis subæqualibus divisis, dente summo subobsoleto); tarsorum posticorum articulo basali quam 2^{us} multo breviori.

Maris quam feminæ antennarum flabello longiori, tarsis anticis robustioribus. Long., 3-3$\frac{1}{2}$ l.; lat., 2-2$\frac{1}{5}$ l.

The uppermost tooth of the front tibiæ is very feeble, and seems to indicate this as a transition form leading on to the *Liparetri* having less than three external teeth. I have two specimens before me, which I believe to be male and female, as the antennal flabellum is distinctly longer and the front tarsi more robust in one than in the other. There is no marked difference between them in respect of the clypeus.

South Australia.

L. incertus, sp. nov. Ovatus; sat nitidus; nonnihil iridescens; supra sat glaber (lateribus piloso-fimbriatis, propygidio pygidioque setis brevibus albidis adpressis vestitis), subtus cinereo pilosus; niger, nonnullorum exemplorum elytris plus minusve piceis vel rufis, antennis (clava excepta), palpisque rufis, pedibus plus minusve rufescentibus; antennis 9-articulatis; clypeo modice reflexo, nitido, sat grosse leviter squamoso-punctulato; fronte antice impressa, crebre punctulata; prothorace fortiter transverso, supra fortius sat crebre punctulato, sat late leviter (basin versus sat fortiter) canaliculato, antice fortiter angustato, lateribus arcuatis (ante basin sat fortiter rotundato-dilatatis); elytris sat elongatis, sat fortiter geminato-striatis, interspatiis sat fortiter sat crebre punctulatis; propygidio subtilius, pygidio magis fortiter, punctulatis, ambobus plus minusve perspicue carinatis; tibiis anticis extus tridentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulo basali quam 2^{us} sat (nec valde) breviori.

Maris quam feminæ antennarum flabello sat longiori, tarsis anticis multo robustioribus, clypeo antice magis truncato et obsoletissime tridentato. Long., $3\frac{1}{2}$-$3\frac{4}{5}$ l; lat., 2-$2\frac{1}{5}$ l.

This species bears much resemblance to *L. picipennis*, Germ., from which, however, it may be at once separated by, *inter alia*, the absence of any erect hairs on the front margin of the pronotum, and the evident (though slight) tendency to tridentation of the front margin of the clypeus in the male. It seems to be a fairly common species in Victoria and New South Wales (southern parts), so that it is difficult to believe Sir W. Macleay had not seen it, but I conjecture that he had not noticed its distinctions from *picipennis*. The colour of the elytra is very variable, but whatever the colour a slight iridescence seems to be constant.

Victoria and New South Wales.

L. vicarius, Blackb. Ovatus; minus nitidus; niger, antennis palpis pedibus elytris (et non-nullorum exemplorum abdomine prothoraceque) rufescentibus; supra glaber; subtus pilosus; antennis 9-articulatis; clypeo minus crebre punctulato, antice late rotundato (vix subtruncato); fronte crebre punctulata; prothorace fortiter transverso, antice sat fortiter angustato, supra minus crebre subtilius punctulato, haud canaliculato, lateribus sat arcuatis: elytris geminato-striatis, inter-spatiis subfortiter sat crebre punctulatis; propygidio pygidioque crebre sat fortiter punctulatis; tarsorum posticorum articulo basali quam 2^{us} sat breviori: tibiis anticis extus tridentatis (dentibus intervallis subæqualibus divisis). Long., 3-3½ l.; lat., 1⅘-2 l.

I think, from slight differences in the form of the abdomen, that I have both sexes of this species before me, but I do not find any sexual characters in the clypeus or tarsi. This insect is near *incertus*, Blackb, from which it differs, *inter alia*, by the considerably less coarse puncturation of its elytra, its non-canaliculate pronotum, and its front tarsi much shorter than those of either sex of *incertus*.

North Queensland.

L. amabilis, sp. nov. Ovatus; parum nitidus; capite prothorace sternisque nigris, elytris abdomine propygidio pygidioque læte rufis, antennis palpis pedibusque ferrugineis vel picescentibus; antennis 9-articulatis, stipite brevissimo; clypeo squamoso-punctulato, antice late subtruncato, cum fronte et pronoto (hoc basin versus glabro) pilis erectis obscure brunneis (certo adspectu nigricantibus) vestito; fronte sat æquali, cum prothorace crebre subrugulose punctulata; hoc fortiter transverso, vix perspicue canaliculato, antice fortiter angustato, lateribus postice ampliato-rotundatis antice sinuatis; elytris minus fortiter geminato-striatis, interspatiis leviter minus subtiliter punctulatis, glabris: propygidio pygidioque pilis brevibus erectis albidis vestitis, hoc grosse (illo sat fortiter) minus crebre punctulatis; corpore subtus albido-piloso; tibiis anticis extus tridentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulis basalibus 2 inter se sat æqualibus. Long., 2⅘ l.; lat., 1⅗ l.

A very distinct species by the structural characters indicated in the tabulation; also by its colouring, which is a uniform bright red, except the black of the head, prothorax, and sterna. It is one of the prettiest of the *Liparetri*. I think the unique type to be a female.

New South Wales (Mulwala); sent by Mr. Sloane.

L. analis, Blackb.? (Mas.). Ovatus; sat nitidus; niger elytris tarsisque obscure rufis, antennis (clava picea excepta) palpisque testaceis, pedibus plus minusve picescentibus: supra glaber (pronoto antice et ad latera pilis fulvis elongatis fimbriato excepto); subtus pilosus; antennis 9-articulatis, stipite perbrevi: clypeo antice leviter emarginato sat fortiter reflexo; fronte crebre subtilius rugatim punctulata, antice impressa, postice longitudinaliter nonnihil subcarinata; prothorace valde transverso, supra sparsius sat fortiter punctulato, subiridescenti, leviter canaliculato, antice sat angustato, lateribus sat arcuatis; elytris minus perspicue geminato-striatis, interspatiis fortiter sat crebre punctulatis; propygidio subtiliter minus crebre (prope apicem magis fortiter) punctulato, longitudinaliter subcarinato; pygidio fortiter sat crebre punctulato, antice longitudinaliter fortiter carinato; tibiis anticis extus tridentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulo basali quam 2^{us} parum breviori. Long., 3 l.; lat., $1\frac{3}{5}$ l.

I have abstained from giving a separate name to this insect, because, in view of the great sexual differences of some *Liparetri*, and of the fact that the unique example described above is a male, while the unique type of *analis* is a female, I see nothing conclusive against their specific identity. The two specimens differ greatly in colouring, and the pygidium of *analis* is non-carinate. The hind tarsi of *analis* (type) have only the basal joint, but it is quite like the basal joint of the hind tarsi of the specimen described above. If further investigation should prove that the male described above is distinct from *analis*, it will be time then to give it a separate name. The *habitat* of the type of *analis* is uncertain. The fact that the basal joint of the hind tarsi is a trifle shorter than the second joint renders it desirable to compare it with the species of the third group, from all of which its nitid pronotum bearing strong, decidedly sparse puncturation, in combination with its colouring and smaller size, readily distinguishes it.

South Australia (Kangaroo Island). In S.A. Museum.

L. consanguineus, sp. nov. Ovatus; sat nitidus; niger, supra nonnihil cœruleo-iridescens, antennis (clava picea excepta) palpisque rufis, pedibus plus minusve picescentibus; supra sat glaber; pronoti marginibus omnibus pilis brunneis elongatis fimbriatis, propygidio pygidioque sparsim pilosis; subtus pilosus; antennis 9-articulatis; clypeo antice late rotundato vix subtruncato, leviter reflexo, crebre subtilius sat profunde (nec squamose) punctulato; fronte sat æquali, fere ut clypeus (sed antice magis subtiliter) punctulata; prothorace valde transverso, supra (basin versus) vix perspicue canaliculato, antice minus angustato, leviter subtilius (in disco sparsim latera versus magis crebre) punctulato, lateribus sat arcuatis; elytris manifeste geminato-striatis, interspatiis fortius sat crebre punctulatis; propygidio pygidioque subopacis, illo leviter sparsius, hoc magis crebre magis fortiter, punctulato; tibiis anticis extus tridentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulis basalibus 2 sat æqualibus. Long., $3\frac{3}{4}$ l.: lat., $2\frac{1}{5}$ l.

A very broad species, bearing much superficial resemblance to several other species, from most of which it is distinguished by the vestiture of its pronotum, that segment being glabrous except on the margins, which are fringed by long, erect pilosity. As the basal joint of its hind tarsi is possibly a trifle shorter than the second joint it seems desirable to indicate the characters that (apart from the hind tarsi) distinguish it from those species of the third group which are not very differently coloured. From all of them known to me it differs, *inter alia*, by the form of its clypeus and the very much feebler and sparser puncturation of its pronotum. The unique type is a male.

South Australia (Tintinarra); in S.A. Museum.

L. puer, sp nov. Ovatus: sat opacus: niger, elytris (his nonnihil iridescentibus) cum propygidio pygidioque piceis vel rufescentibus, antennis (clava picea excepta) palpis pedibusque rufis, elytris basin versus obscure nigricantibus: supra sat glaber, sed capite piloso pronoti marginibus omnibus pilis erectis perlongis fimbriatis propygidio pygidioque sparsim pilosis: subtus pilosus: antennis 9-articulatis (stipite perbrevi): clypeo antice late rotundato (fere subtruncato), sat fortiter reflexo, crebre subtiliter fere ut frons (hoc sat æquali) punctulato; prothorace fortiter transverso, æquali, subtilius subobsolete punctulato, inter puncturas nonnihil ruguloso vel subgranuloso, antice minus angustato, lateribus sat arcuatis; elytris manifeste geminato-striatis, interspatiis fortiter (fere subgrosse) vix crebre punctulatis: propygidio sat fortiter minus crebre punctulato, sat nitido: pygidio sparsius sat grosse punctulato, nitido: tibiis anticis tridentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulo basali quam 2^{us} vix breviori.

Maris quam feminæ antennarum flabello paullo longiori, tarsis anticis longioribus et robustioribus: maris pygidio longitudinaliter leviter (feminæ nullo modo) carinata. Long., $2\frac{1}{5}$ l.: lat. $1\frac{1}{5}$ l.

This very small *Liparetrus* seems not very close to any other species known to me, and clearly distinct from all those described by Macleay. I suspect that Macleay would have placed it in the *discipennis* group near *holosericeus*, Macl., which, however, he places in that group only with doubt. *Holosericeus* is a larger insect, differently coloured, and is glabrous above. It is, moreover, from a widely distant locality. It may be noted that there are a few hairs on the disc of the pronotum of *puer*, but they are quite inconspicuous compared with the strong frill of long pilosity across the front margin.

South Australia (Eucla district).

L. Perkinsi, sp. nov. Ovatus; minus nitidus; niger, sat iridescens; elytris antennis palpisque rufo-testaceis, pedibus plus minusve rufescentibus; supra sat glaber, subtus pilosus; antennis 9-articulatis; clypeo antice dentibus 3 fortibus acutis recurvis armato, nitido, subsquamose vix crebre punctulato, fronte coriacea crebre subtiliter punctulata; prothorace fortiter transverso, vix perspicue canaliculato, supra fere ut frons sed minus crebre punctulato, antice fortiter angustato, lateribus fortiter rotundatis; elytris subfortiter geminato-striatis, interspatiis subfortiter vix crebre punctulatis; propygidio pygidioque æqualibus, æqualiter ut frons sculpturatis; tibiis anticis extus fortiter tridentatis (dentibus intervallis subæqualibus—sed superioribus 2 nonnihil approximatis—divisis); tarsorum posticorum articulo basali quam 2^{us} manifeste (vix multo) longiori. Long., $2\frac{3}{4}$-$3\frac{1}{5}$ l.; lat., $1\frac{3}{5}$-$1\frac{7}{10}$ l.

The unusual character of three sharp recurved teeth projecting from the front of the clypeus distinguishes this species from nearly all its congeners. The two species to which Macleay attributes that character have their head and pronotum villose. I do not find any marked sexual characters in any of the eight specimens that I have seen of this insect, though I think (from slight abdominal differences) that both sexes are present.

North Queensland. (Sent by Mr. R. C. L. Perkins.)

L. alienus, sp. nov. Elongato-ovatus; minus nitidus; niger, antennis (clava picea excepta) palpis elytris pedibus feminæque abdomine rufis; supra totus (propygidio pygidioque albido-pilosis exceptis) pilis sat elongatis nigris erectis minus dense vestitus; subtus cinereo-pilosus; antennis 9-articulatis; clypeo subnitido, squamose punctulato, antice truncato (angulis obtusis); fronte æquali, ut pronotum coriacea sparsim sat grosse punctulata; prothorace fortiter transverso, æquali, antice sat angustato, lateribus arcuatis; elytris sat elongatis, sparsim subseriatim subgrosse nec profunde punctulatis, haud striatis; propygidio pygidioque subnitidis, coriaceis, sparsius leviter subgrosse punctulatis; tibiis anticis extus bidentatis; tarsorum posticorum articulo basali quam 2^{us} vix breviori.

Maris antennarum clava quam feminæ manifeste longiori, tarsis anticis paullo longioribus pygidio subtus producto sic ut segmenta ventralia brevissima sunt in medio. Long., $1\frac{3}{4}$-$2\frac{1}{2}$ l.; lat., 1-$1\frac{1}{5}$ l.

I am not sure that this species might not properly be regarded as the type of a new genus allied to *Liparetrus.* Its long elytra almost covering the propygidium in both sexes and its depressed elongate appearance, together with its peculiar sculpture and vestiture, render it very isolated in this genus. I cannot, however, discover any definite structural character that is not paralleled in some unquestionable *Liparetrus*, unless it be the abdominal character of the male (*i.e.*, the pygidium folded under so as to narrow, as if crowded together, the ventral segments on the middle line). This, however, does not seem sufficient to justify the creation of a new genus. It should be noted that in both sexes the front tarsi are remarkably short, being (even in the male) less than half as long as the hind tarsi; and that the erect hairs on the elytra are disposed in longitudinal rows.

Western Australia. (Beverley; Mr Lea.)

L. rotundicollis, sp. nov. Sat breviter ovatus; minus nitidus; niger vel piceo-niger, iridescens, antennis palpisque rufis, pedibus (et nonnullorum exemplorum pygidio) plus minusve rufescentibus; totus cinereo-pilosus (capite pronotoque fulvo-pilosis exceptis); antennis 9-articulatis; clypeo nitido, crebre subgranulatim punctulato, antice truncato; fronte sat æquali fere ut clypeus punctulata; prothorace fortiter transverso, antice sat angustato, æquali, supra confertim subtiliter ruguloso, lateribus fortiter rotundatis; elytris obsolete geminato-striatis, interspatiis crebre fortius punctulatis; propygidio pygidioque fortiter crebrius punctulatis; tibiis anticis extus bidentatis (dente superiori subobsoleto); tarsorum posticorum articulis basalibus 2 sat æqualibus inter se. Long., $2\frac{4}{5}$-$3\frac{1}{2}$ l.; lat., $1\frac{3}{5}$-$1\frac{4}{5}$ l.

I have seen two specimens of this insect, and do not find any defined sexual characters among them. They are probably females, and it is not unlikely that the male has some distinctive character in the ventral segments and clypeus. The species described above is very different from all its allies (*inter alia*, by the very close, strong, subrugulose puncturation of its elytra, and its colouring), and may safely be described without the knowledge of both sexes. It is not unlike *L. nudipennis*, Germ., superficially, but is very distinct from that species by, *inter alia*, the pilosity of its elytra.

South Australia.

L. ventralis, sp. nov. (Mas.). Breviter ovatus; sat opacus; niger, antennis palpis elytris (his anguste nigrocinctis) tibiis anticis tarsisque omnibus brunneo-testaceis; totus albido-pilosus; antennis 9-articulatis; clypeo nitido minus crebre, fronte sat crebre, rugulosis; prothorace fortiter transverso, antice sat angustato, supra minus crebre punctulato, vix ruguloso, haud canaliculato, lateribus sat rotundatis; elytris vix perspicue geminato-striatis, interspatiis leviter minus subtiliter punctulatis; propygidio leviter sat crebre, pygidio sat profunde minus crebre, punctulatis; tarsorum posticorum articulo basali quam 2^{us} dimidia parte longiori; tibiis anticis unidentatis: segmento ventrali apicali antice longitudinaliter obtuse bicarinato, ad apicem deorsum acute bispinoso. Long., $2\frac{1}{2}$ l.; lat., $1\frac{3}{5}$ l.

This species differs from all the others described, of the same group, by its combination of bicolorous elytra, front tibiæ without any trace of an external tooth above the apical projection, and hind tarsi with basal joint much longer than the second joint. It is rather close to *L. assimilis*, Macl., from which (I have examined the presumable type, unique, in the Macleay Museum) it differs by the uniform whitish colour of its vestiture, *assimilis* having much very dark brown pilosity, as well as by the much longer basal joint of its hind tarsi.

North Queensland.

L. gravidus, sp. nov. Sat late ovatus; minus nitidus; niger, antennis palpis, elytris (his obscuro-cinctis) et (pilus minusve) pedibus testaceis vel ferrugineis; capite, pronoto elytris (basin versus), propygidio pygidioque (hoc cum propygidio etiam setis adpressis albidis vestito) pilis brunneis vestitis; corpore subtus cinereo-piloso; antennis 9-articulatis; clypeo antice truncato, cum fronte (hac sat æquali) pronotoque crebre ruguloso; prothorace fortiter transverso, supra obsolete canaliculato, antice fortiter angustato, lateribus arcuatis; elytris obsolete geminato-striatis, interspatiis leviter nec crebre punctulatis; propygidio pygidioque confertim subtiliter rugulosis; tibiis anticis extus bidentatis; tarsorum posticorum articulis basalibus 2 inter se sat æqualibus.

Maris clypeo quam feminæ magis elongato magis abrupte truncato, antennarum flabello paullo longiori, tarsis anticis multo longioribus. Long., 4-$4\frac{1}{2}$ l.; lat., $2\frac{1}{5}$-$2\frac{1}{2}$ l.

Rather closely allied to *L. luridipennis*, Macl., but larger and differently coloured (the elytra more ferruginous, and with a better defined, dark bordering), the upper tooth of the front tibiæ much stronger, and (especially) the basal region of the elytra pilose.

Western Australia (Swan River); Mr Lea.

L. cinctipennis, sp. nov. Breviter ovatus; minus nitidus; niger, antennis (clava picea excepta) palpis et elytris (marginibus late nigris exceptis) ferrugineis, pedibus plus minusve picescentibus: supra sat glaber, pronoto antice et ad latera piloso-fimbriato, propygidio pygidioque setis adpressis albidis vestitis; subtus cinereo-pilosus; antennis 9-articulatis; clypeo antice truncato, cum fronte (hac sat æquali) pronotoque confertim subtiliter ruguloso; prothorace fortiter transverso, æquali, antice sat fortiter angustato, lateribus arcuatis; elytris obsolete geminato-striatis, interspatiis leviter nec crebre punctulatis; propygidio pygidioque crebre sat subtiliter rugulosis; tibiis anticis extus bidentatis (dente superiori minuto vel subobsoleto); tarsorum posticorum articulo basali quam 2us vix longiori.

Maris quam feminæ clypeo magis abrupte truncato, antennarum flabello parum longiori, tarsis anticis paullo robustioribus. Long., 3 l.; lat., 2 l.

Easily distinguishable from *L. luridipennis*, Macl., and *gravidus*, Blackb., by, *inter alia*, the non-pilose disc of its pronotum and the deep black, much wider, and more sharply defined bordering of its elytra.

Western Australia (Perth).

L. minor, sp. nov. (Mas.)—Ovatus; minus nitidus; piceus, vix rufescens, clypeo antennis (clava picea excepta) palpis pedibus elytrisque testaceo-brunneis; supra glaber; subtus sparsim pilosus; antennis 9-articulatis; clypeo nitido sparsim punctulato, antice tridentato (dente mediano sat acuto); fronte crebre subtiliter subaspere punctulata, sat æquali; prothorace sat fortiter transverso, antice fortiter angustato, supra subtilius sparsim leviter punctulato, postice obsolete impresso, lateribus sat fortiter rotundatis; elytris obsolete geminato-striatis interspatiis sparsius sat fortiter punctulatis; propygidio pygidioque crebre punctulatis; tibiis anticis extus, 1-dentatis; tarsorum posticorum articulo basali quam 2us manifeste breviori. Long., 2 l.; lat, $1\frac{1}{3}$ l.

The clypeus of the female is probably less strongly tridentate than that of the male, but in the male the median tooth is so well defined that it is not likely to be unrepresented in the female. The front tibiæ have no distinct tooth (scarcely even an inequality) above the apical projection. All the species placed by Macleay among those having the clypeus tridentate in the male and which bear any superficial resemblance to this insect, have the basal joint of their hind tarsi longer than the second joint. It should be noted that although in my unique example of this insect the propygidium and pygidium are glabrous, I judge from the nature of the sculpture and the analogy of allied species that those parts are probably abraded, and that in a fresh specimen they might bear some sparse vestiture.

Queensland; Port Mackay (Mr. Lower).

L. brevipes, sp. nov., fem. Breviter ovatus; subnitidus; brunneo-testaceus, antennarum clava capiteque piceo-nigris, prothorace testaceo-rufo; supra glaber; subtus cinereo-pilosus; antennis 9-articulatis; clypeo antice rotundato, ut frons (hac sat æquali) transversim crebre ruguloso; prothorace fortiter transverso, antice sat angustato, supra obsolete canaliculato, subtilius sat crebre punctulato, lateribus arcuatis; elytris sat fortiter geminato-striatis, interspatiis sat fortiter vix crebre punctulatis; propygidio pygidioque fortiter sat crebre punctulatis; tibiis anticis extus 1-dentatis; tarsis brevibus, posticorum articulo basali quam 2^{us} parum breviori. Long., $2\frac{4}{5}$; lat., $1\frac{4}{5}$ l.

