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TRANSACTIONS.

Art. I.—*The Oceanic Languages Semitic:*

By Rev. D. Macdonald, Fate, Havannah Harbour, New Hebrides.

[Read 10th March, 1887.]

III. THE PRONOMINALS.

Under this head are included the Demonstrative Pronouns, meaning this (here), that (there); and the same Demonstratives used as Articles or Emphatics; as Relatives; as Interrogatives; as Indefinites; and as Reflexives.

§ 1. The Demonstratives.

a. The Fatese demonstrative elements may be thus given:—

1. *ma (fa, ua, uo).*
2. *i, e, a, u, o.*
3. *sa, se.*
4. *li, lu (ri, ru, ra).*
5. *ni, in, na.*
6. *ke (ga).*
7. *te, tu.*

The forms in brackets are phonetic variations. Of these seven demonstratives, 1, 2, 3, 5 and 6 are sometimes used alone with a noun, meaning simply "this," as *fatu* stone, *fatu ua, fatu i, fatu se, fatu in, fatu ke,* this stone. The other two, 4 and 7, are used thus only in compounds, but their use in this way, and in other ways, clearly shows that they are demonstrative elements exactly like the other five. The compound demonstrative expressions are very common in Fatese (as indeed in other languages). Thus 1, 3 give us *uase;* 1, 2, *uai;* 5, 2, *nai;* 1, 5, *uane;* 5, 6, *naga;* 5, 7, *netu;* 5, 3, *nis;* 4, 6, *arog.* Then we have sometimes three elements heaped together, or even four, as, 1, 5, 6, *uanaga;* 4, 1, 2, *riuai;* 5, 3, 7, *nistu;* 6, 3, 7, *kistu;* 1, 5, 7, *uantu;* 6, 5, 7, *kintu;* 4, 1, 5, 6, *ru* or *riuanaga;* 2, 4, 1, 2, *eriuai.* Sometimes the same element is doubled, as *nin.* The general effect of this heaping together of demonstratives is emphasis: compare the vulgar English emphatic "*this 'ere*" for this.

These seven demonstratives are, as has been shown in II. (on the Numerals), universal in Oceanic; this of course does not mean that they are all equally in use in every dialect. In the above the principal phonetic changes are in 1, *m* to *f* *(v), u (w),* though those in 4, *l* to *r*, and in 5, *k* to *g*, are also to be noted.

b. The Malagasy demonstratives are thus given in Griffith's Grammar, and are compounded, as will be seen, of the above seven elements:—

Sing. *ity, itoy, itony, io, izato, izatony,* this.
Pl. *ireto, iretoy, iretony, ireo, izatoana,* these.
Sing. *iroa, iny, irikitra, irokatra,* that.
Pl. *iretoana, ireny, ireroana,* those.
Sing. or Pl. *izao, izany, ilehy, iny,* this, that, these, those.

The element 1 (*m*) appears to be wanting in these, though it may be among them disguised as *o* (*u*); it undoubtedly is in the Malagasy, as will be seen below. In the foregoing, *r* is for *l*, *tr* for *t*, *h* for *k*.

c. The Malay demonstratives may easily be seen to be composed of the same elements. Thus *ini, itu, nun,* and Javanese *ika punika (p* for *m)* same as Fa. *uanaga.* That *s, k,* and *m* (as *p*), and *r* for *l*, sometimes as *d*, are original demonstrative elements in Malay, as well as *i, n,* and *t*, will abundantly appear as we proceed.

d. The Samoan demonstratives are composed of the same elements:—

Sing. *o lenei, sinei, sia,* this.
Pl. *ia, nei,* these
Sing. *o lea, o lena, o lela, sena, sisi, siasi, sinasi,* that.
Pl. *na,* those.

In these (*o* is sometimes if not always for *ko*) 1 and 7 are wanting; but they are found in other Maori-Hawaiian dialects, as for instance, 7, Tahiti *teie, tera, tena,* this, that; and 1 as a prefixed demonstrative or article in Tahiti *vau,* Maori *wau* (for *maku*), I, and Tahiti *vera* (cf. Fa. *nara,* I. § 24), they. This *vera* is for *mera.*

§ 2. Comparison.

a. The Semitic demonstrative elements, exactly corresponding to the above as they do, may be thus given :—

1. *ma.* 2. *u, i, a.* 3. *s, z.* 4. *al, la.* 5. *an, na.* 6. *ka.* 7. *t, d.*	For these see Dillman, Eth. Gr., §§ 62-65. Note.—3 and 7 were originally the same.

For 1, *ma*, this, see Sayce, Assy. Gram., p. 60. This *ma* appears as the interrogative, &c., in all the Semitic, and in all our four Oceanic dialects.

b. These seven demonstrative elements are also heaped together in the Semitic dialects for emphasis, exactly as in the Oceanic, thus :—

Semitic.	Oceanic.
Heb. *hua*, hia, see I., § 23.	Sam. *ia*, Malay *iya* (for *ia*), Tongan *aia*.
Eth. $u^{e}tu$, Tig. *ete*	Mg. *ity*, My. *itu*
Chald. *den*, *dena*.	Tah *tena*, Mg. *itony*
Chald. *dek*, Arb. *daka*	Santa Cruz *deka*, Santo *ituga*
Chald. *diken*	Vanua Lava *tigen*
Chald. *hanak*	Santo *neka*, *naka*
Chald. *hen*, Assy. *annu*	Mg. *iny*, My. *ini*, Fa. *in*, *na*, *ne*
Talmud *inhu*	Fa. *inea*, My. *inia*
Tig. *nesu*	Fa. *nis*
Tig. *nate*	Fa. *netu*
Syr. *horko* (here)	Fa. *erik* (this)
Assy. *ullu*	Mg. *aroa*, Fa. *arai*
Eth. *eleku*, Amh. *elehe*, pl.	Mg. *ilehy*, sing. and pl.
Eth. *elu*, pl.	Mg. *ireo*, pl.
Heb. *eleh*, pl.	Tanna *iraha*, *ilia*, *ila*, pl.
Eth. *elekuetu*, *eleketu*, pl.	Mg. *iroakatra*, *irikitra*, sing.
Eth. *elontu*, pl.	Mg. *ireto*, pl.
Chald. *ilen*, pl.	Mg. *ireny*, pl.
Eth. *ze*, Heb. *zeh*	Fa. *se*
Assy. *su'atu*	Mg. *izato*
Assy. *naga*, *'aga*	Lakon *iheog*, Java *ika*
Assy. *'agannu*, *'aganna*	Norbarbar *gene*, Fa. *kin*
Assy. *'agassu*	Fa. *kis*

Assy. *ammu* (*ma*)	Eromanga *imo, yamu*
Assy. *sa'asu, sasu*	Sam. *siasi, sisi*
Tig. *eziu*, sing., pl.	Mg. *izao*, sing., pl.
Mod. Syr. *ani*, pl., sing.	Sam. *na*, pl., sing.

Note in the foregoing, on both sides, the change of *k* to *h*, and of *l* to *r*; and as to the latter, compare further Ges. Heb. Dict. s.v. *aru*. Note also that the whole seven elements, and they only, occur on both sides of the comparison in these compounds.

§ 3. Articles or Emphatics.

a. The articles or emphatics by which is meant simply demonstratives, pre-fixed or post-fixed to nouns, have, as the above seven demonstrative elements applied in this particular way, already all come under notice in I. and II., on the Personal Pronouns and Numerals, especially in the latter: see II., § 2. It was there remarked that these are found used with other nouns, as well as with the numerals. Thus (5) Fa. *nakasu, nakau*, Mg. *ny hazo*, tree; (4) Sam. *le lagi*, (2) Fa. *elagi*, (5) Mg. *ny lanitra*, heaven; (1) Sam. *masina*, Sulu *fasina*, the moon; (5) Fa. *nilagi*, (1) Sam. *matagi*, the wind; (1) Fa. *makau*, a cluster; (7) Ma. *tekau*, ten; (6) Api or Epi, *kabario*, (3) *simberio* and *vario*, Sanguir *vuran*, the moon; (4) My. *rumah*, (5) An. *neom*, (1) Ahtiago *feiom*, (3) Fa. *suma*, house; (6) My. *kanak*, and *anak*, (3) Mg. *zanak*, child; (1) My. *bintang*, Celebes *bituy*, Sam. *fetu*, Fa. *masei*, An. *moijeuv* (final *v* emphatic), (4) Ja. *lintang*, (6) Mg. *kintana*, Ceram *toi*, Matabello *toin*, star. In the above examples the word for "star," as will appear, begins with *t* (*nt*), so that we have as articles prefixed to it *m* (*b, f*, &c.), *l* and *k*. In many cases these articles have been regarded by Europeans and even by natives, as parts of the original word, so that, for instance, the Fatese often say *nasuma* for *suma*, house, as if *s* were a part of *uma*, the original word. So the Samoans say *o le laau*, as if the *la* of *laau* were radical, as Bopp also thought it was, in trying to trace it to the Sanscrit *brakasa*; Prakrit *rukka*, (see his work "Uber die Verwandtschaft der Malayisch-Polynesischen Sprachen, mit den Indisch-Europaischen," p. 4); whereas it is the article prefixed to the original word *au* for *kau*, wood, tree. This may be called the unconscious article, and its being so *unconscious*, points to far distant ages in the past, when it was the consciously used article. Note in the above some of the same suffixed as emphatics, as in the Numerals, to which we now add, completing the list thus :—

1. Yap. *tuv*, An. *moijeuv*, star.
2. Epi *vario*, moon ; Mota *matai*, eye.
3. My. *alas* (Mg. *ala*), forest.
4. My. *layar* (Tag. *layug*), sail.
5. Mg., My. *volana*, *bulan*, moon.
6. Rotti *bulak*, moon.
7. Sumatra *bulet*, moon.

b. The same may now be shown with the Personal Pronouns thus :—

PREFIXED.

1. Tah. *ovau*, Ma. *wau*, I, Tah. *vera*, they.
2. Tanna *iau*, Fiji *koi au* (*ko i au*), I.
3. Mg. *izaho*, I, Tag. *siya*, he.
4. Sumatra *rehu*, New Guinea *lau*, I (IV., § 4, L.).
5. Torres Islands *inau*, Santo *nau*, I.
6. Sam. *'ou* (for *koku*), Fa. *kinau*, I.
7. New Guinea *tau*, Negrito *tiyac*, I.

POSTFIXED.

1. Fa. *komam*, Mota *kamam*, we.
2. Pentecost *kamai*, Paama *komai*, My. *kami*, we.
3. Fa. *akamus* (also *akam*, *kumu*), ye.
4. Mallicolo *amru*, ye (but *ru* compares with "*reo*" in Mg. *anareo*, probably).
5. Fiji *kemuni*, ye.
6. Torres Islands *noke* (for *nauke*), I.
7. Duke of York *muat*, ye.

c. The Fatese articles are *n*, with vowel before or after, as *in*, *ni*, or *na*, the common article, and *e* which is more rare, and the indefinite articles, *te* (=any, whatever), and *sikei*, "one," "an." Used only with names of persons, we have masculine, or with names of males, *ma*, and feminine, or with names of females, *lai* (*le*, *li*).

The Malagasy articles are *i*, *ra*, and *ny* (pronounced as Fa. *ni*), of which *i* and *ra* are used only with proper names, and *ny* is the common article, and identical with Fa. *ni*, *in*, *na*. The indefinite is *iray*, "one, "an."

The Malay has no article like Fa. *ni*, Mg. *ny*. But *ini* and *itu*, this, as Crawford remarks (Cr. p. 28), are used sometimes as "equivalent to our definite article, the." The indefinite is *sa*, "one," "an."

The Samoan common article is *le*, *o* is often used with it, as *o le Atua*, God; or alone, as *o Tangaloa*, Tangaloa. The indefinite article is *se*.

d. The commonest Oceanic article is *n* (*ni*, *ny*, &c.), and it is identical with Fa. *in*, *na*, Mg. *iny*, My. *ini*, this. It prevails in Madagascar and Papuanesia. Several articles are more or less common to Papuan and Maori-Hawaiian, as Sam. *'o*, Fi. *ko*; Tah. *e*, Fa. *e*, or *a*. *Te* is common in Maori-Hawaiian, Santa Cruz *te*, Fa. (indefinite) *te*. The other articles are of comparatively limited use, except Sam. *le*. The Malay, which has no general article like the other three branches of Oceanic, makes up for it by a peculiarly large use of suffixed emphatics, somewhat like the Syriac. The unconscious article in the Malay, as *l* (*d*), in *duwa*, *lima*, 2, 5, is found also in the other branches.

§ 4. Articles and Emphatics, Comparison.

a. For the same demonstrative elements, so many as used, attached to the Semitic numerals (conscious and unconscious articles), see II. As to the Semitic personal pronouns, see I., *an* (5) is the demonstrative most commonly used, prefixed as an article. Thus it is, especially in the pronouns of the first and second persons, found generally in all the Semitic dialects: Heb. *anoki*, I. Arb. *anta*, thou, Heb. *anachnu*, Arb. *nachnu*, we, Arb. *antum*, ye. Now this same element (5) is the one most commonly used thus, with the pronouns in Oceanic, especially in Papuan and Malagasy, also, see I. Thus second person, Mg. *hianao* (*ki ankao*), My. *angkau* (*ankau*), Fa. *nago* (*nako*), Mota *iniko*. With respect to this *an* (5), prefixed to the personal pronoun as an article, it is undoubtedly one of the most ancient features of the Semitic languages, and as, in Oceanic, the Papuan has it as fully as the Heb. or Arb., and more fully than the My. or Ma.-Ha., or even perhaps the Mg. We see that in this point it preserves a more archaic aspect than these other two branches. But the Mg. and Pa. equally have this article as the common article for all nouns. In Assyrian, we have *s* (3) in *see, he, si,* she ; in Harar *k* (6) in *skhakh,* and the same in Assy. *cata,* thou, Mod. Syr. *achton,* ye. Tigre *niska,* thou, *nisu,* he, *nis* (5, 3) compound article, or *nis,* this, *ka,* thou, and *u,* he. We find also in Semitic the same suffixed as emphatics, Tigre *nisus,* he, *anas,* I, *nisatekumos,* ye. In this last example *n, s, t* (5, 3, 7) are heaped together and prefixed, while *s* (3) is also suffixed. See Fa. *akamus,* ye, in § 3. In Chald. *himon,* they, we have *n* (5) final.

b. Generally, as to nouns, the well-known Semitic articles, Heb. *ha,* Phen. *a,* Fa., Tah. *e, a,* § 3, is prefixed, but in Syriac it is suffixed as an emphatic. So Arb. *al* or *le* (as often pronounced), Sam. *le* (South Arb. *m* or *am*), is prefixed. The Ethiopic has no article (prefixed), but appears to have traces of the same post-position article (in the Amharic *u*), as the Syriac. According to Halevy, the Sabaean (Himyaritic) has as suffixed articles or emphatics, *hu,* etymologically identical with Syriac *a, m,* and *n,* or *heu* (*hu* and *n*). This *m* ("mimation") he describes as "a true indefinite article" (the other two being definite), and he compares it with the Arb. nunation: see his "Etudes Sabeennes," VI. Thus Sabaean suffixes to nouns (1), (2), and (5), or (2, 5).

c. But, in addition, generally all the demonstrative particles are found occasionally used in the Semitic like articles: just as in Oceanic: see Malay above. As the Latin *ille* became the article in the Romance dialects, so manifestly both the Semitic and Oceanic articles have been analogously derived, that is, the article was originally a demonstrative, meaning "this," or "he," "she," "it," Thus in Tigre, Jno. ix., 34, we have with *sab,* man, the demonstrative *ete* (Eth. *u'tu,* he, this, the), as an article, *etesab* = the man. So, in verse 24, we have *eze,* this in *ezesab* = the man: compare, in verse 39, *ze* (Eth, *ze,* Heb. *zeh,* this), in *zeolam* = the world. In Syriac, in like manner we have *huo,* this, used as an article, for instance, in Acts viii. 35, *huo ketobo* = the Scripture. In Mod. Syr. "in general, the pronouns *o, e,* and *ani,* are used for the definite article:" Stoddart, Gr., p. 145. This *o* is in the Heb. *hua,* and *e, hia.* In the Semitic and Oceanic, demonstratives are found used both before and after the noun (though most commonly after), hence we find also articles or emphatics both prefixed and post-positive.

d. The Fa. article *e* (or sometimes *a*), as in *e kobu,* or *ekobu,* the house, is, as Gabelentz ("Sesake-Sprach") saw, a shortened form of the personal pronoun, third singular, and so, of course, in Tah. *e* (*a*). Maori *a*, Samoan *i* (with pronouns), San Christoval *a, e, i*, Mg. *i*, and My, *a*, in *aku*, I (and *apa*, what ?) So Heb. *ha*, Phen. *a*, Syr. *a*, Sabaean *hu*, Eth. and Amharic *u* (Halevy VI.), Mod. Syr. *o, e*, are all shortened forms (Halevy) of the pronoun of the third person singular, which in Heb. is *hua, hia*. In Syr., Sab., Eth., and Amh., it is suffixed, in Heb. and Phen., prefixed. Eth. like Malay, uses no prefixed article, but uses for the article sometimes *u*^{e}*tu*, which is identical with Malay *itu*, also in like manner used for the article: see for Eth., Dillm., Gr., § 172 *a*, and note; and for Malay, above, § 33 *b*. The common Semitic pronominal article *an, in*, is the common Pa. and Mg. article, not only with pronouns, but nouns, as *an, ni, ny, in, na*. What in Arb. is *al* (*le*), the article is also in Samoan the article *le*. Thus to exhibit the foregoing tabularly:—

Articles Prefixed.

(7) Tah. *te* (Rarat. *te*)	Syr. *dĕ* (below § 5, *b*.)
(2) Fa. *e, a*, Sam. *o*	Heb. *ha*
San Christoval *e, i, a*	Phen. *a*
Tah. *e*, Ma. *o*	Mod. Syr. *o, e*
My. *a*, Mg. *i*	
(4) Sam. *le*	Arb. *al* (*le*)
(5) Fa. *in, ni, na*, Mg. *ny, an* Tag. *ang* (*an*), Article and Relative of Java *ing* in *ingkang*, Relative and Article.	Heb., &c. *an, in*

It must be remembered that, though these articles on both sides are undoubtedly identical *etymologically*, that does not imply that they are *used* identically in all points, and in fact they are not. The Mg. *an* is found, like the Heb. *an*, used with the pronouns in *hianao (anao)* thou, thee, *hianario (anario)* ye, and in *anay*, us. *Anareo* is for *ankareo*, and this has exactly the same elements as Amharic *alānta*, ye (*ta* being same as *ka*, by interchange of *t* nd *k*), for *ala* = *reo (areo)* = these: see I. The placing of he plural demonstrative before (Amh.) or after (Mg.) he personal pronoun is a mere matter of syntactical transposition.

Articles or Emphatics Suffixed.

Oc. § 3, II. § 2.	Se, abon, a, b.
(1) *v, m*	Sabaean *m*
(2) *o, i*	Sabaean *hu*, Amh. *u*, Syr. *a*
(3) *s*	Tigre *s*
(5) *na, n, ni*	Sabaean *n*

The remark as to etymological identity, and possible or actual difference of use, under the preceding table, applies here also. It will be observed that not all the seven demonstrative elements are on the Semitic side; this, however, may be set down to our ignorance of ancient (and even modern) vulgar Semitic dialects. In Se., as in Oc., the numeral "one" is also used for the indefinite article "an," "a." We formerly showed (in II.) that the numeral "one" itself is of pronominal origin.

§ 5. Relatives.

a. In what follows, the bracketed figures refer to the demonstrative elements as numbered in § 1 *a*, or § 2 *a*.

Mg.	My.	Fa. (Pa.)	Sam. (Ma.-Ha.)
izao	*yang*	*te*	*o le*
lihy	*nen*	*uane*	Tah. *te, tei*
	Ja. *sang, kang*	*nago*	Rarat. *te*
	Tag. *ang (an), na*		
	Ja. *ingkang (inkan)*		

There is a close connection between the article and the relative; *yang* is often = the; *tei* is *te*, the, and *i* (2); *o lē* is *o le*, the, and *e* (2). For *izao*, and *lehy*, see § 2, *b*. Fa. *uane* (1, 5) is like the English "that," demonstrative and relative, as also is My. *nen* (5, 5), and Fa., S. dialect, *naga* (5, 6).

b. Comparison.

sang (3, 5), *izao* (2, 3, 2)	Eth. *za* (3, 2), Assy. *sa*, Heb. *asher, she* (2, 3, 4)
kang (6, 5)	Heb. *ki* (6, 2)
yang, (*a*, see below, *c*.)	Amh. *ya*, (of Eth. *ia*, Dillm. § 144 *a*.)
tē (7, 2), *te*	Chald. *di* (7, 2), Syr. *dĕ, d*
o lē	Mod. Arb. *ellī, el*, (Eth. *ela*, pl.)
nago, nen, ang, na	Eth. *enta* (5, 7)
uane (1, 5)	Arb. *man* (1, 5), *ma*, Sab. *ban, ba*

The Arb. *man* and *ma* differ from *uane* in being used "substantively," Wright, Arb. Gr. § 248. In Fa. *tea* is used for both genders and numbers also substantively, and stands for he who, they who, that which, what. The Fa. *uane* preserves the original demonstrative force much more than the Arb. *man*, which can hardly be said to preserve it at all. The Amh. "prefixed relative pronoun" *yame* is, like Fa. *tea*, used substantively for all genders and numbers.

In Javanese (Crawford, Dissertation, p. 20) "the definite article is represented by the relative pronoun" *kang*, or *sang*. The ceremonial is *ingkang*, perhaps for *inkan*, if Fa. *naga* (for *naka*), thus *inka-n*, *naka*. Now in Mod. Syr. (Stoddart, p. 133) the ordinals are formed by prefixing the relative pronoun *d*, as an article, to the cardinals; *d* was also used thus in Anc. Syr., Uhlemann's Cr. § 78, B 2, *c*. So in Fa., My., and Javanese *ka*, or *ke* (Fa.), identical with the relative pronoun Ja. *kang*, Heb. *ki*, is used exactly like the Syr. *d*, as an article, prefixed to the cardinals, forming ordinals, thus:—Fa. *ketolu* or *katolu*, My. *katiga*, Ja. *katalu*, Mod. Syr. *detela*, Tahiti *te toru*, "third." It occurs also in Mg. as *ha*, in, *e.g.*, *hateloana*, three days; where, however, it does not form the ordinal. Now, for the Javanese *katalu*, we find in Javanese also *pengtalu*, "third," that is *peng* appears to be a relative pronoun article like *ka*. A comparison especially of the prefixed relative articles used in forming the verbal nouns in Ja., Mg., My., Tag., and Fa., shows clearly that it is, and that this *p* (of *peng*) is identical with (1), and the well-known Semitic prefixed relative article *m* (1) used in forming verbal nouns. *Peng* is the same as *pun* in Ja. *punika*, Fa. *uanaga*, see § 1, *c*. The prefixed relative articles used in forming the verbal nouns are *ka* (in Mg. as *ha*) in My., Ja., Tag., and Mg., and in Ma. as *kai*; and *p* (in Mg. as *mp* and *f*) in My., Ja., Tag., and Mg., Fa., Tag., and Mg. also use *n*, as Fa. *na*, *in*, Tagala *ang* (*an*), and Mg. *ny*. Fiji uses *a*, *ai*, (and *na*, *nai*), which compares with Amh. *ya* (*ia*). Fa. uses *te* and *tea* in like manner. The Mg. My., Ja., and Tagala *p* (*mp f*), prefixed relative article, used in forming nouns from verbs, is, as will be shown, etymologically identical with the common Semitic *m* similarly used.

c. The relative (or relative article) is used in Oc. Se. prefixed to the pronoun, usually the suffix pronoun, to form the separate Possessive, both with and without an intervening Preposition. We treat here of the relative thus used without the Preposition, leaving the other till the Prepositions come to be considered :—

(2) *a*. Fa., Mg., Ma. (and Sam.) prefix *a*, Amh. *ya*, as Fa. *agu*, Mg. *ahy*, Ma. *aku*, Amharic *yane*, my, &c.

(5) *n*. Fa., Mg., and Tah. prefix *na*, *an*, &c., Eth. *enti*., Tig. *nat*, and perhaps *na*, as Fa. *anau*, Mg. *nyahy*, Tah. *nau*, Eth. *entiaya*, Tig. *nati*, my, &c.

(4) *l*. Eromanga *ari*, Sam. *la*, Ethiopic *eli*, as Ero. *ariyau*, Sam. *la'u*, Eth. *eliya*, my ; Ero. *arika*, Sam. *lau*, Eth. *eliaka*, thy, &c.

(3) *s*. Tanna *sa*, Sam. *sa*, Ethiopic *zi*, as Ta. *seiau*, Sam. *sa'u*, Eth. *ziaya*, my, &c.

(7) *t*. Eromanga *ete*, Tah. *ta*, Mod. Syr. *d*, as Ero. *etiyo*, Tah. *ta'u*, Mod. Syr. *diyi*, my ; Ero. *eteko*, Tah. *ta oe*, Mod. Syr. *diuk*, thy, &c.

§ 6. Interrogatives.

a. What ?

Mg.	My.	Fa. (Pa.)	Sam. (Ma.-Ha.)
inona	*apa*	*insifa*	*ole ā*
ino	*mana*	*insa*	*se ā*
inona	*pa*	*insifana*	Ma. *aha, ha*
ino	(in *pabila*)	*insana*	
	apa	*sefe*	Tah. *eaha*
	mana	*nafite*	Ha. *he aha*
		nefe	
		uase	Rarat. *eaa*
		nefeha	
		Mota *sava, sa*	
		Epi *aba* or *apa*	
		Tanna *nufe, tufe*	
		An. *inhe*	

Stripping off the well-known articles and emphatics, we find that there is in all these but one interrogative element : thus Malay *apa* is the same as Ma.-Ha. *aha*, *aa*, *ā*, and Fa. *nefe*, Tanna *nufe*, An. *inhe*, is the same as Mg. *ino*, and Fa. *nife* is the same as My. *apà*, as is more clearly seen by stripping off the articles *ne* and *a*, which leaves *fe* = *pa* = what ? In like manner, Rarat. *aa* is the same as Mg. *ino*, An. *inhe*, of which the articles *a* and *in* being stripped off, this is more evident in *a* = *o* = *he* = what ? Mota *sa*, article *s* and *a* = what ? is by contraction for *sava*, as Fa. *insa*, article *ins* and *a* = what ? is for *insefa*. Fa. *nefe* =

sefe = what? the only difference being in the articles *ne* and *se*. Finally, to this interrogative element (*o, pa, ma, fa, va, fe, ha, he, a,*) whether with or without a prefixed article, we find sometimes a demonstrative emphatic, meaning "this," suffixed, as in Mg. *in ona*, My. *mana*, Fa. *inse fana*, or *ins āna*, and *na fete*, An. *ne vitai*, My. *a patah*, Fa. *ne feha* (on *ne fesa*), *uase*. The interrogative element in the above is originally (1), that is *ma*, and the phonetic changes of this *m* here exhibited, are already familiar to us. For the prefixed and suffixed demonstratives (articles or emphatics), see above.

b. Comparison.

(in) o, (o le) a, (s) a	Heb. *mah*
(ins) a, (se) a, (a) a, (in) he	Arb. *ma*
(a) ha, (a) pa, (se) fe	Eth. *mi*, Syr. *mo*
(sa) va, (ne) fe, (tu) fe	Sab. *ma* and *ba*, or *va (m*
(inse) fa	to *b* or *v)*
(in) ona, mana	Syr. *mun, mon, mono*
(inse) fana, (ins) āna	Amh. *mene*
(na) fete, (ne) vitai	Mod. Arb. *made*
(a) patah	Mod. Syr. *mude*

c. Who?

Mg.	My.	Fa. (Pa.)	Sam. (Ma.-Ha.)
iza	*siapa*	*sëi, sē*	*o ai*
zovy	*sapa*	*fëi, fē*	
	mana	Ero. *me* (d *wi*)	Ma. *a wai*
		Tan, *ba*	Tah. *o vai*
		An. *thi*, Fi. *o cei*	
		Santo *ise*	
		Mallic, *kihe*	

Of these Fa. *fëi*, Eromangan *me* (dialect *wi*), Tanna *ba*, Tahiti *vai*, Maori *wai*, Sam. *ai*, are identical, and consist of two parts, *ma* (1), as in *a* and *b* above, and *i*, the personal pronoun, third singular: see I., §§ 13, 23. Mg. *zovy*, My. *siapa, sapa*, Fa. *sëi*, Fiji *cëi* (*i.e.*, *thëi*), Aneityum *thi*, are also identical, being exactly the same as those in the preceding sentence, with article *s* prefixed: thus Fa. *sei* (north dialect) is Fa. *fei* (south dialect), with (3) article *s* prefixed, *sefei* (Mg. *zovy*) being contracted to *sëi*, or *sē*, as Mg. *zovy* is to *za* in *iza*; and as Mota *sava* is to *sa*, and Fa. *sefa* or *safa* to *sa*, and *safana* to *sāna*, see *a* above.

d. Comparison—Who?

Mg.	My.	Fa. (Pa.)	Sam. (Ma.-Ha.)
me, ba, fëi, vai, wai, ai	for *mai* = what, he, or she?	Heb. *mi*	(for *mai* = what, he, or she?)
sëi, ise, iza, sapa, zovy	with (3) article *s* prefixed		cf. Heb. *zeh mi* = this, who?
mana			Mod. Arb. *man*, Ch. *man* Sab. *man, ban*, or *van*

Who? plural: see I. §§ 6, 7, 24.

Ero. *me-e-me*	
Ma. *wai ma*	cf Heb. *mi hemah* = who, they?
Fa. *se mei, se mani*	
Fa. *nara fëi, nara sëi*	Amh. *alaman* = these, who?
Santo *ro se*	

§ 7. Indefinites.

a. In the Oceanic-Semitic, the interrogatives (1) in §6, single or re-duplicated, and with or without prefixed or suffixed emphatics, are used as indefinites, or relative indefinites, signifying "what," "that, which," "whatever," "some," "of what kind soever," "something," "somewhere," &c.; and "whoever," &c., thus:—

Ma. *aha*, My. *apa*, Fa. *sefa*	Heb. *mah*, Arb. *ma*
Fa. *matuna, fatuna*	Ch. *mah, mahdi*
	Syr. *medem*
My. *apaapa*	Heb. *meumah*
Mg. *na inona na inona*	
My. *mana*	Syr. *mono*, Amh. *mene*

So the personal interrogative who? is used indefinitely in the sense of "whoever," "some one," "some," "any one," thus:—

Fa. *se*, Mota *isei*	Heb. *mi*
Mg. *nazovy nazovy, na iza na iza*	
My. *siapa siapa*	
My. *mana*	Arb. *man*

In the Oceanic-Semitic, many other pronominals, indefinites, &c., are formed from the seven demonstrative elements in §§ 1, 2. As usual, in this also the Oc. has greater variety.

b. But very remarkable, and worthy of special notice, is the use of the above (*a*) indefinite (1) after the verb, which is preceded by the negative, somewhat as we say in English "at all," "however," &c., as "he did not come *at all*," thus: Fa. "ti mas mau," Amh. "alematame" (*i.e. ale mata me*), Fo. (Ma.-Ha.) "si mai mau," Aniwa (Ma.-Ha.) "si mai mana."

These (leaving out the verbal pronoun) may all be rendered in English, literally, "not come at all," or "not come however;" but as actually used, this suffixed indefinite makes no translatable difference in the sense, giving merely a vague emphasis. Harari agrees with Amharic in this use of this suffixed indefinite: see for Amharic Isenberg, Gr. pp. 152, 3; and for Harari, Burton's "Footsteps in East Africa," Appendix.

§ 8. Reflexives.

In Mg. "self" is expressed by *hiany*, or *tena*, or *niany tena*. These words are purely demonstrative. Compare Maori *ano*, self, and Arb. *hanu*, "ipse (tu)." *Tena* compares with My. *den*, self, Maori *tonu*, simply, only, self. The My. common word for "self" is *diri*, which looks like a reduplication of the personal pronoun, 3rd singular, *dia*, he, she, it. *Dia* is for *ria*, that is *lia*; compare *duwa* for *ruwa*, that is *luwa*, the numeral 2. It *(diri)* is also used for "he," and in Javanese as *dewe* (Ja. often vocalises My. *r*) it alone is used for he, she, it. This *diri* is substantially identical with Eth. *lala*, *lali*, "er er, er selbst, selbst," Dillm. Gram. §§ 62, 150. Like the Ethiopic *lali*, it takes the genitive suffix of the pronoun, as Eth. *lalikamu*, My. *dirikamu*, yourselves, &c.

But the further discussion of Reflexive Pronouns will come under the Verb in its Reflexive or Reciprocal forms.

Note 1.—Also we shall now be prepared, as we proceed, to recognise the pronominal particles used in the conjugation of the Verb, formation of Nouns, Substantives, or Adjectives, and in Adverbs, Prepositions, and Conjunctions.

Note 2.—As to the Alphabet and changes of letters, all that need be said, till they come to be specially treated, is that in I. and II. changes in letters the Oceanic are exhibited very fully in the words compared; and that, as to a comparison of Oceanic alphabets and letter changes with Semitic (see the Oceanic-Semitic words in I. and II. for some examples of letter changes), we find no other principles exemplified than those we find in comparing the various Semitic dialects, as to Alphabets and letter changes, with each other.

IV. THE VERB.

§ 1. Before speaking of the Verb proper, it seems desirable to say a word or two as to the following particles.

a. The particle of comparison in Oceanic-Semitic is *k'* (alone or combined with other particles) "as," thus:—

Mg.	My.	Fa. (Pa.)	Sam. (Ma.-Ha.)
tahaka	*bagai*	*taka, takan*	*faapei*
	bagibagi	*baka,* Fi. *vaka*	
	ka	*ki*	
hoatra	Ja. *kaya, kadi*	*kite, kita*	
	Sunda *kawas*	*kua*	

So "how?" literally "as what?" thus:—

ahoana	*bagimana*	*kua*	
		kuin	
akory	*mangapa*	*kasa, kasafa*	
	Bugis *mago*	*kasana*	
		kaibea	
		Epi *kavai*	
		Fi. *vakaevei*	*faapefea*

b. Comparison, "as," "thus."

ka	Heb. *ka, ke*
kadi, kite	Aram. *kade, kedi*
taha, taka	Syr. *dak*
	Mod. Syr. *daka*
takane ("as this")	Syr. *dak 'ano* ("as this")
hoatra, kawas	Eth. *kamaze* ("as this")
kua	Eth. Arb. *kama*
baga (i), faa, baka, vaka	Heb. *bek (oh)*
bagaimana	Eth. *bakama*
bagini	Sab. *bakana,* Heb. *beken*

Comparison, "how?" ("as what?")

kaibe	
kavai	Tigre *kamai*
kua (kuwa)	
kuin, ahoana, akory	
kasafa, kasa, kasana	
mangapa, mago	
bagimana	
vakaevei, faapefei	

The Oceanic-Semitic particles "as" is *ka,* to which is prefixed the preposition *b',* Eth. *ba,* "in," "to," without any appreciable difference often in the sense, either in Semitic or Oceanic: see the above examples. In Fate, we say either "bisa *baka* Fate," or "bisa *ki* Fate," speak Fatese, literally "speak *as* Fate." So Eth. *kama* = *bakama* = as.

§ 2. Now the *ka* or *ki* which we have just seen, denotes "as" with or without the preposition *ba,* denotes also a preposition "to," "towards," &c., as we shall now see, and as before, with or without *ba.*

Halevy ("Etudes Sabeennes," IX.) has shown that in Sabaean *ka* = "to" is used as the sign of the accusative and even of the dative, exactly as the preposition *le* in Hebrew, and especially in Syriac. In Amh. ka (or *ha*) denotes "to, from, out of, (more) than," Isenberg, Gr., p. 154. We have already seen, III., § § 1, 2, that *ka* (6) is an Oc.-Se. demonstrative particle, and III., § 5, that *ki* is a relative pronoun in Hebrew. As the preposition "to," "towards," we find it thus:—

Mg.	My.	Fa. (Pa.)	Sam. (Ma.-Ha.)
ho and *hank* = any (*ank* is perhaps for *ka*)	*ka, akan*	*ki*	*i* *ma ki*

The other preposition, Eth. *ba,* Heb. *be, ba,* Arb. *bi, fi, ba,* Syr. *ba,* Fiji *vei,* Aneityum *vai,* is found joined with the preceding *(k')* in the sense of "to," "towards," thus:—

Mg.	My.	Fa.	Sam.
	bagi, baki	*baki* d. *baka*	Ma. *whaka*

Fiji *vaka* = Fa. *baka* = "as," "thus;" so Sam. *faa,* § 1, and My. *bagi* = Fa. *baki, baka* = Ma. *whaka* = "to," "towards," § 2. But the Fate *baka,* Fi. *vaka,* "as," has the Heb. and Eth. *ka,* "as," whereas the My. *bagi,* Fa. *baki* or *baka,* Ma. *whaka,* "to," has the Sabaean and Amharic *ka* "to." And so again, the causative prefix, Fa. *baka,* Fi. *vaka,* Sam. *faa,* Ma. *whaka,* is neither of these, neither "as," nor "to," though it has been generally held to be one or the other, or rather both, compare III., § 16. It cannot be "as," because the *ka* which alone has the force of "as," is very often entirely wanting in the Oceanic causative prefix; and it cannot be "to," because the *b'* and *k'* which express "to" are sometimes both wanting in the Oceanic causative prefix.

The causative prefix, *baka,* is explained below as *b* for *m,* the participial *m, a,* the causative prefix, and *ka,* verb substantive. For *ka* is not only as we have seen, a demonstrative, the particle of comparison "as," and a preposition "to," but as we shall now see, also a final conjunction "that," "to," "in order that," and a verb substantive much used as an auxiliary.

§ 3. The final conjunction *ka,* signifying "that," "to," "in order that:"—

Mg.	My.	Fa.	Sam.
ka, aoka		*ka, ga*	*i, ia*
			Ma. *kia*

COMPARISON.

ka	Arb. *ka*	Tig. *ka*
i (for *ki*)	Heb. *ki*	
kia		

§ 4. VERBS SUBSTANTIVE.

These fall naturally to be considered before discussing the conjugation of the Verb.

a. The particle *ka,* as a verb substantive. Owing to the practice in Oceanic-Semitic of prefixing the negative adverb to the verb substantive, and forming a compound word, meaning literally "is-not," "no," we have a simple means of comparing Oc. and Se. verbs substantive. The three principal Semitic negative adverbs are Arb. *ma,* Heb. *lo, la, le,* Eth. *ale,* always prefixed, and Eth. *i* (or *ai*) also always prefixed. Now these are the three principal negative adverbs in Oceanic also—Heb. *le,* Sam. *le,* Fa. *ti, ta, ri,* and *tsi,* My. *ta,* Mg. *ts'y* and *di,* are all identical; see for the phonetic changes of *l* II., on the numeral 2, where also Sam. retains the original *l.*

Now the verb substantive *ka* is found thus in Oceanic, with prefixed negative :—

(with *l* negative)

Mg.	My.	Fa.	Sam.
*tsia (*for *tsika)*	*tak*	*tika*	*leai (*for *le kai)*
	Palan *diak*	*rika*	
diahoe (di akoe)		*tsika*	
		tsia	

Compare Arabic *la yakun, layaku.*

(with *m* negative)

My. *bukan*	cf. Arb. *ma yakun*
Utanata (Pa.) *pakana*	
Lifu *pako,* Epi *maka*	Mod. Arb. (Baghdad) *maku*

(with *i* negative)

Sam. *i'ai,* Tongan *ikai*	Eth. *ako*

As to the weakening of the initial *k* of this verb to *h* or a breathing in Mg. and Sam., compare the Amharic in which it is likewise changed to *h.* In Arabic its final *n* is sometimes elided. The Arb. *kana* is much used as an auxiliary: Eth. *kon,* Amh. *hon,* My. *kana,* to be able, seem radically identical with this, as also Mg. *hay,* to be able. My *akan,* shall, will, may belong here.

b. The common verb substantive in Malay is *ada,* to be, identical with Mg. *ary.* This by the change of *l* to *r,* and *d,* cf. numeral 2, in II., is identical with Eth. *halawa, halo,* Amh. *ala,* Tig. *ali,* verb substantive, to be, and used as an auxiliary. Halevy derives the Arb. article *al* or *hal* from this verb, that is, he derives this demonstrative from this verb. In My. with the negative we find it thus:—*tiada, tida, tada, tadak,* and in Mg. as *tsiary, tsiadry,* (Errub and Maer *lola*), Ambrym *tolo,* Bisayan *dili,* Amharic *lela.*

With *m* negative we find it in Epi. ma*raka* = My. ta *dak.* Paama *boel,* Maori *hore.* Halevy (Polynesian Grammar) suggests that *oloo* is a verb substantive in Samoan: Pratt (Sam. Gr.) gives it as *loo.*

c. In Mg. *isy* is the common verb substantive, with negative *tsy, isy, ts, 'isy.* This is identical with Heb. *es,* Arb. *aisa,* with negative *laisa, leis,* Syr. *ith,* with negative *lath,* Ch. *ita* and *lo ita.* This Semitic verb substantive is used also as an auxiliary in Heb., and especially in Aramaic. It seems to be this verb substantive that we have with negative *ma* in Segaar *mati,* Onim *matio,* Papua kowiay, *marate.* Connected with this probably, is the demonstrative *t,* III., § 2, *a* (7), or *s* (3), as some Semitic scholars think: see Ges. Heb. Dict. s. v., *eth,* at end.

d. In Fa. the common verb substantive is *bi, fi,* in one dialect *bai* or *bei,* in another *mi.* This verb substantive is found widely used in the New Hebrides, with and without the negative. With negative it is in Fa. *tiba, riba, tab.* It is identical with Arb. *fi*, literally "in," and Arb. *fih*, Eth. *ba*, literally "in, it," used as a verb substantive in Mod. Arb., Caus. de Percival, Gram. Arab. Vulg., §§ 286-7, and in Ethiopic, Ludolf-Dict. s. v. With negative Eth. *aleba*, is identical with Fa. *tiba, riba*; the Arb. with negative *ma*, is *ma fi* or *ma fih*. With Fa. *bi, bei, bai*, is identical Tahiti *vai*, "to be."

e. The Javanese verb substantive is *ana*, to be, to possess. This is found in Mg. *manana*, to possess, for which see Griffith's Mg. Gr., p. 31. It is identical with Heb. *hinneh* (Ges. Dict., the demonstrative, III. § 2, *a.* (5), used as a verb substantive, or auxiliary.) Arb. *inne* (Newman, Handbook Mod. Arb., p. 43), Eth. *ene* (Dillmann, Eth. Gr. § 160, *a.*) and Amharic *na*, with pronoun *na wĕ*, "he is," which Isenberg (Gr. p. 64) calls "the Irregular and Defective Verb Substantive." In Oceanic, with the negative it appears in for instance, Gaudalcanar *mania*. Fa. *ane, en* (see *f*), means to be, to abide, to dwell.

f. It has been shown in I., that the Personal Pronoun, third singular, is the same in Oceanic and Semitic. This pronoun originally demonstrative, III., § 1, 2, *a.* (2), was in Heb. *hua, hia*, Mod. Arb. *hu, hie*, Syr. *hu, hi, u, i*, Mod. Syr. *o, e*, &c., used as the verb substantive, and in fact, was radically identical with the well-known very ancient verb substantive (much used as an auxiliary) Heb. *hayah*, Ch. *hăwāh*, Syr. *hwo* and *uo*, in Mod. Syr., often a mere vowel. Hence in Mod. Syr. (Stoddart, p. 34), it is impossible to tell whether the modern verb substantive is derived from the ancient verb substantive or pronoun. So in Oceanic we find the verb substantive (whether derived from the ancient verb substantive or pronoun, amounts to the same thing), with the negative thus:—

(With negative *l.*)

Gaudalcanar *tau*, Ysabel *teo*, Eromanga *tawi*, Fiji *tawa*, Tongan *tai*. Syr. *lau*, or *lao*, and *lowo*, Mod. Syr. *le, wa*, &c.

(With negative *m.*)

Ysabel *bai*, Gaudalcanar *mai*, Mara-masiki *mau*, Florida *mua*, Nifilole *bawo*, Mod. Arb. *mahu, mu*. Compare *ma fih*, in *d.*; the *fih* is *fi*, "in," "is." and *h* for *hu*, "he," "is." The derivation of the preposition *fi*, and pronoun *hu* helps to explain how they can be used as verbs substantive. Compare also Mod. Syr. *biwa*, present participle of the verb *wa*, to be. For Arb. *fi*, Eth. *ba*, &c., the derivation suggested by Halevy is the best. He derives it from the verb, which in Heb. is *ba*, to enter, come, the cognates in Arb. being *ba* and *fa*.

The Fa. *an*, *ane* (see *e.*) is sometimes pronounced *à*, as if *a* were the verb substantive and the *n* suffixed to it for emphasis, "is, there." The *n* certainly suggests the ideas of emphasis and distance. With the participial *m* (soon to be discussed) this in Fa. is *ma*, and *man*, as "i ma rarua," it is in the canoe, or "i man tafa," he is (away or yonder) on the hill. In Fa. *an* is used as an auxiliary to denote continuing action, as *is*, in "he *is* talking."

g. Note how most of these verbs substantive either are derived from pronominals, or become pronominals; for in every case it may not be easy to determine whether the verbal or pronominal idea was the more original. This throws a new light on the demonstrative elements in III. §§ 1, 2; with (2) compare *f.* in this section; with (3) and (7), *c.;* with (4), *b.;* with (5), *e.;* and with (6), *a.*

h. This throws light also on many of the Oceanic Personal Pronouns. Thus to take those beginning with *l*, it seems that the *l*, changed sometimes to *r*, and *d* (see *b.* above) is rather the verb substantive than the article, III. § 3, *b.* (4), though, as this verb substantive and article are radically identical, it is difficult sometimes to distinguish between them. A comparison of *form* and *use* will prove however that it is really in this case sometimes the verb substantive used as an auxiliary and not the article :—

	I	Thou	He	We	Ye	They
Pt. Moresby	*lau*					
Lobo	*laku*					
Sumatra	*rehu*	*rio*	*dio*			
Malay	*daku*	*dikau*	*dia*		*dikau*	*dia*
Ja		*dika*				
Mg.		*rika*				
		roky				
Nigrito					*dicamu*	
Fa.						*ru(eru)*
						Dual *ra (era)*
Sam.						Dual *la*
Epi						*le*
Eth.	*haloku*	*haloka*	*halo*		*halokemu*	*halawu*
Amh.	*alahu*	*alah*	*ale*			*alu*

These generally correspond thus Fa., Eth., Amh., *ru* or *eru*, *halawu*, *alu* = they are, they were. Fa. *eru* is a "verbal pronoun," and corresponds to the auxiliary use of the Eth. and Amh. With Eth. *elu*, originally *elum* = they are, *ela* feminine, simple meaning "these:" compare the common word for "they" or "these" in Oceanic (see I.) "They are" readily became "they" and "these." This thoroughly explains the prefixed *l* (*r*, *d*) in the numeral 2, Mg. *roa*, My. *duwa*, Fa. *rua*, Sam. *lua* (see II.), and in the Dual Verbal Pronoun, Fa. *ra*, or *era*, Sam. *la* (see I.) ; originally identical that with the Numeral is the Article, that with the Pronoun is the Verb Substantive. And thus we see also why the numeral is *rua*, *lua (r-ua, l-ua)*, the pronoun *ra*, *la (r-a, l-a)*, the numeral being the separate dual pronoun *uma*, *huma*, with the article *l* prefixed to it, whereas the pronoun is really the 3rd person dual of the perfect of the verb substantive. Thus *ra*, *la* consists of *r* or *l*, the verb substantive, and the suffixed verbal dual pronoun *a*, contracted for *huma*, as it is found in, for instance, Arb. (*a* contracted for *huma*) in the 3rd person dual of the perfect of verbs. *Ra*, *era*, and *la*, and Fa. *ru* or *eru* (3rd person plural of the perfect of the verb substantive), point to a very ancient time when the Oceanic languages possessed the suffixes of the perfect, and we may infer the imperfect inflexion also, like all the ancient Semitic languages ; and when probably the ancient Semitic mother-tongue of the Arb. and Eth. had not yet given birth to these two daughters ; but when, even then, before the Oceanic branch shot out over the sea, and become separate from the parent stem, the original *huma*, as suffixed to the verb 3rd person dual perfect, had become contracted to *a*.

It is quite certain then, that in Oceanic, some of the personal pronouns, whether separate or verbal pronouns, are really ancient Semitic inflexional compounds of the personal pronouns and a verb substantive, that in common use have come to be regarded as mere personal pronouns, or even in the third person, as mere demonstratives, like "this" or "these."

Take another Semitic verb substantive in Arb. *kana*, with sometimes the *n* elided, Eth. *kon*, usually as *ka* in Oceanic, with the *n* elided, and compare Eromangan *kik*, Fate *kag*, and *kaiga* (for *kak*, *kaika*,) Harari *akhakh*, Malay *kangkau* (cf. *dikau*), thou, with Eth. *konka*, thou art (Arb. *konta*), second person singular of the perfect.

The third great Semitic verb substantive and auxiliary, see *f.* above, is generally in Oceanic, and often in Mod. Syr., a mere vowel, and on this account, and because of the difficulty or impossibility of always distinguishing between the verb substantive and the demonstrative radically connected with it, we do not discuss it in this connection at present. As to the verbal pronouns or "fragmentary pronouns," we find them in some dialects of Oceanic and Mod. Syr., the ancient so-called tense-inflexion being lost, used with the participle: see Stoddart, p. 161. But neither in Mod. Syr. nor Oceanic are they all the same as in the ancient Semitic. Yet some are the same, and those independently formed are equally with the ancient Semitic verbal pronoun, *fragments* of the full or separate pronoun, and having the same elements radically identical. See the separate and verbal pronouns in I., and compare the *suffixed* nominative "fragments" in the so-called "pronominal adjunctive" of the Malagasy.

A fourth great Semitic verb substantive, see *c.* above, has the same ambiguity (verb or demonstrative) about it, and is used with the personal pronoun before a participle for the finite verb, thus Heb. *eshka moshia,* thou savest, literally "thou-art saving." This explains the Oceanic method, and particularly the Mg. pronoun with the verb, thus, *izaho* = I am ; *izy,* he is ; *izahay,* we are ; *isikia,* we are, inclusive ; that is, the Mg. *iza, isi,* is substantially identical with the Heb. verb substantive, *esh,* Aram. *ith,* and the compound of this with the personal pronoun expresses with the participle the finite verb : compare Negrito *siko,* Heb. *eshka,* thou (art), and Negrito *sikam,* Heb. *eshkem,* ye (are), with Syr. *itha,* I am, compare Sam. *ita,* I (am).