An exceptionally wide species, and with unusually short tarsi. It is not very close to any other species known to me except the next species to be described (*L. Blanchardi*, sp. n.), but bears considerable superficial resemblance to *L. lætus*, Blackb., which, however, *inter alia*, has antennæ consisting of only eight joints, and front tibiæ conspicuously bidentate externally.

Western Australia (Perth).

L. Blanchardi, sp. nov., fem. Sat breviter ovatus: minus nitidus; brunneo-testaceus, fronte et (angustissime) elytrorum basi nigris, sterno paullo infuscato; supra fere glaber (pygidio sparsius brevissime villoso); subtus cinereo-pilosus; antennis 9-articulatis; clypeo nitido leviter squamose punctulato, antice subtruncato (latissime rotundato): fronte sat æquali, subtilius minus crebre punctulata; prothorace fortiter transverso, antice fortiter angustato, supra postice vix manifeste canaliculato, sat crebre minus subtiliter punctulato, lateribus fortiter rotundatis; elytris leviter geminato-striatis, interspatiis sat fortiter sat crebre punctulatis; propygidio pygidioque crebre minus fortiter punctulatis; tibiis anticis extus

1-dentatis; tarsis modice elongatis, posticorum articulis basalibus inter se sat æqualibus. Long., 2 l.; lat,, $1\frac{1}{5}$ l.

Somewhat closely allied to the preceding. Disregarding the somewhat considerable differences in colouring, it differs, *inter alia*, by the sculpture of its head, the much more strongly rounded sides of its pronotum, and its considerably longer tarsi.

Queensland (Port Mackay).

L. Leai, sp. nov. Ovatus; minus nitidus; niger, antennis (clava excepta) palpis et elytris (his anguste piceo-cinctis) brunneo-testaceis, pedibus picescentibus; supra fere glaber, propygidio pygidioque setis adpressis albidis vestitis; subtus cinereo-pilosus; antennis 9-articulatis; clypeo (ut frons, hac sat æquali) transversim ruguloso, antice subtruncato; prothorace fortiter transverso, antice angustato, supra postice vix canaliculato, leviter sat crebre vix subtiliter punctulato, lateribus arcuatis; elytris leviter geminato-striatis, interspatiis sat fortiter vix crebre punctulatis; propygidio pygidioque sat crebre sat fortiter (hoc quam ille magis fortiter) punctulatis; tibiis anticis extus 1-dentatis; tarsorum posticorum articulis basalibus 2 inter se sat æqualibus. Long., 3 l.; lat., $1\frac{3}{5}$ l.

I believe that both sexes of this species are before me; if so the sexual characters are slight, consisting in a slight additional robustness in the front tarsi (and especially the front claws) of the male. It is possible, however that the specimen I regard as the female may be a somewhat feebly developed male. This species bears much superficial resemblance to *L. ovatus*, Macl., but differs, *inter alia*, by its front tibiæ having no external tooth above the apical projection and its pronotum having no dorsal channel except a faint impression close to the base (which is entirely wanting in very few *Liparetri*).

Western Australia: Perth (from Mr. Lea).

L. rugatus, sp. nov., fem. Late ovatus; minus nitidus; niger, antennis (clava obscura excepta) palpis elytris (his basin versus nigricantibus) abdomineque obscure rufis, pedibus picescentibus; supra in pronoto propygidio pygidioque pilis erectis vestitus; subtus cinereo-pilosus; antennis 8-articulatis; clypeo crebre sat fortiter punctulato, antice truncato, fronte sat æquali, fere ut clypeus punctulata; prothorace fortiter transverso, antice sat angustato, supra æquali, inæqualiter (prope apicem et basin fere ut frons, in disco magis grosse minus crebre) punctulato, lateribus arcuatis; elytris vix manifeste geminato-striatis, interspatiis fortiter crebre subrugulose punctulatis transversim rugatis; tibiis anticis extus 3-dentatis (dentibus intervallis subæqualibus divisis); tarsorum posticorum articulis basalibus 2 inter se sat æqualibus. Long., 3½ l.; lat., 2⅕ l.

This species is evidently allied to *L. ferrugineus*, Blanch., from which it is easily distinguishable by, *inter alia*, the much closer and stronger puncturation of its elytra, and the very evidently greater length of the basal joint of its hind tarsi.

North Queensland.

L. insolitus, sp. nov. Ovatus; vix nitidus; niger, antennis (clava excepta) palpis, elytrisque (his ad basin anguste nigricantibus) ferrugineis, pedibus et nonnullorum exemplorum pygidio picescentibus; supra (elytris—nisi ad basin summam—capiteque exceptis) pilis erectis fulvis vestitus; subtus cinereo-pilosus; antennis 7-articulatis; clypeo sat subtiliter subsquamose punctulato; fronte leviter inæquali, quam clypeus magis subtiliter magis crebre vix squamose punctulata; prothorace fortiter transverso, antice fortiter angustato, supra minus perspicue canaliculato, subgrosse nec profunde vix crebre punctulato, lateribus modice arcuatis; elytris sat fortiter geminato-striatis, interspatiis sat fortiter sat crebre punctulatis; tarsorum posticorum articulo basali quam 2^us^ parum breviori; tibiis anticis extus tridentatis.

Maris clypeo antice abrupte truncato (fere subemarginato); tarsis anticis sat elongatis; propygidio sparsim dupliciter (subtiliter et subfortiter), pygidio magis fortiter magis crebre, punctulatis.

Feminæ clypeo antice minus abrupte truncato, tarsis anticis brevioribus, propygidio pygidioque confertim rugulosis. Long., 3½-4 l; lat., 2-2¼ l.

This species may be described as superficially a close ally of *L. phœnicopterus*, Germ., having antennæ consisting of only seven joints. No other known to me of the species with similar antennæ (seven-jointed) bears the least resemblance to it.

Western Australia: Swan River (Mr. Lea).

MICROTHOPUS.

I diagnosed the genus *Macleayia* in Tr.R.S.S.A., 1887, and in the same volume added a note as to the possibility of its identity with Burmeister's genus *Microthopus*. Since that time I have had the opportunity of examining large numbers of *Liparetroid Coleoptera*, from Western Australia, and as I have not met with any insect more likely to be *Microthopus*, I have recently reconsidered the question of the identity with it of *Macleayia*, and am now of opinion that the two genera cannot be separated. The discrepancy between *Macleayia* and the diagnosis of *Microthopus* consists in the flabellum of the antennæ of the male of *Macleayia* being five-jointed, while it is said to be three-jointed in *Microthopus*. The extreme variability of the antennal structure, however, among many Australian *Melolonthides* that seem to present no other difference likely to be generic, seems to forbid the acceptance of that as a valid generic character. Indeed, having now seen what I believe to be the male of my *M. hybrida* (the second species that I attributed to *Macleayia*), I am fairly confident that in that insect the flabellum of both sexes is three-jointed. Therefore, I do not regard *Macleayia* as more than a subgenus of *Microthopus*, containing only one described species (*singularis*, Blackb.), while two described species (*hybrida*, Blackb., and *castanopterus*, Burm.), are of *Microthopus* in the strict sense. It is even possible that *hybrida* is a variety of *castanopterus*, as there does not seem to be any good character to separate them, apart from colour; but it would not be safe to pronounce them specifically identical without examining a specimen agreeing in all respects with Burmeister's description.

Burmeister distinguishes *Microthopus* from *Liparetrus* by characters that are quite insufficient now that the species of the latter genus have been found to be so numerous and varied in structure, viz., its more elongate elytra and less convex pygidium. It is well differentiated, however, by a character that I have already referred to (Tr.R.S.S.A., 1898, p. 31), as of great value for the generic distribution of the Australian *Melolonthides*, viz., the sculpture of the elytra, which in *Microthopus* (but in no *Liparetrus* known to me), consists of well-defined, uniform striation.

AUTOMOLUS.

In Tr.R.S.S.A., 1898, p. 31, I suggested the possibility of the species on which this Tasmanian genus was founded being congeneric with some of those of which Macleay formed his second section of *Liparetrus*. I am now, after a much more extensive study of *Liparetroid Lamellicornes*, very confident that my conjecture was correct. As is so frequently the case in respect of the *Melolonthides* of Australia, the genera involved in this discussion have been rendered more difficult to identify by the absence of knowledge, on the part of their founders, of the extreme variability of the antennæ of the insects in question. Burmeister gives "nine-jointed antennæ" as a generic character of *Automolus*, and Macleay makes "antennæ eight-jointed" the essential character of his second section of *Liparetrus*. As I have already remarked, authors have so obviously been in the habit of assuming it unnecessary to count the joints carefully in more than one of an aggregate (of Australian *Melolonthides)* of evidently closely allied species, that there is no reason whatever for deciding against the identity of two generic names merely because the insects they are applied to have antennæ differing in the number of joints And, in the case of the species under discussion, the further consideration must not be overlooked that they have antennæ of which the stipes is extremely short and difficult to examine. In the present case the really reliable distinction of most of the species included by Macleay in his second section of *Liparetrus* from all of those which he places in the first section is to be found in the structure of the front tibiæ—which have two adjacent external teeth close to the apex, and one (a very small one) close to the base (the margin of the tibiæ between them being straight or all but straight)—a structure which I have seen in no *Liparetroid* species that is not obviously a close ally of these insects *(e.g., Automolus (Liparetrus) poverus*, Blanch.). That structure is assigned by Burmeister to the front tibiæ of *Automolus:* and the assignment to it of nine-jointed antennæ need occasion no difficulty in associating it with species having similar tibial structure and eight-jointed antennæ, because on the one hand Burmeister might be almost excusable if he miscounted the joints of such obscure antennæ, and, on the other hand, at least one of the species before me with the tibial structure indicated above, has nine-jointed antennæ.

As regards Burmeister's species *(A. angustulus)*, the description is in general certainly suggestive of my *Automolus (Liparetrus) alpicola*. I am, however, confident in saying that the antennæ of the latter have only eight joints, and I have not met with it, nor seen it, from Tasmania. These considerations combined lead me to the opinion that *A. angustulus*, Burm., is a species that I have not seen, and which has not been redescribed by any author. I regard *Automolus* as a valid genus.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of South Australia

(Incorporated)

FOR 1904-5.

ORDINARY MEETING, NOVEMBER 1, 1904.

THE PRESIDENT (J. C. VERCO, M.D., F.R.C.S.) in the chair.

EXHIBITS.—A. H. C. ZIETZ, F.L.S., C.M.Z.S., a large number of the preserved skins of the Australian honey-eaters. The PRESIDENT exhibited three volutes from the lobster pots, Victor Harbour, the markings beautifully preserved, named respectively *Voluta exoptanda*, *V. papillosa*, *V. fulgetrum*. These shells had been taken into the pots by the later occupiers—hermit crabs—in search of food.

PAPERS.—"New Species of South Australian Marine Mollusca," by J. C. VERCO, M.D., F.R.C.S. DR. VERCO, in introducing his paper, called the attention of the meeting to some interesting features in some of the molluscs therein described, the *Glycimeris sordidus*, the shell of which shows periods of rest, which are not found in its very near ally, *G. pectenoides*. In this latter shell, in the older stages, growth ceases, and the mantle contracts. *Modiola pœnetecta*, almost covered with epidermis, whilst *M. australis* is much less so. In these species a very marked difference exists in the filaments of the epidermis. *Trigonia bednalli*, probably a variety of *margaritacea*, a genus now found only in Australian seas, but remarkable as found fossil from very early geological ages. DR. VERCO also drew attention to very marked differences between *Ovula*, of which a very fine specimen was shown, and *Cyprœa*.

ORDINARY MEETING, APRIL 4, 1905.

THE PRESIDENT (J. C. VERCO, M.D., F.R.C.S.), in the chair.

NOMINATION.—DOUGLAS MAWSON, B.Sc., B.E., Lecturer in Mineralogy and Petrology in the University of Adelaide, as a Fellow.

EXHIBITS.—A. H. C. ZIETZ, F.L.S., C.M.Z.S., exhibited a number of flies collected near Adelaide, all well-known

European species, including the European blowfly *(Musca vomitoria).* This is the first record of this species for Australia. J. G. O. Tepper, F.L.S., gave an interesting account of the growth, development, and nature of the gadfly, and exhibited a very prolific plant of the Umbelliferous order, probably *Ferula*, growing near Adelaide.

Papers.—"An Outline of a Theory of the Genesis of Motion in Living Bodies," by T. Brailsford Robertson, introduced by Professor E. C. Stirling, F.R.S. "On the Formation known as Glacial Till of Cambrian Age in South Australia," by J. D. Iliffe, B.Sc.,and Herbert Basedow. "New Species of South Australian Marine Mollusca" (part 2), by J. C. Verco, M.D., F.R.C.S. "Additions to the Cambrian Fauna of South Australia," by R. Etheridge, jun., Hon. Fellow. "South Australian Nudibranchs and an Enumeration of the known Australian Species," by Herbert Basedow and Charles Hedley, F.L.S. "On the Naticoid Genera, Lamellaria, and Caledoniella, from South Australia, " by Herbert Basedow. "Report on the Mollusca collected by Herbert Basedow, on the S.A. Government N.W. Expedition, 1903," by Charles Hedley, F.L.S. "Description of New Australian Lepidoptera," by Oswald B. Lower, F.E.S. (Lond.).

Ordinary Meeting, May 2, 1905.

The President (J. C. Verco, M.D., F.R.C.S.), in the chair.

Ballot.—Douglas Mawson, B.Sc., B.E., Lecturer in Mineralogy and Petrology in the University of Adelaide, was elected a Fellow.

Nominations.—George Brookman, Gentleman, as a Fellow; Charles Hedley, F.L.S., and Thomas Gill, I.S.O., Under-Treasurer, as Hon. Members. G. M. Thomson, F.L.S., F.C.S., as a Corresponding Member

Exhibits.—Mr. Edwin Ashby, bird skins from Kangaroo Island. Amongst these may be mentioned *Calyptorhyncus viridis* (Viell), Leach's cockatoo and egg, the red-rumped ground wren *(Hylacola cauta)* (Gould), *Ptilotis cratitia, P. lencotis, Meliornis australasiana, M. novæ hollandiæ, Acanthorhynchus tenuirostris, Glycyphila fulvifrons,* all honey-eaters; *Strepera melanoptera, Platycercus elegans*, and others. The absence of several species of birds, found in Southern Yorke Peninsula, from Kangaroo Island, and the presence of others, unknown in the vicinity of Adelaide, but common to the Victorian side, would, according to Mr. Ashby, seem to indicate that the last connection of the island with the mainland was at its eastern end. Mr. Zietz, F.L.S., C.M.Z.S., male and female of the king quail *(Excalfactoria* *australis)*, from near Victor Harbour, and, for comparison with Mr. Ashby's specimens, *Calyptorhynchus naso*, cock and hen and two eggs, from MacDonnell Ranges, also *C. furnereus* and *C. banksii*. Mr. J. G. O. TEPPER, F.L.S., exhibited tsetse flies.

MR. HOWCHIN, F.G.S., then opened the discussion on Messrs. Iliffe and Basedow's paper on the Cambrian glaciation in South Australia. In a carefully considered address he showed that the beds in question had no resemblance to a crush conglomerate, as advocated by the essayists, but that they answered in every particular to a glacial till laid down by floating ice. The paper was a crude attempt to explain phenomena with which the writers had insufficient acquaintance. Mr. D. MAWSON, B.Sc., B.E., in supporting Mr. Howchin, said that from a petrological examination of these rocks there was no evidence in support of the theory of their being crush conglomerates produced by cataclastic action.

PAPERS.—"South Australian Decapod Crustaceans," part 2, by W. H. BAKER. "Description of Vertebræ of *Genyornis newtoni*," being part 3 of "Memoirs on Fossil Remains of Lake Callabonna," by PROFESSOR E. C. STIRLING, M.D., F.R.S., and A. H. C. ZIETZ, F.L.S., C.M.Z.S.

ORDINARY MEETING, JUNE 6, 1905.

THE PRESIDENT (J. C. VERCO, M.D., F.R.C.S.) in the chair.

NOMINATION.—DR. ROGERS, M.A., as a Fellow.

BALLOT.—The following were elected:—GEORGE BROOKMAN, Gentleman, of North Gilberton, as a Fellow; CHARLES H. HEDLEY, F.L.S., Naturalist, Australian Museum, Sydney; and THOMAS GILL, I.S.O., Under-Treasurer, as Hon. Members; and G. M. THOMSON, F.L.S., F.C.S., Chemist and Bacteriologist, Dunedin, New Zealand, as a Corresponding Member.

EXHIBITS.—A. H. C. ZIETZ, Assistant Director of the Museum, a very large and beautiful collection of Australian finches' skins. Mr. ZIETZ described the birds, their nests, and also mentioned the parts of Australia in which the various species were found.

PAPERS.—"An Aroid New for Australia," by J. H. MAIDEN, F.L.S., Director of the Botanic Gardens, Sydney. "Further Researches on the Alpha Rays of Radium," by PROFESSOR W. H. BRAGG, M.A.

ORDINARY MEETING, JULY 4, 1905.

THE PRESIDENT (J. C. VERCO, M.D., F.R.C.S.), in the chair.

BALLOT.—DR. R. S. ROGERS, M.A., Adelaide, was elected a Fellow.

EXHIBITS.—DR. VERCO, several specimens of *Atlanta*, and one of *Carinaria australis* (Quoy & Gaimard), which add two species, two genera, and a new order to the Nucleobranchiata of South Australia. *Gibbula coxi* (Angas) and *G. lehmanni* (Menke), which had hitherto been confounded. *Astele subgranularis* (Danker). This, which had been described from Bass's Straits, is a half-grown individual of *A. subcarinatum* (Swanson). Several examples of *Crassatellites ponderosa* (Gmelin), hitherto known as *C. castanea*, of Reeve, to illustrate differences of shape and weight and colouration. J. G. O. TEPPER, F.L.S., described a new species of mantis *(Fischeria quinquelobatus)*, captured during the N.W. Government expedition, and Phasmides, *Lonchodes caurus*, *Cryptocrania cornuta*, *Acrophylla nubilosa*, *A. paula*, *Necrosia bella*, and *Bacillus peristhenella*, all taken in the same expedition. DOUGLAS MAWSON, B.Sc., B.E., then gave an address on "Theories of the Earth's Origin." Introducing the subject, MR. MAWSON stated that the harmonies of the solar system proclaim for the individual planets a common origin. Theories dealing with the past history of our own planet must, therefore, relate to the others, so that it is necessary, at the outset, to be thoroughly acquainted with cosmical geology in all its aspects. To this end the physics of the solar system, together with a brief description of the constituent factors, was then shortly summarised. The nebular theory was propounded by Kant, and given mathematical form by Laplace in his "Mechanique Celeste," over a century ago. The original theory was later strenuously upheld by Herbert Spencer and John Fiske, whose logic failed to disclose its several inaccuracies. This theory traces the beginning and development of the solar system from an original gaseous nebula, an exceedingly tenuous and intensely heated cloud of matter extending in a spheroidal form, beyond the orbit of Neptune, the outermost planet. Of late years such serious objections have been raised to this theory, that it has been generally discredited. Sir Norman Lockyer, in 1890, brought forward his meteoric hypothesis. Reasoning from his extensive investigations in spectrum analysis, he states his views as follows: —"Nebulæ are really swarms of meteorites, or meteoric dust in the celestial spaces. The meteorites are sparse, and the collisions among them bring about a rise of temperature sufficient to render luminous their chief constituents." Professor Chamberlin, of the University of Chicago, has, during the last five or six years, propounded a theory to explain the development of the heavenly bodies depending upon mechanical principles essentially different from those embodied in previous arguments. He explains his "planetesimal hypothesis," as he calls it, in the following terms:—"The prevailing form of the smaller nebulous areas of the heavens is a spiral, in most of which two arms are discernible. Such a form would be developed from any nebulous body were another of sufficient mass to pass close to it, in the way that, say, comets sweep around the sun. It is further thought that the gaseous matter of the arms formed by such a disruptive approach would solidify into tiny planetesimals, which, in course of time, becoming concentrated by their mutual attractive forces, would produce relatively large masses of matter (the planets), whirling in the same direction, around the parent body (the sun)." Mr. Mawson then shortly referred to some of the leading points of difference in the geological development of an earth, built up, after the "planetesimal hypothesis," of aggregations of cold particles, and not originally intensely heated, as required by the nebular hypothesis.

ORDINARY MEETING, AUGUST 1, 1905.

THE PRESIDENT (J. C. VERCO, M.D., F.R.C.S.), in the chair.

EXHIBITS.—A. H. C. ZIETZ, F.L.S., C.M.Z.S., a block of opal of a variety known as "pineapple opal," from its shape. Unlike ordinary opal it is composed of large crystals. The specimen was found at the White Cliffs opal fields. The mineralogist of the Australian Museum, in Sydney, declared this variety to be a pseudomorph after Glauberite. He also exhibited another mineral of very similar structure, which has not yet been analysed. This was found at the Blinman Mine, embedded in clay. Mr. ZIETZ also exhibited two British slugs, found in an Adelaide garden, *Limax arborum*, which in England lives in birch trees, and *Limax gagatus*. The PRESIDENT, several molluscs, illustrating the change of form in the same species as it passes through the four stages of growth—embryonic, adolescent, mature, and the senile. *Latirus aurantiacus*, gradually developing in weight, in the rudeness of the nodules, and in the size and cave-like appearance of the perforation. *Voluta adcocki* (Tate), in which, at a certain stage of growth, a change took place in the colour pattern. A *Brachites*, from Port Lincoln, in which the minute valves of the embryo gradually open out and become connected by shelly matter, in the form of a large, tapering tube, resembling coral. DR. VERCO stated that a protoconch, found alone, had been described as a separate genus *(Sinusigera)*, but when older specimens were collected it was shown to be a *Purpura;* also that in some species the protoconch was sinistral, while later developed portions of the shell were dextral.