Again, to take the ambiguous or demonstrative verb substantive of *e* above, it is used exactly in the same way before a participle in Semitic for the finite verb : thus compare Heb. *hinka,* Mod. Arb. *innek,* Amh. *nah,* with Sumatra *enko,* Mota *iniko,* Motlav. *inek, nek,* Fa. *nago* (for *nako*), Malay *angkau* (for *ankau*), thou (art), the last is plural : compare Heb. *hinkem,* Arb. *innekom,* with it, and with Fa. *nimu* (for *nikemu*), ye (are). So compare My. *inia,* Fa. *enea, nai,* with Arb. *inneho,* Heb. *hinno,* Amh. *nawĕ,* he (is).

§ 5. In the Semitic languages we find sometimes the finite verb, in the present, past, and future tenses, expressed in the manner just pointed out, by these verbs substantive or pronominal particles with personal pronouns attached, along with the participle; or by the participle alone: Ges. Heb. Gr. § 134. The participle with the separate personal pronoun, or noun in the nominative, in Anc. Syr. denoted the present tense (see Ahlemann's Gram. § 64, 2, *a*); in the same way, and sometimes by help of the auxiliary verb and particles, it denoted the past and the future, Ibid. B. and C.; and the various moods, Ibid. 3. In Syr., Ibid. § 65, 1, A., the present is expressed "usually by the participle," in the manner just noted; and so the past, Ibid. B. The Oceanic Semitic personal pronouns in the nominative include, more or less clearly, the idea of the verb substantive. The tenses of the Oceanic verb are, generally speaking, as we shall now see, expressed in the above way by means of the participle; the ancient Semitic tense-forms, called the perfect and imperfect, having disappeared from the Oceanic, perhaps to a still greater extent than from the Mod. Syr.

§ 6. The Tenses.

a. The Present. The present tense in Oceanic is expressed generally by the participle alone, but sometimes emphasised by a verb substantive or particle. Crawford (My. Gr. p. 48) says, "The verb in its simple or compound form expresses present time, when no other is specified or implied, as . . *diya makan*, he eats." So Mg. *izy mihinana*, Fa. *i kani*, Sam. *e'ai oia* (ps. *'aina*), he eats. In the Sam. alone, in these examples, a particle *e* is used. In this word, *m* is prefixed in Mg. and My., not in Fa. and Sam. But in Mg. *izy matahotra*, My. *diya manakut*, Fa. *i mitaku*, Sam. *e mata'u oia*, he fears, the *m* is prefixed in all. But while this verb never appears in Fa. and Sam, without the *m*, in Mg. we have it as *tahotra*, and in My. as *takut*. This prefixed *m* is most used in Mg., next most in My.; and in Mg. it is most used in the present tense, and hence by some people has come erroneously to be regarded as a mere sign of the present in that language. It is, however, in Mg. what it is in My., Fa. and Sam., and that is, the *m* of the participle, and it is because it is such that it so naturally and usually expresses the present, though it not infrequently expresses the past in Oceanic. This *m* is undoubtedly identical with the common and well-known Semitic *m*, originally pronominal (III. § 2, *a* (1), Ges. Heb. Gr. § 52, 1) of the participle; and the Semitic participle, with and without the prefixed *m*, is used in exactly the same way as the corresponding Oceanic participle, to express usually the present tense, but pretty often also the past: see § 5. This *m* will frequently come before us as we proceed in connection with the other parts of our subject.

In My. the verb substantive *ada*, in Sam. *loo* and *o*, § 4, *b*, *f*, in Fa. *mo*, *bo*, coming before the participle, have the same effect as the verb substantive in English before the present participle, as, *ada makan* = bo *kani* = is, or are eating. Fa. *mo* or *bo* is the verb substantive in § 4, *f*, with the participial *m* prefixed, or it is the participle of the verb substantive. For the Sam. sign of the present (also of the future): see § 4, *f*.

b. The Past.

Mg.	My.	Fa.	Sam.
n	*de, di*	*ka*	*ua* (also present)
		(d. *kui*)	Ma. *kua*
(*t*, with adverbs)	Tag. *na*	Fi. *ka*	Tongan *na*
		Tan. *n*, *in*	Sam. *na*
		Fi. *a*	Rarat. *i*
		Fi. *sa* (also present and future)	

1. *N*, *in*, *na*. For this demonstrative verb substantive auxiliary in Semitic: see § 4, *e*. It is used in Heb. with the participle to denote the present, the past, and the future: see § 5, and Ges. Dict. s. v. *hinneh*, at end. In Motlav (Pa.), it denotes the present, and also in Tagala (present and past), in Fiji, it denotes the future.

2. *Sa* (past, present, and future); *t*, Sam. *te* (present and future). For Semitic, see § 4, *c*.

3. *Ka*, *kui*, *ua*, *kua* (Tongan *gua*, Fotuna *ko*, present; Rarat., Fotuna, Aniwa, *ka*, Florida and Gaudaleanar *ke*, Mg. *h* (for *k*), *ho* (for *ko*, with adverbs), future. For Semitic, see § 4, *a*., Mod. Syr. *ke*, narrative tense.

4. *De*, *di*, past and future. For Semitic, see § 4, *b*.

5. *A*, *i*. For Semitic, see § 4, *f*. Mod. Syr. *ai* or *i*, narrative tense.

In Hawaiian, *e* before the verb, sign of present and future, after the verb, "signifies *previous*, *beforehand*, and forms thus, with the preterite a sort of pluperfect, and with the future a second future," as *ua lawe e au*, I had taken, *e lawe e au*, I shall have taken, Hale, Po. Gr. So in Fa., but in Fa. the *e* is put immediately after the sign of the preterite, *ka* (= *ua*, Hawaiian), and future, *ga* (= *e*, Hawaiian), thus *a ka e ban*, I had gone, *a ga e ban*, I shall have gone. For a pluperfect and future perfect formed by the same verb substantive, § 4, *f.*, put after a preterite and future: see Uhlem. Syr. Gr., § 65, D.A., cf. Mod. Syr., Stoddart, p. 40.

c. Future.

Mg.	My.	Fa.	Sam.
h	*akan*	*ga bo*	*e, te*
	de, di	*ga uo*	
		go	Rarat. *ka*
		ka fo	Fotuna } *ka*
		ba mo	Aniwa } *ka*
		Florida *ke*	Tah. *e*
		Fi. *na*	
		Mota *te*, Tan. *te*	
		San Christoval *i*	

1. *na*, see *b.* 1.
2. *te*, see *b.* 2.
3. *h* (for *k*), *ka*, *ke*, see *b.* 3.
4. *de*, *di*, see *b.* 4.
5. *e*, *i*, see *b.* 5. The Syr. verb substantive (§ 4 *f.*) before the participle expressed the future.
6. *ka*, *ga*, Fa., see § 3.
7. *mo*, *bo*, *fo*, see *a.* above.
8. *ba*, *mba* (Mg. *fa*, *mba*) = *ga*, in 6. Compare Arb. *fa*, which sometimes "plays the role of a final conjunction."

§ 7. The Moods.

The Imperative, or Permissive, Conjunctive and Infinitive.

Mg.	My.	Fa.	Sam.
cf. *ho* and *hi*	*de*	*ba*	*ia ē*, *ina ē*
aoka (for *as*, § 4, *f.*)		*ko*, *ki*	*ia* (for *kia*)
		bafo, *kofo*	Rarat. *ka*
		Fi. *me*	*kia*
		Mota *si*	
		Gaudalcanar *ti*	

1. *ko*, *ki*, *ia*, *ka*, *kia*, see *a.* 2.
2. *ba*, *me*, see *a.* 3.
3. *ia ē*, *ko fo*, *ba fo* (contracted to *bo*), see for *e* and *fo*, § 6, *c.*

So in Chaldee, the *final conjunction, le* (originally Arb. *li*) prefixed thus to the same verb substantive, gives it a "conjunctive, optative, and imperative power," Ges. Heb. Dict., s. v. *l.* The Chaldee conjunction is *le,* the Fa., Fi., and Sam. equivalents, *ba,* Fi. *me* (Arb. *fa*; *ki, ia* (for *kia*), *ka* (Arb. *ka,* Tigre *ka*), have already been dealt with. Gaudalcanar *ti* compares with Ch. Syr. *di, de,* and Mota *si,* with Eth. *za,* Sam. and Hawaiian *ina,* with Arb. *an,* final conjunctions; and with Sam. *ina e;* compare An. *namu* (*mu* = Fa. *mo, fo, bo,* § 6, *a.*) The infinitive thus expressed is like the English "to go," or "that he go," *e.g.,* "I told him to," or "that he should go;" so Mod. Syr. Stoddart, p. 166. Thus the Oceanic uses the same particles before the verb to express these moods as the Semitic; the Anc. Se. uses generally the imperfect ("future") of the verb after these particles, but sometimes the participle: Syr. Gr. § 64. The Oc., like the Mod. Syr., having lost the inflexion of the imperfect, uses the participle instead after these particles, just as does the Mod. Syr.: Stoddart, p. 108. This of course follows from the fact that in the tenses, §§ 5, 6, the participle has, in Mod. Syr. and Oceanic, taken the place of the Anc. Se. imperfect. In Oc.-Se. the infinitive is sometimes expressed by one verb following another, without any prefixed particle; the following verb in Oc. is the participle: compare Syr. for the same, Gr. § 64.

My. *de* is to be compared with the Chaldee final conjunction *le,* Arb. *li.*

4. The infinitive verbal noun will be treated of below.

5. The My. imperative is expressed very much like the English by the verb used alone, as *makan,* eat, or with the pronoun following it, *makan kamu,* eat ye.

6. The Mg. expresses the imperative, 2nd person, by suffixing *a* to the verb, as *mandrobo,* to flatter, *mandroboa,* flatter. So Javanese suffixes *a,* and sometimes *an,* as *balang,* to throw, *balanga,* throw, *kon,* to order, *konan,* order. Crawford, Diss. p. 25, says, "The Javanese imperative affords, with the exception of the Javanese genetive, the only example, that I am aware of, in the Malayan languages of an inflexion." This Mg. and Ja. *a* is undoubtedly the same *a* which is suffixed to the ordinary imperative in Heb. to form the emphatic imperative (Ges. Gr. § 48, 5), as "*qum,* stand up, *quma,* up! *ten,* give, *tĕna,* give! In Mg. also the suffixing of this *a* causes the accent to be strongly thrown

forward towards the end of the word, thus, "*mandràra*, to forbid, *mandrarà*, forbid." So *mandèha*, to go, *mandehàna*, begone! And the suffixed *an* of the Javanese seems also undoubtedly the same as the *an* of the Energie Imperative of the Arb., as *uqtul*, ordinary imperative, kill, *uqtulan*, kill!

§ 8. The Participle.

We have seen in the foregoing that the Oc. verb, present tense, corresponds to the Anc. Semitic participle. The *m* participial inflexion is one of the striking features of the Semitic languages, as it is also in an unmistakable manner of the Oceanic languages: see § 6. More will be found below on the passive participle with *m*, and the formation of verbal nouns.

§ 9. Particles connecting the Verb with its object.

a. These particles direct the action of the verb to the object, giving it either a transitive or a causative force. Many of them have been glued on as suffixes to the verb, especially in Mg. and My., though in Fa. and Sam. also, and now appear in the dictionaries as radicals; thus the verb "to drink" appears in the My. dictionary as *minum*, as if the final *m* were a radical letter, whereas a comparison of dialects, Fa. *minu*, Sam. *inu*, shows that it is not, being the suffixed transitive particle. Not all verbs take these particles in Oceanic; some govern the object directly, without any intervening particle:—

Mg.	My.	Fa. (Pa.)	Sam.
(a)	*kan, i*	*ki, baki*	*i, ia*
ami	Ja. *ake, akan*	*fi, gi, mi, ti, ri*	*ia, te*
	i, ni, kakan	*si, saki, maki*	Rarat *ki*
	Bugis *ri*	*taki, raki, naki*	*i, ia*
		Fi. *a, ca, ga, ka*	
		ma, na, ra, ta	
		va, wa, ya, caka	
		kaka, laka, maka	
		raka, taka, vaka	
		waka, yaka	
		Ero. *ra, ira, pu*, or *bu*	
		An. *ira, vai, an*	
		Tan. *ya, te*	
		Epi. *ba, ban, ka, kan*	
		Florida *li, lagi*	
		vi, vagi	

b. The force of these, and the extent to which they are used in different dialects vary. In Mg. *a*, in Sam. *te (ia te)* are used before pronouns. We may now compare:—

1. *A, ia, i, ki, ya.* Arb. *iya, ka, ki, kan* ("to"), Amh. *ka*, Eth. *kiya*, Sab. *ka*.
2. *An, ni.* Tig. *en-*, or *ne*, accusative sign. Heb., Ch., *an*, *en*, "nun epenthetic," or "nun demonstrative."
3. *Ca, te, ti, ta*; *si.* Heb. *oth, et.*
4. Mg. *ami*, Fa. *mi*, Fi. *ma*, Heb. *'im*, Arb. *ma*, Syr. *'ame* ("with," &c.)
5. *Ri, ra, li, ira* ("to, at"), Heb. *le*, Arb. *li.*
6. *Ba, va, bu, vi, fi* ("to, in") Syr. *ba*, Heb., Arb., Eth. *ba.*

Eth. *kiya*, Arb. *iya*, Heb. *oth* or *et*, are pronominals or demonstratives used as signs of the accusative before pronouns. But Eth. *kiya* in Sabaean as *ka* (Halevy 93, rightly) is used as the mark of the verb object before pronouns and nouns; Heb. *et* is so also; and Arb. *iya*, identical with Eth. *kiya*, as *ki*, *i*, and *ia*, or *ya*, is used in Oc. as the mark of the verb object before nouns and pronouns. On the origin of *kiya*, see Dillmann Eth. Gr. §§ 65, 150. Thus Sam. *i*, *ia*, is for *ki*, *kia*, and so of course Malay *i* is for *ki*, as Arb. *iya* (another form nearer the original is *hiya*, Wr. Arb. Gr. I. § 188) is for *kiya*. For the pronominal origin of Heb. *oth*, *et* (Aram. *at*, *iat* or *yat*), see Ges. Heb. Dict. s. v. Eth. *kiya* is a compound of the demonstrative *k'*, and the demonstrative used as the 3rd person singular *i*, or *ia*, he, ipse, self, Ges. s. v. This is why these compounds, Eth. *kiya*, Arb. *iya* or *hiya*, Heb. *oth* or *et*, Aram. *yath* (*i.e. ia th*, cf. Sam. *ia te*), also have the meaning sometimes of self. As to the double use as a demonstrative and a preposition, see III. §§ 1, 2, and IV. § 2; and as to the derivation of prepositions generally from pronominals, see Bopp, work cited, p. 113. It is certain, however, that not all the Oc.-Se. prepositions are derived from pronominals.

c. As to the prepositions 1, 4, 5, 6, their general meanings are given above, but when used as particles connecting the verb with its object, it is impossible to give briefly their very various meanings and uses. The dictionaries and grammars must be consulted. For instance, 5 is much used, especially in Aramaic, as a mere mark of the verb object, as it is in Bugis *ri*, Eromanga *ira*, *ra* (Gordon's M. S.

Grammar), Aneityum *ira, irai* (in Gabelentz); exactly so, 1, *ka* (*ki, i*, &c.), is often used as a mere mark of the verb object in Sabaean, and in My., Fa., and Sam. (*i* for *ki*, cf. Raratongan). So also 6, *ba*. &c., is used in Heb. sometimes as a mere transitive particle (Ges.) between the verb and its object, as in Fi. *vei* and An. *vai* (in Gabelentz). In each of these three particles, the notion of *motion to* is radical. In Hazlewood's Fi. Gr., 2nd Ed., p. 33, it is said, "it appears also to be a rule that verbs of motion will take *va* for their termination, as *lakova*" (*lako*, to go), and on p. 35, *va* is identified with the preposition *vei*, "to," "in," literally "in it," An. *vai*, it being pointed out that "*va* in the Rewa dialect is still the same as *vei* or *ki*, to:" compare III., § 2. Fi. combines these two prepositions, thus *kivei* (*ki* first) = Fa. *baki*, Maori *whaka*, Malay *bagi*, "to," "towards," (*ba* first). The preposition, 4, "with," &c., is very common in Mg., Papuan, and Ma.-Ha. But when used as a particle between the verb and its object, its meanings are very various, as may be seen by consulting on the one hand, the Mg. Dict. of Freeman and Johns, and Cr. Gr., pp. 198, 221-2; and on the other, Ges. Heb. Dict., under the word.

d. It has already been remarked that the verb followed by these particles, has either a transitive or causative force. Thus Fi. "*sobuca na vanua* (go down), *sobutaka na vanua* (take down)," that is, the latter with compound particle, *taka*, is causative, the former has *ia* merely pointing to the verb object. Compare Fi, *rogo ca*, to hear (*ca* makes it transitive), *rogo taka*, or *rogorogo taka*, to tell, to cause to be heard. In Fa. this verb is transitive, by merely putting the object after it without any particle, like *ca*, but the particle *ki*, instead of *taka*, makes it causative, as *rog nafisan*, hear the word, *rogorog ki nafisan*, proclaim, or make to be heard the word. In My. the transitive is *dangar*, in which the particle *r*, 5, is glued on to the verb *danga* = Fa. *rogo*, (pronounced *rongo*), and Ero. *digi* (pronounced *dingi*). My. *i* (for *ki*) and *kan* (*ki* strengthened by demonstrative *n* or *an*), are exactly like the others, thus My. *tangisi*, to bewail, and *tangiskan*, id., are the same as Fi. *tagica* and *tagicaka*, Fa. *tagisi*, all being merely transitive; but in My. *takuti*, *takutkan*, to frighten, the particles (*i* and *kan*) give the verb a causative force. To both of these words, *tangis* and *takut*, before the particles *i* and *kan* are attached, it is to be noted that the particles *s* and *t* had been in ancient times attached, so that now they are treated as if a part of the root. This, however, they are not, for these verbs in, for instance, Fa. are intransitive, *tagi,* to wail, *tagisi,* transitive, to bewail, Sam. *tagi,* to wail, passive, *tagisia* (when the same particle *s* appears); Fa. *mitaku,* to fear: cf. Sam. *mata 'u,* Fa. transitive, *mitau ki,* Bugis, *matau ri,* Sam. passive, *mata 'utia,* in which the same *t* transitive particle, as in *takut,* appears: cf. also Mg. *matahotra* (which seems to be for *mataku-ra,* rather than *mataku-ta*: compare *ampitahorina,* in which the *tr* is *r*), in which the *tr* may be for *r,* the same transitive particle (*ri*), as appears in the Bugis. These examples show how the verb object particles or ancient prepositions used as such, have become disguised in the lapse of ages, and made to appear radical parts of the verbs; and they show also, that at least, to a large extent, the particles are used for one another in different dialects, in Oceanic, just as in Semitic. Such particles sometimes gave to the verb, in Semitic also, a causative as well as a transitive force; thus Ges. says, "Since *be* in this signification is a particle of *transition,* it is not to be wondered at that it should give a transitive power to some verbs, and even a causative, such as is elsewhere expressed by the conjugation Hiphel." The common Oceanic particle giving this causative force to some verbs is *i* (for *ki*), or *ki, ka,* either compounded with other particles for emphasis, as *ake, kan,* or alone, and synonymous with *ba* as a "particle of transition," having the meaning of "to."

e. With respect to the Sam. passives *tagisia, mata'utia,* the *s* and *t* are the verb object particles, and the other particles, as well as these are found in the Ma.-Ha. passives 1, and reciprocal form 2, and in the Mg., My., Fa. and Sam. verbal noun terminations 3, thus:—

2. Sam. *'i, a'i, fa'i, sa'i, ta'i, ma'i na'i, la'i.*

1. Ma. *kia, ngia,* Sam. *fia, gia, lia, mia, sia, tia.*

3. Ma. *ranga, manga, anga,* Sam. *saga, taga, 'aga, laga, faga, maga, aga.*

In these *ga (i.e. nga)* is for *na,* the original *n* having been changed to *ng.* The verbal noun terminations, 3, in Fa. are *an* or *ena, siena, tiena, kien, rien, fien, mien, nien* (the final *a* not always pronounced, *e* is for *a*); so My. *san, tan, gan, ran, pan, man, nan;* so Mg. *ana, sana, zana, tana, hana (*for *kana), rana, fana, vana, mana.*

In the above 1, 3, the first letter is in every case the verb object particle, with which we are now familiar; in 2 these particles are, except the first, compounded (cf. Fi. *aka, vaka,* &c.) of *a, fa, sa, ta, ma, na* and *la,* and *ki.* It may be remarked that these particles are found occasionally in the Sam. Dict. glued on to the simple verb (as in Mg. and My., and sometimes in Fa.), for instance *'i* in *tafa'i, fa'i* in *atofa'i, a'i* in *gava'i, ta'i* in *lapata'i, sa'i* in *leoleosa'i, na'i* in *taona'i,* and *ma'i* in *tanuma'i.*

Note.—The Semitic preposition (often used like the above 1, 4, 5, 6, as a verb object particle) "from," &c., in Heb. and Arb. *min, mi,* Syr. *men,* Eth. *ĕma,* Sab. *m, b* (Halevy 95) is undoubtedly in Oceanic used as a verb object particle like the above, but it need not be said that it is impossible to distinguish it, so far as its form or sound is concerned, owing to phonetic similarity and corruption from 4 *(m),* and 6 *(b).* It can only be distinguished from them by the sense and the usage.

§ 10. The Derived Verb Forms.

A. The Causative.

This is formed by a prefixed particle which is really the same in every case, though sometimes apparently different, thus:—

Mg.	My.	Fa.	Sam.
1. *ma, man,* &c.	*ma, man*	*ba, bĭ*	Ma. *wha*
a, an	*mang*	Fi. Mota *va*	
	Ja. *a, an*	Lifu, Mare *a*	
2. *mampi, mampa,*	*ang*	Aneityum *imi*	
ampi, ampa, ampan		Ero. *ampĭ*	
3. *maha, mampaha*		Fa. *baka, faka*	Sam. *faa*
aha, ampaha		Fi. *vaka*	Ma. *whaka*
		Mota *vaga*	Rarat. *aka*

The causative particle in all these prefixes is *a,* which sometimes, but rarely, is weakened to *ĕ* or *ĭ.* Thus to take:—

1. Mg, *ma, man,* Fi., Fa., Mota *ba, va,* Ma. *wha,* and My. *ma,* are all identical. But Mg. *ma* is a compound of the participial *m,* and the causative prefix *a*; in the future and past tenses only the *a* appears, as *velona,* alive, *mamelona,* make alive, future *hamelona,* shall make alive, past *namelona,* made alive. The *a* alone therefore is the causative prefix. Compare Lifu and Mare *a.* In Fa. *ba,* Fi. *va,* Ma. *wha,* the

participial *m* is changed into *b, v,* and *wh,* and like the My. *m* in *ma* is inseparably attached to the *a,* that is (as in the Mod. Syr. causative) only the participle is used.

2. We have the very same as this Fa. *ba,* Fi. and Mota *va,* Ma. *wha,* in An. *imi,* Ero. *ampĭ,* Mg. *ampĭ, ampa*; but to this also Mg. prefixes the participial *m.* The same is found sometimes in Papuan, Araga as *ma va* (Codrington, "The Melanesian Languages," p. 187.) It is really doubling the participial *m,* though unconsciously.

3. In Mg. *maha* we have the participial *m* as before separable, *a* the causative prefix, and the verb substantive *hv* (see above § 4, *a.,* and § 6, *b.*), so that *aha* means *make to be.* In Papuan and Ma.-Ha. this *m* being as before inseparable and changed to *b, f,* and *v,* and *wh,* in *baka, faa, vaka, whaka, vaga,* and in Mg. itself, as in 2, inseparable and changed into *mp.,* as in *ampa,* in *ampaha.* Again as in 2, before *ampa,* so before *mapaha,* Mg. admits the participial *m.*

b. The above may be thus shown :—

1. The simple caus. Oc. prefix Mg. *a.* Lifu, Mare *a.*

2. This *a* with the participial *m* (changed to *b, f, v, wh, mp,* &c.) as Mg. *ampa,* An. *imi,* Ero. *ampe,* My. *ma,* Fa. *ba (bĭ),* Fi., Mota *va ma, wha.*

3. The simple *a* prefixed inseparably to the verb substantive Mg. *aha,* Rarat. *aka.*

4. The *a* with the inseparable *m,* in 2, prefixed inseparably to this verb substantive, Mg. *ampaha,* Fa. *baka, faka,* Fi. *vaka,* Mota *vaga,* Sam. *faa,* Ma. *whaka.*

Note 1.—Perhaps Rarat. *aka* belongs to 4, not to 3.

Note 2.—While the above as compared are etymologically identical, allowance must be made for difference of use.

Note 3—In Mg. and My. *man, mang,* Ja. *an, ang,* the *n, ng,* may be roughly described as euphonic, though, as will be seen below, they are not perhaps purely euphonic. The other phonetic changes are mainly those of *m* (participial) to *b, f, v, wh,* and *mp.* The *a* also appears sometimes, but rarely, as *ĭ* or *ĕ.*

c. Comparison : see Semitic Grammars.

The causative is formed in Syr., Assy., Arb., and Eth., by prefixing *a* (sometimes weakened to *ĕ, ĭ*), this has been softened from *ha,* of which the *h* is retained in Sab. and

Heb. This *h* is generally believed by Semitic authorities to be weakened from an original *s* (sometimes *sh* and *t*, in Shaphel and Thaphel) : see Dillmann, § 79, Wright I., § 45, Halevy, p. 37, points out that this *h* is regularly *s* in one Sab. dialect. Shaphel, as well as Aphel, is used in Aram. In Assy., Shaphel is the more prevalent, as well as original form : Layer, Assy. Gr., p, 63. The causative participle has of course the *m* prefixed, and its vowel was originally *a* as preserved yet in Heb. and Syr. The Syr. causative participle is of the form *Maphel*, Heb. *Maktil*. This participle came to be used sometimes in Syr. as a distinct causative form, and was called the Maphel (conjugation) form, and it is the only causative form now used in Mod. Syr. : Stoddart, p. 110.

Thus the *a* of *b*. 1, is the *a* of the Aphel form ; and the *ma* (*ba*, *fa*, &c.) of *b*. 2, is the *ma* of the Maphel form ; in *b*. 3, we have the Aphel or causative of the verb substantive, *ha*, *ka* ; and in *b*. 4, the causative of the same Maphel form.

Note.—As to the nasal *n*, *ng*, of *b*., note 3, while it is so far euphonic, it may *sometimes* or in some measure, represent the consonant of the *original* Semitic causative particle :

Mg.	My.	Fa.	Sam.
live, *velona*	*idup*	*mauri*, Fl. *vola*	*ola*
die, *maty*	*mate*	*mate* (Fi. id.)	*mate*
fear, *tahotra*	*takut*	*mitaku* An. *imtae*	*mata 'u*

Causative.

mamelona	*mangidupi*	*bakamauri* Fl. *vavola*	*faaola*
mahafaty	*mamatikan*	Fi. *vakamatea*	*tamate*
mahatahotra	*manakuti*	*bakamatakuki* An. *imiimtae*	*faa* *mata 'u*

Note 1.—Fi. and My. use the transitive suffixes with the causative ; in Fa. *ki* is often used in like manner.

Note 2.—The same changes of this participial *m* to *f*, and *mp*, occurs in the verbal nouns. So also in Mg. *fahadimy ny*, *ampahadimy ny* (*dimy* 5). Compare Mg. "*faharoany*, *ampaharoany*, the second," for change of *fa* and *ampa* ; and compare Santo "*vakaruana*, second" (Gordon). For "to do a second time," the Mg. uses in the foregoing instances, the causative prefix without the verb substantive *ha,* as *manindroa,* for *maniroa, i.e., marua* = Epi. *varua* ; so for "to do a third time," Mg. *manintelo,* for *manitelo, i e., matelo* = Epi. *vatolu.* In Fa. and Sam. the causative of the verb substantive *(ka)* is used, as *bakatolu, faatolu, bakarua, faalua.* To turn the numeral into a verb, with very various meanings is common to Oc. and Se.: compare in Heb. the numeral 3, which treated as a verb, Piel form, has as one of its meanings (Ges), "to do a third time;" and the numeral 10, which in either the Piel or Hiphil (causative) form, means "to give tithes," "to tenth." In these it is not the verb form, but usage, that has determined special meanings.

It may be observed that just as in Pa. and Ma.-Ha. *va,* and *vaka* have about the same force (My. never uses the verb substantive, *ka,* thus) ; so Mg. *ma,* and *maha,* and *mampa,* and *mampaha,* have all about the same force, thus :—*isy,* to be, *manisy* and *mampisy,* to make to be ; so *vitrikia,* vigour, causative *mahavitrikia, and mampahavitrikia,* to make vigorous, to inspirit.

d. It will be noticed in the above that the Sam. causative of the verb *mate,* to die, is *tamate* ; that is the causative prefix is *ta.* This is a well-known causative prefix in the Ma.-Ha. Halevy (Ro. Gr. § 54) has observed that in most, if not all, of these dialects, *ta* is also employed as a causative prefix, "as Tahiti *tamā,* to cleanse, from *mā,* clean." It is especially common in Tahiti : see the Tah. Dict. s. v., where it is said to have the same force as *faa.* Sam. *faafana,* to warm food over again, Tah. *tahana,* Mg. *manafana,* and *mahafanafana.*

This *ta,* causative prefix, is the *tha* or *ta* that appears in Syr. Thaphel (Heb. Tiphel) of which we formerly spoke.

e. If we have in Oceanic the one form of the Semitic causative prefix in *ta,* it is only reasonable to expect to find the other *sa* (Shaphel or Saphel). In Fa. we have *fera,* or *berafera,* to be scattered, dispersed ; *taferafera,* scattered (reflexive to be explained below) ; My. *tabur* ; causative *sabera ki,* to scatter (anything) ; My. *sibar* ; Java *sabar* (and *mawur*), id. In Fa. we have *gara (kara),* strong ; the causative of which is *sigiri,* to strengthen, to make strong. In Sam. we find a word *vili* in *viligia,* to air, dry in the wind, and in *savili,* to blow. Compare *fue* and *safue,* to beat ; *lulu* and *salulu,* to shake. Compare also My. *salam* (Ja. *silam*) to dive, immerge, plunge, with *kalam,* to sink to to the bottom, and *dalam,* deep.

f. The signification of the Se. causative form is 1, transitive or causative; 2, intransitive; and 3, intensive: see the Se. Grammars, and particularly Syr. Gr. § 23, 2, and § 24, 2, comparing the Mod. Syr. It may be remarked that Saphel (Shaphel) is commoner in Fa. and My., and Thaphel (Tiphel) in Tahitian, than they are in, for instance, Hebrew.

Note 1.—The force and use of My. causative prefix *ma* (Ja. *a*) has been somewhat obscured by the enormous use in that dialect of the transitive suffixes, or rather suffix *i (ki)*, *kan*, yet Marsden rightly called it the "transitive prefix."

Note 2.—In Mg. *manka* (for *maka*), and *maha* are identical, being the one a mere phonetic variation of the other.

B. The Reflexive or Reciprocal.

In Mg., My., Fa., and Sam., along with the causative or transitive, we find the intransitive Reflexive or Reciprocal forms, now to be considered:

a. The simple Reflexive.

Mg.	My.	Fa.	Sam.
mi	*be, bar*	[*i, ia*]	[*ina, ia*, &c.]
i			
miha	Madura *e*		
iha			

Mg. *i* is the reflexive pronoun, self. It is identical with the personal pronoun, third person, in Mg., My., Fa., and Sam. In Madura, *e* is the same; thus causative Mg. *ma, a*, Madura *a*, reflexive Mg. *mi, i*, Madura *e*. This latter is called the passive (for which it serves), by Crawford. Fa. *i* or *ia*, is simply the pronoun, third person singular, used also for "self" in the accusative; and Sam. *i*, in *ina*, and *ia*, is the same, and used thus, forms in that dialect, and Ma.-Ha. generally, the passive, that is, the reflexive-passive.

Comparison—

The Mg. reflexive form compares substantially with the Assy. and Heb. *niphal*, Arb. *infala*, and Sab. similar forms. This ancient Semitic form is made by prefixing to the verb the reflexive pronoun (in Heb. *hin*), apparently the personal pronoun, third person, strengthened by the demonstrative *n*, and this *n* is often assimilated. This personal, in Heb. *hua*, *hia,* is identical with the Oc., Mg. *i.* Sam. *suffixes* both the Mg. *i,* as *ia,* and the Semitic *in,* as *ina.* Mg. also suffixes *ina,* using it for the passive, like the Sam.

It is remarkable that the Mg. and Javanese infix retains the *n,* as does the Semitic, thus Mg. *fitaka,* deceit, *finataka,* deceived; *faoka,* wipe, *finaoka,* wiped; *vidy,* buy, *vinidy,* bought. So Javanese *charita,* a tale, *chinarita,* to be told; *rayah,* to plunder, *rinayah,* to be plundered; *panggih,* to find, *pinanggih,* to be found, (Crawford, Diss. pp. 24, 27). The Arb. XIV. and XV. forms infix *n* after the second consonant of the triradical verb. So of quadrilaterals, the IIIRD form "corresponds to the VIITH of the triradical, with this difference, that the characteristic *n* is not prefixed, but inserted between the second and third radicals," Wr. Gr. § 71.

In Assy. the compound reflexive *tan* is infixed after the first radical in "Iftaneal," as *ictum, ictantum.* In Amh. this *tan* is prefixed.

b. The Reflexive prefix *ta.*

This, as already observed, occurs (see above, *A. e.*) in Fa. *taferafera,* My. *tabur,* scattered, of which see the causative in the place cited. So Fa. *tagara,* strong (Shaphel *sigiri,* to make strong), My. *tagar,* id. Fa. *folo,* to twist, *tafolo,* twisted, &c., &c. See Codrington, work cited, for this prefix in other Papuan dialects, pp. 183-4. Sam. *fuli, tafuli,* Fa. *tafulus; fo'i, tafo'i,* to turn over, return; *tagulu,* My. *dangkur,* to snore, Fa. *goro, koro*; My. *ngrok.* My *pelaka,* broad, *mitapelaka,* to be wide; *boroaka, taboroaka,* bored through; *borotsaka, mitaborotsaka,* to slip. My. prefixed *tar,* "passive," may be this *ta* and *r* reflexive pronoun (as in *bar,* see below): cf. Amh., as to *form* of compound *tan.*

Comparison—

Fa. *bora,* to slit, tear lengthwise, Arb. *fara,* id.; Fa. *tabáre,* to be opened (as a door), to be chinked, Arb. *tafarre* (VTH form) slit, rent. This *ta,* reflexive pronoun, is also the prefix of the Arb. VITH form; it compares with the Syr. *eth,* in Ethpeel, Ethpaal, &c. The Arb. VTH is made by prefixing this *ta* to the IIND, which is intensive by doubling, like Piel, the second radical. Hence in Fa. this form is often intensive, as *bisa,* to speak, *tabisa,* to speak earnestly; *usi,* to investigate, *täusi,* to investigate thoroughly, Arb. *takazzi,* id. Fa. *usi* is for *kusi,* the *k* being sometimes pronounced. This *ta* is prefixed in the three Eth. "Reflexive-

Passive" forms, and in the Amh. IVTH form (passive and reflexive."

c. The Reciprocal Prefix.

Mg.	My.	Fa.	Sam.
ifa	*be, bar*	*bi, fi* Fi. *vei* Fagani *fai* Mota *var*	*fe*

This combines the causative and the reflexive prefixes, the Mg. being reflexive and causative, the others causative and reflexive; and in Fi. and Sam., are suffixed also to the verb with this prefix, the transitive particles, *e.g.*, *ni* in Fi. *veilomani*, Sam. *fealofani.* The causative prefix alone, or aided by these, directs the attention away to a more distant and complicated object, to "one another," instead of "oneself" (reflexive form). But it is the same reflexive pronoun *i*, in both the simple Reflexive and the Reciprocal. The My. *bar* compares with the Mota *var* (Codrington), but *bar* forms intransitives, or the simple Reflexive, *var* the Reciprocal. Is this *r* = *diri* (My.) = self? My. *be* much used in talking (Marsden), as *bar* is in writing, may be identical with Sam, *fe.* Fa. *bi, fi* form is sometimes reciprocal, and sometimes intransitive or simple reflexive, like Malay.

Comparison—

The prefix in Syr. Ethtaphal, like the Mg. is reflexive and causative, Assy. *Itaphal,* and that in Assy. *Istaphal* or *Istanaphel,* is like the My., Fa., and Sam. causative and Reflexive; so (by "transposition") Syr. Eshtaphel. In these we have *eth* or *ta* (see *b.*), or *tan.* As to meaning, there is exact enough correspondence; "Eshtaphel has sometimes a passive, and sometimes a reciprocal signification, or it forms intransitives: see Syr. Gr., § 24, 2.

§ 11. THE PASSIVE VOICE.

In Oc., the passive voice is either formed by *a*, the reflexive pronoun attached to the verb, or *b*, a verb substantive, or *c*, it is marked by a prefixed *m.* As to *a*—

Mg.	Sam.
1. *ina. ana*	1. *ina, ia, a*
2. *fina, nina, mina* *sina, tina*	2. *fia, gia, lia* *mia, sia, tia*

In 1 we have the Oc.-Se. reflexive pronoun alone in *i, ia, a,* or strengthened by the demonstrative *n* (see § 10, *B. a.*). But here it is suffixed, there prefixed or infixed. In 2, the initial consonants *f, r, m,* &c., in *mina* or *mia, fina* or *fia,* &c., are the transitive or verb object particles: see § 9, *e.* Halevy (Ro. Gr. § §55-6) observes, "It is remarkable that some of the active verbs of the Eastern dialects seem to be derived from the passive forms of New Zealand, as . . . *kini,* N.Z., to pinch, passive *kinitia,* Hawaiian *'initi,* to pinch." This verb is in Fa. *kini,* as *kini naus,* "nip reeds," *kinitia,* "nip or pinch it." Thus *kinitia* is not passive at all in Fa., and the *t* is simply the transitive particle directing the action of the verb to *ia,* "it," or "self." When Fa. uses this *ia* (or *i*) for "self," as it sometimes does (with and without a transitive particle), the expression is always reflexive, not passive; on the other hand, in Sam. the expression is always passive, the original reflexive meaning having passed into the passive.

1. The Malagasy, rarely the Ja., often infixes this *in,* which the Mg. usually, the Sam. always, suffixes, and the original reflexive meaning has passed into the passive. The Mg. drops, or does not use the *n* with the suffixed reflexive pronoun in the "Imperative passive," as "*sotro,* drink, *sotroina,* is drunk; imp. *sotroy,* let it be drunk, *i.e.* drink;" prefixed to the verb in Mg. it is also without the *n,* and reflexive rather than passive, as it is also in Sam. and Fa. (prefixed): § 10, *B. a. b.* The Se. Niphal form is much used as a passive.

2. The reflexive pronoun *ta* prefixed makes a form frequently used as a passive in Oc. and Se. My *tar* forms a passive: § 10, *B. a. b.* As to the "change of the reflexive into the passive" in Indo-European, as well as in Semitic, see the Note in Ges. Heb. Gr. § 51, p. 86.

b. The passive formed by a prefixed verb substantive.

My.	Fa. (Pa.)
di.-, ka-	Fiji, *ra-, ka-*
Ja. *di-, ka-*	
(My. *kana*)	

My. *di* and Fi. *ra* are probably the same. My. *di* seems to be an abbreviation of the verb substantive *ada,* which is identical with Mg. *ary* and *ala,* Tig. *ali,* Eth. *halo,* see § 4, *b.*

In the Fa. *ra* does not form a passive, thus, *usi*, to follow, &c., *rausi*, to follow, literally, is following.

My. *ka* (and *kana*) is same as Fi. *ka*: for this verb substantive, see § 4, *a*. In Oc., as well as in Arb., it is found as an auxiliary, not only of tense and mood, but also of voice. Here as in Arb. (Newman, § 133) it is used "to make a passive verb, as in English." This formation is also found in Ma. and Mg.

c. The passive (in a limited sense) marked by a prefixed *m*. This *m* is the participial *m*, and it is of course not to it that the passive force of the word is due.

Fa. *baku*, to pluck out, *mafaku*, Sam. *mafa 'ifa 'i*, plucked out.

Fa. *ligi*, *ligisi*, to pour out, passive *maligisi*, *maligi*, Sam. *maligi*, poured out.

Fa. *lubaki*, to pour out, passive *malubaki*, poured out; reflexive-passive, *talubaki*, id.

Mg.	My.	Fa.	Sam.
malemy	*lamah*	*meilum*	(soft)
malemilemy		*meilumlum*	
manify	*nipis*, *mimpis*	*manifenifi*	*manifinifi* (thin)
mafanafana	*panao*	*(ben)*	*mafanafana*
mafana			Ma. *mahana*, warm

These are simply participles or verbal adjectives, and correspond to the Semitic participles or verbal adjectives, formed from the active or passive voice of the verb, by prefixing *m*. In Ma., *mahana* is an adjective, "warm;" in Tahiti, it is a noun, signifying "the sun," "a day."

d. The Fa. like the Mod. Syr., makes little use of the passive, and like the Mod. Syr. can only express it usually by a periphrasis.

§ 12. The Verbal Nouns.

a. The verbal noun suffix, *ana*, *an*.

In Mg., My., Fa., and Sam., a verbal noun is formed by suffixing to the verb *n*, *an*, *ana*; this in Sam. and Ma.-Ha., has been corrupted to *nga*, *anga*. This verb may have suffixed to it a transitive particle, before taking the verbal noun particle; thus My. *minum*, has the transitive particle *m*, to which the *an* is suffixed, giving *minuman*. Hina in Ma.-Ha. (cf. Halevy, Po. Gr. § 57), we have the simple *anga*, and with the transitive particles, *kanga*, *manga*, &c.; and so in Mg., My., and Fa., see § 9, *e*. In Fa. at least, the verbal noun, with, has a slightly different meaning from that without the particle; with it, it is active, without it, passive (cf. Halevy, loc. cit.) The verbal noun of *mate*, to die, is in Mg., *hafatesana*, My., *kamatian*, Fa., *namatiana*, Mangareva (Ma.-Ha.), *materanga*, (and *matenga*), dying, death. My. and Fa. are without a transitive particle, but Mg. and Mang. have the one *s*, the other *r*: see § 9, *e*. for lists.

b. The Verbal Noun Prefixes.

1. In the above words, *hafatisana*, My. *kamatian*, *ka*, *ha* is prefixed, and in Fa. *namatian*, *na* is prefixed. Fa. *na* is the article, and *ka* (*ha*), is an article also; see III. § 5. This article *ka*, with another pronominal element, *i*, as *kai*, prefixed, forms in Maori the verbal noun denoting the agent, as *hanga*, make, *kaihanga*, maker.

2. The relative article in My. forming the verbal noun denoting the agent, is *pa*, connected with the interrogative *pa* and for *ma*, see III. § 5. In Mg. this is *mp* (and *f*), as in the case of (the identical) participial *m*, § 10, *A*. *e*., note 2. Examples—My. *pambunuh*, Mg. *mpamono*, a killer, one who kills. The same relative article, My. *p*, Mg. *f*, is used with the verbal noun that is formed by the suffix *an*, as My. *pambunuhan*, murder; and Mg. has *fahafatisana*, as well as *hafatisana*, death. Mg. *fisotro*, drink tea, is an example of the *f* prefixed, without the suffixed *an*.

It will be observed that the suffix *an* gives the verbal noun a passive signification. Fa. *famien* (fami, to eat), may mean *eatable*, *to eat*, *for eating*, and *food*.

c. Comparison—

1. Suffix *an*. We find this in all the Semitic languages, and the word *korlean*, offering, may be taken as an example. In Eth., Dillm. Gr. § 122, -*an* and -*na* form abstract substantives, as, *berhan*, light, from *barha*, to be bright, and *erekan*, and *erekana*, nudity, from *areka*, nudus fuit; so Fa. *malamala*, to be naked, *malamalan*, nakedness. Dillmann says of this *an* " sie ist sicher fürwortlichen ursprungs." It is the common Se. demonstrative *an*, *na*: see III. §§ 1-2.

2. The prefixes *p*, *mp*, *f*, are all phonetic variations of the one original *m*. This is the *m*, of pronominal origin, that plays so conspicuous a part as a formative prefixed letter in the Se. languages, forming nouns from verbs. Thus the Aram. (cf. Ges. Gr. § 84, II. 14) forms the infinitive of the verb by it, and (Isenberg, Amh. Gr. 62) in Amh. "the infinitive or verbal substantive is formed by the prefixion of *ma* to the simple form." Dillmann (Eth. Gr. § 113) says: "dagegen ist der in allen Semitischen Sprachen vielgebrauchti Vorsaz *ma* im Sinne von *der*, *welcher*, oder *das*, *was* (der Fragewurzel § 63 entstammerd), auch im Aeth. überaus stark verbreitet um Aussagewörter, näbur Participia mit participähnlichen Adjectiven, und Sachwörter abzuleiten." Like Mg. *mp*, My. *pa*, this Eth. *ma* forms the verbal noun denoting the agent, Dillm. § 114. And like Mg. *f*, My. *p*, this Eth. *ma* forms nouns denoting the instrument, vessel, production, thing of any kind, action, manner of the action, Dillm. § 115.

§ 13. The foregoing discussion covers a good deal, but not the whole of the ground.

Corrections—

I. § 25. The comparison between *tomi* and *tome* is given up.

II. § 11, 3. It should have been stated that Sumatra *sakoorang*, 9, is perhaps from *sa*, 1, and *koorang*, "less."

Art. II.—*On the Fungi Growing in Mines.*

By Henry Thomas Tisdall, F.L.S.

[Read March 10, 1887.]

Part I.

The northern portion of the district between the River Thompson and the River M'Allister, in Gippsland, is covered with a series of hills, ranging from 1000 to 3000 feet above the level of the sea. These hills form three main ridges running northward, and culminating in Mounts Aberfeldy and Useful.

Geologically speaking, it is all of upper silurian formation, the stratification showing shales, sandstones, alternating with layers of hard diorite and quartz. During a trip with Mr. Reginald Murray, he pointed out the horizontal layers of basalt overlying the almost vertical rocks, Mount Useful, Mount Aberfeldy, Fullarton's Spur; in fact, nearly all the higher mountains in the district are covered in this manner, while the lower hills show no trace of later volcanic action. Masses of orthocerate limestone are found in the basin of the River Thompson. One enormous mass, over 200 feet thick, rises out of the Deep Creek.

Veins of quartz abound everywhere, and in some places it becomes auriferous. Cohen's reef is a splendid specimen of these auriferous veins; like the rest of the rocks in the district, the strike of this reef trends 20° west of north, and it has a westerly underlie. The lode itself is very rich in minerals, iron and arsenical pyrites abound, and for years it yielded an average of 2 ozs. to the ton. The total quantity of gold obtained has already reached nine tons. When first discovered, the gold-bearing stone was at the surface, but northwards it dips so much that long tunnels had to be driven, and shafts sunk in order to follow its course. In the Long Tunnel, for instance, the adit level was commenced about 100 feet above Stringer's Creek; it is driven in about 800 feet, principally through hard diorites intersected with occasional veins of quartz; at the end of the tunnel a large chamber was excavated about 100 feet long by 40 feet wide. Here are placed the pumping and winding engines, worked entirely by compressed air, obtained through iron pipes from an immense pneumatic engine outside. The shaft is sunk in the middle of the chamber, and has been opened out at every hundred feet in order to catch the ever-dipping lode. They are opening out now at the nine hundred feet level. The plan adopted for opening a level is to drive a tunnel from the shaft until it cuts the lode, then work upwards to the next level, removing everything between the hanging wall and the other side. This varies in thickness from five to fifty feet, the empty space is then filled up with mullock. The tunnels in the various levels are lined with round timber, about two feet in diameter, placed vertically a few feet asunder. The logs on each side of the tunnel are kept apart by cap pieces of the same size, heavy slabs, placed horizontally, reach from one set of timber to the next, thus covering both walls and ceiling with wood. In the older and unused tunnels this timber is covered with fungoid growths. Masses of white silky hyphomycetes hang from the roof, shaped like stalactites, and often reach four or five feet in length. The timber used in the mine consists chiefly of Eucalyptus Sieberiana, E. Capitellata, E. Obliqua, E. Amygdalina, E. Viminalis; the first of these, E. Sieberiana, is by far the best; it lasts many years. It is remarkable to see the great varieties of colours assumed by the fungi in the mines, when we consider that they never receive any light from the sun. White is certainly the prevailing hue, but black, red, scarlet, delicate pink, and all shades of brown and yellow, are quite common. An instance of the rapidity of growth of this vegetable product, came under my notice whilst in Walhalla. The manager had occasion to have a plat cleared of timber and well scraped at 12 o'clock midnight, at 6 next morning he was astounded at finding the whole plat covered with fungi. He immediately sent for me, and I found that not only were they fully grown, but the spores perfectly ripe. It was an Agaricus (Psathyrella). Berkeley gives wonderful instances of the rapid growth of fungi, and Dr. Lindley says that the cells of the Lycoperdon giganteum multiply at the extraordinary rate of 60,000 million in a minute. The growth of fungi, even when deprived of light is exemplified by Dr. Badham's story of a gentleman placing a cask of wine in a cellar by itself for three years; the cask leaked; a fungus sprung up, and grew to such a size that when the cellar was opened it was completely filled by this winebibbing vegetable, the empty cask was found on the top of the fungus, pressed closely against the roof. Dr. Carpenter mentions that the paving stones in the town of Basingstoke were completely lifted out of their places by the growth of Agarics underneath. The most noticeable plant in the mine is the Hyphomycetes already mentioned; it hangs down from the roof, sometimes by a narrow stem formed of loose fibres, then swells out very much, finally tapering towards the end. It is entirely composed of very fine silky fibres, interwoven so as to form a kind of fleece. So watery are these fungi that, having dried one five feet long and eighteen inches in diameter, it just weighed one ounce. On submitting a piece to the microscope, very small transparent cells may be perceived fastened like tiny nobs on the hairs, these are the spores, and they fall off in such quantities that the air is quite full of them; I feel convinced that the stifling suffocating feeling, which comes over any one that breathes the atmosphere of the tunnel for some time, is due to their presence. A curious species of Cantharellus is not uncommon, it is of a brownish-yellow, tinged with a delicate green. In the dark corners behind the posts, bright yellow patches may be perceived; these are polyporei. A very pretty Agaricus (Mycena) is found at the foot of partly decayed posts, it grows on the dust which crumbles off. In a future paper I propose to deal more systematically with this subject.

Art. III.—*Notes on the Occurrence of Glaciated Pebbles and Boulders in the so-called Mesozoic Conglomerate of Victoria.*

By E. J. Dunn, F.G.S.

[Read May 12, 1887.]

At Wooragee, near Beechworth, there occurs a conglomerate of peculiar character. In a base of fine clay are distributed in a heterogenous manner, well rounded pebbles and boulders of many varieties of schist, quartz-rock, sandstones, shales, granite, agate, jasper, porphyry, &c., and also angular and sub-angular fragments and masses of rock.