Paper.—"Description of New Australian Lepidoptera," by **Oswald B. Lower**, F.E.S., Lond.

Annual Meeting, October 3, 1905.

The President (J. C. **Verco**, M.D., F.R.C.S.), in the chair.

The annual report and balance sheet were read and adopted.

Election of Officers.—J. C. Verco, M.D., F.R.C.S., as President; Professor E. H. Rennie, D.Sc., F.C.S., and Rev. Thomas Blackburn, B.A., as Vice-Presidents; Walter Rutt, C.E., as Hon. Treasurer.

Election of Members of Council.—Dr. Cleland and W. B. Poole.

Election of Auditors.—J. S. Lloyd and David Fleming.

Papers.—"On the Recombination of Ions in Air and other Gases," by Professor **W. H. Bragg**, M.A. "Notes on Some Decapod Crustaceæ" (No. III.), by **W. H. Baker**. "Description of Australian Curculionidæ, with Notes on Previously Described Species (Part III.), Subfamily Otiorhynchides," by **Arthur M. Lea**. "Description of a New Species of Mantidæ and of Six New Species of Phasmidæ, collected in the North-West Region of South Australia," by **J. G. O. Tepper**, F.L.S. "Further Notes on the Australian Coleoptera," by **Rev. Thomas Blackburn**, B.A.

ANNUAL REPORT, 1904-5.

The Council has to report that the work of the Society in the various departments of science has been maintained. The following papers have been read or laid on the table:—"New Species of South Australian Marine Mollusca," by J. C. Verco, M.D., F.R.C.S., parts ii. and iii. "Additions to the Cambrian Fauna of South Australia," by Robert Etheridge. "An Outline of a Theory of the Genesis of Motion in Living Bodies," by T. Brailsford Robertson. "On the Formation known as the Beds of Glacial Till of Cambrian Age in South Australia" by J. D. Iliffe, B.Sc., and Herbert Basedow. "South Australian Nudibranchs and an Enumeration of the Known Australian Species," by Herbert Basedow and Charles Hedley, F.L.S. "On Naticoid Genera, Lamellaria, and Caledoniella, from South Australia," by Herbert Basedow. "Report on the Mollusca collected by Herbert Basedow, on the S.A. Government N.W. Expedition, 1903," by Charles Hedley, F.L.S. "South Australian Decapod Crustaceans," parts ii. and iii., by W. H. Baker. "Description of Vertebræ of Genyornis Newtoni, being part iii. of Memoirs on Fossil Remains from Lake Callabonna," by Professor E. C. Stirling, M.D., F.R.S., C.M.G., and A. H. C. Zietz, C.M.Z.S., F.L.S. "An Aroid New for Australia," by J. H. Maiden. "Further Researches on the Alpha Rays of Radium," by Professor W. H. Bragg, M.A. "Description of New Australian Lepidoptera, with Synonymic Notes, No. xxiii.," by Oswald Lower, F.E.S. (Lond.). "On the Recombination of Ions in Air and other Gases," by Professor W. H. Bragg, M.A. "Description of Australian Curculionidæ, with Notes on Previously Described Species, part iii., Subfamily Otiorhynchides," by A. M. Lea. "Descriptions of New Species of Mantidæ, and of Six New Species of Phasmidæ, collected in the N.W. Regions of South Australia by H. Basedow," by J. G. O. Tepper, F.L.S. "Further Notes on the Australian Coleoptera," No. xxxv., by the Rev. Thomas Blackburn, B.A.

Among the new periodicals received this year the following are, perhaps, worthy of mention:—The Maryland Geological Survey, Report of the South African Association for the Advancement of Science, and the Journal of the National Museum, Monte Video.

The publications of this Society are well distributed throughout the civilised world. Exchanges are made with 25 learned Societies in the United Kingdom, with 52 in Europe, 33 in the U.S. of America, 7 in Canada, 5 in South and Central America, and 6 in India, Japan, and the Pacific. Some 15 or 20 more of the publications are sent to the other States of the Commonwealth and New Zealand.

The Society now includes 12 honorary and 9 corresponding members, 65 fellows, and 2 associates.

For some time past the financial position of the Society has been far from satisfactory. Actuated by a desire to help us out of our difficulties, the President (Dr. Verco) has very kindly offered to give £1,000 towards the formation of an endowment fund, provided that the additional sum of £2,000 shall be first obtained elsewhere. The Council hopes that some help will be forthcoming to enable the Society to take advantage of this most generous offer.

The space reserved for books and literature in our present quarters is hopelessly inadequate. The Government has recently been approached with a view of securing better accommodation in this respect for the Royal and other local Societies. It is hoped that something may shortly be done in this matter.

THE TREASURER IN ACCOUNT WITH THE ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED)

Dr.	£	s.	d.	£	s.	d.
October 1st, 1904.						
To Balance				99	14	6
" Subscriptions—						
Royal Society	58	5	0			
Malacological Section ...	0	17	6			
Microscopical Section ...	6	12	6			
				65	15	0
" Donations—						
Dr. Verco, to illustrate Transactions	116	9	0			
Mr. H. Basedow, to illustrate Transactions ...	7	0	0			
Mr. J. Dennant, to illustrate Transactions ...	9	0	0			
				132	9	0
" Government Grants—						
On Subscriptions ...	56	14	9			
For Printing Reports on Scientific Investigations in South Australia ...	150	0	0			
				206	14	9
" Sale of Transactions ...				4	11	0
" Bank Interest				4	1	10
				£513	6	1

Cr.	£	s.	d.	£	s.	d.
By Transactions—						
Printing	81	16	11			
Illustrating	130	15	0			
Publishing	10	4	8			
				222	16	7
" Memoirs—						
Printing	18	15	0			
Illustrating	48	7	3			
				67	2	3
" Grants—						
Field Naturalists' Section ...	10	0	0			
Malacological Section ...	1	0	0			
Microscopical Section ...	5	0	0			
				16	0	0
" Wages—Caretaker				3	0	0
" Printing, Postage, and Stationery				10	10	6
" Advertising				3	8	8
" Exchange on Cheques ...				0	2	0
" Balance—						
In Savings Bank, September 30, 1905 ...	189	4	0			
In Treasurer's hands ...	1	2	1			
				190	6	1
				£513	6	1

Audited and found correct,

J. S. Lloyd, F.I.A.S.A., } Auditors.
David Fleming, }

Walter Rutt, Treasurer.

Adelaide, October 1, 1905.

DONATIONS TO THE LIBRARY

FOR YEAR 1904-5.

TRANSACTIONS, JOURNALS, REPORTS, ETC.

Presented by the respective Editors, Societies, and Governments.

AUSTRIA AND GERMANY.

Berlin—Königl. Preuss. Meteor. Instits. Bericht, 1903. Veröffentlichungen der Ergebnisse, 1899, Heft. Do. do., der Niederschlags-Beobachtungen, M. and J. D., 1898. Abhandlungen der . . . Band 2, Nos. 3, 4.

——— Königl. Preuss. Akademie der Wissenschaften zu Berlin. Sitzungsberichte, 1903, Nos. 19-40; 1904, Nos. 25-55

——— Deutsches Meteorologisches Jahrbuch, 1903, Heft. 2.

——— Berliner Gesellschaft für Anthrop. Ethnol. und Urgeschichte, Zeitschrift für Ethnologie—Jahrgang, 35, Heft. 6; do., 36, Heft. 3, 4.

——— Gesellschaft für Erdkunde, Zeitschrift der, 1902, No. 9; 1903, Nos. 1, 5, 8, 9, 10; 1904, Nos. 1-8, 10; 1905, Nos. 1, 2.

Fribourg—Berichte der Naturforschenden Gesellschaft zu Fribourg, Band 40.

Göttingen—Königl. Gesellschaft der Wissenschaften zu Göttingen Math. Phys. Klasse, 1904, Heft. 1, 2, 4, 6; 1905, Heft. 3; do. do., Geschaftliche Mittheilungen, 1904, Heft 2; 1905, Heft. 1.

——— Nachrichten von der Konigl. Gesellschaft der Wissen. und der Georg., August, 1904, Heft. 3, 4, 5.

Heidelberg—Berichte uber Land—und Forstwirtschaft in Deutschostafrika, Band 2, Heft. 4.

Kiel—Schriften Naturwissenschaften Vereins für Schleswig-Holstein, Band 1-12.

München—Sitzungsberichte der K.B. Akademie der Wissenschaften zu München, Math. Phys. Klasse, 1905, Heft. 1. Abhandlungen der do. do., Band 22, Abteil. 1, 2.

Nürnberg—Abhandlungen Naturhistorischen Gesellschaft zu Nürnberg, Band 15, Heft. 2.

Vienna—Kaiserliche Akademie der Wissenschaften in Wien Sitzung, der Math. Naturwiss., 1904, Nos. 10-13, 19-24; 1905, Nos. 1-10, 15-17.

——— Do. do., Anzeiger Math. Naturwiss., Nos. 25-27, 1904; 1903, Nos. 2, 3; 1904, Nos. 2-15; 1905, Nos. 1, 2, 6-9, Jahrgang, 1904.

——— Arbeiten des K.K. Gradmessungs Bureau-Astron., Band 13.

——— K. Königlichen Zool.-Botanischen Gesellschaft in Wien, 1903, Band 53, Heft. 1-10.

——— Annalen K.K. Naturhistorischen Hofmuseums, Band 18, Nos. 2, 3, 4; Band 19, Nos. 1, 2, 3.

Würzburg—Sitzungs.-Berichte Physikalisch—Medicinischen Gesellschaft zu Würzburg, 1904, Nos. 1-10.

AUSTRALIA AND NEW ZEALAND.

Adelaide—Public Library, Museum, and Art Gallery, Annual Report, 1903-4.

——— Woods and Forest Department, Annual Progress Report, 1903-4.

——— Royal Geographical Society, Proceedings, 1903-4, vol. vii.

——— Adelaide Observatory, Meteorological Observations, 1899, 1900, and 1901.

——— Department of Mines, Supplement, 1905; Review half-year ending December, 1904.

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LIST OF FELLOWS, MEMBERS,

ETC.,

OCTOBER, 1905.

Those marked (L) are Life Fellows. Those marked with an asterisk have contributed papers published in the Society's Transactions.

Any change in the address should be notified to the Secretary.

Date of Election.

Honorary Fellows.

1893. *Cossman, M., Rue de Maubeuge,, 95, Paris.
1897. *David, T. W. Edgeworth, B.A., F.R.S., F.G.S., Prof. Geol., Sydney University.
1888. *Dennant, John, F.G.S., F.C.S., Inspector of Schools, Camberwell, Victoria.
1876. Ellery, R. L. J., F.R.S., F.R.A.S., Gov. Astron., the Observatory, Melbourne, Victoria.
1890. *Etheridge, Robert, Director of the Australian Museum of New South Wales, Sydney.
1905. Gill, Thomas, I.S.O., Under-Treasurer, Adelaide.
1893. Gregorio, Marquis de, Palermo, Sicily.
1905. *Hedley, Chas. H., Naturalist, Australian Museum, Sydney.
1855. Hull, H. M., Hobart, Tasmania.
1892. *Maiden, J. H., F.L.S., F.C.S., Director Botanic Gardens, Sydney, New South Wales.
1898. *Meyrick, E. T., B.A., Elmswood, Marlborough, Wilts, England.
1876. Russell, H. C., B.A., F.R.S., F.R.A.S., Gov. Astron., Sydney, New South Wales
1894. *Wilson, J. T., M.D., Prof. of Anatomy, Sydney University.

Corresponding Members.

1881. Bailey, F. M., F.L.S., Colonial Botanist, Brisbane, Queensland.
1881. *Cloud, T. C., F.C.S., London, England.
1880. *Foelsche, Paul, Inspector of Police, Palmerston, N.T.
1893. *McKillop, Rev. David, Daly River Mission, N.T.
1886. Nicolay, Rev. C. G., Fremantle, W.A.
1883. *Stirling, James, Melbourne, Victoria.
1893. Stretton, W. G., Palmerston, N.T.
1905. Thomson, G. M., F.L.S., F.C.S., Dunedin, New Zealand.

Fellows.

1895. *Ashby, Edwin, Royal Exchange, Adelaide.
1902. *Baker, W. H., Glen Osmond road, Parkside.
1901. *Basedow, Herbert, Kent Town.
1887. *Blackburn, Rev. Thomas, B.A., Woodville.
1886. *Bragg, W. H., M.A., Prof. of Mathematics, University of Adelaide, S.A.
1905. Brookman, George, North Gilberton.
1883. *Brown, H. Y. L., F.G.S., Gov. Geologist, Adelaide.

1882. Browne, L. G., Davenport Chambers, Currie street, Adelaide, S.A.
1899. Browne, T. L., Marlborough Chambers, Adelaide.
1893. Brummitt, Robert, M.R.C.S., Gilberton.
1904. Brunskill, George, Rotorua, Auckland, New Zealand.
1904. Christie, William, Adelaide.
1879. *Cleland, W. L., M.B., Ch.M., J.P., Colonial Surgeon, Resident Medical Officer Parkside Lunatic Asylum, Lecturer in Materia Medica, University of Adelaide.
1895. Cleland, John B., M.D., Adelaide.
1876. (l) Cooke, Ebenezer, Commissioner of Audit, Adelaide.
1887. *Dixon, Samuel, Bath street, New Glenelg.
1902. Edquist, A. G., Hindmarsh.
1886. Fleming, David, Barnard street, North Adelaide.
1904. Gartrell, Jas., Burnside.
1904. Gordon, David, Gawler place, Adelaide.
1880. *Goyder, George, A.M., F.C.S., Analyst and Assayer, Adelaide.
1896. Greenway, Thos. J., Adelaide.
1904. Griffith, H., Hurtle square, Adelaide.
1896. Hawker, E. W., F.C.S., Adelaide.
1899. *Higgin, A. J., Assistant Lecturer on Chemistry, University of Adelaide.
1891. *Holtze, Maurice, F.L.S. Director Botanic Gardens, Adelaide.
1883. *Howchin, Walter, F.G.S., Lecturer on Geology and Palæontology, University, Adelaide.
1902. Iliffe, Jas. Drinkwater, B.Sc., Prince Alfred College, Kent Town.
1893. James, Thomas, M.R.C.S., Moonta.
1902. Jeffreys, Geo., Gilbert Place, Adelaide.
1900. *Johncock, Chas. F., Morphett Vale.
1898. *Koch, Max, Port Pirie.
1897. *Lea, A. M., Gov. Entomologist, Hobart, Tasmania.
1884. Lendon, A. A., M.D. (Lond.), M.R.C.S., Lecturer on Forensic Medicine and on Chemical Medicine, University and Hon. Physician, Children's Hospital, North terrace, Adelaide.
1856. *Lloyd, J. S., Alma Chambers, Adelaide.
1888. *Lower, Oswald B., Broken Hill, New South Wales.
1905. Mawson, Douglas, B.Sc., B.E., University, Adelaide.
1874. Mayo, Geo. G., C.E., Tatham street, Adelaide.
1897. *Morgan, A. M., M.B., Ch.B., Angas street, Adelaide.
1884. Munton, H. S., North terrace, Adelaide.
1859. (l) Murray, David. Adelaide.
1883. Phillipps, W. H., Adelaide.
1886. Poole, W. B., Savings Bank, Adelaide.
1904. Reissmann, Charles, M.A., M.D. (Cantab.), B.Sc. (Lond.), etc., Adelaide.
1885. *Rennie, Edward H., M.A., D.Sc. (Lond.), F.C.S., Professor of Chemistry, University of Adelaide.
1905. Rogers, R. S., M.A., M.D., Flinders Street, Adelaide.
1869. *Rutt, Walter, Chief Assistant Engineer, Adelaide.
1891. Selway, W. H., Treasury, Adelaide.
1893. Simson, Augustus, Launceston, Tasmania.
1857. *Smeaton, Thomas D., Mount Lofty.
1900. Smeaton, Stirling, B.A., C.E., Engineer-in-Chief's Office, Adelaide.
1871. Smith, Robert Barr, Adelaide.

1881. *Stirling, Edward C., C.M.G., M.A., M.D., F.R.S., F.R.C.S., Professor of Physiology, University of Adelaide, Director of S.A. Museum.
1904. Taylor, William, St. Andrews, North Adelaide.
1886. *Tepper, J. G. O., F.L.S., Entomologist, S.A. Museum. [Corresponding Member, 1878.]
1897. *Torr, W. G., LL.D., M.A., B.C.L., Brighton.
1894. *Turner, A. Jefferis, M.D., Brisbane, Queensland.
1902. Vandenbergh, W. J., Barrister and Solicitor, J.P., Adelaide.
1889. Vardon, Hon. Joseph, M.L.C., J.P., Gresham Street, Adelaide.
1878. *Verco, Joseph C., M.D., F.R.C.S., Lecturer on the Principles and Practice of Medicine and Therapeutics, University of Adelaide.
1883. Wainwright, E. H., B.Sc. (Lond.), St. Peter's College, Hackney, Adelaide.
1878. Ware, W. L., J.P., Adelaide.
1859. Way, Right Hon. Sir Samuel James, Bart., P.C., D.C.L., Chief Justice and Lieutenant-Governor of South Australia, Adelaide.
1904. Whitbread, Howard, Currie street, Adelaide.
1902. *Woolnough, Walter George, D.Sc., F.G.S., University, Sydney.
1886. Zietz, A. H. C., F.L.S., C.M.Z.S., Assistant Director, South Australian Museum, Adelaide.

Associates.

1901. Collison, Edith, B.Sc., Medindie.
1904. Robinson, Mrs. H. R., "Las Conchas," Largs, South Australia.

APPENDICES.

FIELD NATURALISTS' SECTION

OF THE

Royal Society of South Australia (Incorporated).

TWENTY-SECOND ANNUAL REPORT OF THE COMMITTEE.

FOR THE YEAR ENDING SEPTEMBER 30, 1905.

Last October the Field Naturalists' Section of the Royal Society celebrated the twenty-first anniversary of its inception. The function was highly successful, but amidst the congratulations there was an element of regret from the fact that the Society was about to lose the services of its indefatigable Hon. Secretary (Mr. W. H. Selway), owing to his projected departure for England.

The same number of evening meetings and excursions have been held as last year, and the members maintained an equal interest, both at the meetings and in the field work. Last year's attendance was a decided improvement on the previous year's, and this has been maintained.

The meetings held during the season were as follows:—

1904.

October 19. Conversazione, Twenty-first Anniversary.

November 29. Last evening meeting for the season. Scientific results of three days' excursion to Blumberg.

1905.

April 18. Paper by Miss E. Benham, "Some Changes in Vegetable Cells Connected with the Formation of the Embryo." Resignation of Mr. W. H. Selway as Hon. Secretary, presentation to him, and election of Mr. E. H. Lock to the position.

May 16. "Geological Notes," by Mr. Douglas Mawson, B.Sc., B.E.; "Microscopical Notes," by Mr. E. J. Bradley.

June 20. Discussion on subject of Chairman's annual address, "Animal Instinct or Reason," by Mr. E. H. Lock.

July 18. "A Visit to Tuggerah Lakes," by Mr. J. W. Mellor.

August 15. "Visit to Tasmania," by Mr. F. R. Zietz and Mr. J. W. Mellor.
September 19. Annual meeting.

The subjects under discussion were of the usual scientific order, but rather more of the educational element than during the previous year. This phase of work is to be commended. Miss Benham's paper upon "Vegetable Cells," with illustrative diagrams, was distinctly educational in character, and the same remark applies to the address upon "Geological Observations," by Mr. Douglas Mawson. Mr. J. W. Mellor and Mr. F. R. Zietz were good enough to give members a glimpse of the "Tuggerah Lakes" and of various places in Tasmania. Both of these addresses were exceedingly interesting, and on the subject of ornithology very instructive.

An evening was devoted to the scientific results of the three days' excursion to Blumberg, when Mr. A. Zietz dealt with the bird life; Mr. Griffith, Coleoptera; Mr. J. G. O. Tepper, botany; Mr. S. Smeaton, geology. Mr. E. H. Lock introduced a discussion on "Animal Instinct or Reason." The subject was a new form of study at the meetings, and proved interesting.

The conversazione to celebrate the twenty-first anniversary of the Section was a great success. The exhibition of natural history specimens would have done credit to a museum, and the regret was expressed that it could not be on view for more than one evening. It demonstrated the fact that the members of the Section have been doing a great amount of work in making private collections.

A very instructive and interesting feature of the evening meetings has always been the exhibits. These have not been so numerous as at some of the meetings of previous years, and it is hoped that members will not allow this practice to lose its interest. Perhaps the most striking feature of exhibits has been the keen interest taken in the collection of orchids. The Chairman of the Section has created quite a new enthusiasm in this branch of botanical study. His explorations in field work, ably assisted by Mrs. Rogers, have resulted in a splendid collection, taken at all times of the year, and the members will congratulate them upon having added three species not previously recorded by the Section, and one apparently not recorded at all in Australia. In the same direction, note must also be made of the records of Mr E. Ashby, who has from time to time sent in specimens and records of orchids as they appeared in the vicinity of Blackwood.

The field excursions were as follows:—

1904.
Oct. 1. Gandy's Gully.
Oct. 15. Typical orchard, Mylor.
Oct. 29. National Park.
Nov. 12. Blumberg (three days).
Dec. 17. Last excursion for the season, Norton's Summit.

1905.
Feb. 18. Dredging excursion, Port River.
June 3. Blackwood (Viaducts).
June 17. Belair (National Park).
July 15. Black Hill.
Aug. 12. Teatree Gully.
Sep. 1 Scott's Creek (three days' camp).
Sep. 23. Coromandel Valley.

The excursion to Gandy's Gully was a new field for exploration, and the record shows that while it would seem difficult to find new places for excursions, there are yet a number of places not yet visited that would well repay the trouble of finding them.

The Typical Orchard at Mylor was revisited after a lapse of some two years, and the object lesson of fruit culture here was well demonstrated.