The approximate area of this conglomerate was communicated to the Mining Department in 1871. The depth is not known, but in the very early days of gold mining in this neighbourhood, a shaft was sunk 100 feet into it, at Magpie Swamp, without piercing the underlying rock. This conglomerate rests either upon granite or silurian beds. Outliers of similar conglomerate occur to the N.W. of El Dorado; at various points on the road between Wangaratta and Kilmore; and are also mentioned by Mr. R. A. F. Murray, in the Geological Survey Progress Report for 1884, as existing at Bacchus Marsh, at the Barrabool Hills, and in South Gippsland. In this report, a glacial origin is suggested, as best explaining the peculiarities of this conglomerate, but no distinct striations had been observed in the pebbles.

In New South Wales, what appears to be the same conglomerate, is described by Mr. C. S. Wilkinson, F.G.S., Government Geologist, and allusion is made to the great angular masses found in it, and a glacial origin also surmised, but no direct evidence was attained of striations.

Quite recently, while examining the conglomerate at Wooragee, I detected distinct striations on the boulders and pebbles, and also observed flat surfaces, and the peculiar fractures of the pebbles, so characteristic of conglomerates that have been formed through glacial action.

In South Africa, what appears to be the exact counterpart of this conglomerate, exists. It is known there as the Dwyka conglomerate, and it forms the base of a great system of fresh water strata. The lowest division of these beds is known as the Ecca beds or Lower Karroo beds. They are probably carbonaceous in the lower portion, and are characterised by an abundance of fossil wood (silicified), and by a *Glossopteris* that appears to be identical with the Glossopteris Browniana of New South Wales; also small sauroid remains. The second division is known as the Karroo beds, and best known for its richness in sauroid and other remains that have been so wonderfully worked out by Sir R. Owen. The third and newest division is known as the Stormberg beds, in the lower portion of which are the coal measures, and workable seams of coal. Associated with the coal seams, are shales thickly studded with fern impressions, among which Sphenopteris Elongata, Pecopteris Odontopteroides, Cyclopteris Cuneata, Taeniopteris Daintreei, &c., abound.

The glaciated nature of the conglomerate was established in South Africa in 1872, by the writer finding numerous examples of striated, grooved, and otherwise glaciated stones on the banks of the Orange River, but the full extent and the relations of this conglomerate to the Karroo beds was not fully worked out until last year, when my report on it was published by the Cape Government.

Sir R. Owen after having all the available fossil evidence before him, inclines to the view that the Karroo beds belong to the carboniferous period; if such is the case, the glacial conglomerate in South Africa must, at any rate, be palæozoic in age, and enquiry is suggested as to whether the Victorian conglomerate is not older than mesozoic.

Should the conglomerates on the two continents prove to be stratigraphically identical, they will furnish excellent bench-marks for working out the comparative geology of the two regions.

Examples of the striated stones from Wooragee, are placed in the Technological Museum for inspection.

Art. IV.—*On the Fungi Growing in Mines.*

By Henry Thos. Tisdall, F.L.S.

[Read May 12, 1887.]

Part II.

In accordance with my promise, I visited Walhalla during the Easter holidays, in order to secure some fresh specimens of Fungi from the Long Tunnel Mine. Mr. Ramsay Thomson, the manager, gave me every facility for exploring the mine; but warned me that the fresh timber and increased ventilation would greatly impede, if not entirely destroy, my chances of success.

I arrived on Thursday afternoon, and as the next day would be a holiday, Good Friday, I was only allowed to visit number three level.

This tunnel was dry and very warm, and I found the managers assertion was quite correct; for instead of having to stoop or almost crawl, as formerly, amongst half rotten timber, crushed down to less than three feet by the superincumbent rock masses, I found upright seven-foot posts supporting a good roof, the whole being well slabbed and made very comfortable for every one except myself, as, alas, fungi were apparently things of the past. After traversing nearly a thousand feet of the level, I was rewarded by finding a partly deserted nook, with roof and sides fairly covered with fungi. Hyphomycetes hung from the cap timbers, their fleecy masses taking innumerable shapes, the commonest being like a huge pear made of snow, hanging by a long thin dark stem. Amongst these I discovered a very pretty agaricus; it hung from the roof by means of a number of fine thread-like fibres, springing from about the centre of the pileus; these fibres join in one string, and are fastened to the partly decayed roof. The pileus was a pure creamy white, flattish, but the margin turned downward and then inward, margin not even, but bulging in separate lobe-like sections. In other specimens, the campanulate form, with a fairly even edge, was common. The lamellæ, at first a beautiful light orange, afterwards becoming brown; the gills were decidedly forked, fleshy, shallow and separated. These characteristics would place them amongst the genus Cantharellus Fe.

As I quite agree with the remarks made by our President at the last meeting, namely, "That the main object of an outlying Society, such as ours, is more the obtaining of facts and placing them on record, than of merely theorising concerning them," I am quite content, therefore, to state such characteristics concerning fungi as I am in a position to describe, leaving the responsibility of classification to such veterans in science as Dr. Cooke or Professor Berkeley.

To return to our cantharellus, the fibres connecting the pileus with the timber of the roof do away with the use of the stem, which is accordingly absent, and its place is shown by a raised ring, similar in width and thickness to the lamellæ. The plant is generally solitary, but very often three or four grow so close together as to overlap; and, in some instances, I discovered groups of several dozens springing from bundles of fine dark intermixed fibres.

A very curious hydnum was occasionally to be found hanging from the beams by innumerable fine silky hairs springing from all upper portions of the pileus, which consists of a rough whitish floccose membrane. The hymenium is spread over spines, which are cylindrical, or rather conical, very even, tapering towards the tops; each of which ends in a circular plane. These spines grow rather crowded, and are of an orange yellow colour.

It might be supposed that at a thousand feet below the surface seasons would cease to influence plants, but I found that many fungi were either altogether absent, or their hard dry remains only left to tell the tale. I was very anxious to explore the lower and damper levels of the mine, so I went down at midnight after Good Friday. In the sixth and eighth levels I found many fungi that would not grow in the dryer atmosphere of No. 3. I was particularly struck with some lovely agarics growing in tufts from the decayed remains of a hyphomycetes hanging from the roof, pileus campanulate, striæ very distinct, giving the edge a crenulate form ; so soft and brittle were they that I did not succeed in saving a single specimen ; however, I stood under an umbrella, up to my ankles in water, for nearly half an hour, to get a fair sketch of the plants with their surroundings. The lamellæ grow from the margin in two lengths, remote, white stem, almost translucent, long, attenuated towards centre, solid, with very short floccose hairs. In No. 8 level it was very wet, and fungi were to be found even on comparatively new timber. A semi-transparent polyporus is very common, hard, very uneven, all over knobs and excrescences, except where the hymenophorum appears, the pores are small, but deep and irregular, and the hymenium presents a bright orange, contrasting well with the browns and glassy grays of the matrix. Some of the slabs were almost covered with a creeping hyphomycetes, spreading out in all directions, in the same manner as lichens; they are protean in shape, some as fine as threads, creeping in radial form from a somewhat thicker centre ; in other specimens the branches get wider and wider until they look like ribbons, but the ends of all invariably split up into very fine threads. The foregoing are formed of exceedingly fine soft silky fibres, which take root in the timber as they radiate, making it impossible to remove them without destruction. In one species the substance is thicker and the structure is not so soft and silky but rougher, almost corky, although still brittle. This fungus is covered with excrescences, and all the specimens I found were divided into three thick branches, each ending in knobs thicker than the stems ; the knobs were coloured brown, whilst the remainder was white with occasional brown patches.

Another distinct species was leathery, and peeled off easily from the post on which it grew ; the structure was floccose, and all branches ended in from three to five pointed ends, even in the very young plants the clavate endings were distinctly visible. I noticed that the timber most liable to the attacks of fungi was that of the messmate (Eucalyptus Obliqua) easily recognisable by its bark. I should mention that the clavate endings were of an elongated cone-shape, white, and velvety to the touch, but much firmer than the rest of the plant. In a very wet part of No. 8 level the rotten timber produced a very pretty agaric, pileus campanulate, of a light lavender colour, striæ well-marked, making the edge of the pileus uneven. The stem long, solid and firm, the lamellæ white and remote. I was so impressed with its likeness to the agarics, which I found on the decayed hyphomycetes in No. 6 level, that I went back to compare them, but the colour, general shape and mode of growth are so different that I am convinced they are a separate species, though both evidently belong to the genus Agaricus Mycenæ, as the spores are white, the form campanulate, margin straight, and stem cartilaginous. In No. 8 level I found some very poor half dried specimens of an exeeedingly curious fungus, no living ones could be observed anywhere. Mr. Thomson has forwarded me some since, and I have examined them minutely. They grow in bunches, like wire grass, hanging down from the cross beams as long branched fibres. The stems are solid, varying from $\frac{1}{8}$ inch in diameter to mere threads. The cross section is nearly circular, flattening slightly where the stem branches, which it invariably does dichotomously. The mode of branching is peculiar; the stem becomes thicker and flatter, then stops short, and the twin branches sprout from each side, widening abruptly. The substance of the plant, as revealed by the microscope, is floccose, the fine hairs being closely pressed together. A thick, very dark purple bark surrounds the stem, this becomes brittle when dry, and sometimes scales off. At the tips of the branches the bark ceases, and a light coloured fleshy substance appears; this is quite white in the living plant, and is crowded with tiny spores, fastened like bunches of black grapes. The form of this fungus seems to me to bring the algæ and fungi into very close relationship; it looks exactly like seaweed, as it hangs from the roof, floating loosely in the air.

Some years ago my attention was drawn by a miner to an extraordinary vegetable production growing in No. 3 level, at the base of some rotten slabs; being anxious to watch its growth, I would not remove it, and I determined to copy it *in situ.* I obtained four candles, placed them on the ground with the flames touching, then I lay down at full length on the dry floor of the drive, and after a couple of visits, obtained a faithful, if not artistic copy of the fungus. The main portion of the plant was stiff, I might say leathery, and this was crossed by girdles made of fine white silky hairs, each of these hairs was dotted all round with spores. I visited the mine several times to examine the fungus, and as it seemed to retain its original form, I at length intended to remove it out of danger, but I had delayed too long; the ruthless foot of some passing miner must have kicked it from its hiding place and I saw it no more. Since then I have diligently explored, but was never successful in finding another specimen. A miner brought me a species of clavaria, which he said he had picked off a post in No. 3 level, but I have never been able to find one of that particular kind myself.

Many kinds of club-shaped fungus have been found by me in the mine, but I have not been fortunate enough to get sufficient data in the shape of spores, &c., to determine their proper classification. However, Baron von Müller has kindly promised to send the specimens to Europe, with my notes thereon, and doubtless, in a short time I shall be enabled to append a full and correct list of them, with descriptions in the Transactions of the Society.

I have questioned the miners concerning luminous fungi in the mines, but they say they have never seen any; this is singular, for agaricus candicans is very plentiful in the neighbourhood, and Humboldt is quite enthusiastic as to the splendour of some luminous species in mines. In fact, that is the only mention I have seen of fungi in connection with mines. Another curious proof of nature's modifying her apparently fixed rules, is exemplified in some of the agarics and hydnei which I found. The rules amongst these orders are, that the hymenium should turn from the light, and that the stem, if any, should support the plant above it. Of course, there is no light except the passing candle of the miner, but the hymenium faces such as there is; again, the stems in these plants are suppressed altogether, and fibres from the top of the pileus support the weight which is placed below it.

Turning from the plants themselves to their effect on those who are brought in close and hourly contact with them, I may premise, by stating the well-known fact, that fungi are plants that imbibe oxygen and exhale carbonic acid, this alone would have a prejudicial effect on those working in their neighbourhood.

Professor Berkeley, speaking on this subject, in his "Outlines of British Fungiology," says, "Fungi were long regarded as the mere creatures of putrescence, and therefore, as the consequence, not the cause of disease, but almost everyone is now ready to acknowledge what a weighty influence they have in inducing diseased condition. Unfortunately, the fungi which occur in the diseases of man, have seldom been examined by persons intimately acquainted with these fungi, so that the species or even genera in question are often doubtful. It is, however, certain that many of those which are found on different parts of the mucous membranes of animals, in a more or less advanced stage of growth, are like the fungi of yeast, referable to common species of mould. It is not probable, that in these cases, fungi originate disease, though they frequently aggravate it. The spores of our common moulds float about everywhere, and as they grow with great rapidity, they are able to establish themselves on any surface where the secretion is not sufficiently active or healthy to throw off the intruder. Where the spores are very abundant, they may sometimes, like other minute bodies, obstruct the minute cells of the lungs, but there is no reason to believe that they induce epidemic diseases."

I may here remark, that I had not seen the foregoing paragraph when I first formed the idea that fungi spores might have something to do with the lung diseases common amongst miners, but whilst hunting up information on the subject, I came across this passage which certainly upholds my preconceived idea. The greater proportion of the fungi which I have been describing, are certainly closely related to the moulds referred to by Professor Berkeley; in fact, I have very little doubt that they are nothing but huge overgrown members of the same family, swollen to extravagant dimensions by the heat and moisture by which they are surrounded. In Dr. Cunningham's report of his "Microscope Examination of Air," conducted in India (1872), he says, "That spores and similar cells were of constant occurrence, and were generally present in considerable numbers. That the majority of cells were living, and ready to undergo development on meeting with suitable conditions was very manifest, as in those cases in which preparations were retained under observation for any length of time, germination rapidly took place in many of the cells."

With reference to the size of these spores, Dr. Cooke remarks, that "The largest spore is microscopic, and the smallest known scarcely visible under a magnifying power of 360 diameters." Taking into consideration the confined space in which miners must necessarily work, and the immense number of spores from such a quantity of fungi as used to grow in the tunnels, I think we may safely take it for granted that fungi are, or were, deleterious to weak lungs. The next question then is how to get rid of them? The manager of the Long Tunnel at any rate has answered this question, to a certain extent, in a very practical way, for his repairs have nearly extirpated the fungi from some of the levels. But if we turn again to professor Berkeley's "Outlines," we find the following: "The rapidity with which spawn penetrates, and the depth to which it enters, is often quite surprising. The most solid timber in a few months will sometimes show unequivocal traces of spawn. I have seen, for instance, elm trunks which were perfectly sound when felled, penetrated by the end of the second year with spawn to within a few inches of the centre; and in this case it must be remembered that vegetation goes on in the trunk for nearly a twelvemonth before any fungi can establish themselves." Now it is simply absurd to suppose that a mining company could keep on constantly renewing timber to keep down these destructive pests. Several gentlemen belonging to our Society suggested painting the timber with certain acids, and I intended to try this plan at Walhalla, but my short stay prevented me; however, I have asked the manager, Mr. Ramsay Thomson, to paint certain marked posts with different acids, and so find out which is the best, and I have little doubt that he will accede to my request. The following remedies are mentioned by Berkeley—salt, lime, sulphate of copper, corrosive sublimate, and arsenic. If we are fortunate enough to hit on a really good and cheap remedy, we will not only be able to show how to extirpate an enemy to human life, but also to offer a premium to mine owners to use the remedy, for if the fungi in mines can be destroyed the timber will most certainly last twice as long.

Art. V.—*On the Production of Colour in Birds' Eggs.*

By A. H. S. Lucas, M.A. Oxon., B.Sc. Lond.

[Read May 12, 1887.]

The question of the cause of the coloration of birds' eggs has often been referred to, but has not, to my knowledge, been adequately treated of in any work on Oology. Perhaps we may consider the latest views on the subject to be those enunciated by Mr. H. Seebohm in his lecture at the London Institution, December 20, 1886. I had published in the Melbourne *Leader* of December 26, 1885, a popular account of the colours of Australian birds' eggs, in which I advanced suggestions which seemed to me to throw light on the subject. After reading the abstract in *Nature* of the interesting lecture by this high authority, I have thought it worth while to make a more formal scientific record of the ideas broached in the *Leader*.

My hypotheses may well be encountered with criticism, but they do serve at least very conveniently to connect a multitude of facts together. The antiquity of the Australian Avi-Fauna, and the preservation of ancient types, render a comprehensive consideration of Australian eggs of the greater value. My suggestions have been founded on studies of large collections, and after a certain amount of experience in the field. Australian eggs yield a rich abundance of facts which are of scientific interest *per se*, and which will be of still higher value if we can discern their bearing on biological problems.

We take it that the natural or original colour of birds' eggs is the pure white of the mineral substance (carbonate of lime) of which they are composed, just as the natural colour of bone is white, and that, too, of the shells of mollusca, &c. All shells are secreted by animal membranes. In the mollusca, an external layer of membrane usually remains free from admixture of mineral matter, as an animal epidermis, which can be peeled off. But this is not the case with birds' eggs; they possess a membranous lining, generally white, occasionally brownish or bluish, but outside this the animal substance and mineral matter are intimately commingled to the very surface. Colour, if produced, is then, in almost all eggs, ingrained. Often it can be detected incorporated in the inner layers of the shell, as blotches beneath the surface.

Birds' eggs have many foes. Even where man has not appeared upon the scene, a number of systematic nest-robbers exist. Snakes, the great lace-lizard (*Hydrosaurus* or *Varanus varius*), which takes such liberties with the settlers' hen roosts, the "native cats" (*Dasyurus viverrinus* and *D. maculatus*), perhaps the bush rats, and last, but by no means least, other birds, and especially the crows, are very destructive of our native birds' eggs, and of the young birds in the nest. To such intruders pure white eggs would be a conspicuous and gratuitous advertisement, and the birds would be exposed to undue danger while in the egg. As has been remarked hundreds of times before, we accordingly find that white eggs, and especially eggs of shining or pearly whiteness, are almost always found in nests which either conceal the eggs completely, or which are themselves completely concealed. Thus the cookatoos, parrots, parrakeets, and other members of the family, in almost all cases, build in holes of trees, usually high up and quite out of reach. Owls build in holes of large gum trees; kingfishers, including the laughing jackass *(Dacelo gigas)*, in holes of trees or banks; the diamond birds, the roller, and bee-eater, in holes in trees or in burrows. The penguins and many of the petrels lay their eggs at the extremities of long burrows in the ground, facing the sea. The eggs of all of these groups of birds are white.

The eggs of the doves, pigeons, and podarguses are beautifully white, often shining as if enamelled. The birds construct slight nests of twigs, placed crosswise on horizontal branches of trees. Much light can pass through the interstices between the twigs, and it is a difficult matter, even for the trained human eye, to detect from below whether there are eggs in the nest or not. Here the white, light-reflecting eggs are at a positive advantage.

The Australian finches conceal their eggs in the depths of relatively huge covered baggy nests, provided with side spout-like entrances. The eggs are in no way visible from without, are securely stowed away, and are pure white. All of the English finches, on the contrary, lay in open nests, and the eggs are spotted, usually, too, on a neutral-tinted ground. In this case we may presume that we have preserved the ancestral type in Australia.

Since a glaring uniform white must be a dangerous colour for exposed eggs, we are not surprised to find that variations, favourable to preservation, have been originated and preserved, and that colour is now a protection to the great majority of eggs. In all cases we have to consider two questions: (1) How could the colour have been acquired? and (2) How is the colour now protective or otherwise beneficial? That natural selection would be called into play to preserve favourable markings or tints we may allow, but we believe, with Mr. Seebohm, that "natural selection is not the cause of evolution" in this case, "but only its guide."

The first question then is, how could the colour have been acquired? and I do not know that anyone has attempted hitherto to give any answer to it. The following has occurred to me as a probable explanation of the process; at least the phenomena are referred back to principles already recognised.

In the first place, it is important to note that the shell of the ovum is formed in the third portion of the oviduct ("the uterus"), and entirely during the 12–18 hours which immediately precede the expulsion or laying of the egg. This is the length of the period in the case of the common fowl; we may assume, generally, a similar number of hours, probably shorter, in the case of the smaller species. That the formation of the shell is a process distinct from the formation of the yolk, is further brought before us strikingly, by an experiment of M. Tarkhanoff. He introduced a small ball of amber into the upper part of the ovarium, and obtained later on a quite normal egg, with chalazæ, albumen, and shell, but with the ball of amber in place of a yolk.

At the breeding season, the females of certain animals are well-known to be especially impressionable, and we think that the effect of the surroundings during the time of the formation of the shell, upon the mental or nervous constitution of the bird, is a main factor in the production of colour in the eggs. Any variations of value are seized on by natural selection, and transmitted by the principle of heredity. Individuals at the present day are influenced in part by the surroundings, but mainly restricted by the tribal habits of generations. We have, in fact, sufficient adherence to type for an experienced collector to be tolerably sure of the species of bird to which a particular egg belongs, but sufficient variation to make him wonder at the differences which often exist between eggs of the same clutch. As we find in all groups, that some species are more stable and less variable than others, so the eggs of some birds are apparently fixed in colour and pattern, while those of others vary within wide limits.

We will now consider in detail, the influence of surroundings, and the utility of the effects produced.

The general tint of the egg is often protective. The colour of the ground prominently before the vision of the laying bird, is reproduced in various shades in the eggs of the pheasants and partridges, and in our mallee hen (*Leipoa ocellata*) and megapode. In the rich brown variety of the egg of the domestic fowl, we probably see the colour developed in the feral state, now usually lost by reversion to the original white, as there is no longer advantage to be gained by its retention.

In addition to the protective ground tint, darker spots and markings lend further security. The eggs of the sand-pipers and dottrells cannot be distinguished, even when seen, from the sands on which they lie, without close concentration of the attention. Grouse and quail, rails and night-jars, plovers and terns, oyster-catchers and gulls, all lay on the ground, with or without nests, and the eggs exhibit different shades of the soil or of the rocks, with an appropriate ornamentation of spots, blotches, and smears.

White eggs become similarly less conspicuous if the white be broken up, by the introduction of spots or blotches of shading. This is a very simple, but by no means, ineffective means of avoiding detection. The eggs of the Australian shrike-thrushes, white-winged corcorax, and frontal shrike-tits, are good instances of exposed white eggs so protected. In many families it is noteworthy that those kinds of eggs which are quite concealed are white, while those which are exposed are speckled or freckled. In the tree swallows and martins, we find a graduated series. The eggs of the English sand-martin, laid at the ends of tunnels in soft sandstone, are quite white. Those of the Australian tree-martin which lays in spouts of trees, are very slightly spotted. Those of the fairy martin, laying in social colonies, under the eaves of houses, &c., are more freely flecked. Lastly, the English swallow, and the Australian welcome swallow, which builds under bridges, or in shallow spouts of trees, in more exposed situations, are plentifully covered with spots. So amongst English titmice (a family wanting in Australia), the only purely white eggs are those of the long-tailed titmouse, whose long and roomy mossy nest, with side entrance, often contains a clutch of a dozen or fourteen eggs. The warblers, the larks, and the honey-eaters, are other families of birds with spotted eggs.

The experiments of Jacob (Genesis xxx. 37-43) are recorded as having been successful in producing mottled colours in the animals under his charge. By the simple device of placing green rods before them at the time of conception, in which he "pilled white strakes, and made the white appear which was in the rods." "And the flocks conceived before the rods, and brought forth cattle ringstraked, *speckled* and *spotted.*" It is then not difficult to understand that surrounding objects of very different appearance, but of unequally coloured surface, might as readily produce spots and speckles on bird's eggs, as on the skins of mammals.

In the case of the honey-eaters, we may venture a surmise as to what the parti-coloured objects are which produce the spotted eggs. The eggs of these birds are of various shades of ground colour, white, buff, salmon, flesh-coloured, with small dots or flecks of purple, chestnut, reddish-brown, or even black. The birds, as their name denotes, may be seen busily extracting the honey from the flowers by means of their long tongues. Familiarity with pale and warm-tinted flowers and with the dotted orange, red, purple, or black anthers, may possibly account for the coloration of this type of egg.

Many birds which nest in trees or bushes have eggs which are of a pale or darker green ground hue, speckled or splashed over with olive or brown, reminding one of the different shades of the surrounding foliage, and, moreover, difficult to see from a distance through a bower of leaves. Such are the eggs of the crows, magpies, and crow-shrikes, the species of grauculus, the English black-birds, and the Australian mountain thrush and robins. In this case both origin and use of the colour are apparent.

Eggs with irregular streaky lines of bizarre appearance are found in a few families. In England, the yellow-hammers and buntings are good examples. In Australia, we have the *Pomatostomi.* The eggs of the latter are about an inch long and three-quarters of an inch at the widest, olive-brown, with all kinds of hieroglyphic pencillings in black. Both families line their nests with hair, and the eggs are protected by their resemblance to the lining of the nest. Gould similarly remarks, in speaking of the Victorian lyre-bird, "the colour resembles, in fact so closely, that of the feathers with which the nest is lined, that it is not easy to detect the egg."

Eggs of a pale bluish or greenish uniform tint are common. Such neutral tints are found in the grebes, cormorants, swans, ducks, and geese, the mangrove bitterns, the glossy ibis; and attaining to the deepest and loveliest shade in the herons. Just as the hue of the eggs of the pheasants, &c., may have been suggested by that of mother earth ever before their eyes, so these tints of the water birds' eggs may have arisen from the contemplation of vast sheets of water.

and the consequent impression upon the mental organisation of the parents. This peculiarity of colour, too, has been of service in rendering the eggs less easy of detection, as being of neutral hues, or as resembling, more or less, the water around or near the nest.

But the brightest blues of all occur, very exceptionally, in groups of birds of totally different habits, in no way adapted to an aquatic life. Such are, for instance, amongst English birds, the thrush and the starling, the hedge sparrow and lesser redpole, the wheatear, and to a less extent, the stone-chat and whin-chat. Amongst Australian birds, are those of the naturalised Indian or Ceylon mynah, the coach-whip bird, and the wedge-bill, and the species of *Zosterops,* a small family allied to the honey-eaters. Such examples, it is to be noted, are extremely scarce. It is difficult to surmise the causes which can have combined to produce this unique coloration. If the "motive" be protection, it must fall under the general principle, that intruders are shy of the brightly coloured objects. Some support for this view may be derived from Mr. Bates' well-known observations on deterrent colours amongst insects. It is difficult, moreover, to discover a blue in the surroundings of the birds, which could produce so pronounced a mental conception of this colour. It may be the blue of the butterflies on which they feed. It may be the blue of the aerial vault above. It would seem, if this second suggestion be the right one, that very few indeed of the birds have their attention attracted strongly by the azure of the skies, while they occupy their aerial homes.