National Park was twice visited, and, although well known to most of the members, it was found that this ground is by no means exhausted.

The annual three days' excursion in November was held this year again at Blumberg. The same hospitality that was extended to the Section on a previous visit was again heartily given by the residents, and a new programme having been laid out for excursions, the engagement was highly successful and enjoyable.

The Port River was again visited, and the results to the Microscopists were successful, while an additional interest was realised in noting the progress of the construction of the Outer Harbour.

Blackwood is regarded as the most prolific field for botanical collecting, and this year an excursion to the neighbourhood of the Railway Viaducts proved a new source of interest to those attending.

Blackhill and Teatree Gully are both well known to the members; but they never fail to produce something worth the effort of exploring. Both places were visited, and also the vicinity of Norton's Summit. The latter, however, was more in the nature of a picnic to close the list for 1904.

On the 1st of September the members ventured upon a new departure in arranging a three days' Camp at Scott's

Creek, which had not been previously visited by the Section. The result of this experiment is best summed up in the wish expressed by several members "that arrangements should be made for another excursion in November of a similar character." The matter is now under consideration.

Next Saturday the vicinity of Sturt River at Coromandel Valley will be visited, to complete the list of twelve excursions for the year under review.

It is very gratifying to note that, during the year, seventeen names have been added to the list of membership.

It is a coincidence, that, in April of 1904, the Chairman (Dr. E. Angas Johnson) resigned his position to make a visit to England. In the same month of the following year (1905) the Secretary resigned for the same purpose. Both vacancies were filled by Mr. Lock, which may also be regarded as an unusual circumstance. In the resignation of Mr. Selway the Section was deprived of the services of the most indefatigable worker the Section had ever had, and his services were appropriately acknowledged by a suitable presentation of a Floral Address.

SEVENTEENTH ANNUAL REPORT OF THE NATIVE FAUNA AND FLORA PROTECTION COMMITTEE OF THE FIELD NATURALISTS' SECTION OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA, FOR THE YEAR ENDING SEPTEMBER, 1905.

At a meeting of the Committee, held in November last, on the occasion of the retirement of their Chairman from the Commissionership of the National Park, a resolution was passed, as follows:—"That the Committee exceedingly regret the resignation of Mr. Dixon as a Commissioner of the National Park, and wish to place on record their appreciation of the able manner in which he has represented them while upon the Board." It was at the same time decided that Mr. Ashby should be recommended for appointment in his place. This suggestion was sent on to the authorities, but without avail, another gentleman being appointed. The Committee therefore, have now no representative upon the Board. As it was through the persistent exertions of the Committee that the National Park was established, they consider that they have a good claim to representation, and they are further strongly of opinion that at least one Commissioner should be a naturalist.

An application having been made for a lease of the Cape Borda Lighthouse Reserve for a cattle station, the Secretary to the Marine Board courteously wrote, asking whether any reason could be adduced why, in the interests of the fauna, it should not be granted. On the Committee representing to the Marine Board the desirability of protecting the indigenous kangaroos and wallabies on the reserve, the application was refused.

Referring to the resolution passed by the International Ornithologists' Congress recently held in London—"The Congress appeals most strongly to the Government of the Commonwealth of Australia to pass legislation to prevent the wholesale destruction of penguins and all those birds boiled down for oil in the lands under its rule"—a letter has been received from the Crown Lands Office, seeking information as to whether further protection to these birds is desirable in South Australia. The Committee recommend that instructions should be given to the lighthouse-keepers at various stations, and especially at the Neptune Islands, to as far as possible prevent the destruction of penguins, mutton birds, and all other birds during their respective close seasons, and that the police in outlying districts should also be specially directed to enforce the observance of the Birds' Protection Act.

SAML. DIXON, Chairman.

Adelaide, September 19, 1905.

FIELD NATURALISTS' SECTION OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDIN., SEPTEMBER 30, 1905.

Dr. Receipts.	£	s.	d.	Expenditure.	Cr. £	s.	d.
To Cash in hand, September 30, 1904 ...	3	2	11	By Advertising	0	11	0
" Subscriptions for 1904-5	11	7	6	" Printing	3	18	6
" Grant from Royal Society	10	0	0	" Conversazione	12	6	0
" Surplus from excursions	1	16	0	" Postages	4	19	9
				" Stationery, etc.	0	15	0
				" Caretaker	1	5	0
				" John Hill & Co.	0	13	0
				" Cash in hand, September 30, 1905 ...	1	18	2
	£26	6	5		£26	6	5

Audited and found correct.

WALTER D. REED. } Auditors.
J. S. LLOYD,

Adelaide, September 29, 1905.

E. H. LOCK, Hon. Secretary.

MALACOLOGICAL SECTION

OF THE

Royal Society of South Australia (Incorporated).

ANNUAL REPORT FOR 1904-5.

The Committee has to report that there are now thirteen members of the Section. During the past year eleven meetings were held, at which the average attendance was seven.

Steady progress has been made in the routine work of revising the census of South Australian gastropods, and, following Zittel's classification, all the species have been dealt with, from the *trochidæ* to the *naticidæ.* In addition, four papers have been contributed to the transactions of the Royal Society—two by Dr. J. C. Verco, entitled "Notes on South Australian Marine Mollusca, with Descriptions of New Species, parts i. and ii."; one by Mr. H. Basedow, in collaboration with Mr. C. Hedley, "South Australian Nudibranchs, and an Enumeration of the known Australian Species"; and another by Mr. H. Basedow on "New Species of South Australian Lamellaria and Caledoniella."

The following is a copy of the balance sheet:—

RECEIPTS AND EXPENDITURE FOR 1904-5.

Receipts.

Dr.	£	s.	d.
To balance brought forward	0	6	3
" Subscriptions	1	10	0
" Grant from Royal Society	1	0	0
	£2	16	3

Expenditure.

Cr.	£	s.	d.
By Postages and Sundries	0	14	1
" Honorarium to Caretaker for 1904 and 1905	1	0	0
" Balance in hand	1	2	2
	£2	16	3

R. J. M. CLUCAS, Hon. Secretary and Treasurer.

MICROSCOPICAL SECTION
OF THE
Royal Society of South Australia (Incorporated).

ANNUAL REPORT FOR 1904-5.

CHAIRMAN—D. FLEMING.

COMMITTEE—W. B. POOLE, D. GORDON, W. FULLER.

HON. SECRETARY—E. J. BRADLEY, Dover Street, Malvern.

The second year's work of the Section has been successful in promoting the objects contemplated, viz., the encouragement of microscopical research as a means of intelligent recreation. Satisfaction is felt at the action of the Council of the Adelaide University in establishing, at the request of Mr. Gordon and a number of our members, a class for the study of microscopical technique. The average attendance at the evening meetings has been 15, whilst the total number of members on the roll at present is 43.

The following meetings and excursions have been held during the session:—

September 27, 1904—Annual general meeting.

October 22—Excursion to Port docks and swamps.

October 25—Paper on "Foraminifera," by MR. E. J. BRADLEY.

November 22—Paper on "Nodules on Roots of Legumes," by MR. W. B. POOLE.

February 18, 1905—Dredging excursion to Port River and Outer Harbour.

March 28—Paper on "Some Changes in Vegetable Cells in Connection with the Formation of the Embryo," by MISS BENHAM.

April 25—Examination of live material obtained from the River Murray by the Boys' Field Club.

May 23—Examination of Mr. G. Crase's collection of show objects.

June 29—MR. S. SMEATON, B.A., gave an explanation of the "Functions of Hairs of Plants" and "Lori of Ferns," and exhibited a large collection prepared by Mr. T. D. Smeaton. MR. W. P. DOLLMAN gave a practical demonstration of "Microphotography."

July 25—Question Box Evening—MR. E. J. BRADLEY gave an exhibition of slides illustrating the "External Anatomy of the Honey Bee."

August 19—Excursion to ponds at Blackwood.

August 22—Mr. W. B. Poole gave a demonstration and paper on "Cutting, Staining, and Mounting Plant Sections," with an explanation of the structure of plant stems.

September 23—Excursion to ponds at the Black Road, O'Halloran Hill, and also Happy Valley Reservoir.

David Fleming, Chairman.
Edgar J. Bradley, Hon. Secretary.

MICROSCOPICAL SECTION OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA.

Balance-sheet, Session 1904-5.

Receipts.

	£	s.	d.
Cash in hand at beginning of Session ...	1	16	5
Grant from Royal Society	5	0	0
Subscriptions, 1904-5	6	12	6
	£13	8	11

Expenditure.

	£	s.	d.
Postage	1	17	0
Printing	2	3	6
Stationery	0	6	5
Subscriptions paid to Treasurer of Royal Society	6	12	6
Duty Stamp	0	0	1
Attendance (Caretaker)	1	5	0
Balance in hand	1	4	5
	£13	8	11

Edgar J. Bradley, Hon. Secretary.

Audited and found correct.

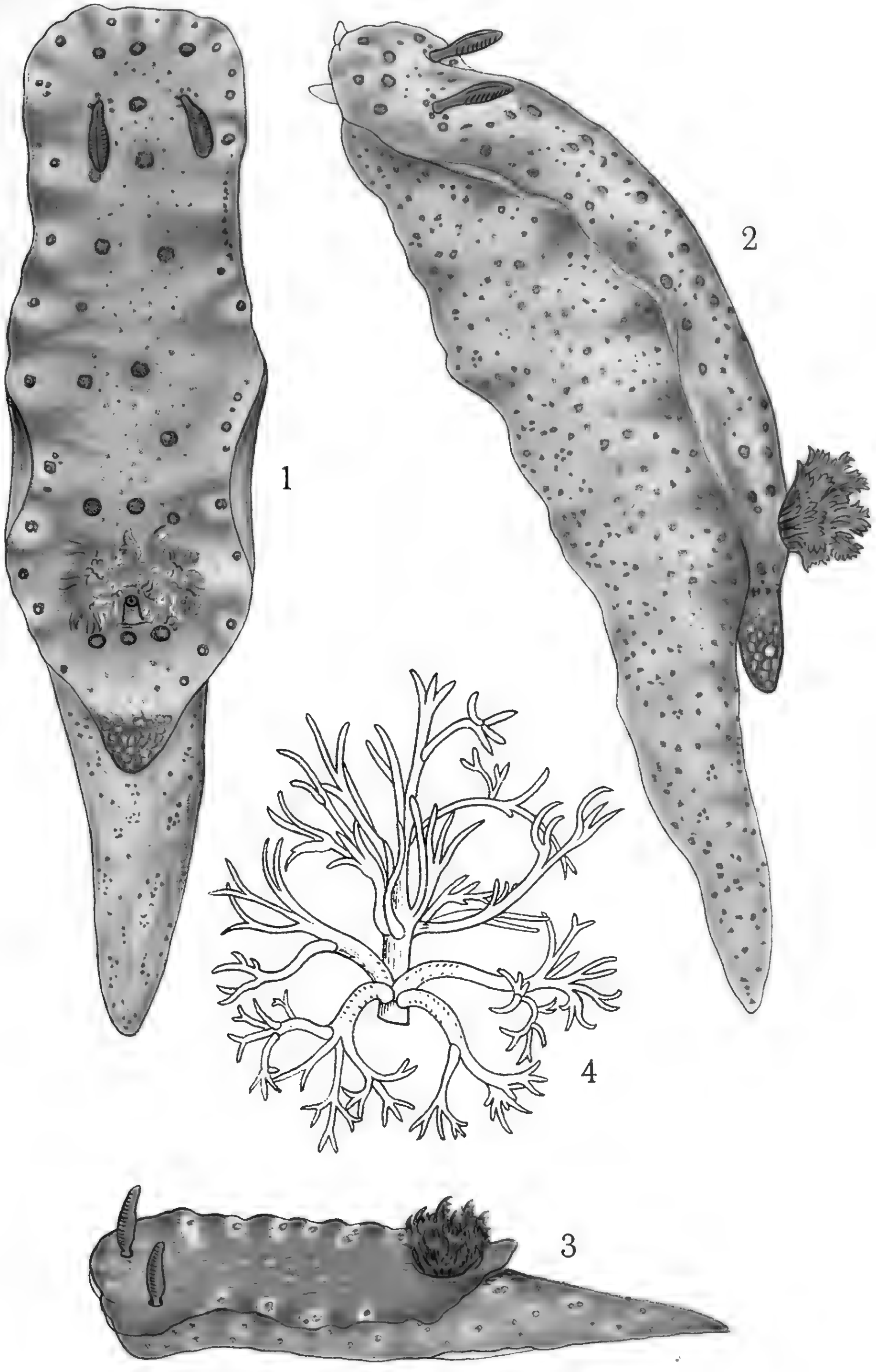
S. Smeaton, } Auditors.
Theo. Godlee, }

GENERAL INDEX.

[Generic and specific names printed in italics are described as new.]

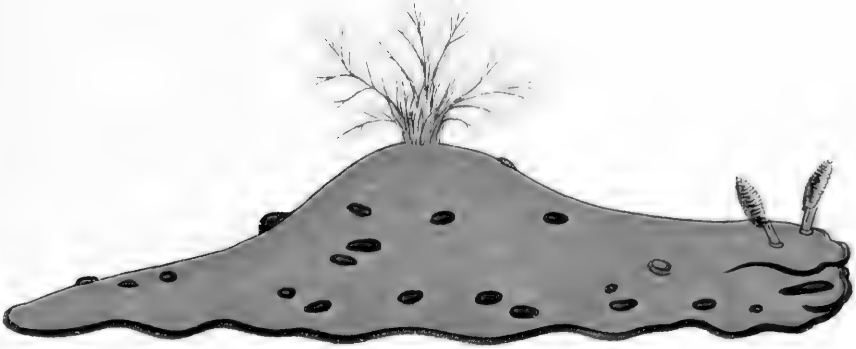
A3745—Hussey & Gillingham, Printers, 26 and 28, Waymouth Street, Adelaide, So. Aus.

PLATES I. TO XXXVI.



H. Basedow del. et pinx. ad nat.

CERATOSOMA BREVICAUDATUM, Abraham.



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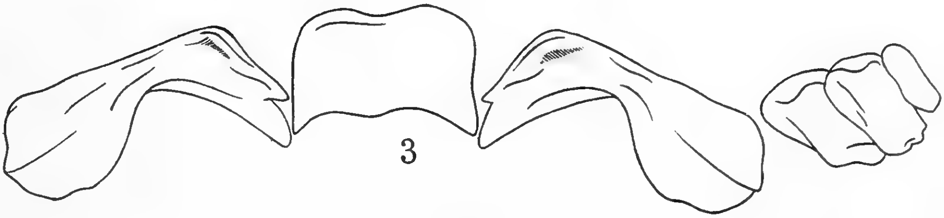

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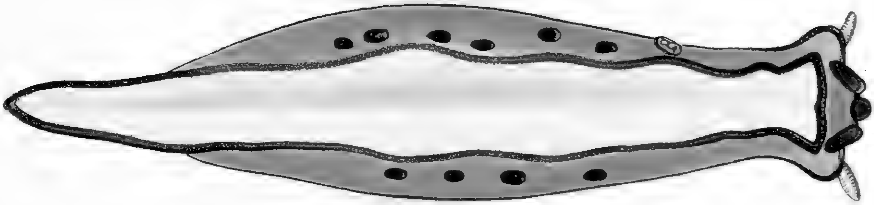

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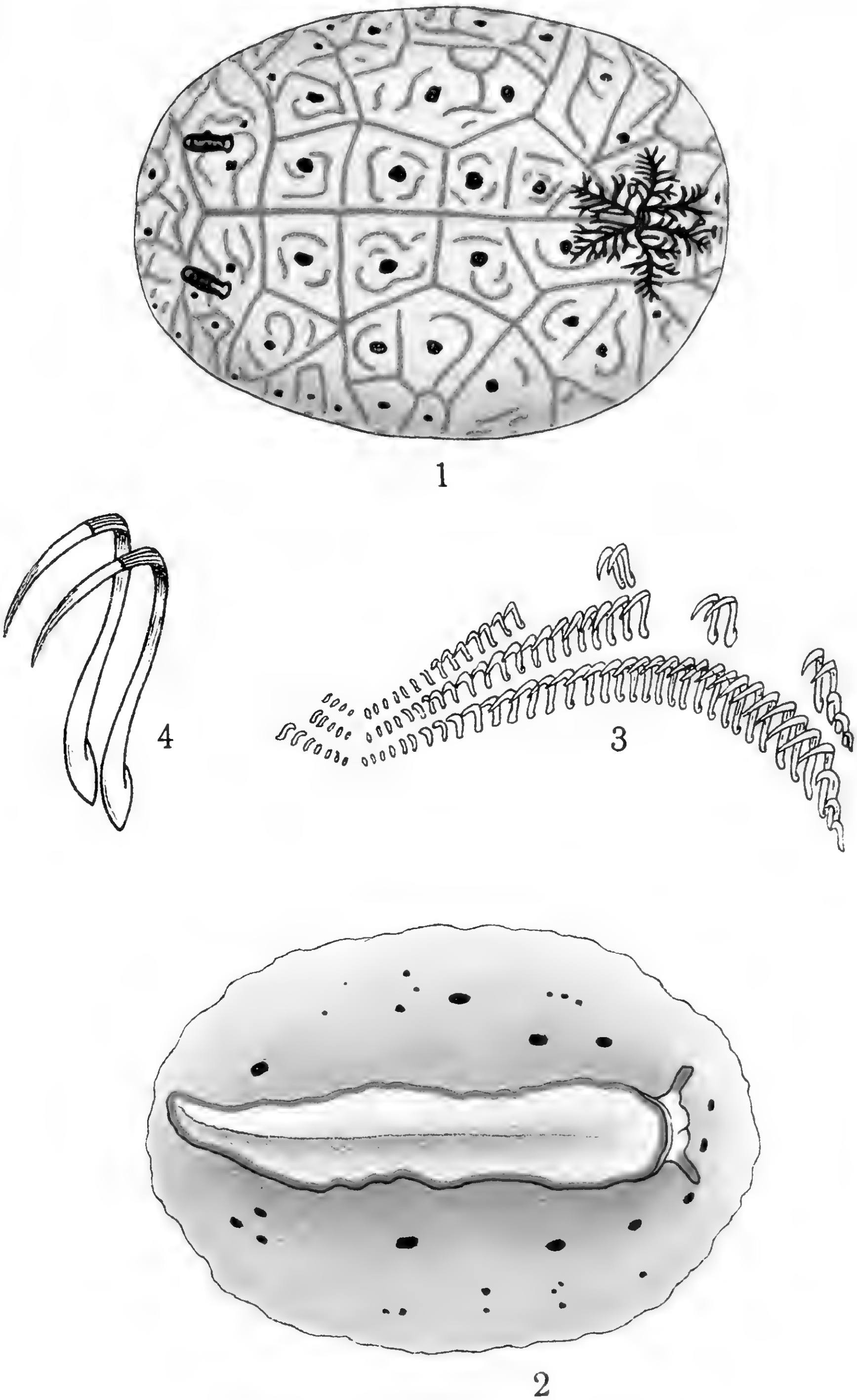
NEMBROTHA VERCONIS, Basedow & Hedley.



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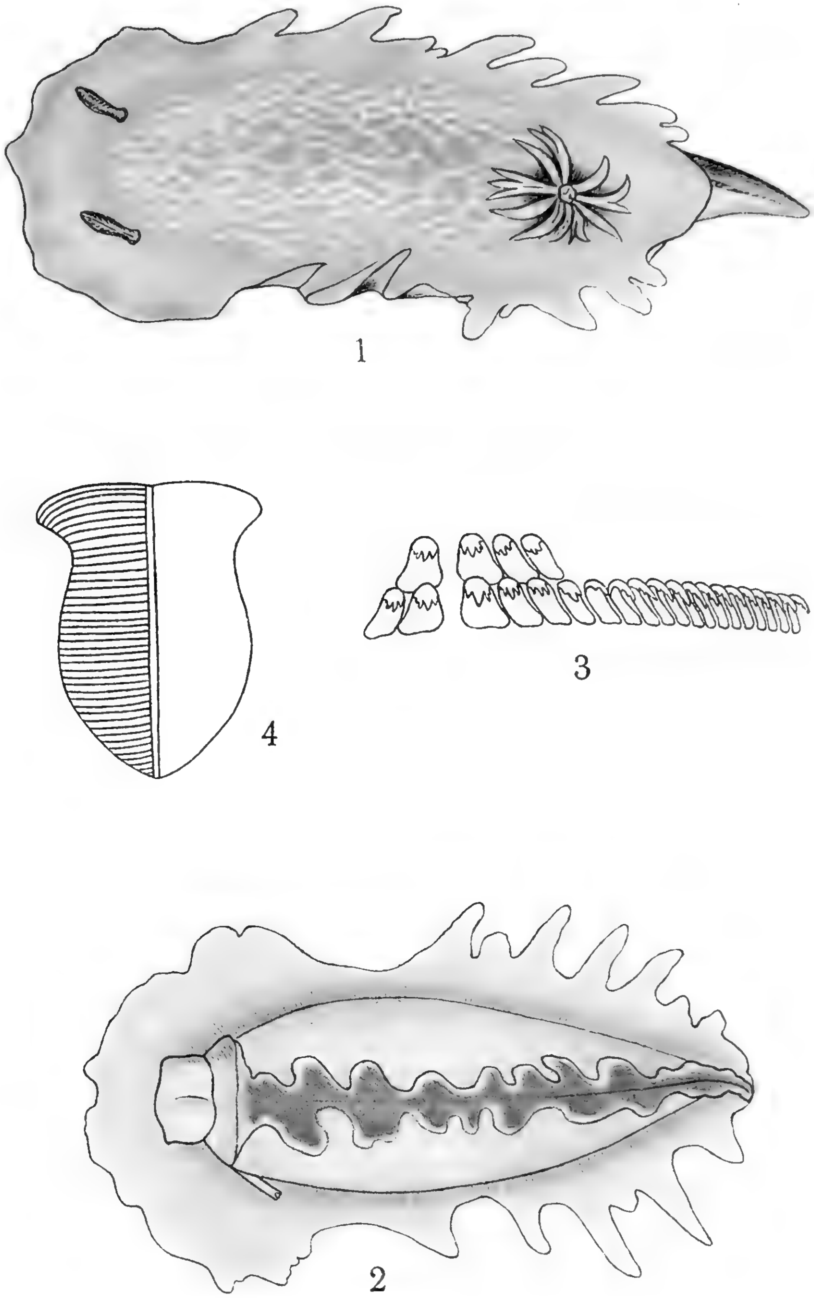
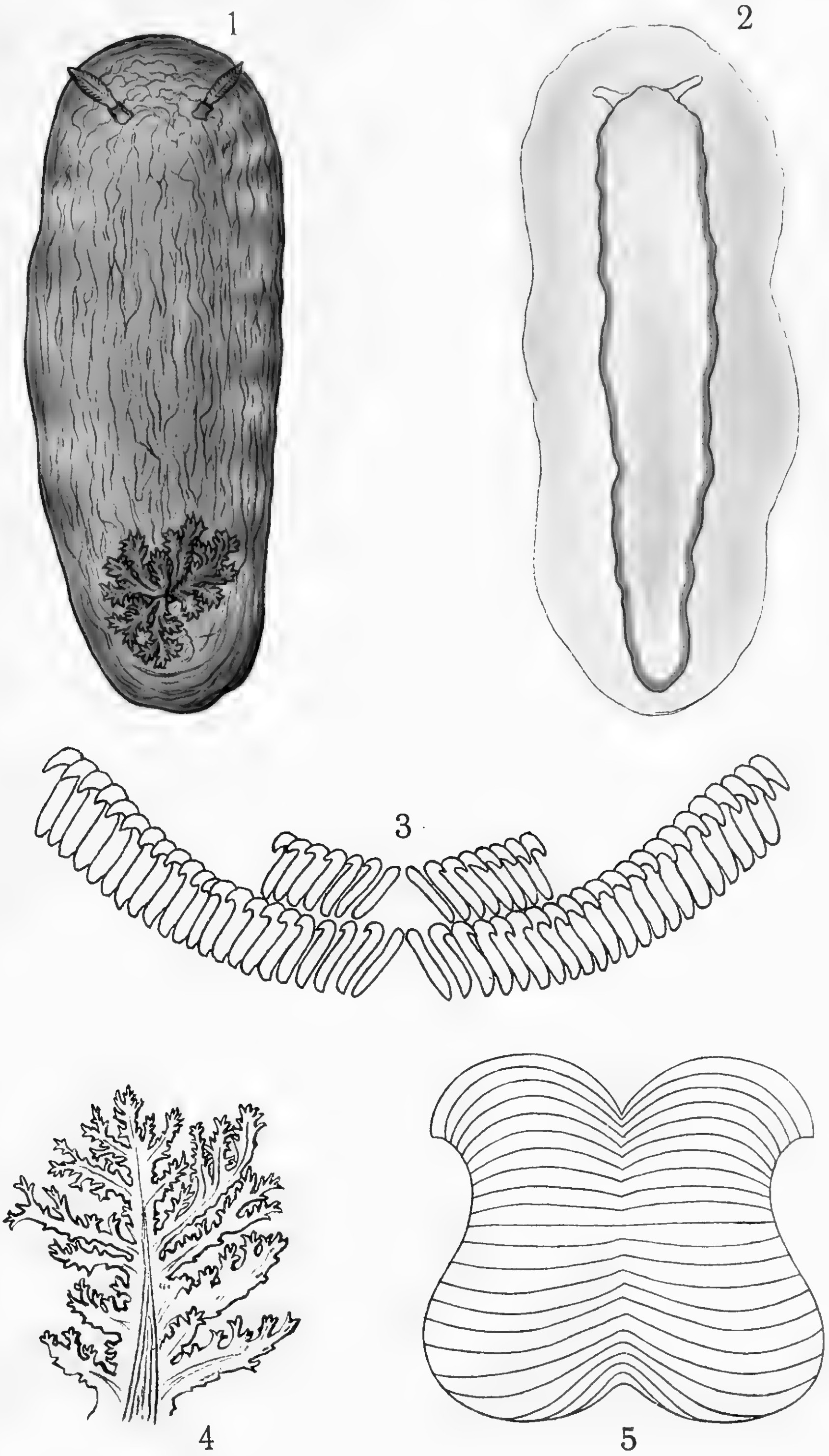
HALGERDA GRAPHICA, Basedow & Hedley.



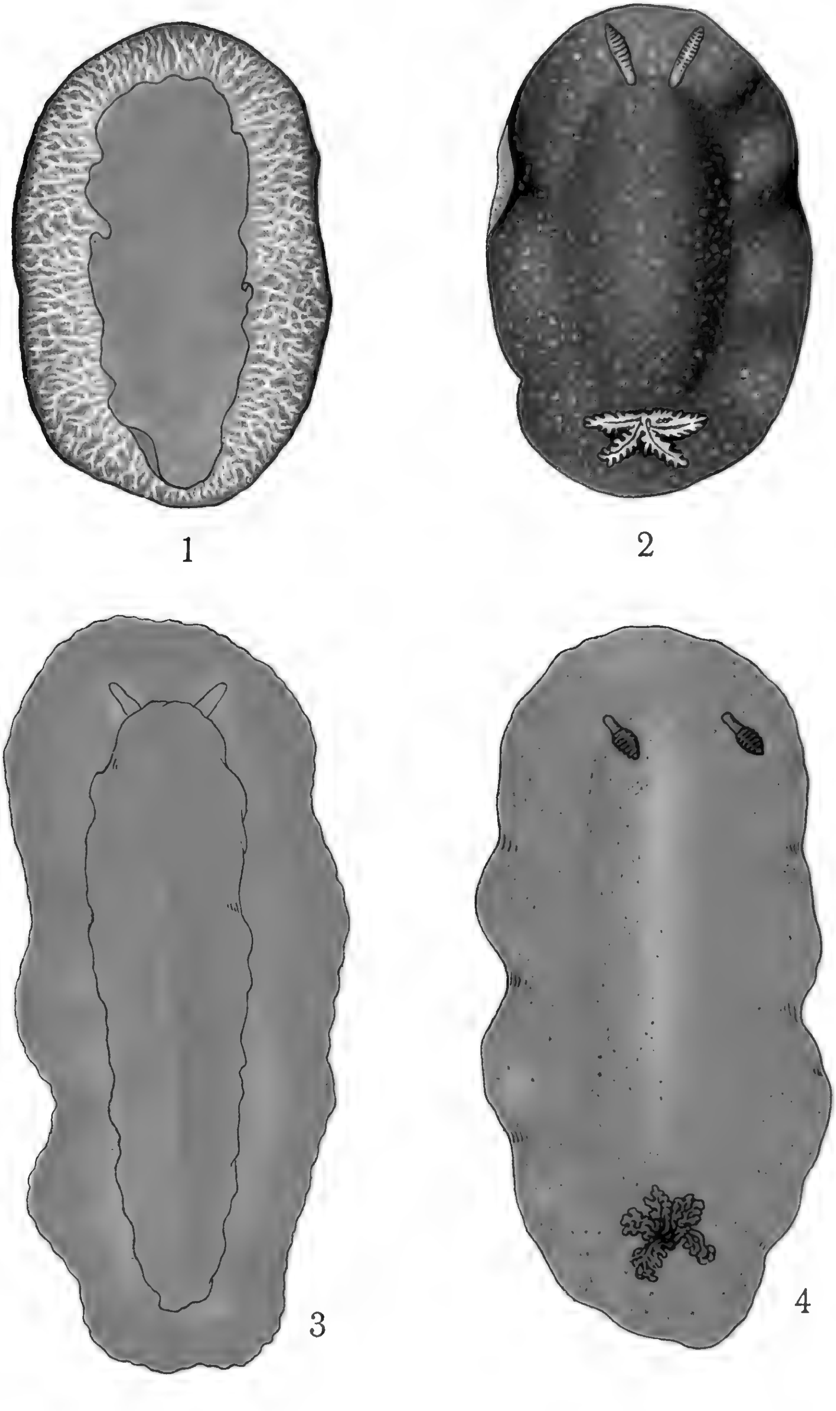
H. Basedow del. et pinx. ad nat.

ALBANIA VERCONIS, Basedow & Hedley.



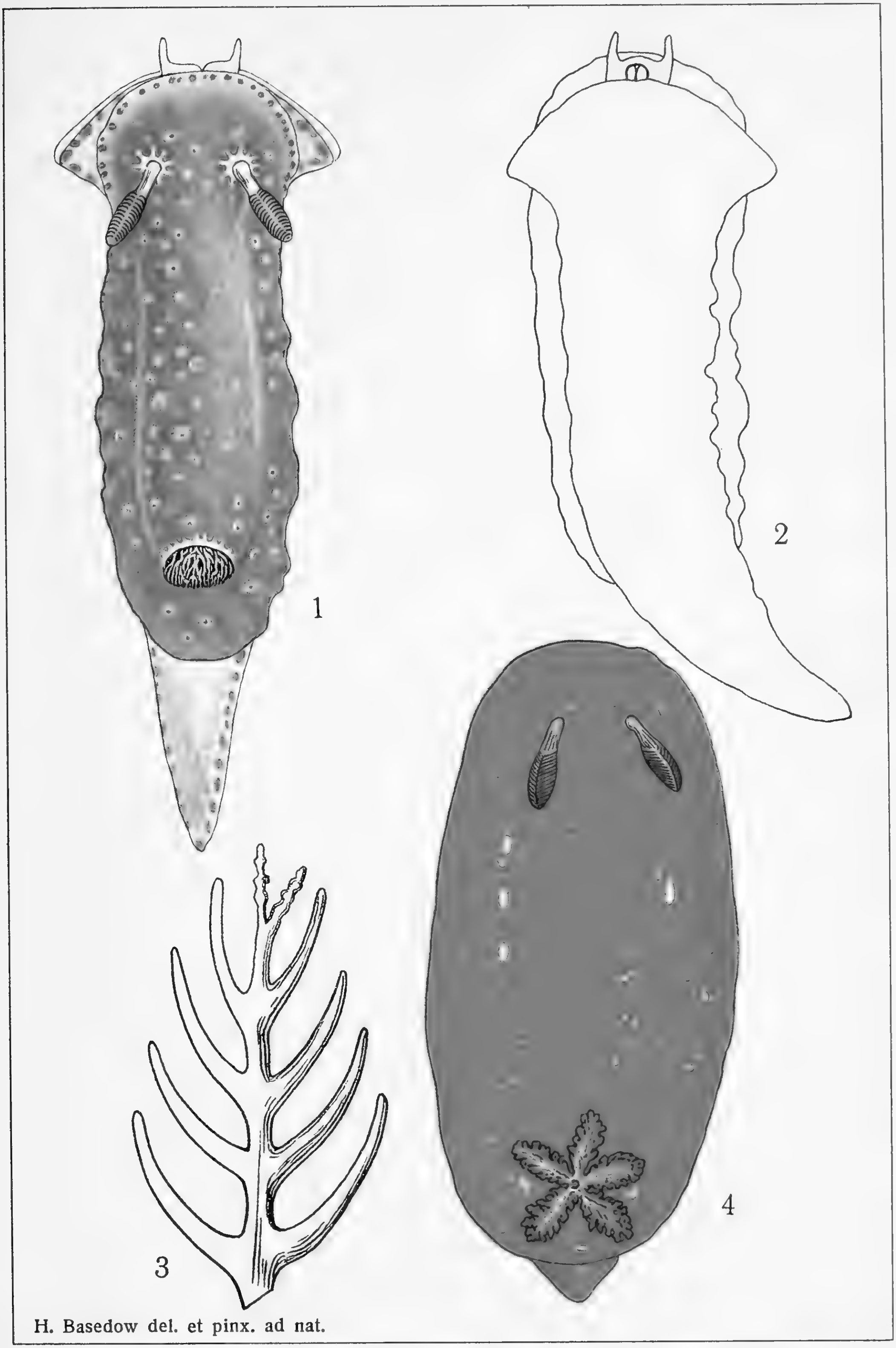
H. Basedow del. et pinx. ad nat.

ARCHIDORIS VARIA, Abraham.

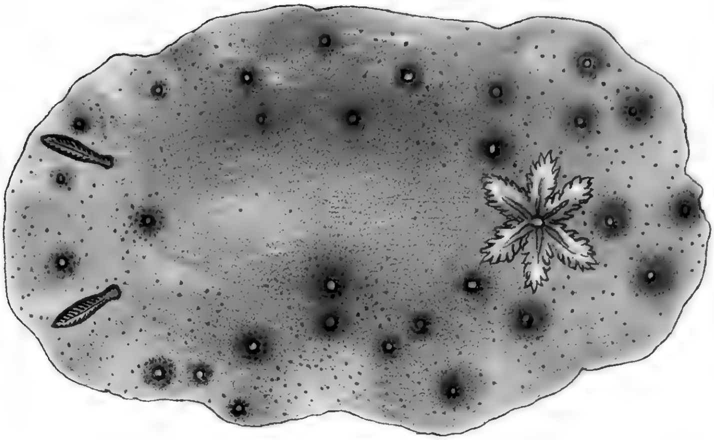


H. Basedow del. et pinx. ad nat.

1 & 2. DORIOPSIS CARNEOLA, Angas.
3 & 4. ARCHIDORIS STAMINEA, Basedow & Hedley.



1, 2 & 3. HYPSELODORIS EPICURIA, Basedow & Hedley.
4. DORIOPSIS AUREA, Quoy & Gaimard.



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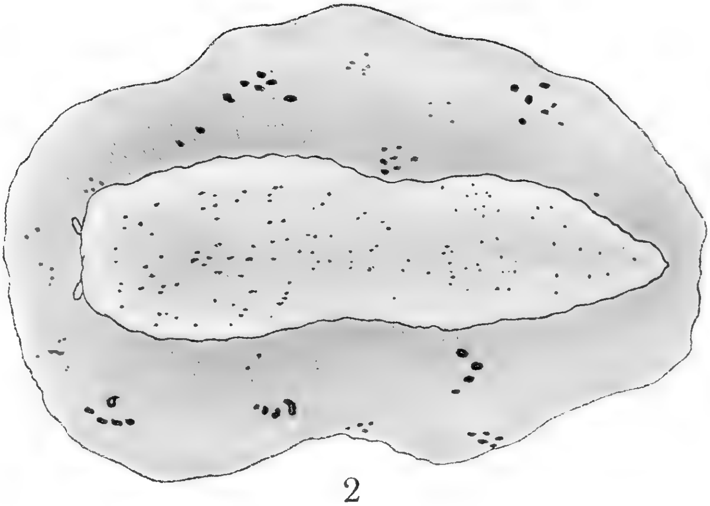

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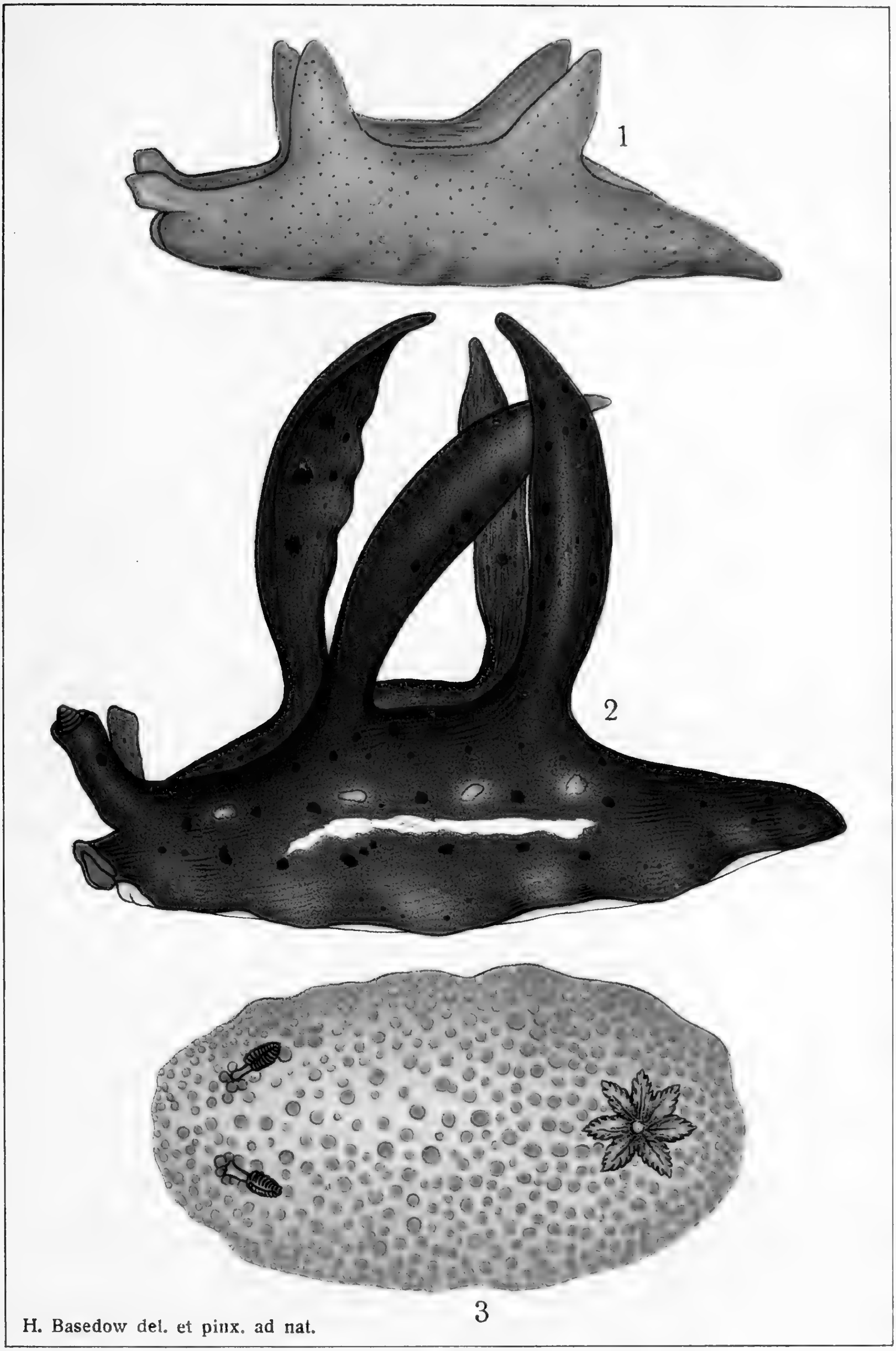
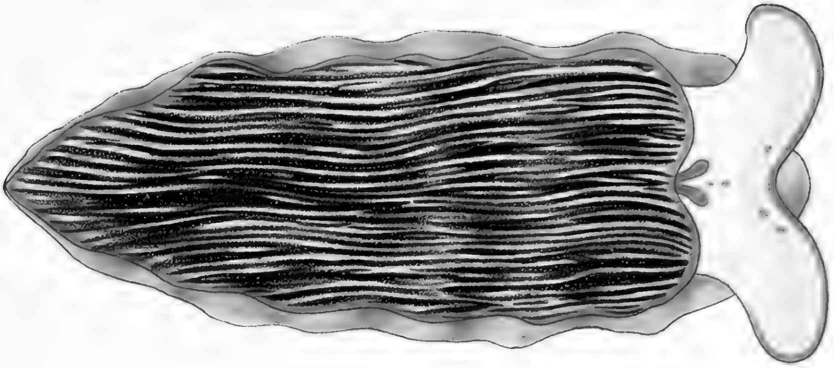
H. Basedow del. et pinx. ad nat.

ALLOIODORIS MARMORATA, Bergh.



H. Basedow del. et pinx. ad nat.

1 & 2. SCYLLÆA PELAGICA, Linne.
3. STAURODORIS PUSTULATA, Abraham.



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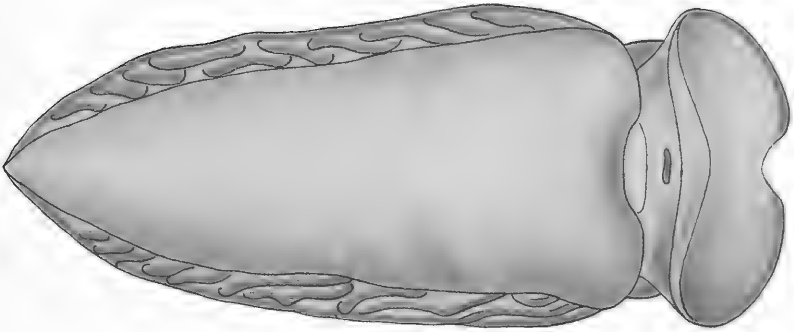

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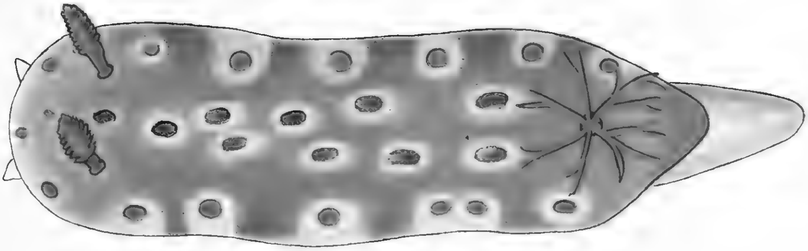

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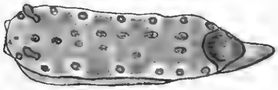

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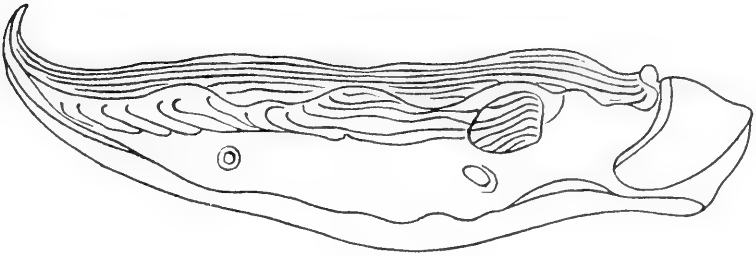
1 & 2. PLEUROPHYLLIDIA CYGNEA, Bergh.
3 & 4. CERATOSOMA ADELAIDAE, Basedow & Hedley.