The eggs of the ostrich vie in colour with the pale yellow sand of the African desert, in which they are buried for the sake of incubation by the sun's heat; but those of the emu, laid in the Australian bush, are, as every one knows, dark green. Here we have an indication that the Australian bush is not made up of yellow sandy deserts. The emu, in fact, scoops out a hole in the ground amongst low scrub, and contemplates eucalypts and salt-bush, and other dull vegetation. Its eggs are exposed and protected by their colour. The cassowary, laying and living amongst the bright green of the tropical grasses, and the vivid green of a more diversified tropical foliage, produces lighter and brighter green eggs.

With the birds of prey the mental perception of habitual surroundings seems to have been intense (as might have been expected from their known keenness of vision), and the influence upon the colouring of the eggs remarkable. The nests of the eagles, falcons, and hawks are large, and exposed on the tops of trees or on the ledges of lofty cliffs. The eggs are generally more or less blotched with rusty red, presenting a marked resemblance to old blood spots, such as the family are so well acquainted with. The nankeen kestrel breeds in spouts of trees, where, of course, the colour cannot be protective, yet the eggs retain the family peculiarity. Here we see natural selection apparently ruled out of court, and mental receptivity as the sole cause of the variations in the one specified direction. The eggs of the other members of the family are, from their situation, inaccessible, and it therefore seems very questionable whether the factor of natural selection has operated at all in the case of the eggs of this group.

We find very different degrees of development of the blotches. In one clutch of the sparrow-hawk *(Accipiter torquatus)* one egg was white, a second smudged, and the third well blotched. In a clutch of the goshawk *(Astur approximans)*, again, one egg was smudged, one smudged and blotched, and the other blotched. Similar gradations are to be observed in the average colour of the species. The eggs of the harriers *(Circus)*, which lay on or near the ground, and generally among thick scrub, and those of the crested hawk *(Baza subcristata)*, which builds in the holes of trees, are pure white; and we have gradually more and more colour introduced, until the climax is reached by the brown hawks *(Jeracidea berigora)* and kestrels *(Tinnunculus cenchroides)*.

Great irregularity and much play of variation amongst individuals, characterise eggs, which derive their colour from changing and varying appearances. We obtain thus a natural explanation of the infinite variety of colouring in the eggs of the rapacious birds, and of such birds as the magpies and the sparrows.

Many birds continue to protect their eggs themselves, consciously or unconsciously. Some, as the partridge, will cover up the eggs when they leave the nest. The grebes lay eggs which are at first white, but become stained by mud from the body of the sitting mother bird, usually brown and gradually browner, a tint well in keeping with the colour of the nest, of the dead reeds and leaves. Many of the sea birds, too, by fouling their eggs, no doubt materially assist in preserving them.

The English cuckoo commonly chooses the nests of larks or of wagtails for its egg. When found in the nest of a lark, especially of a tit-lark, the egg is very dark; and when found in that of a wagtail, much lighter. This looks like proof positive of the effect of mental impression in producing the colour of the egg. More rarely, the egg of the cuckoo is found in other nests, such as that of the hedge sparrow. It is most likely that in this case, the cuckoo had in the course of nature laid its egg, and not being able to find an appropriate nest near, was driven to make use of that readiest to hand. For nothing could be more conspicuous than the contrast between the colours of the eggs. Our Victorian cuckoos are likewise eclectics. The pallid cuckoo often plants its cream or flesh-coloured and spotted eggs in the nests of honey-eaters, the eggs of which its own thus resemble. The bronze cuckoo patronises the dome-shaped nests of little birds, in which the egg will not be seen, and into which it doubtless conveys its egg by means of the bill, for the cuckoo is much too large a bird to obtain entrance into the nest by the tiny opening which serves for the rightful owners. The brush and the narrow-billed cuckoos place their eggs in the nests of superb warblers and acanthizas, and the eggs of both are white, with very fine dots.

The subject it will be seen is as yet still entirely in the domain of observation. Experiments are wanting. It is to be hoped that they will be forthcoming. Opportunities exist, notably in the case of the domestic birds, and of birds which breed easily in confinement. But we must not expect too much, to be able to produce extreme effects. Mr. E. B. Poulton's interesting series of experiments on the production of colour in the pupæ of certain British Lepidoptera, show that the capacity for variation in each species is (for a single generation) limited, and that the variations tend in quite definite directions. It is probable, however, that results of sufficient, and perhaps in some cases of striking, interest are to be obtained by careful and systematic experimentation. And the field is open.

Art. VI.—*The Geology of the Portland Promontory, Western Victoria.*

By G. S. Griffiths, F.G.S.

[Read June 9, 1887.]

The area which I propose to describe is a promontory, terminating in three bold rocky headlands, Capes Bridgewater, Nelson, and Grant, and two open bays, and these features jointly constitute one of the most southerly extensions of Australia. The town of Portland, which gives its name to this promontory, is situated on the eastern side of its neck.

If we take a map of the locality, and run a line from Narrawong due west, until it cuts the beach at Discovery Bay, it will mark the base of the promontory, which we shall find to be about twenty-two miles across, while the length of its coast line is some sixty miles. The promontory is for the most part a low table land, which increases in height as we go from north to south, and which has bold bluffs for most of its sea margin. Where the coast is low, as it is between Whaler's Bluff and Narrawong, the strand crosses the site of a former shallow arm of the sea, the bed of which has been elevated just sufficiently to form dry land, and the old margin of this ancient bay is formed in part of bold bluffs, similar to those which edge so much of the promontory. The surface of this tableland is very undulating, which characteristic is, on the south-western edge, largely due to the presence of sand dunes, and elsewhere is the result of unequal erosion. Its highest points are Mount Richmond, 740 feet high, and the extinct Bridgewater volcano, 449 feet.

I.—Its External Relations.

From a geological point of view, the Portland Promontory is but a corner of a large area occupied by upraised seabeds of Tertiary age. Some time in the Eocene, if not before it, the south coast of Victoria and South Australia was depressed, and the ocean extended several great arms for considerable distances within the present shore line. One of these gulfs stretched from near Adelaide to near Geelong, and occupied a great part of the valley of the Lower Murray. The Grampians and the Otway Ranges were islands in this tertiary sea. Miocene marine beds are exposed in the banks of the Murray at the north-west bend, and in the cliffs of the south coast, in patches from the head of the Australian Bight to Western Port, and a snow-white horizontal stratum of that formation is visible in the craters of some of the volcanoes which stud the centre of the region. These miocene beds rest unconformably upon mezozoic rocks at Cape Otway; upon paleozoic rocks in South Australia; and upon both of these formations at different points around the Grampians. They are nearly everywhere covered by beds of a more recent age, and at Portland, the miocene rock forms the base-course of the cliffs.

The area having been covered with marine deposits, was then raised sufficiently to expose them to view, and these, with others of æolian or volcanic origin, which are superimposed, will form the subjects of this sketch.

II.—The Portland Promontory.

In this locality the undermentioned formations are exposed, but I would remark, that no single section anywhere contains all the members:

Recent.—The sand dunes of the coast; the marine sands and clays of Narrawong Bay; the marine shell bed of Nelson; the latest lava flows of the Bridgewater volcano.

Pleistocene.—The false bedded or æolian limestone; the lower lava flows of Bridgewater.

Pliocene.—The lava flows of Nelson, and the lowest flows, with the bedded volcanic ash, of Bridgewater.

Upper Miocene or Upper Murravian.—The oyster bed of Whaler's Bluff; the lava flows of Portland Bay.

Lower Miocene or Lower Murravian.—The foraminiferous limestone, or chalk with flints, of Portland Bay.

III.—The Miocene Formations.

The foraminiferous limestone, or chalk with flints. This rock is a conspicuous feature in the cliffs at Portland. The exposed portion forms a syncline about two miles long, the crest of which rises some thirty feet or so above the beach at the Whaler's Bluff, whilst the extremities dip out of sight at the lighthouse to the south, and at the Narrawong siding to the north.

The upper edge of the synclinal fold has a serrated appearance, probably due to the slipping down of masses of the much decomposed miocene basalt, which forms the upper portion of the cliff.

The rock is a snow-white material, moderately hard, but friable, and very porous. Its matrix is a chalky dust, a mass of microscopic foraminifera, which have been identified as being for the most part, globerigina bulloïdes, and orbulina universa. There is with these an abundant admixture of bryozoa, echini, pectens, terebratellæ, and pteropods, all more or less broken, and an occasional fishbone. The coarser ingredients are often arranged in layers one or two inches thick, and of considerable horizontal extent. These layers stand out in a slight relief on the cliff face, and this seems to be due to the presence in them of great numbers of siliceous organisms, which afford, by their partial decomposition, a siliceous cement, less affected by weathering than the calcareous cement which elsewhere binds the mass.

This chalk-like limestone is overlaid, conformably as it seems, by a bed composed principally of oyster shells (*Ostrea Sturtiana*). Owing to the talus of loose decomposed lava from overhead, it is not easy to say what may be the exact thickness of this bed, but I think that it probably averages a foot.

These two formations, the limestone and the oyster bed, weather more slowly than the volcanic rock above them, and consequently, the cliff face, where it is built up of these different materials, presents a section having a marked character. The portion composed of lava, slopes at an angle of about forty degrees, while that of limestone is almost vertical. (See Sketch H.)

These formations (the limestone and the oyster bed) are exposed at the surface only in one locality, that of the Borough of Portland. The outcrop there extends from the Courthouse, along the Cliff Road, to the bridge at the mouth of the Wattle Hill Creek, a distance of about a quarter of a mile, and thence it runs inland up the valley, for about a mile. The creek has cut through a great thickness of volcanic rock, and it has eroded to a small extent the underlying chalk limestone; thus the exposure of the latter at this spot is to be accounted for.

Although the chalk-limestone dips under foot at the Portland lighthouse, and is not again visible until the South Australian border is approached, yet there is evidence of its continuity. It must outcrop in the sea bed, not far beyond low water mark, and that frequently, for flints derived from it are plentiful on the beach as far as I went, viz., up to the east end of Discovery Bay. At Danger Point I found, thrown up on the lava rocks, a block of this chalk, about 20 lbs. in weight. The mass was clasped by the roots of a thick fucus *(macrocystis pyrifera)*. Probably the seaweed had been violently torn up in some storm, and being very tough, it had wrenched the block of chalk, on which it had grown, out of its sea bed, and then had, by its great buoyancy, floated it ashore. Again at Bridgewater, there is a stratum of pure white colour, which forms a most conspicuous undulating stripe along the cliff face, for it is sandwiched in between ash-beds of a dark brown or buff colour. It is about five inches thick. It appeared to be the ejected powdery débris of a chalk substratum, that had been drilled through as the vent of the volcano was being formed. There can be little doubt but that the rock occurs there at a comparatively shallow depth.

Investigations by the Rev. Julian Woods and Professor Tait, into the fossils of these formations, and of their extensions along the coast and elsewhere, place the oyster beds in Upper, and the foraminiferous limestone in the Lower the Murravian series—respectively the equivalents of the Upper and Lower Miocene.

IV.—The Volcanic Rocks.

Rocks of volcanic origin cover a large portion of the Promontory. The most considerable accumulation occurs along the south-west shore of Portland Bay. It extends from Cape Grant to the Narrawong siding; thence it turns to the north-west, or inland; its thinned edge crosses the railway line near the nine mile post; it overlaps Bat's ridges on the north side of them; and then it dips under the falsebedded limestone at the Black Gully on the Bridgewater road. Probably there are outliers of this much eroded rock outside of this area, just as there are small patches of the underlying limestone exposed within it.

The Rev. Julian Woods thought that this lava flowed from a crater situated where isolated rocks now form the group known as the Laurence Rocks. I know of no facts inimical to this theory, and the circumstance that the lava beds thin out as they recede from that neighbourhood is in its favour. I searched carefully for elongated vesicles in the lava, as evidence of the direction of its flow, but could find none *in sitû*, though I saw them in many of the loose boulders, where they were valueless to me. It is right to say, that Mr. Dennant, F.G.S., questions this view, on the ground that the Laurence Rocks are capped with limestone and not with ash, as asserted by Mr. Woods. As I did not visit the islets, I cannot say which of these authorities gives the correct facts, but it seems to me that such a low vent might easily have become covered up with a limestone deposit subsequently, and, therefore, I think that Mr. Woods may be right in his theory as to the location of the crater, even if he should prove to have been wrong as to the nature of the capping.

The lava of this area is in some places at least 150 feet in depth, but the mass is built up of an enormous number of separate flows. These vary in thickness from one to ten feet. The beds are lenticular in transverse section, and none that I saw were more than 100 yards wide. They are bedded more or less horizontally. The thickness of the whole mass varies greatly within short distances, and I think that much of this inequality is due to aqueous erosion, for the most marked differences occur in the neighbourhood of the existing or of the sites of former watercourses. The biggest of these have but a feeble flow now, though it is likely that during some portion of the post-miocene period their streams were of a much greater volume than they are to-day, and consequently, that they then had much more power. This eroding action has been further promoted by the fact that the coast edge has been rising rather faster than the parts inland; for just as a circular saw cannot cut into a log unless the latter be pushed against it, so a stream, that has reached its base-level of erosion, cannot deepen its channel, unless the latter is being raised so as constantly to expose a lower stratum of of its floor to the scour. The south-east margin of this peninsula has cockled up, but the flowing water has preserved its channel by cleaving the rim to sea level.

In places the lava lies immediately upon the miocene shell bed, but I did not detect any changes in the latter, such as are usually caused by contact with heated masses.

I was much struck with the great differences in colour, degree of hardness, vesicularity, decomposition, and thickness of bedding, displayed by the lava within short distances.

Woods has tested the rock, and he assigns to it the following composition :—

$Si. O_2$	...	...	...	·60
$Fe. O.$	...	...	...	·20
Al_2O_3	...	...	...	·10
$Ca. O.$, $Mg. O.$, $H_2O.$	...	...	...	·10
				1·00

He terms it an augitic or doleritic lava, and it seems to me that it might equally well be called an andesite.

A fine grained yellow, slightly vesicular and very decomposed lava occurs in a little bay immediately south of the lighthouse. It is found at, and a little above, the low water level, and its softness probably accounts for the formation of the little bay. Similar flows occur at the sea level in all the indentations between this bay and Danger Point, and I noticed that wherever the coast juts out the rock at the sea level is a dark durable lava. The yellow lava appeared to me to be of a more acid nature than the darker kinds, for it preserves its light colour even where it is very hard and undecomposed. At Black Nose Point the rock is a dark massive hard basalt, and it is so very vesicular that a gas cavity, which I measured, had a major axis 18 inches long and a minor one measuring 12 inches; and I saw many others as large as it. A tiny rivulet enters the sea near to this point, and thereabouts the cliffs lose their height, and then the coast forms a low double shelf. (See Sketch K.) A pebble ridge extends from this place to Danger Point, a distance of one mile. The boulders are of basalt, with an abundant admixture of rolled blocks of volcanic ash, and flints. The ash may come from the Laurence Rocks, one mile to seaward of the ridge; but if it does not, it is hard to say whence it is derived, as there is no other deposit of the material, known to me, nearer to it than Cape Bridgewater, which must be 15 miles distant. This volcanic formation dips out of sight under pleistocene limestone about two miles to the west of Cape Grant.

Another volcanic flow occurs at Cape Nelson. The traveller from Portland strikes the south end of Nelson Bay, at a point about two miles from the lighthouse. He there finds himself standing on the brink of an amphitheatre of limestone cliffs, almost vertical, and in height from 150 to 200 feet.

The beach which fringes the centre of the bay disappears towards its two seaward extremities, and here the lofty cliffs are undercut by the waves. Hereabouts also, there is a slight bend in the line of cliff, low down on the salient angle, of which a bed of black lava is a conspicuous feature in the buff coloured wall. It is about three or four feet thick; it appears to be about thirty feet above the sea level, and it dips inland, *i.e.*, to the south-west, at an angle of about six degrees. The same bed re-appears in the next jutting point, which is distant about 300 yards to the south. A second flow appears below it, some twenty feet thick of limestone lying between the two beds. The bottom flow forms the base of the cliff. Here again, the dip of the flow is inland (south-west), but the angle is about ten degrees. (See sketch T.)

As the cliffs were inaccessible, I had to make my observations from above, at a distance of about 250 yards.

The lava again creeps up the cliff from under foot as we proceed south, and it forms its base, from this point outwards, all round the cape. I was able to descend and examine it only at one point, and that was under the lighthouse. The cliff there is 180 feet high. The upper 100 feet consists of a current bedded calcareous sandstone (termed by me limestone, for brevity), and the lower 80 feet of black lava, the latter formation apparently subdividing again into two major divisions, each about 40 feet thick, and each made up of several flows. The lava forms two platforms, and the cliff has a profile shown in the sketch. (See sketch M.)

The under surface of the limestone is as level as a shelf, and in some places, it projects over the lava as much as 20 and 25 feet. (See sketch J.) The latter weathers the faster of the two rocks, and its face is tattooed with the concentric rings of brown and yellow, characteristic of the decay of lava. From the centres of many of these boulders nodules of darker rock project, and a great number of greenish-white zeolites stud the surface of the lava, standing out in bold relief. Streams of hard water leak out at the junction of the two formations. These have coated much of the lava with a crust of slippery magnesian travertine. Its colour varies between shades of dirty brown and dirty green, but these tints may be due to the growth of microscopic plants on the moistened surfaces. Every pool in the upper rocks has a margin of lime crystals, due to the evaporation of this hard water. As the water drips from the limestone cornice it forms stalactites, the white forms of which, being relieved by the shadow cast behind them by the deep ledge, stand out as a rude dog-tooth moulding along the junction. (See sketch V.) The step-like profile of the cliff indicates a change in the sea level. Volcanic rock appears to underlie the whole of this cape. It dips under limestone in Bridgewater as in Nelson Bay, but what its northerly extension under the limestone may be, it is impossible to say.

The third occurrence of volcanic rocks within this area is at Cape Bridgewater. The dunes end, and bold hills begin, at the west end of Bridgewater Bay, half way between Vance's and McKinlay's. At the point where the fishermen's undercliff road starts, smooth wave-worn tabular rocks peep up through the sand of a wide beach, between the high and low water marks. These are stratified ash beds of a buff colour, but they are speckled with minute black cinders. The layers are each from one to four inches thick, and the tint of each is proportioned to the abundance of the cinders. On the beach one hundred yards south of these ash beds other smoothed rocks crop up, but they are composed of a dark hard lava. Immediately beyond these rocks, beds of both ash and lava are to be seen in the face of the cliff. The ash here is intensely hard, and is very massively bedded. The colour of the upper part is buff, and that of the lower is brown, and the upper edge of the brown bed forms a syncline. The dip of the beds varies both in angle and direction within short distances. The angle of those first seen does not exceed ten degrees, and their dip is north-east; but near McKinlay's (half a mile further south) the dip is first east, then east south-east, while their angle has risen to 40°. The ash begins to contain larger scoria as we go south, and these have their vesicles filled with amygdules. The upper edge of the ash is some 25 feet above the beach, and the upper part of the bold cliff is composed of the false-bedded limestone, first noticed at Cape Nelson.

At the fishermen's huts, the limestone rests directly on the lava, but it is unaltered along the plane of contact.

About a quarter of a mile south of the fishermen's huts the cliff shows an interesting section. At the top there is about 40 feet of limestone, then 30 feet of thick bedded lava, 3 feet of olive green ash, in thin layers, then eight or nine distinct shallow flows of black slaggy lava ; and under these 5 or 6 feet of olive green bedded ash, and then the face is marked by a bouldery beach. The special feature of the section is the lower lava flow. The nine thin beds of the latter form a mass crescentic in section, with the horns pointing slightly downwards. It is about 20 feet thick in the centre, and at a distance of 50 feet on either side of the central point it tapers out. No parting material separates the several flows; the lowest lies conformably upon an ash bed, and is tolerably compact, but the top one has a slaggy scoriaceous surface. The south edge of the flow is truncated, by the cliff turning sharply to the west, so as to give a section of it almost at a right angle to that just described. In this longitudinal section the lava and ash beds are seen to have a dip to the east of forty degrees. (See sketches X^1 and X^2.)

About 50 yards south of the crescentic-sectioned lava beds, the ash beds are traversed by a vertical lava dyke, which, emerging from the sea, rises to a height of about fifty feet. It is composed of two slabs of about equal size, the total thickness of the dyke being about two feet; its strike is north-east and south-west. The ash beds are darker for a few inches on either side of it, as if they were somewhat burnt.

Mr. Dennant has recently stated, that this dyke joins the overlying basalt, and his paper contains a drawing showing such a junction. After a very careful examination of the cliff, I must say that I could see no such confluence. The dyke tapers to a point at the top, and terminates in the ash at a considerable distance beneath the lava. There may be a junction, nevertheless, though it is not visible in the section. To the south of the dyke most of the cliffs rose sheer out of deep water, and could not be reached. Examined through a glass, they presented a solid smooth wall of ash 250 feet high, and nearly vertical. It will be noticed, that between the first place of appearance of the ash and this point, a distance of half a mile, the ash beds have increased in thickness from 5 feet to 250 feet, and their dip has increased from ten to forty degrees. The cinders contained in the ash have increased from the size of peas up to that of blocks a foot long. At some points I noticed pseudo-dykes in the ash, formed of a sort of soapstone.

Having ascended the cliffs from the fishermen's huts, I found that the limestone disappeared about half way up the hill, at about 200 feet above sea level, and lava, weathered into boulders, then showed through the turf. When nearly over the dyke, I found that the hill rose inland from the cliff edge very steeply. Its crest is a few hundred feet distant from the cliff edge, and it has an altitude of 449 feet. Over an area of six or seven acres the surface is a mass of rugged lava. Immediately to the north of this outcrop is a a slight hollow or dell, in extent about one acre. This depression may be the nearly obliterated vent of a small and much decayed volcanic cone. A lava flow extends from the rocky crest towards the south-west; it is about a chain wide and a quarter of a mile long, and it does not reach the sea. This flow has a quite fresh look, and it is the only one within this area that I have seen, which has such a very recent appearance. Both the strike of the lava dyke and the dip of the lenticular lava bed are directed towards this crater. The dip of the ash beds from a point near Vance's up to Cape Bridgewater forms a series of radial lines, which centre here also, and if the strikes of the several beds were worked out, I believe that they would form segments of circles grouped around this hill.

About a mile south from the crest of this extinct volcano, the cliffs, from trending south-east, turn abruptly to the west. This corner forms Cape Bridgewater. Directly the cape is rounded the ash beds dip steeply to the north-east, and disappear under level bedded lava flows, which then form the whole height of the cliff. A mile to the west this cliff is 150 feet high perpendicular, and built up of level layers of solid lava, as regular in their courses as mason work. A thin stratum of the false-bedded limestone and some loose sand cap the whole. (See sketch P.)

At Liddle's Watering Place, a spot some three miles north-west of the crater, the cliffs are 130 feet high; the lava portion being about 70 feet, and the limestone 60 feet thick. The lava is hard and dark, and occurs in rude hexagonal columns. It has been cut into two well-marked wide platforms, and the upper one is greatly encrusted with travertine, deposited by the calcareous springs. (See sketch R.)

It will be noticed that the height of the lava in the cliffs just west of Cape Bridgewater is 150 feet. At Liddle's it is only 70 feet, and at White's, only a mile away, it disappears altogether under the limestone, which, appearing at the Cape as a layer a foot or so through, becomes 60 feet thick at Liddle's, and is still deeper at White's. Therefore it appears to me, that this cinder cone was breached on its south-west side, at the extreme point of Cape Bridgewater, where the wall of ash ends abruptly, leaving a chasm which was then filled to its brim with lava flows.

I set down the ages of these volcanic rocks as being pliocene, pleistocene, and recent. At Portland the extremely decomposed and oldest flows lie conformably upon the Upper Miocene oyster beds. At Nelson Bay a lava bed is intercalated between beds of limestone of pleistocene age, and at the Bridgewater crater a great thickness of rock is crowned by a little lava flow, already described, which looks as fresh as if it had welled out but a few years ago, although the lower flows dip under the pleistocene limestone.

V.—The Pleistocene, or False-bedded Eolian Limestone.

This is the most extensive formation exposed in this district, and its position upon the western or windward side of the promontory, challenges attention when we are considering its mode of origin. The rock is a moderately compact breccia, composed of broken marine organisms, mainly shells, cemented together by a calcareous paste, which is coloured by iron oxides. These latter give to the strata various shades of red, yellow, and grey. The stone appears to harden with exposure, and this probably is the result of the more complete solidification of the external portions, by the infilling of all the interstices of that part of the breccia, with travertine, supplied by the soakage through it of rain and spray, carrying carbonic acid.

The composition of the rock seems to vary slightly from point to point, for Mr. Woods describes it as containing lime, magnesia, and silica, with traces of sesqui-oxide of iron, and sulphate of lime, while Mr. Dennant says that it is a carbonate of lime, with four per cent. of silica.