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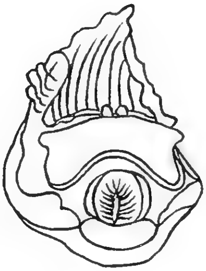

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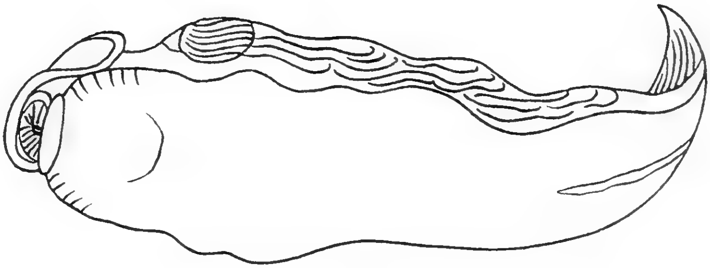

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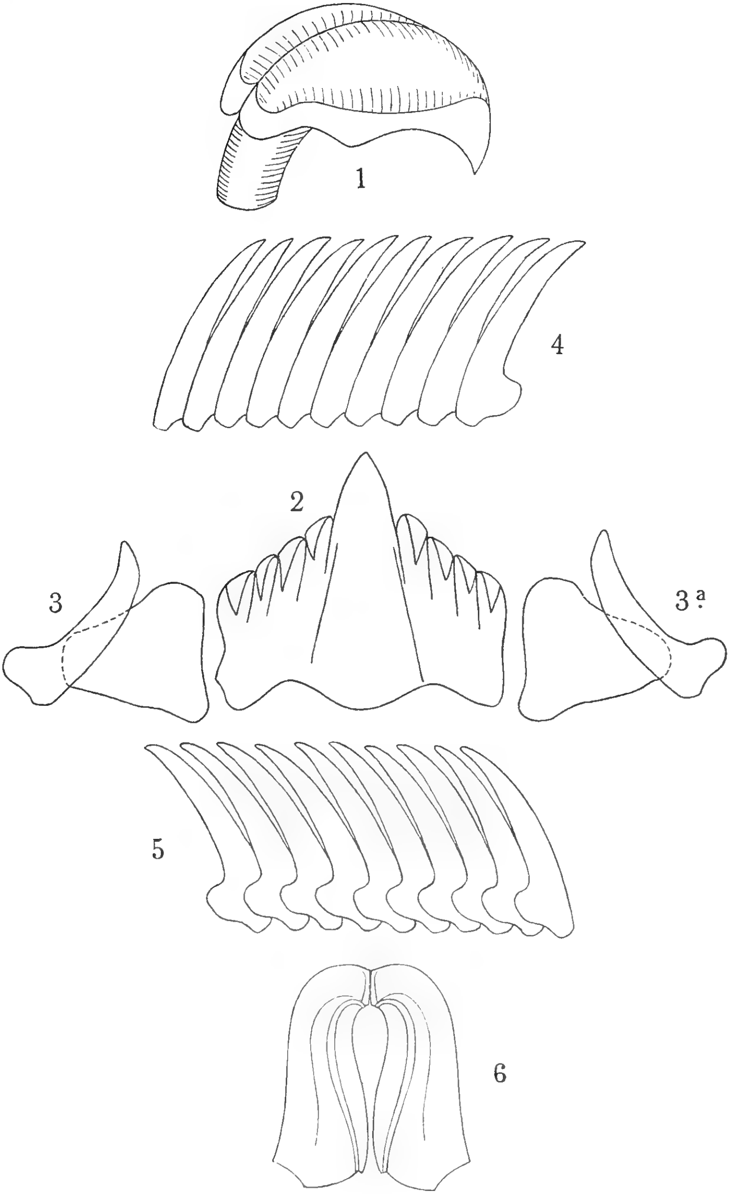
H. Basedow del. et pinx. ad nat.

PLEUROPHYLLIDIA CYGNEA, Bergh.



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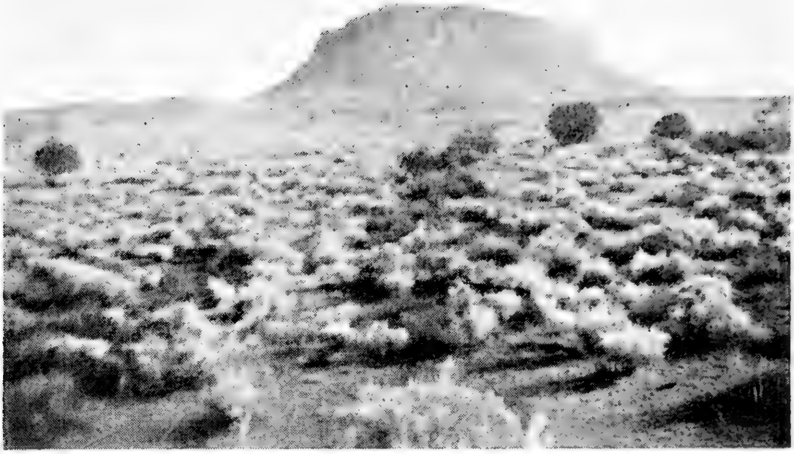

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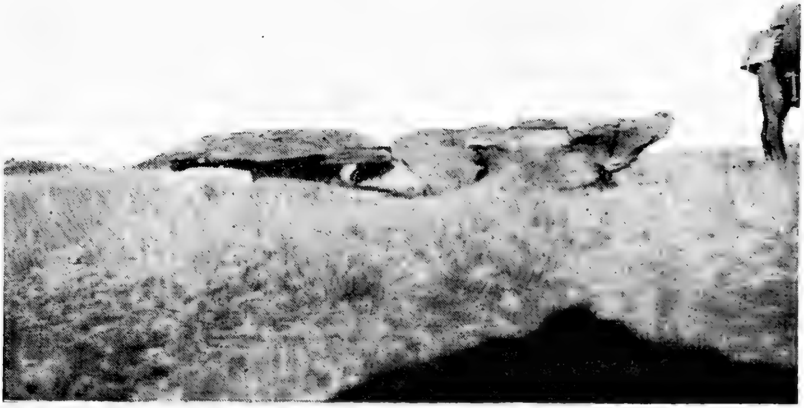

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H. Basedow, Photo.

Hussey & Gillingham, Printers, Adelaide.

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Hussey & Gillingham, Printers, Adelaide.

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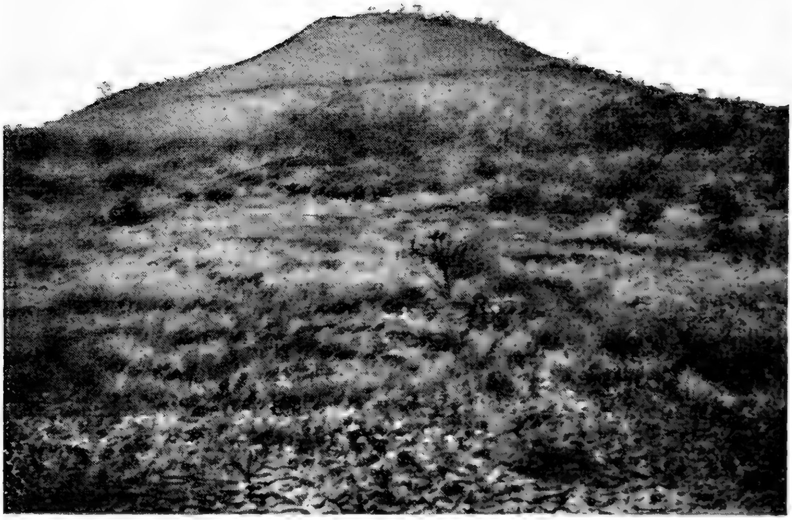

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Hussey & Gillingham, Printers, Adelaide.

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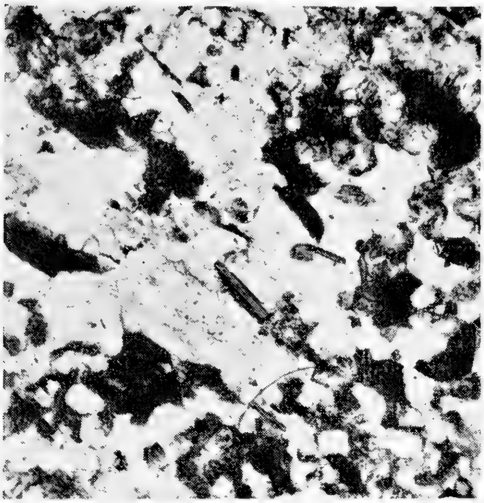

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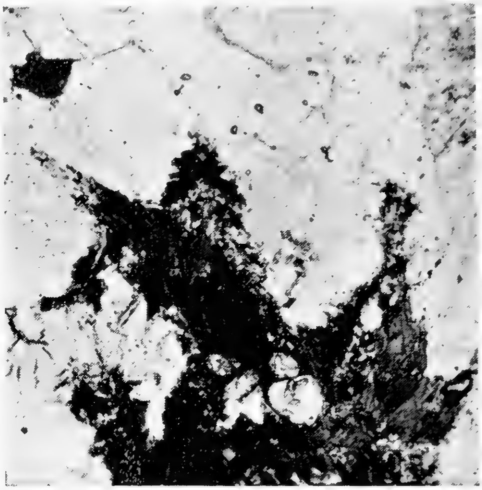

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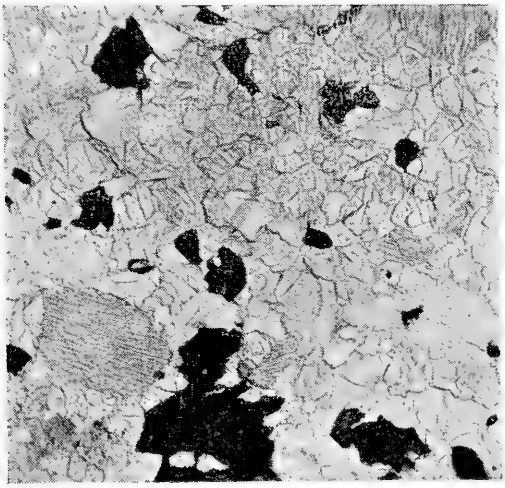

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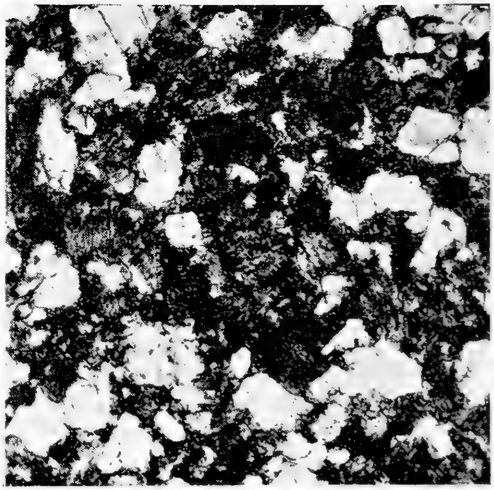


4

H. Basedow, Photo.

Hussey & Gillingham, Printers, Adelaide.

SKETCH SECTION

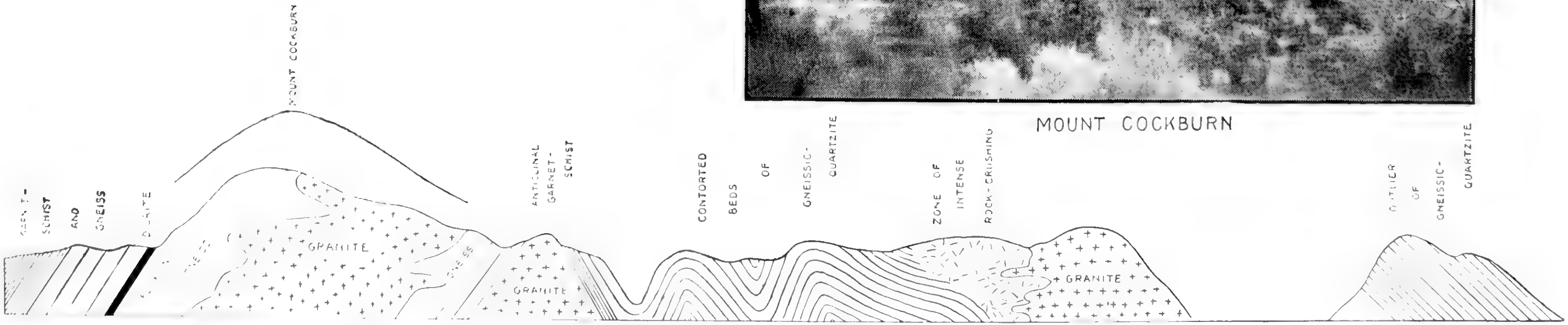
across the

MANN RANGES,

extending South from Mount Cockburn.

Distance: About 2½ Miles.

MOUNT COCKBURN



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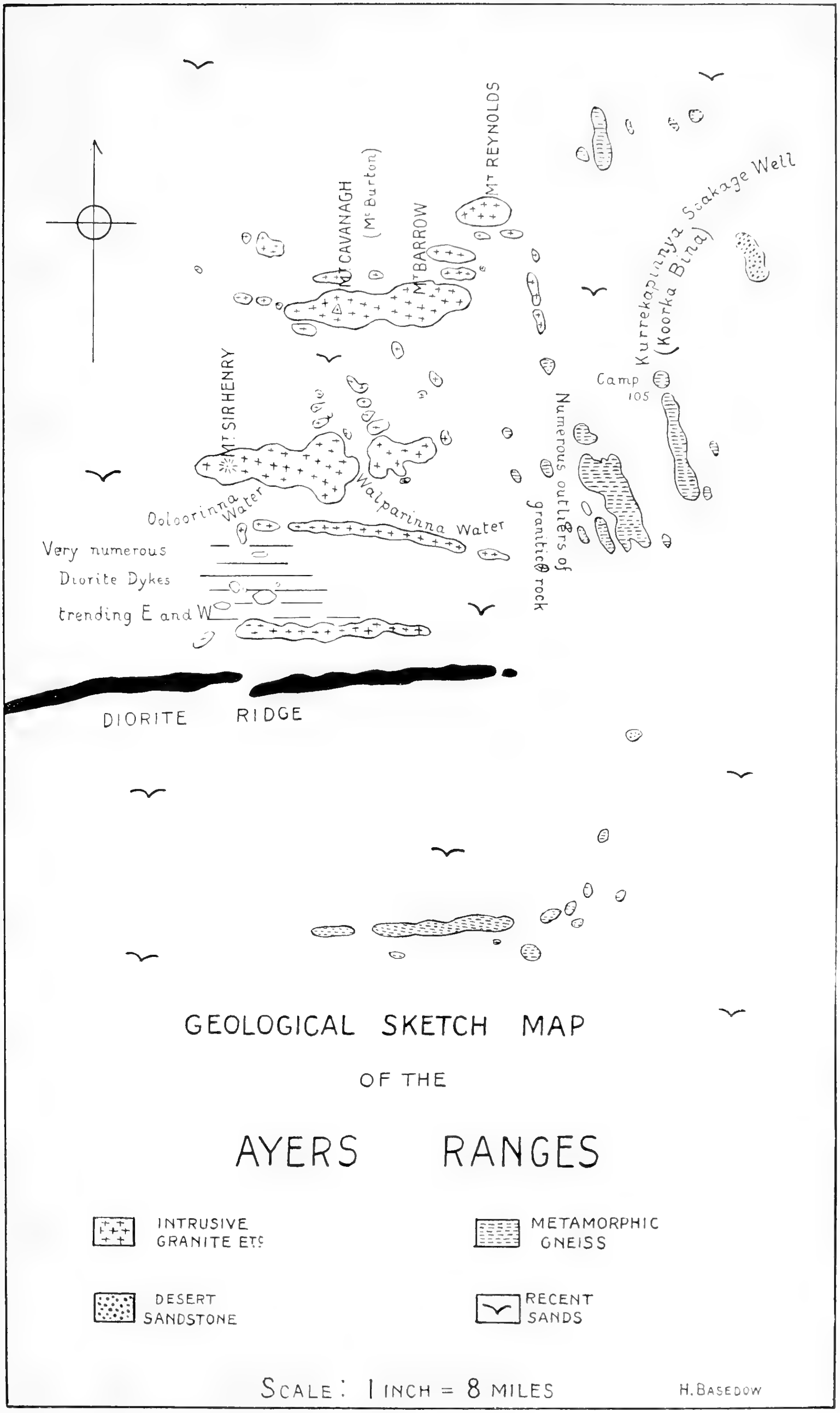
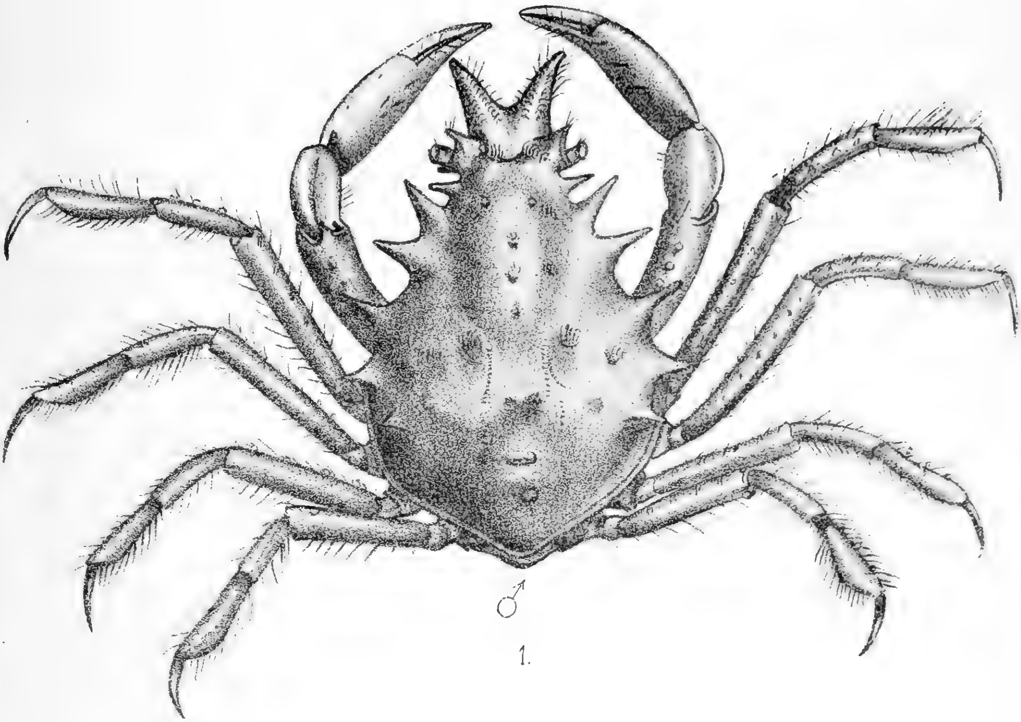
Hussey & Gillingham, Printers, Adelaide.



GEOLOGICAL SKETCH MAP
OF THE
AYERS RANGES

Hussey & Gillingham, Printers, Adelaide.



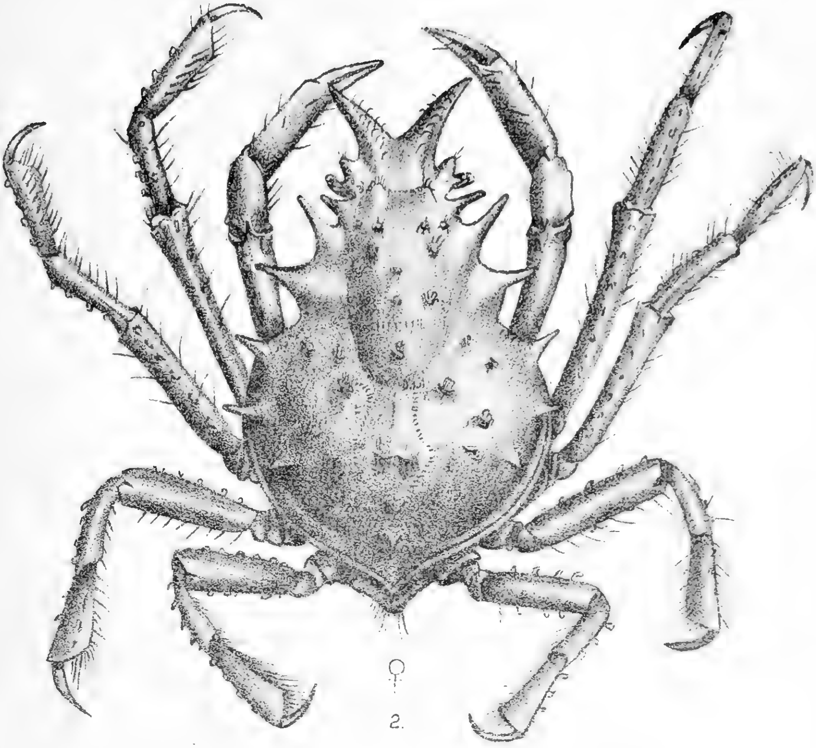
1.

1a.

J. W. H. D. DEL.

HUSSEY & G[illegible]

HALIMUS LÆVIS.