The formation is composed of beds from 10 to 20 feet thick, and these are disposed horizontally. They are all markedly false or current bedded, the minor laminations being about two inches thick, and seldom longer than 15 or 20 feet. The latter dip in all directions, and at all angles up to about thirty degrees. Mr. Dennant asserts that their dip is often *quâ-quâ-versal,* though I cannot confirm this statement. I understand, that a dip to be *quâ-quâ-versal,* must slope from a centre, but I have discovered none that were so arranged; still, if the term may be stretched to describe strata which, being contiguous, dip in all directions, but which nevertheless, have no relation to any common centre, then I can admit that it is applicable in this case.

Another statement made by Mr. Dennant is, that the laminations of the strata are "always parallel to the bedding planes." My observations failed to discover any example of this parallelism. The laminations were at an oblique angle to the bedding planes in all the sections that I saw, and I noticed that nearly every stratum was characterised by a mean angle of dip peculiar to itself, and that this mean angle was persistent in the same stratum, over long distances. The section at Liddle's Watering Place is an interesting example of this peculiarity. (See Sketch R.)

The formation is very barren of fossils, but Professor Tate has discovered in the South Australian extension of the deposit, land shells at various depths. Upon the evidence afforded by these land shells, the rock has been pronounced to be of an eolian origin. Mr. Dennant believes that it is a mass of consolidated sand dunes, and states that the outline and structure of the original dunes are displayed in some of the cliffs, but I have not been able to recognise them, even in the "Cloven Rock," the locality which he instances. The stratification of the rock, as illustrated by the Liddle's Watering Place section, is I think, incompatible with the view that the formation consists of sand dunes merely consolidated, for there, each stratum has its own horizontally arranged peculiarities of colour and lamination, a feature which is not illustrated in the sections of any sand dunes that I have seen, and which could not be produced, as far as I know, where the materials accumulate upon the undulating surfaces assumed by blown sand.

It may be said that the horizontal bedding planes are merely divisional joints, due to changes in the materials occurring subsequent to their deposit. Were such their origin then, the false bedding would, as often as not, pass out of one stratum into the next, and the colouring matter would be distributed without reference to the lines of joint. Now, I have already said that each pair of bedding planes enframes its own pattern of dip, and that it outlines a particular tint. Such a linear distribution of these features must indicate a different age, and a separate, though otherwise similar origin for each stratum in the formation, and if this deduction be allowed, then it must also be admitted that the rock cannot be merely consolidated sand dune.

The embedded land shells would appear to indicate that its origin must be eolian, but it seems to be equally clear, that the several strata must have been, *ab origine*, so many distinct formations deposited at different times, and under conditions which, although mainly similar, were variable in some minor respects. It seems to me that each of these rock courses is but the truncated remnant of a separate generation of sand dunes, a thin horizontal slice of their confluent hardened bases. What agency is there that could grind down such mammillated deposits, until but a a thin veneer of the material of each one is left? The only one known to me is that of the sea, assisted by repeated slight land oscillations. Rapid and repeated changes in the sea level are not improbable occurrences upon a coast line which is studded with volcanic craters, and scarred with raised beaches. The latter phenomena testify to a condition of unstable equilibrium existing between the subterranean forces, which would account for the mobility of its surface, and would explain its alternate emergence and immersion; its burial under a beach drift at one period, and its disappearance under a shallow sea at another.

This limestone deposit does not appear to be a thick one, for many years ago, two bores were put through it in a search after coal in Nelson Bay. The records of the strata passed through appear to have been lost, but Mr. Must, who with the Messrs. Henty, controlled the enterprise, tells me that the first bore was sunk on the top of the limestone cliff, and that it was stopped by basalt. The second one was started on a ledge which occurs low down in the face of the cliff. The rod passed through the limestone into a thin stratum of red sandstone, and then through beds of red and blue clay. It was stopped in the latter at a total depth of only seventy feet. This would give 250 feet as the thickness of the limestone at this point, and this is probably as thick as it is anywhere. No basalt was met with in the second bore, and no chalk, although it is likely that the latter would have been reached within a short distance further down, as elsewhere, a shallow deposit of red and blue clays overlies it.*

For instance, a Mr. Smith has sunk to obtain water in his strawberry garden, near to the Bridgewater Road, and within the Borough of Portland. He tells me that after passing through beds of red and blue clay, and then through a shell bed, the bore entered the chalk, and struck water at a depth of thirty feet. At this spot there is no eolian limestone, and the surface stratum is a very thin deposit of decomposed lava.

The centre of the Portland Promontory is occupied by a low range of hills, known as Bat's Ridges. These hills are an extension of this limestone formation, and they are perforated by many caves, some of which are of considerable length. Professor Tate has assigned this limestone formation to the pleistocene period, and while the Rev. Julian Woods says that it is pliocene, Mr. Dennant describes it as "Recent."

VI.—The Recent Formations—the Sand Dunes.

Sand dunes occur in long narrow strips, bordering those portions of the coast which are exposed to the strong south westerly winds which prevail here.

Their spread inland appears to me to be an exceedingly recent movement, due to artificial causes. Mr. Kennedy who has resided at Bridgewater for forty years, tells me that when first he came to the district, the sand dunes were very much narrower than they are now, and that their surfaces were then bound down by various grasses. These began to be eaten down when cattle were introduced, and the coastwise traffic commencing simultaneously, the dray wheels destroyed the roots left by the cattle, and so let loose the sand. By these means the surface features of the parts adjacent to the coast have been greatly altered of late years.

The dunes are composed of comminuted shells, mixed with a little siliceous sand. The materials are coarser than those which compose the false-bedded limestone, and they

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* Had these operations been conducted under the direction of any one with geological knowledge, the bore would have been started in the neighbourhood of the Botanical Gardens, at Portland, in the chalk. The money was wasted in putting a bore through the limestone at Nelson Bay.

are considerably coarser than the sand now on the beach at the spots where I took samples for comparison, but Mr. Dennant tells me that he has found beach sand in the locality of a very similar character.

Where the dunes have been breached I saw some very faint traces of bedding, the layers being about two inches thick. I saw no horizontal divisions, and no linear arrangement of either dip or colour, such as characterises the false-bedded limestone. On the contrary, all the material seemed to be perfectly homogeneous and almost structureless at every level that I could examine it.

VII.—Marine Beds, Bridgewater.

On the summit of the Cape Nelson cliffs, 180 feet above sea level, the limestone is partly covered by a sand bed, which originally may have been three or four feet thick, but which is now so far blown away that only wind-swept and smoothed knolls are left. All these knolls are capped by a bed of recent shells, two or three inches thick.

A similar shell bed occurs further inland, as for instance where the Bridgewater road crosses a little rivulet opposite to Wilson's farm. This spot must be two miles from the beach and about 175 feet above sea level. The vehicular traffic has cut trenches into the soil and these expose shallow sections. These show a stratum of shells a few inches below the surface. The shell bed rests upon a shallow sand bed, and this lies upon the pleistocene limestone. As the road winds round and over the hills, this bed is noticed closely following their contours, indicating that they are parts of the bed of a sea or lake which has disappeared.

I noticed upon the crests and sides of many of the hills, patches of a much whiter and denser limestone. These may be deposits of travertine, due to the oozing out of drainage waters, which have now, from some cause, ceased to flow; but I understand Mr. Woods to say, that they are marine deposits, formed when these rocks were the bed of a shallow sea, and that he has found marine fossils in them. These marine deposits have suggested to me that, at the time when the land stood 200 feet lower than it does now, and when these hills were just immersed, that then high lava cliffs probably extended as a sea wall or breakwater for some miles to the south of the present coast line.

That these cliffs were somewhere breached so as to admit the sea over the lower land behind them, and thus an inland sea was created, resembling, in the form of its sea wall, Port Phillip Bay, Port Jackson, or the Gippsland Lakes. In the quiet waters of such a closed-in sea, the undulating surfaces of the limestone hills, with their shelly investiture, might have been preserved intact. Similar shaped banks now occur in Port Phillip Bay, especially towards the Heads, and they are known to be similarly covered with shells. The slowly retreating waters of Port Phillip Bay are to-day leaving behind them, all round its shores, shell beds in nowise different in appearance from those on the hills and cliffs of Nelson and Bridgewater. These shell beds are intermediate in age between the pleistocene limestone and the recent dunes.

VIII.—Marine Beds, Bolwarra.

Between Portland and Narrawong the cliffs recede inland. Alluvial flats, crossed by low sand ridges, take the place of the bold hills of lava and limestone. A very old resident of Portland, Mr. Douglass, to whom I am considerably indebted for local information, tells me that a farmer living on these flats has bored for water. The rod passed through many beds of drift sand, mud, and clay, and reached a depth of 100 feet without meeting with any indication of a bed-rock. From the nature of these beds, I judge that the locality was once the site of an arm of the sea, and the present contour of the land suggests that, in the immediate past, a narrow strait cut off the bold extremity of the Portland promontory from the main land, leaving it a small, steep-sided, volcanic island.

IX.—The Raised Beaches and the Sea Caves.

All along this coast there is evidence of much recent change in the sea level. On the Portland beach, in front of the Court House, the chalk cliffs are undercut, showing that the waves once reached them. The entire cliff face is vertical, and is so sharply cut and so slightly weathered, that much time cannot have elapsed since this happened; but the grass-grown sand heaps at their bases indicate that the sea has retreated.

Nearly opposite to the south end of this cliff, a boulder bed bars the creek mouth, the boulders of which have probably accumulated in comparatively deep water. Now, however, it forms a grass-grown ridge, about 6 feet high, and permanently out of the water, so that houses have been built upon it. The sea is now removing this spit by cutting it backwards.

Mr. Pile, a shipping agent long resident at Portland, assures me that a shallowing movement has been continuous, rapid, and marked along the south coast for many years past.

The local fishermen say that many well-known rocks, to reach which they had to wade through the surf thirty years ago, are now high and dry ; and the masters of the coasting steamers declare that, from the Otway westward, the soundings are getting shoaler. And there is other evidence which shows that an upward movement of the land, or the retreat of the ocean, has a considerable antiquity. For instance, in the sloping face of the cliff, underneath the Portland lighthouse, I found a bed of recent shells 2 feet thick (sandwiched between beds of decomposed basalt, which are evidently only so much talus), and situated about 30 feet above sea level. (See sketch I.)

Between Blacknose and Danger Points, there is a raised beach, about one chain wide, and this also is about 30 feet above sea level. It is covered with a growth of large ti-tree and shrubs. (See sketch K.)

In Nelson Bay, the limestone cliffs are from 150 to 200 feet high, and nearly perpendicular. At a considerable height above the beach, there is a shelf which runs for miles. It is quite a chain wide in many parts and it is well covered with trees and shrubs. (See Sketch L.)

At Cape Nelson there are two well defined platforms cut out of the basalt, one at about 10 feet, and the other at about 30 feet above sea level. (See Sketch M.)

As Bridgewater is approached by the road, the country is ridged and furrowed with rolling hills, mostly parallel with the beach. Half a mile east of Vance's the road enters a trough formed by two of these land rolls. The seaward ridge seems to be merely a sand dune, but the inland one, presents to the road a vertical wall of limestone, undercu into caves. I estimate that the base of this cliff must be quite 20 feet above sea level, and be seven chains distant from high-water mark. This is an old sea cliff, and its appearance is best shewn in the sketch and section. (See Sketches S^1 and S^2.)

At Cape Bridgewater a wide flat platform occurs in the hard ash beds some three or four feet above low water level; it has once been quite a mile long, but it has been greatly broken down. It is now 50 feet wide in places, and it is level in a striking degree. (See Sketch O.)

At Liddle's watering place there are two ledges in the basalt, one about five feet, and another at about 25 feet above sea level. (See Sketch R.)

All these platforms are now disappearing. The action of the sea at its present level is highly destructive of the lower ones, and in the very act of breaking them down it is carving out a still lower shelf some 15 or 20 feet below those which are being destroyed.

In consequence of this action, the ledges everywhere are more or less breached; in many places they have been almost entirely removed, and the remnant form ragged edged, but broad flanges along the cliff foot.

Another evidence of the altered levels is supplied by the caves at Bridgewater. They occur only in the cliffs which are composed of volcanic ash. The largest one is situated at the extreme point of this Cape, which it drills through. My examination of it was hurried by the nature of the weather, so that I had not time to measure its dimensions, but I should say, that it is about 300 feet long, 60 feet wide, and 40 feet high. At low water the floor of the south or ocean end is three feet above the tide, and that of the north or Bridgewater Bay end, has then about four feet of water over its sill. The sea flows into the cave for a distance of about 70 feet in ordinary weather, and the waves break upon a steeply inclined beach of sand and shingle.

Fifty yards west of this cave there is another one which is about 50 feet long, 30 feet wide, and 10 feet high near the entrance. It is situated about 30 feet above sea level, and its mouth is almost closed up with grass-grown cliff-talus. The upper end of the cavern is full of large and small water-worn boulders. The fishermen told me that the cave mouth had been choked with fallen rock as I saw it, during all the twenty-five years of their residence at the Cape.

A third cave, known as the water cave, lies immediately north of the big cave. Its floor is still so deep under water that in fine weather the rollers do not break when they enter it. I judge that the depth of water must be 20 feet.

A fourth cave, near by, is three or four feet above high water mark, and it is so dry that the fishermen have lived in it for months at a time.

The positions of these caverns relative to the sea level, point to a still proceeding elevatory movement of the coast.

The big cave must have been quite 20 feet lower when the ocean carved it out. The second of those described is now far out of reach of the waves. It must have stood 50 feet lower than it does to day, when the grind of the surf bored it out of the rock, and ages may have passed since its rolled stones were last wet with the surf.

The fisherman's cave must have altered its level by 24 feet, but the great water cave is still in the course of erosion having its floor about 20 feet beneath the sea surface, and its roof 15 feet above it. Every lift of the sea must roll the grinding shingle upon its floor, and, in rough weather, the air suction due to the draw-back, must be an enormous force, quite sufficient to drag out of its walls every block of stone that the battering of the breakers has loosened.

While the existence of these raised beaches is evidence of an upward movement, the occurrence of exceedingly deep water at the very foot of some of the cliffs is an indication that the present elevatory movement was immediately preceded by a considerable depression. If we take the Admiralty chart and note the soundings we shall see that the cliffs on the east side of Cape Grant have their bases in 72 feet of water. They rise almost sheer from that great depth. The soundings and the outlying rocks show that the present line of cliffs does not represent the original southern edge of the lava flow. That margin lay out in the offing. Its present position is due to the fact that the cliff has been cut back by the sea. The rocky floor, now 70 feet deep under water, must once have been at least 50 feet higher, to allow the waves to operate upon the mass out of which its precipices have been carved. Since that time there has been a downward movement, and an upward one, the latter of which has long been in progress, and has, moreover, been varied by several periods of rest.

Conclusion.

It may be noticed, that my sketch map differs materially from the Geological map issued by the Government. I might say, that before I commenced the task of preparing mine, to avoid going over ground already occupied, I took the precaution of asking at the office of the Geological Survey Department what data it possessed in relation to the Portland promontory. In reply to this enquiry I was told that the Government Geological Surveyors had not visited it, and that the department had no official records of its character, nor any plans of the district. My map does not pretend to be more than a first sketch. Before it can be complete many details will have to be filled in, and some parts of the boundaries of the formations on the north-western base of the promontory may be modified, as the result of a fuller examination. In the mean time, if it should point out an interesting field of work to other geologists, it will have served its purpose.

Art. VII—*On the value of* J, *and the value of* g.

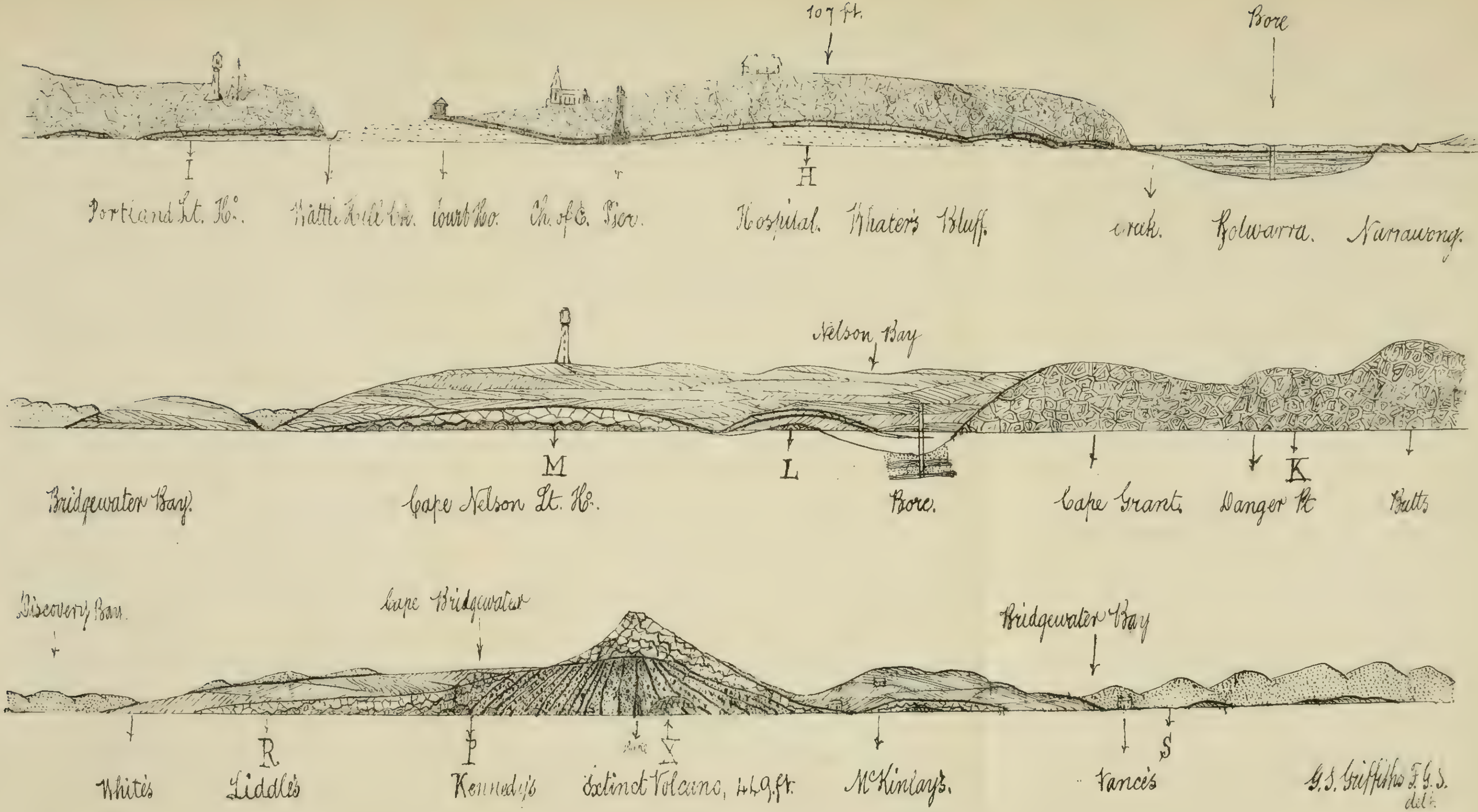
By Professor H. M. Andrew, M.A.

[See Proceedings, page 91.]

Art. VIII—*Note on the Proposed Photographic Charting of the Heavens.*

By R. L. J. Ellery, F.R.S., F.R.A.S.

[See Proceedings, page 93.]

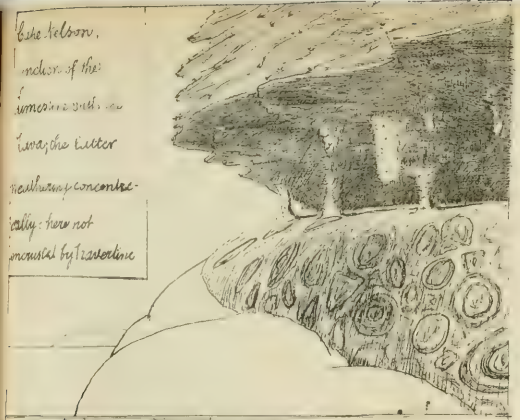


THE PORTLAND PROMONTORY.

Coast Section from Narrawong to Discovery Bay about 60 miles.

Miocene Chalk (M.C.) · Miocene Oyster Bed (M.O.) · Lava (L) · Pleistocene Limestone (P.L.) · Ash (A) · Dunes (S.)

Volcanic L Miocene Chalk. MC Pleistocene Limestone PL Sand dunes S Recent Marine Alluviums AL Boundaries
The arrow heads on the coast line lettered thus, → H, refer to sectional drawings.
DISCOVERY BAY
Mt. Richmond 740 ft
Batts Ridges
Surrey R.
Narrawong
Bolwarra
PORTLAND BAY
Railway
Whalers Bluff
PORTLAND
Pier
Wattle Hill Ck
MC
Light house
Bridgewater Road
Racecourse
BOROUGH
Cemetery
Butts
Black nose point
Danger Point
Laurence Rocks
Cape Grant
Bore 70 below S.L
NELSON BAY
Lava
Cape Nelson Lt ho.
Whites
BRIDGEWATER BAY
Lava lips
Extinct Volcano
Cape Bridgewater
GEOLOGICAL SKETCH MAP OF THE PORTLAND PROMONTORY
SCALE TWO MILES TO THE INCH
G. S. Griffiths F.G.S. delt.

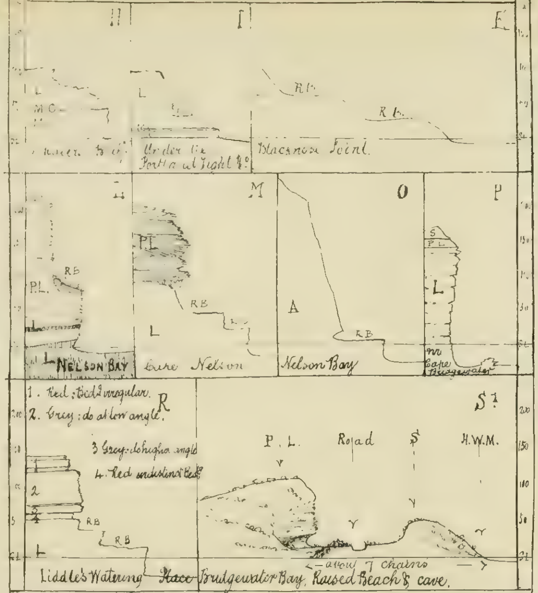


Cape Nelson, junction of the limestone with lava; the latter weathering concentrically: here not encrusted by travertine

Elevation & ground plan of Cliff at Bridgewater. The Ash beds A are all bedded, but vary much in color. C is a stratum of white chalky rock.

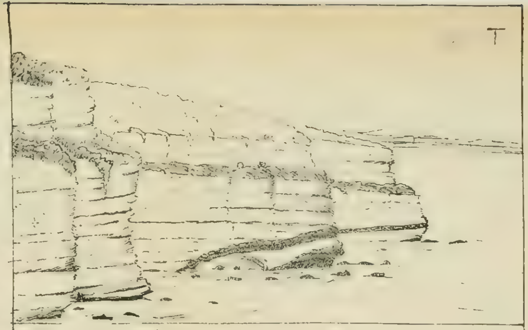
G. S. Griffiths dell.

CLIFF PROFILES and RAISED BEACHES, PORTLAND PROM^{TRY}.

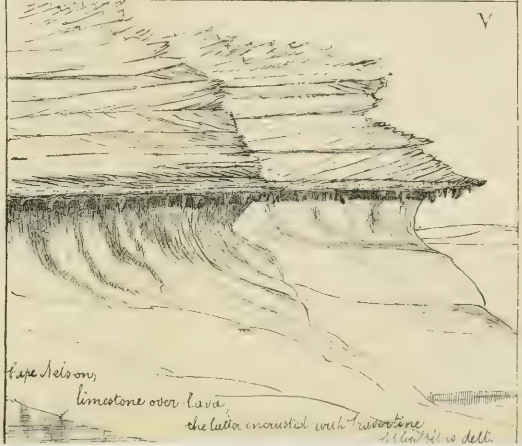


Raised Beach with caves Bridgewater Bay. For Section see S¹.

G. S. Griffiths dell.



Cliffs of Pleistocene limestone, two miles N.E. of Cape Nelson lighthouse about 200ft high, shewing lava beds and raised beach.



Cape Nelson, limestone over lava, the latter encrusted with travertine

G. S. Griffiths dell.

PROCEEDINGS.

1887.

PROCEEDINGS.

ROYAL SOCIETY OF VICTORIA.

[N.B.—The remarks and speeches in the discussions are taken down verbatim by a shorthand writer, and afterwards written out at length with a typewriter, for reference and reproduction, if required; and therefore, more is seldom given herein than an indication of their general drift. If any person should wish to refer to the verbatim report, he can apply to the Secretary to the Society, who will give him an opportunity of transcribing it; or if he reside at a distance, so much as he requires will, upon payment of the cost of reproducing it, be forwarded to his address.]

ANNUAL MEETING.

Thursday, 10th March, 1887.

Present: the President, Professor W. C. Kernot, in the chair, and twenty members and associates.

The following Office-bearers for the ensuing year were duly elected:—President, Professor W. C. Kernot, M.A.; Vice-Presidents, Mr. J. Cosmo Newbery, B.Sc., C.M.G., and Mr. E. J. White, F.R.A.S.; Treasurer, Mr. H. Moors; Librarian, Mr. J. E. Neild, M.D.; Secretaries, Mr. H. K. Rusden and Mr. G. W. Selby; Members of Council, Mr. E. Bage, Mr. C. R. Blackett, F.C.S., Mr. A. H. S. Lucas, M.A., F.G.S., Mr. S. W. McGowan, Mr. W. H. Steel, C.E., and Mr. Alexander Sutherland, M.A. The following Members of Council continued in office:—Mr. R. L. J. Ellery, F.R.S., Mr. G. S. Griffiths, F.R.G.S., Mr. Louis Henry, M.D., Mr. James Jamieson, M.D., Mr. H. F. Rosales, F.G.S., and Mr. J. F. Rudall, F.R.C.S.