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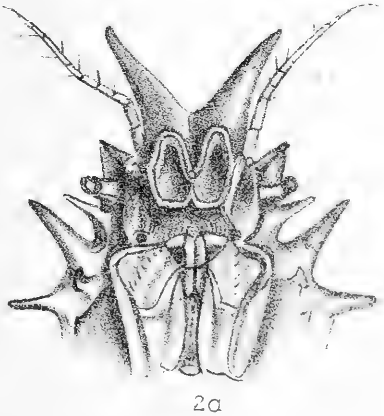


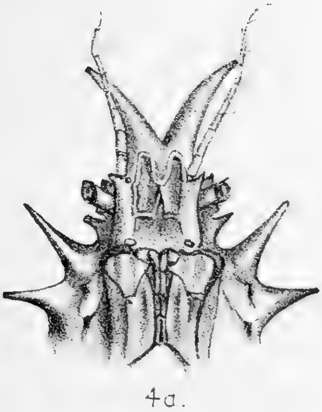
2a

3

W.H.B. DEL.

HALIMUS TRUNCATIPES. H. TUMIDUS.

♂
4



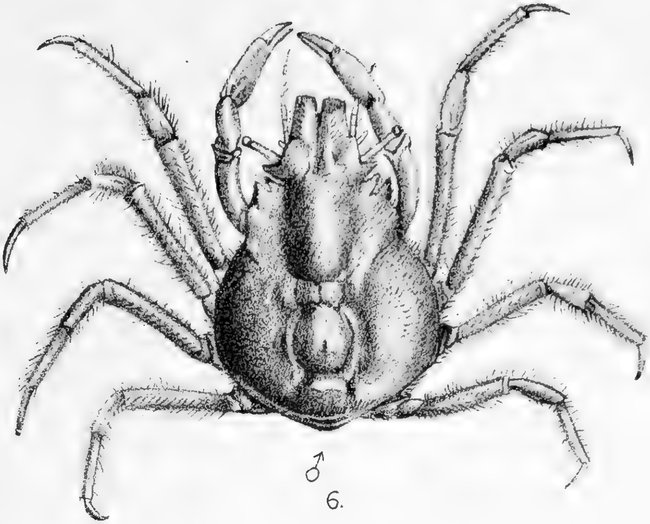
4a.

5.

W.H.B. DEL.

HUSSEY & GILLINGHAM. LITH.

HALIMUS GRACILIS. H. TUMIDUS var. GRACILIPES.



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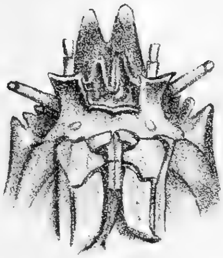

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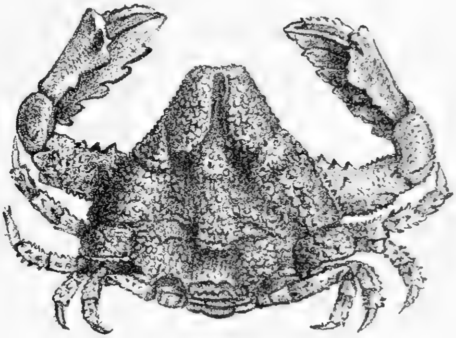

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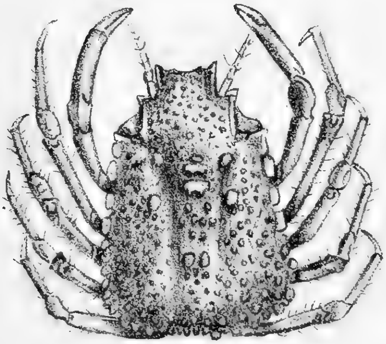

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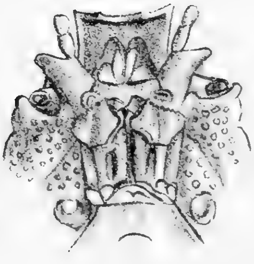

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W.H.B. DEL

HUSSEY & GILLINGHAM LITH

PARAMICIPPA HISPIDA. MICIPPA MASCARENICA. THYROLAMBRUS EXCAVATUS.


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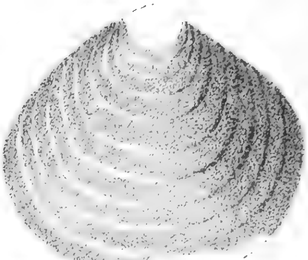
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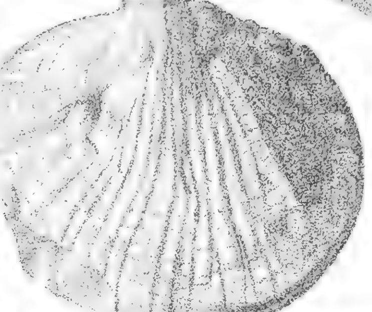
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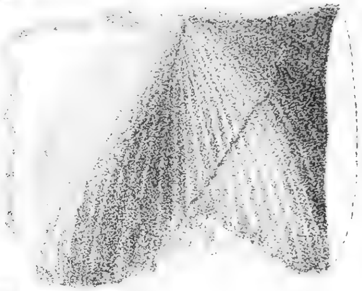
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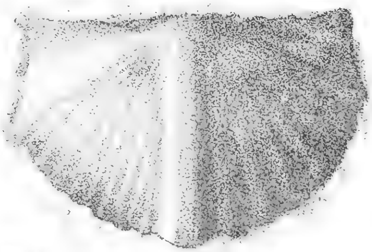
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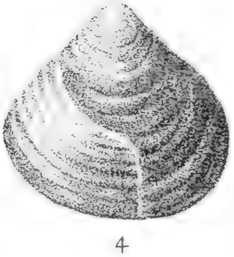
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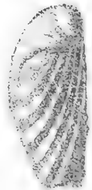
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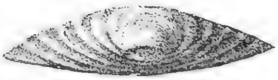
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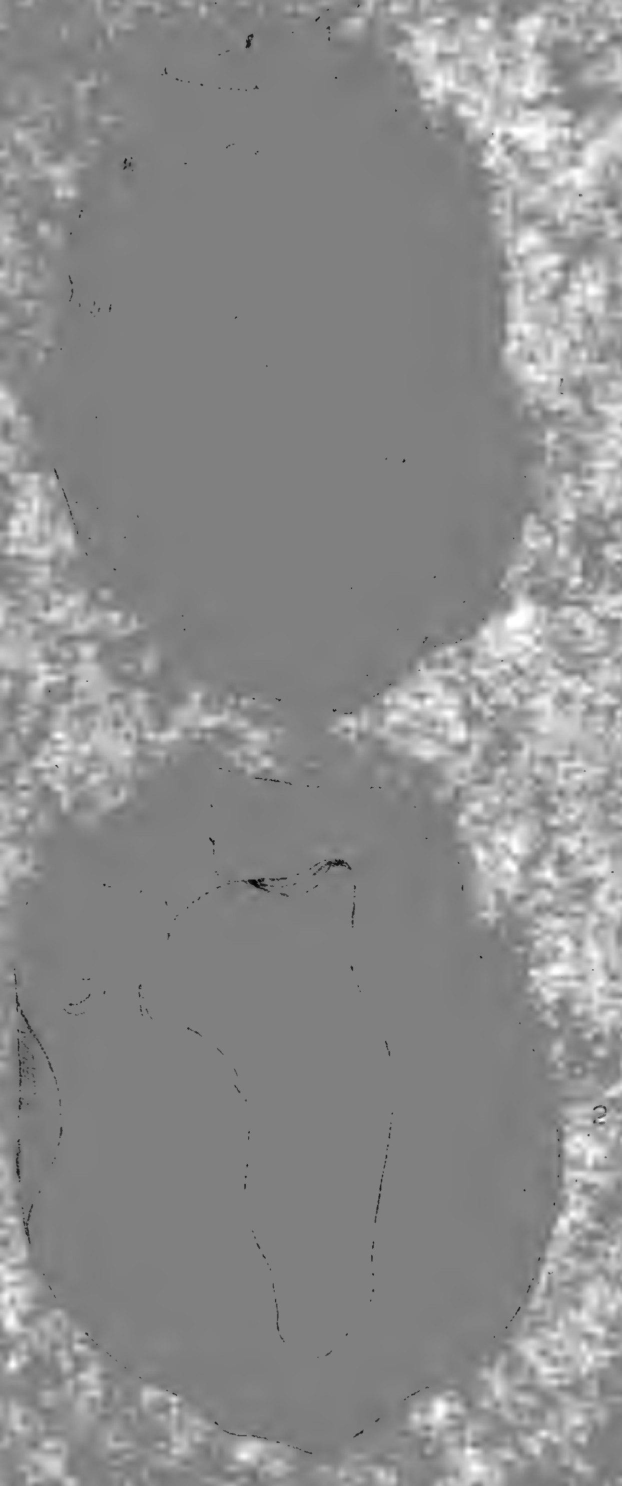
J. RICHARDSON, DEL ET LITH.

HUSSEY & GILLINGHAM LITH.



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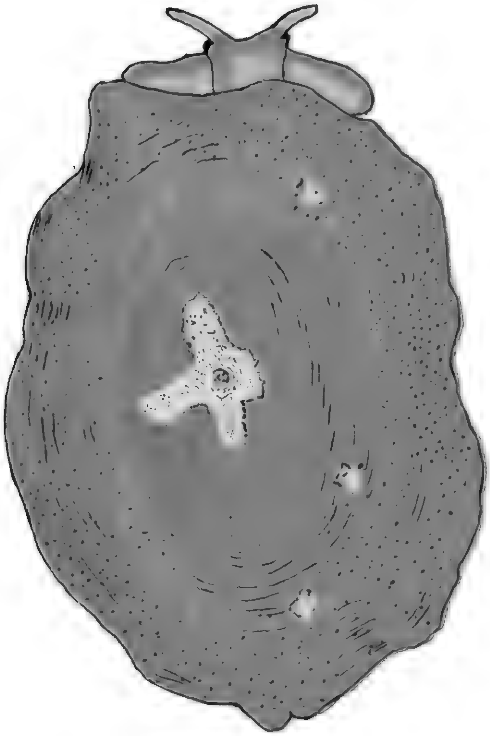

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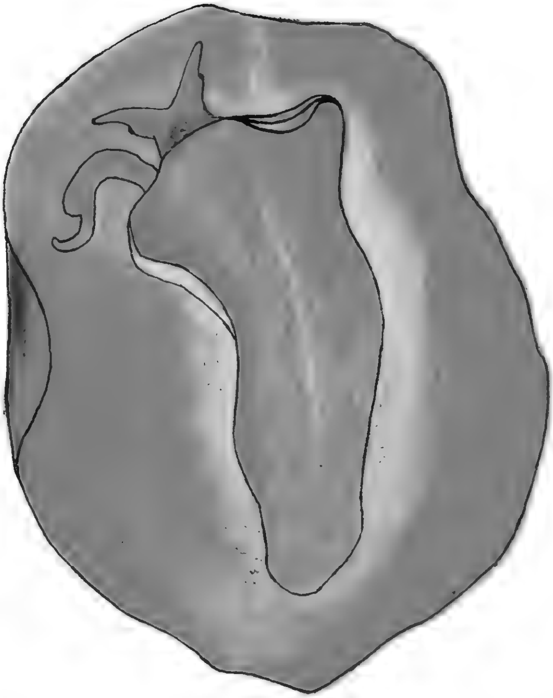

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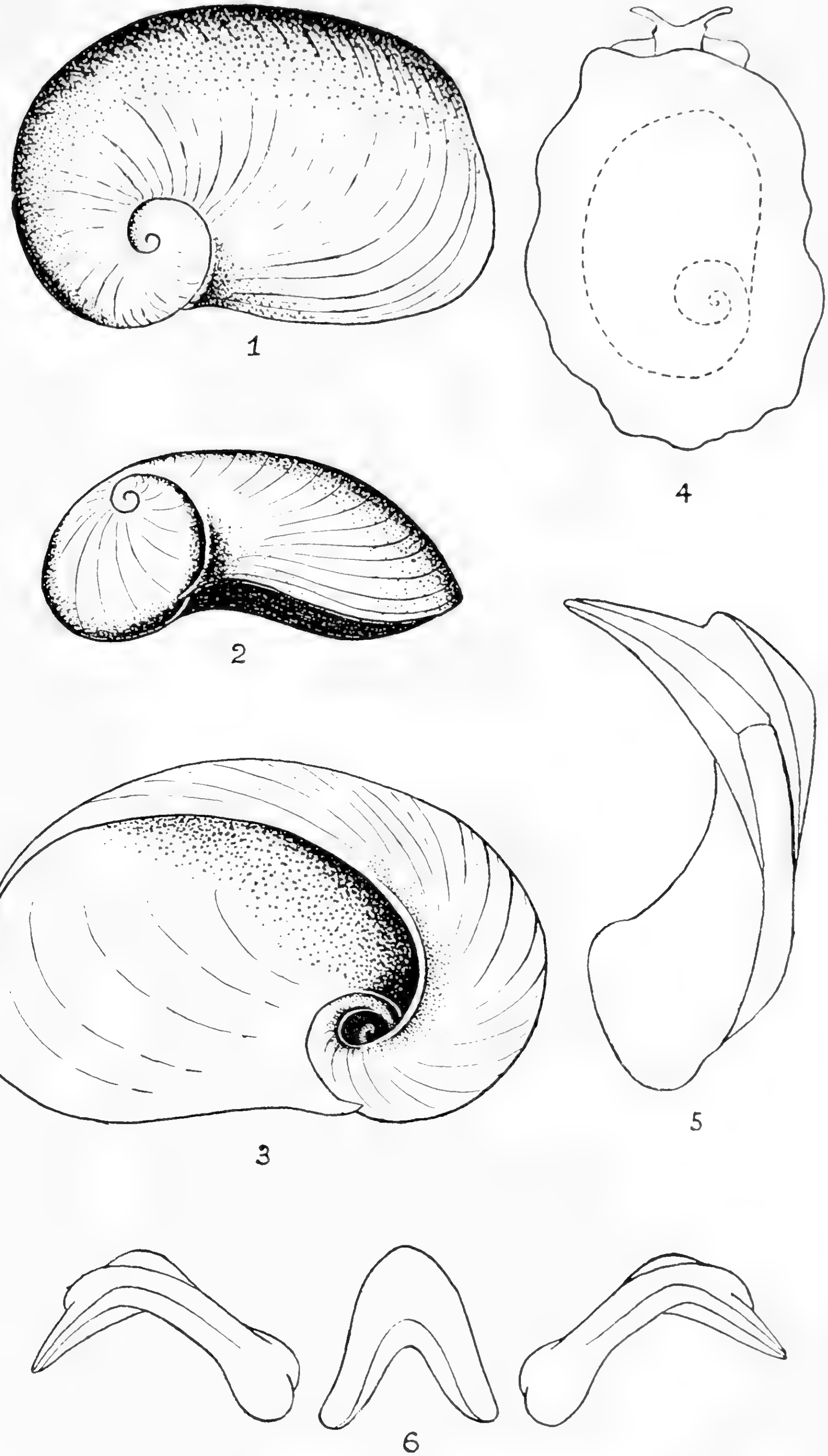

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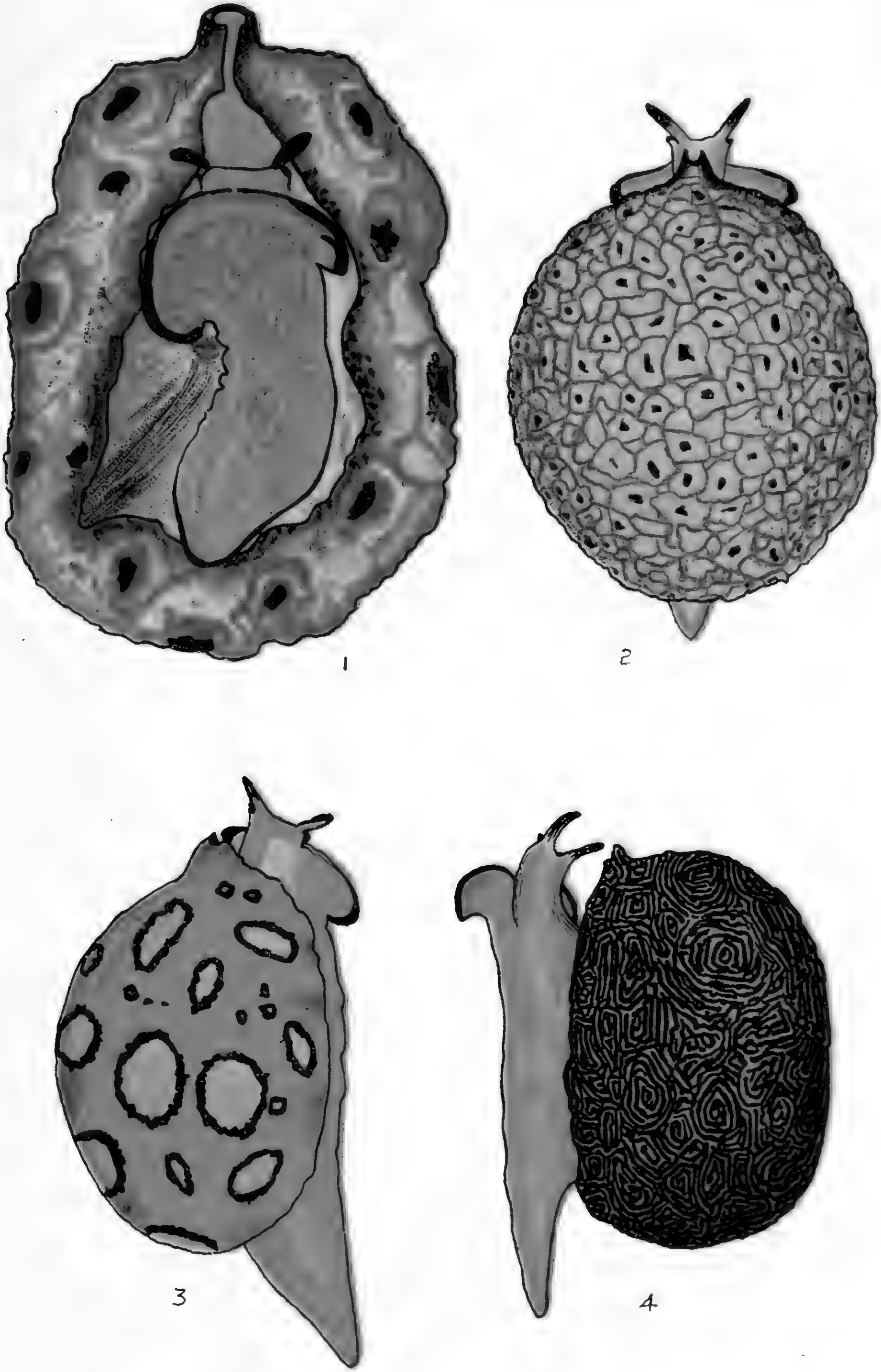

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HUSSEY & GILLINGHAM. LITH

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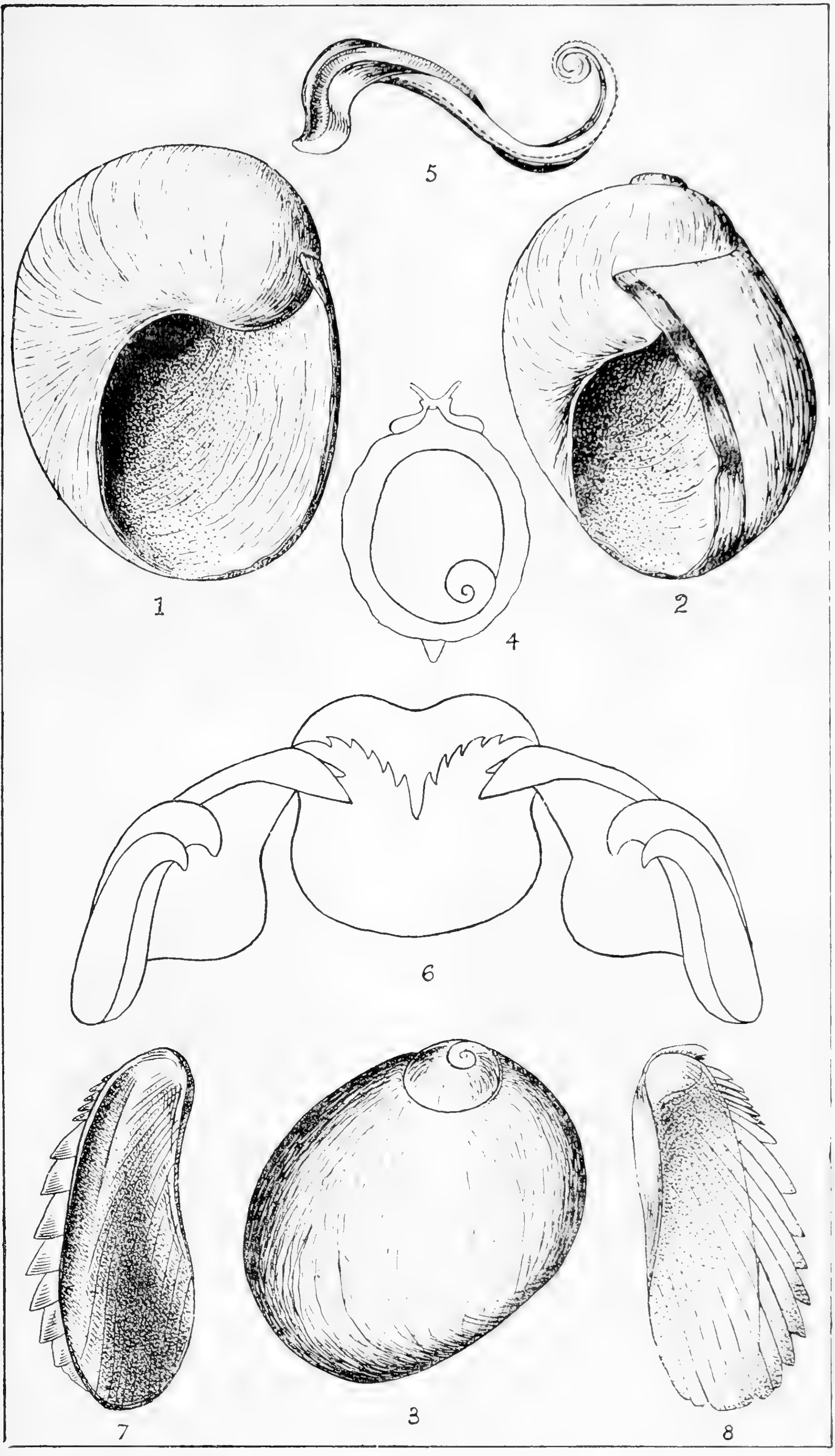

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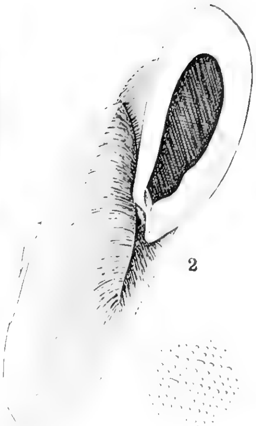
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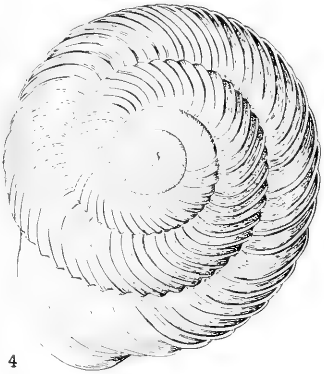
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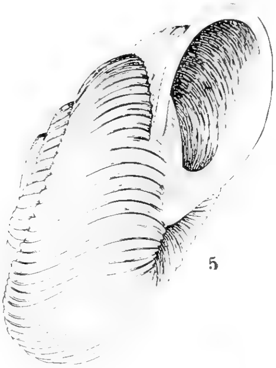
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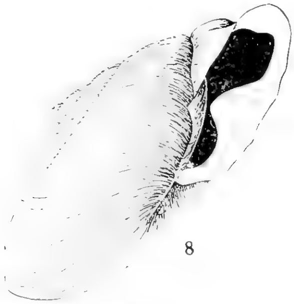
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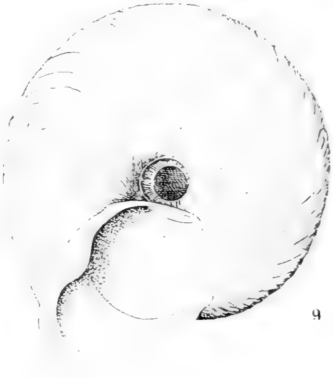
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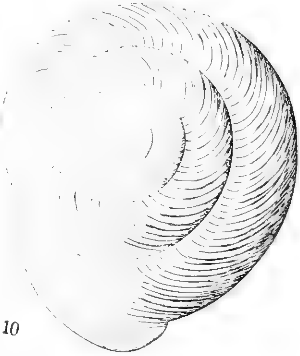
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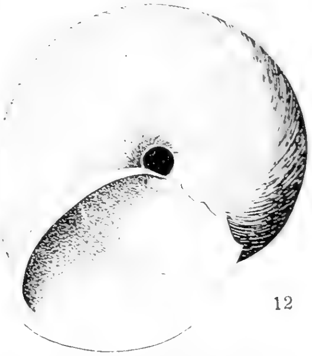
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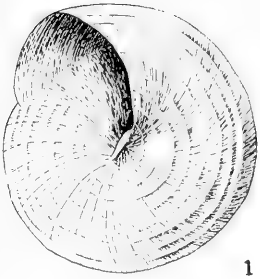
C. Hedley del.

Hussey & Gillingham, Printers, Adelaide.



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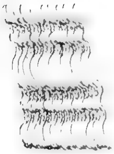

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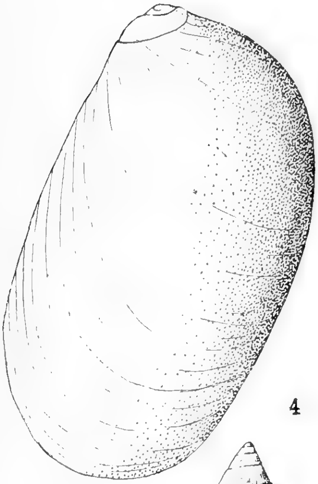

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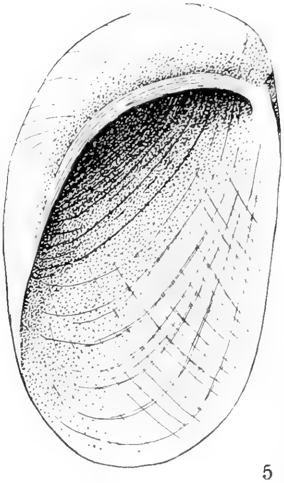

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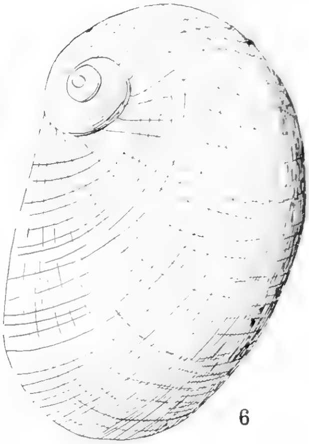

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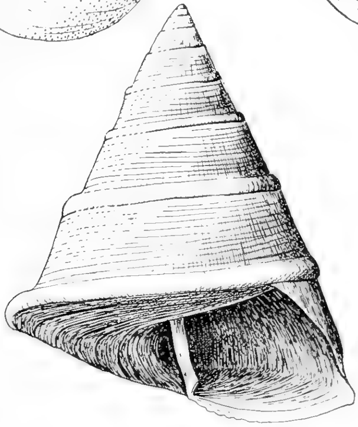

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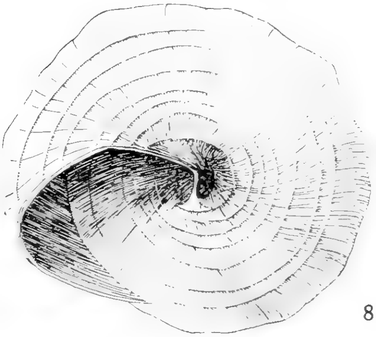

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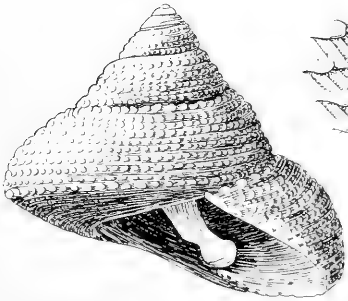

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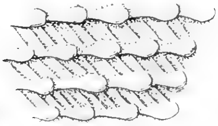

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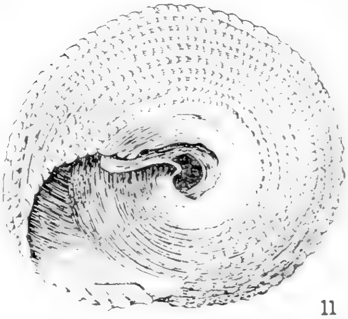

11

H. L. Kesteven, del

Hussey & Gillingham, Printers, Adelaide.

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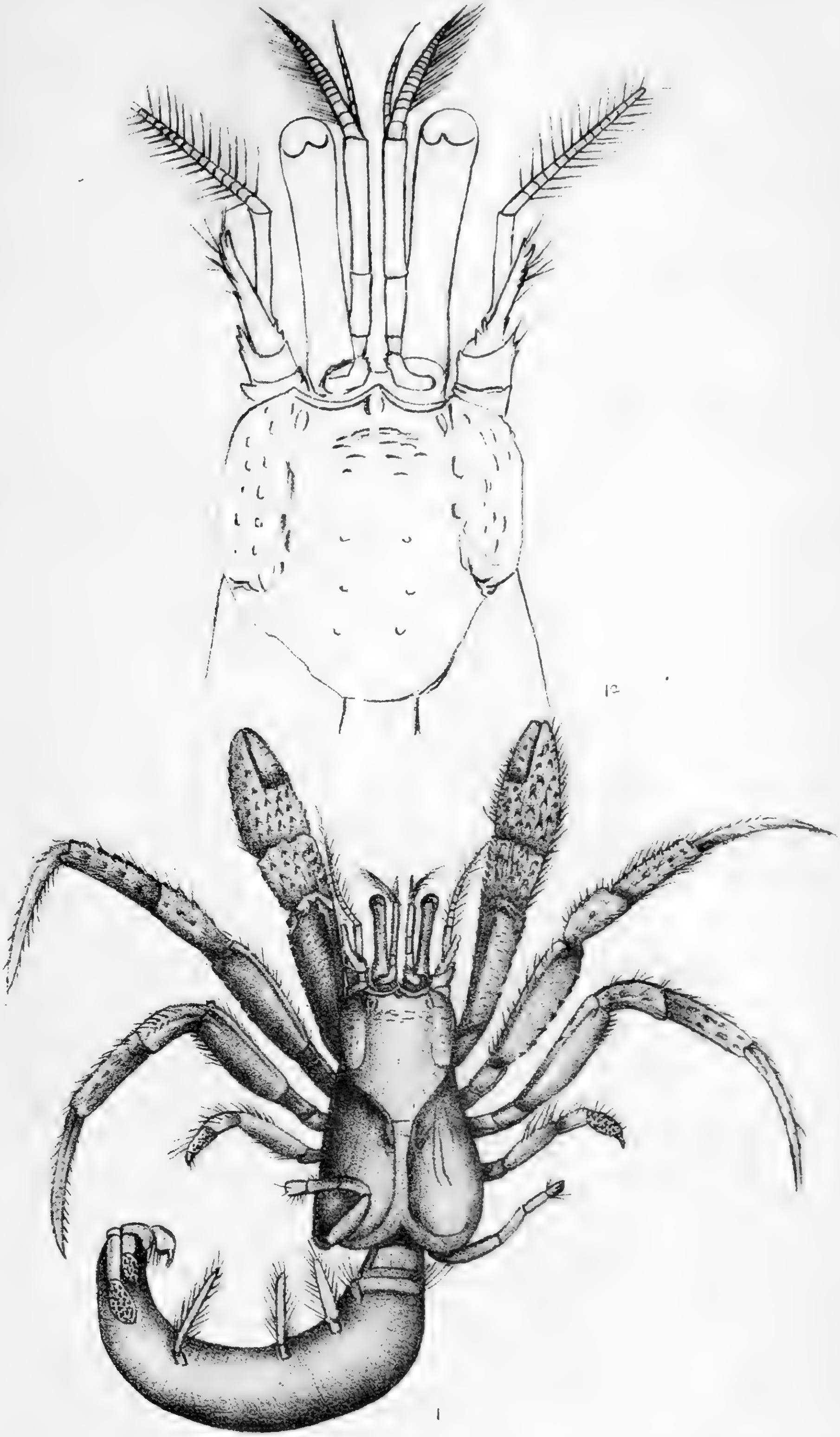
HUSSEY & GILLINGHAM LITH.

PAGURISTES FRONTALIS.



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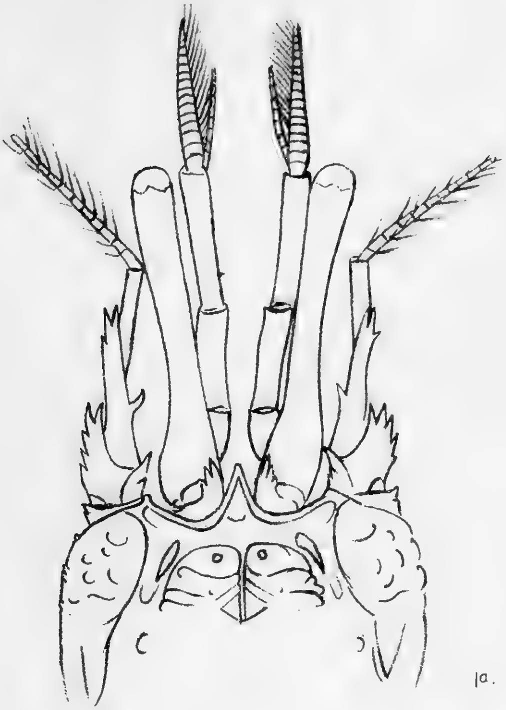

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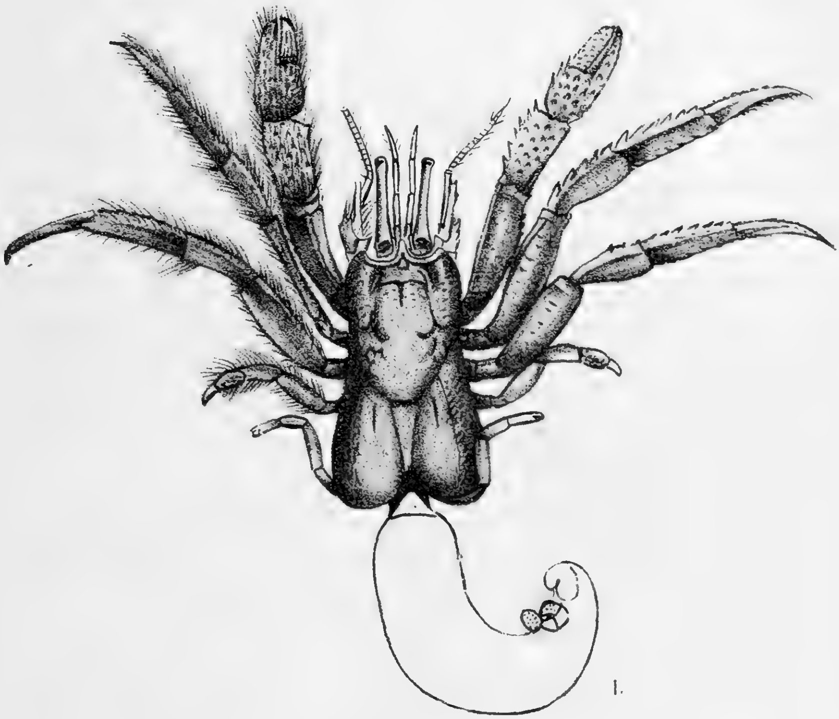

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HUSSEY & GILLINGHAM LITH.

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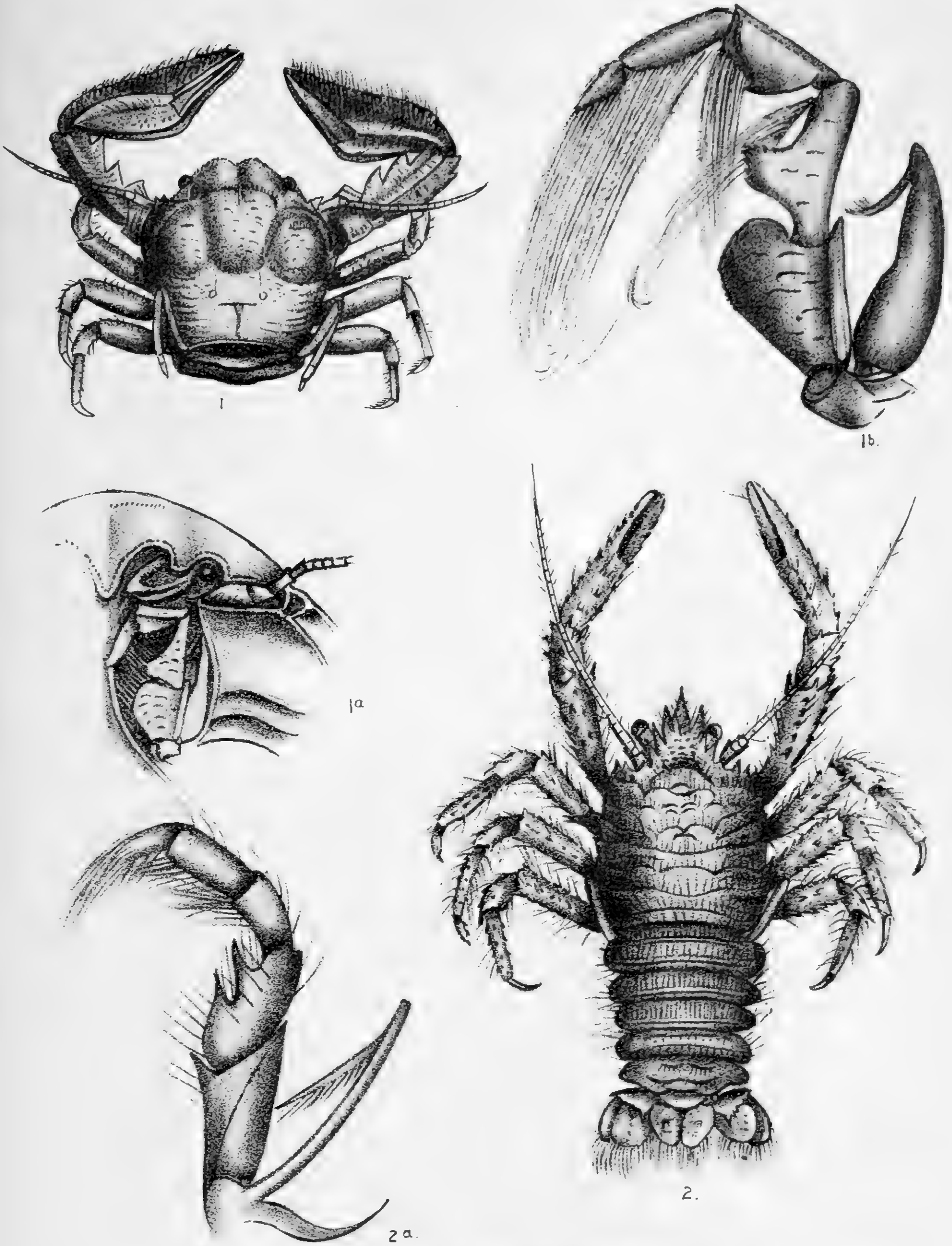
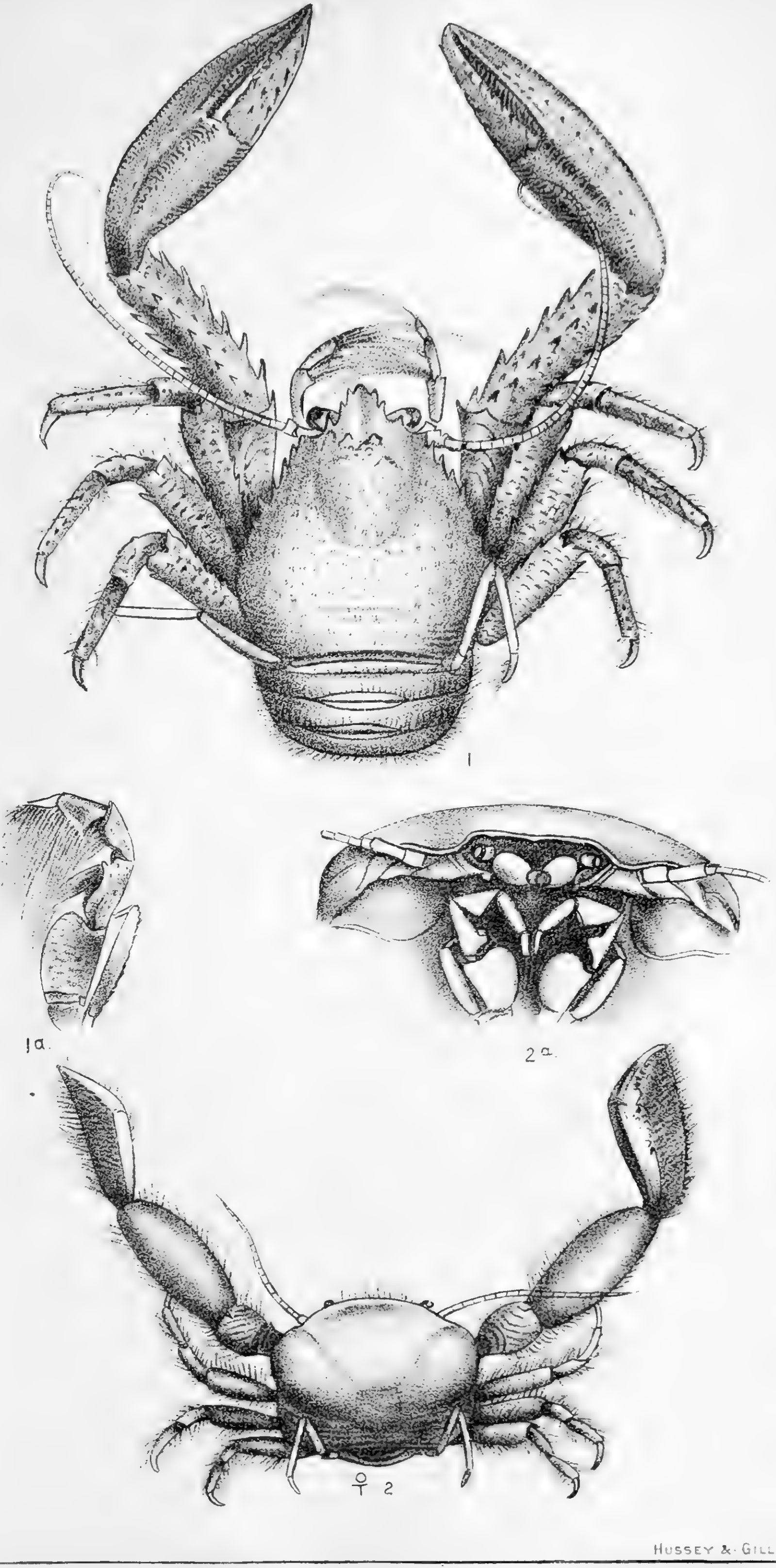


W H B DEL
HUSSEY & GILLINGHAM. LITH.

PORCELLANA ROSTRATA. GALATHEA SETOSA.



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1a.

2a.

♀ 2

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HUSSEY & GILLINGHAM. LITH

PETROCHELES AUSTRALIENSIS. POLYONYX TRANSVERSUS.

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Appendices.