The Annual Report of the Council and Balance-sheet for 1886 were then presented, and after some discussion as to the manner in which the credit balance was brought to account, and some questions asked and answered respecting the Davy Fund, they were received and adopted on the motion of Mr. Marks and Mr. A. H. Jackson, as follows :—

Annual Report.

Your Council has the honour to report that the following papers were read during the session of 1886 :—

On the 11th March, Dr. M'Gillivray's "Description of New or Little-known Polyzoa," Part X., and Rev. D. Macdonald's "The Oceanic Languages Semitic."

On the 8th April, Mr. F. A. Campbell's "On the Stability of Structures in regard to Wind Pressure."

On the 13th May, Mr. Griffiths' "Notes on Kerguelen's Land."

On the 10th June, Mr. Wakelin's "On the Possibility of the Force Producing Gravitation not Acting Directly on every Particle of a Planet," and Mr. F. A. Campbell's "On the Stability of Structures in Relation to Wind Pressure, No. 2.—Bridges."

On the 8th July, Dr. M'Gillivray's "Description of New or Little-known Polyzoa," Part XI., and Dr. Verbeek's "Report on the Eruption of Krakatoa."

On the 12th August, Professor Kernot's paper "On Lightning Conductors," and Mr. W. M. Bale's "On the Genera of the Plumulariidæ, with Observations on various Australian Hydroids."

On the 9th September, Mr. Griffiths' "On the Official Reports of the Tarawera Eruption."

On the 14th October, Mr. A. W. Howitt's "On the Area of Intrusive Rocks at Dargo," and Mr. A. H. S. Lucas' "On the Sections displayed in the Coode Canal," and "On the Sound Organs of the Green Cicada."

On the 11th November, Dr. M'Gillivray's "Descriptions of New or Little-known Polyzoa" Part XII., and "Catalogue of the Marine Polyzoa of Victoria," and Mr. John Dennant's "Notes on Post Tertiary Strata in South-western Victoria."

On the 9th December, Professor Krause's "On the Tripolite Deposits at Lilicur," and Mr. F. A. Campbell's "On the Want of a Uniform System of Experimenting upon Timber."

During the year five gentlemen were elected as ordinary members of the Society, namely, the Hon. F. D. Derham, and Arthur Lynch and A. C. Wannon, Esqs., on the 13th May; and Wm. Lucas and Gerard Wight, Esqs., on the 12th August. Three as country members, namely, John Dennant, Esq., on the 8th April; D. M. Davies, Esq., M.L.A., on the 10th June; and W. D. T. Powell, Esq., on the 9th September. Six as Associates, namely, R. W. Chapman, James F. Cole, and Sydney Horsley, Esqs., on the 13th May; and T. E. Jackson, Richard Matthews, Esqs Dr. J. J. Wild, on the 10th June, Dr. R. D. M. Verbeek, of Buitenzorg, Java, author of an elaborate report on the Krakatoa Eruption, was, on the 9th September, specially elected as an honorary member under Law XXIV.

On the 3rd June the Council appointed as members of an Australian Antarctic Exploration Committee (jointly with the Royal Geographical Society of Australia, Victorian Branch, who appointed a like number) Professor Kernot, Messrs. Ellery, Griffiths, Rusden, Selby, and Dr. Wild, and the Committee was re-elected in December, to enable it to act during the recess. Also, on the 11th November, Messrs. Ellery, Griffiths, and Rusden were appointed as a Printing Committee to attend to the preparation of the Twenty-third Volume of the Transactions during the recess.

A conversazione was held in the new Masonic Hall, Collins Street East, on the 26th October, at which His Excellency the Governor and a large number of ladies and gentlemen attended. The President delivered his annual address, Mr. Griffiths read a paper on "Antarctic Exploration," and Mr. Sutherland gave a paper on "Allotropism," illustrated by experiments. A record of the numerous and interesting exhibits will be found in the Proceedings of the Society, Vol. XXIII., which will be issued in the course of the month. Your Council regrets that it could not be completed before, and recommends that in future, for many reasons, the annual volume be printed off as soon as possible after the last meeting in each session.

Your Council desires to remind members that the shorthand writer's notes of the discussions are written out at length with a type-writer, and preserved for reference if desired, and that this will account for the brevity of the notes of speeches in the printed Proceedings of the Society.

Report of Section A.

The papers contributed during the past year have been less numerous than in former years, but the subject matter has been more closely connected with practical work than in some previous papers.

The following papers were read :—

March 31st.—"Boiler Explosions," by Professor Kernot.

April 28th.—"The Testing of large Dynamos," by Mr. John Booth, M.C.E.; "Modern Marine Indicator Diagrams," by Mr. C. W. Maclean, C.E.

May 26th.—"Collimation in Levels," by Mr. G. R. B. Steane, C.E.

June 30th.—Discussion continued on the last-mentioned paper, and "Some Notes on Mr. J. A. L. Waddell's pamphlet on Japan Railway Bridges," were read by Professor Kernot; another paper, "On Safety Valves," was read by Mr. C. W. Maclean, C.E.

Dr. *The Hon. Treasurer in Account with the Royal Society of Victoria.* **Cr.**

To Balance from last Balance-sheet		£662 14 10	By Printing and Stationery	£185 14 9
,, Government Grant—			,, Additions to Lodge	200 6 0
Balance of 1885-86	£50 0 0		,, Books	12 9 6
Portion of 1886-87	150 0 0		,, Binding	1 0 0
		200 0 0	,, Freight and Charges	0 18 6
,, Entrance Fees (8)		16 16 0	,, Conversazione, &c.	30 9 0
,, Subscriptions—			,, Rates	4 13 4
65 Ordinary	136 10 0		,, Gas and Fuel	7 18 1
1 Do. (Half-year)	1 1 0		,, Clerical Assistance	79 16 8
28 Country	29 8 0		,, Reports of Proceedings	18 18 0
1 Do. (Half-year)	0 10 6		,, Hall-keeper	6 0 0
36 Associates	37 16 0		,, Collector	23 4 11
Arrears	33 12 0		,, Insurance	3 10 0
		238 17 6	,, Postage	29 14 10
,, Rent and Gas		12 3 0	,, Petty Cash, Advertising, &c.	9 13 11
,, Sale of Transactions		1 3 6	,, Balance in Bank	545 19 6
,, Interest		28 12 2		
		£1160 7 0		£1160 7 0

Compared with the Vouchers and Bank Pass-book and Cash-book, and found correct,

H. MOORS,
Hon. Treasurer.

(Signed) JAMES E. GILBERT,
ROBERT E. JOSEPH, } Auditors.

Dr. *The Hon. Treasurer in Account with the Fund in Aid of the Widow of the late Dr. Davy.* Cr.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance in Bank	£111	12	0	By Paid to Mrs. Davy	£16	19	0
,, Interest	5	7	0	,, Balance in Bank	100	0	0
	£116	19	0		£116	19	0

Examined and found correct,

H. MOORS,
Hon. Treasurer.

2nd March, 1887.

JAMES E. GILBERT, }
ROBERT E. JOSEPH, } Auditors.

STATEMENT OF LIABILITES AND ASSETS.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.
To Three Debentures outstanding	£15	0	0	By Estimated Value of Outstanding Subscriptions	£40	0	0
,, Interest unclaimed	12	12	0	,, Do. do. Rents due	10	0	0
,, Estimated Amount of other Outstanding Liabilities	20	0	0	,, Hall, Library, and Furniture	3700	0	0
,, Balance in Bank—Davy Fund	100	0	0	,, Balance in Bank—Davy Fund Account ..	100	0	0
,, Balance	4248	7	6	,, Do. do. General Account	545	19	6
	£4395	19	6		£4395	19	6

The Annual General Meeting then adjourned and an ordinary meeting was held. The President in the chair.

A ballot was taken for the following gentlemen, who were declared duly elected ; namely, as members:—Mr. A. H. Jackson, B.Sc., F.C.S. Mr. J. B. Lewis, Mr. J. J. Wild, Ph. D., F.R.G.S.; and as associate :—Mr. W. H. Irvine.

Letters were read from Dr. Verbeek, of Buitenzorg, Java, acknowledging the notice of his election as an honorary member of the Society, and one from Captain Fairweather, of Dundee, respecting Antarctic Exploration.

The Librarian reported that 200 volumes had been added to the Library during the recess.

Dr. Wild then gave an abstract of a paper contributed by the Rev. D. Macdonald, Fate, New Hebrides, on "The Oceanic Languages Semitic." (Article I. Transactions.) It was resolved that the paper be printed in the Transactions of the Society.

Mr. H. T. Tisdall then read some "Notes on Fungi in Mines." (Article II. Transactions), which were mainly introductory to further papers which he proposed to read on the same subject, and related to the mines at Walhalla.

Discussion ensued, in which the President, Mr. Marks, Mr. White, Mr. Lucas, Mr. Blackett, Mr. Sutherland and Mr. Tisdall, took part.

Thursday, April 14*th*, 1887.

In consequence of the death of Mr. S. W. McGowan, a member of the Council, the April meeting was postponed as a tribute of respect and regret.

Thursday, May 12*th*, 1887.

Present: the President, Professor W. C. Kernot, M.A. (in the chair), and 25 members and associates.

The Librarian Dr. Neild, announced that 155 volumes and Scientific Periodicals, had been received since the last meeting.

The President mentioned with regret, the recent death of Mr. S. W. MacGowan, who was one of the oldest and most active members of the Council of the Society, besides being a public officer of long service and great value. On the motion of Mr. Ellery and Mr. White, the Hon. Secretary was desired to address a letter of condolence to Mrs. McGowan, expressive of the great regret of the Society, and sympathy with her in her bereavement.

Mr. Ellery proposed that Mr. Bosisto be elected a member of Council, in place of Mr. McGowan, deceased. The matter was referred to the Council.

The PRESIDENT then referred to the railway accident of the preceding evening, by which among others Mr. J. Cosmo Newbery, Vice-President of the Society had been injured severely, and Mr. E. S. Parkes an old member of the Society, had been killed.

The PRESIDENT then read a letter from the Trustees of the "Elizabeth Thompson Fund, of $25,000 bequeathed by Mrs. Elizabeth Thompson, of Stamford, Conn., U.S.A., for the advancement and prosecution of scientific research *in its broadest sense*," inviting applications for assistance.

Mr. GRIFFITHS read a paper (contributed by Mr. E. J. Dunn, F.G.S.) entitled, "Notes on the Occurrence of Glaciated Pebbles and Boulders in the so-called Mesozoic Conglomerate of Victoria." (Article III. Transactions.) Discussion ensued, in which Mr. Ellery, Mr. Lucas, the President, and Mr. Griffiths took part.

Mr. H. T. Tisdall then read a paper (No. 2), "On the Fungi Growing in Mines," (see Article IV. Transactions), which he illustrated with plant and drawings. Discussion ensued, in which the President, Mr. Griffiths, Dr. Jamieson and Mr. Tisdall took the principal part.

Mr. A. H. S. LUCAS, M.A., then read a paper, "On the Production of Colour in Birds' Eggs." (See Art. V., Transactions.) Discussion ensued in which Dr. Jamieson expressed the opinion that a larger amount of evidence would be required to prove the theory advanced. Mr. Lucas replied and the proceedings terminated.

Thursday, 9th June, 1887.

Present: the President, Professor W. C. Kernot (in the chair), and 16 members and associates.

The following gentlemen were duly elected by ballot:—Professor David Orme Masson, as a member of the Society; Mr. C. H. Richards, as a country member of the Society; and Mr. Pietro Baracchi, Mr. James Blackburn, Rev. A. W. Cresswell, Mr. W. S. Dawson, Dr. Thomas Porter, and Mr. G. A. M. Pringle, as associates.

Mr. JOSEPH BOSISTO having been nominated by the Council as a member thereof, in the place of the late Mr. S. W. McGowan, was duly elected.

It was resolved that a congratulatory address to Her Majesty upon her Jubilee, should be prepared and presented at the approaching Levee.

The PRESIDENT announced that the Microscopical Society of Victoria had offered to amalgamate with the Royal Society, and to form Section D, for the study of the Microscope and its applications; that the Council had accepted the offer, under Law LIII.;

and that the members of the Microscopical Society would probably be balloted for at the next meeting of the Royal Society. He hoped that other Scientific Societies would follow the example set by the Microscopical Society.

The Librarian, Dr. NEILD, in making his usual report upon the Library, referred to the President's recent munificent donation of £2000 to the University, to be devoted to Scholarships in Physics and Chemistry, and trusted that others would do likewise.

The PRESIDENT thanked Dr. Neild for his "honourable mention" of the fact, and gave as his reasons for specially supporting the Sciences of Physics and Chemistry, rather than his own profession of Engineering, that they had been particularly interesting to him in his early career; that they really were the bases of all other sciences; and that he thought that their importance had scarcely been adequately recognised hitherto in the University.

Mr. G. S. GRIFFITHS, F.G.S., then read a paper "On the Geology of the Portland Promontory." (Article VI., Transactions.)

Mr. ELLERY thought the paper embodied valuable work. He regretted that the Geological Survey of the country had been discontinued before the Portland district had been surveyed. The Society and the colony were all the more obliged to Mr. Griffiths for his contribution to geological knowledge. He thought the Government would, perhaps, publish the sketch maps which Mr. Griffiths had made.

Mr. SUTHERLAND regretted that such work had been neglected by the State, and that it should be left to such gentlemen as Mr. Howitt, Mr. Stirling, and Mr. Griffiths, who could devote only their holidays to it. Their work was not only very creditable, but extremely valuable. He alluded to the theory, that the land as well as the sea was gradually rising and subsiding, but it appears from Dr. Croll's "Climate and Time," that it was the sea only and not the land which did so.

Mr. ELLERY said it was commonly asserted that there was such gradual elevation and subsidence, but he thought the evidence was extremely doubtful. It was a question very difficult to determine, and required continued observations during centuries. High and low water marks are occasionally great subjects of dispute, and he doubted if they could be fixed with accuracy. He had recommended the establishment of tide gauges at various places in the Straits.

Mr. WHITE remarked on the constant removal and uncertainty of land marks, which would otherwise be useful.

After some remarks from the President as to the care with which statements on the subject should be received, Mr. Griffiths expressed his thanks for the criticism upon his paper, and replied to it at some length; and the meeting adjourned.

Thursday, 14th July, 1887.

Present: the President, Professor Kernot (in the chair), and 40 members and associates.

Professor W. Baldwin Spencer was duly elected by ballot a member of the Society.

The PRESIDENT congratulated the Society upon the nature of the first business of the evening, which was the absorption into the Royal Society of the members of the late Microscopical Society, who would now form Section D, as provided in Law LIII.

Mr. ELLERY moved the formal admission of 41 members of the late Microscopical, as members of the Royal Society, and 5 as honorary members. Fourteen of them were already members of the Royal Society. The others will elect before the 1st January next, whether they will be members or associates of the Royal Society. No entrance fee will be asked from any of them, as they bring with them to the Royal Society, their library, microscopes, and other property.

It was intended to hold a special meeting of the Council after the conclusion of the business of the evening, at which the officers of Section D would be appointed.

Mr. C. R. BLACKETT seconded the motion, and all the members of the late Microscopical Society were then duly elected members of the Royal Society.

Mr. LUCAS moved the appointment, to effect a systematic Biological Survey of Port Phillip, of a Committee of the following gentlemen:—Mr. W. M. Bale, Rev. A. W. Cresswell, M.A., Dr. McGillivray, Professor W. Baldwin Spencer, Mr. C. A. Topp, M.A., LL.B., Mr. J. Bracebridge Wilson, M.A., and Mr. Lucas, B.Sc., M.A.

Mr. ELLERY seconded the motion, but hoped the researches of the Committee would not be restricted to Port Phillip Bay.

The motion was carried.

Professor ANDREW then read his "Note on the Value of J, and the Value of g." He said that the remarks he had to make on the value of J, the mechanical equivalent of heat, were due to a paragraph in "Notes on Popular Science," by Dr. J. E. Taylor, F.G.S., which appeared in *The Australasian*, of 12th August, 1882, which stated that Dr. Joule had re-determined the value of this important physical constant, which was given as a 774·1 foot pound per degree Fahrenheit for Manchester. He had accepted the statement made so circumstantially, and quoted it in his University classes. He had, however, failed to find any corroboration of Dr. Taylor's science letter in any of the scientific journals. On the contrary, Professor Everett, in the last edition of his *Unity and Physical Constants*, published at the end of last year, gives 1878 as the date of Joule's latest experiment, and

773·24 as the value of J for sea Level at Greenwich. It was, however, somewhat remarkable that, assuming 32·151 (ft. sec.) as the value of g in Melbourne, this number became 774·16 foot lbs. degree Fahr., which closely corresponds with the result given in Dr. Taylor's science letter to *The Australasian.* This led him to his second note, on the value of g, or the intensity of the force of gravity. Professor Neumeyer, when in Melbourne, had in 1860 made a series of observations with a modification of Kater's pendulum in the cellar of a house in Domain Road, which was for the purpose connected with the then newly-built observatory by a telegraph wire. Mr. Ellery had informed him that no results had been obtained, or at least published, as Neumeyer found a defect in his pendulum after returning to Berlin. Professor Andrew suggested that, although for all practical, and for most scientific purposes, the computed value of g for Melbourne, as given in his previous note, might be used, yet its value by direct observation ought to be found. He would suggest that as he had made provision for a clock and an experimental pendulum in the plans for the physical laboratory which the University Council was doing its best to get built and equipped, the Royal Society might subsidise the University grant, and get apparatus which would be better than what would be absolutely necessary for students in physics, or the Society might fairly undertake the investigation.

Mr. Ellery said that the difficulty to which Professor Andrew had referred was connected with a comparison of the determination of the lengths of the Bessel pendulum employed, made at home, here, and then again on Professor Neumeyer's return. These seemed to show a permanent elongation, and so the results had been set aside. There would be no difficulty in accepting the suggestion; the Observatory would render all possible assistance.

Mr. White said that when he went to Berlin a few years ago he talked with Professor Neumeyer about his pendulum observations in Melbourne, and was assured that the discrepancies mentioned by Mr. Ellery had been overcome, and results had been obtained.

The President remarked that for engineering purposes the rough values 772 and 32 for the J and g were sufficiently accurate, yet that, as a scientific Society, it behoved them to determine them with the utmost accuracy.

Professor Andrew suggested that Professor Neumeyer should be asked by the President to send the results of his observations in 1860 to the Society, as they would be most interesting and valuable.

The President announced the receipt of, and laid upon the table, a medal and diploma from the Victorian Commissioners to the Colonial and Indian Exhibition, for the exhibits of the Royal

Society. Also a copy of the Illustrated Handbook of Victoria, issued by the Victorian Commissioners at the Exhibition.

Mr. Ellery then read a note "On the Proposed Photographic Charting of the Heavens." He said that for some years, photography had been a very useful hand-maiden to astronomy. Since the introduction of the rapid gelatine plates, the utility of photography in that direction had been immensely increased. Very greatly improved photographs of comets and other heavenly bodies could now be taken under that process. During the last three or four years, too, immense strides had been made in the direction of charting the stellar heavens. In Paris particularly they had made great progress in that direction. By means of special telescopes at the Paris Observatory, they had obtained charts of stars down to the 14th magnitude that had astonished everyone who had seen them. Last year a circular was sent from the Paris Observatory, intimating that a conference was to be held at Easter this year of all astronomers who could attend, to consider as to the best means of carrying out a scheme for the complete photographic chart of the heavens. As Mr. Russell, Government Astronomer of New South Wales, had determined to go to the old country about that time, he (Mr. Ellery) did not think it necessary to accept the invitation. The conference was held, and it decided that this great work should be carried out. But there were in the southern hemisphere only a very few observatories, compared with the number in the northern hemisphere. Indeed, the number was so few, that it was considered doubtful at first whether the scheme could be effectively carried out. It was estimated that the cost for each national observatory would be about £4000 for instruments and appliances. The work would extend over some years. At the conference Mr. Russell expressed his opinion that the co-operation of the Melbourne and Sydney Observatories might be considered assured. He (Mr. Ellery) laid the matter before the Government, and the Government quite concurred in the proposal. He believed that the Melbourne Observatory would take its part in the scheme. Two new observatories were wanted for the purpose, one in the Island of Réunion, and the other in the southern part of New Zealand. Nearly all the present observatories in the southern hemisphere were in similar latitudes, and if observatories were established at the places just mentioned, a little more ground could be covered. It had been found that stars down to the 15th and 16th magnitude could be obtained on a photographic plate by exposure for one or two hours. The smaller the star, the longer the exposure must be. To get photographic pictures of stars during that period, the telescope must be kept moving with the apparent movements of the stars. For that purpose, a clockwork arrangement was necessary, and of such a perfect character as to be scarcely attainable. In taking the Paris photographs, not only was clockwork used, but there was an auxiliary means of shifting the telescope by hand. The mechanical means of getting the precise motion required occupied the attention of the conference. He had not received all the detailed reports of the proceedings, so he scarcely knew what was finally decided upon in that direction. The telescope required for the scheme had an aperture of 13in., in diameter, and was about 13ft. in length, and the object glasses had been made with optical properties such as would give good photographic images on the plates. It was proposed to take in a field of about four degrees for each plate, and the plates would be arranged in a uniform order, and would overlap. It was expected that about 4,000,000 stars would be charted, so that the arrangement of the plates would be no light task. A great many stars of small magnitude were photographed which could not be seen by the eye, even with the best telescopes. It was very possible that many more stars would be found on these plates than could be seen. As to the movement of the telescope, a very ingenious apparatus had been contrived by Mr. Grubb. If it fulfilled expectations, one of the great difficulties in the way of carrying out this great work would be surmounted. It had been arranged that all the photographic plates should be made by one maker, and it was agreed that it was very desirable that all telescopes should be of one particular class and size, and, if possible, by the same makers. It would be at least another year before operations could be begun, and the work would occupy five or six years.

The PRESIDENT said with reference to the statement that stars could be photographed, although invisible to the telescopically assisted eye, the rays from them being actinic rather than luminous, that it was a question whether some others might not be lost if some are gained. He estimated that some 100,000 photographs would have to be taken and compared. This would give some idea of the enormous work involved. If it were possible to obtain such a chart by any means 2,000 years old, it would be of immense value to us now; 2,000 years hence, posterity will have such materials towards furnishing a history of the heavens.

Mr. WHITE thought it scarcely possible to keep a star bisected by mechanical means, on account of variations of temperature constantly varying refraction. The work of cataloguing the stars when photographed, will take many years to complete. As the work must be done, the sooner it begins the better.

Mr. ELLERY mentioned that some years ago he had obtained photographs of different coloured stars in groups, which reversed their relative sizes. Those photographs would be useful now. If stars were photographed to the 10th magnitude there would be nearly 2,000,000 of them; if to the 11th there would be nearly double that number. The chart would furnish a good basis for future work by furnishing a true picture of the heavens at a certain date, and would mark a very important epoch in the science of astronomy.

The meeting then adjourned.

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1887.

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PRESIDENT'S ADDRESS.

Royal Society of Victoria.

PRESIDENT'S ADDRESS

Delivered by PROFESSOR W. C. KERNOT, M.A., C.E., December 9th, 1887.

It would ill befit the President of a Society bearing the title "Royal," to commence his Annual Address in the present year, without reference to the great event that has marked it, the jubilee of the reign of Her Majesty Queen Victoria. The period of fifty years extending from A.D. 1837 to A.D. 1887, has not only been marked by the reign of one of the worthiest sovereigns that ever filled the British throne, but also has been characterised by such unprecedented activity in all branches of scientific investigation, and such an amount of progress in the practical application of scientific results, as to become unique in the history of the world.

Surrounded as we are every day by the outcome of all this intellectual labour, we are apt to take our railways and steamships, our tramways and telegraphs as a matter of course, and to forget that the world went on its way for many thousands of years without the aid of any of these modern appliances of civilisation.

In order to realise the magnitude of the changes that have taken place during the present reign, let us turn our attention to the state of the physical sciences and their applications at the date when the young Princess Victoria suddenly found herself in possession of the British crown, and contrast it with what we see around us at the present moment.

Unquestionably, the most remarkable advance, and the one calculated to have the profoundest effect upon the human race, is the establishment of the great telegraphic system which at present encloses the whole earth in its network of wires, that like the nerves of the human body, convey intelligence almost instantaneously to the most distant parts. Fifty years ago, this had no existence whatever. An excellent Encyclopædia published as late as 1841, after describing various modes of signalling by flags, boards, or beacon fires on mountain tops, concludes thus :—" Of late years several very interesting experiments have been made of the practicability of conveying intelligence with the speed of lightning by means of galvanism."

The practical application and commercial success of the electric telegraph is by common consent of the leading electrical experts, dated from an experiment made by William Fothergill Cooke and Charles Wheatstone, on the 25th July, 1837, about one month after the coronation of Her Gracious Majesty. On this occasion, intelligible messages were sent between Euston Square and Camden Town, a distance of about two miles, by means of five copper wires, laid in grooves in a triangular wooden rail and five magnetic needles at each end which were deflected by the currents of electricity passing through the wires. Cooke and Wheatstone's apparatus was patented on December 12, 1837, but for some years little was done with it. At last, however, it was taken up by the Government, and by the railways, the former recognising its probable value in time of war, the latter its usefulness in controlling the operations of that great system of transit which was beginning to spread its giant arms abroad through the length and breadth of the kingdom.

In 1850, a new and most important departure was made. Up to this time it was supposed that the telegraph wire could traverse the dry land only, and that the seas must continue, as heretofore, to separate nation from nation, but now a wire covered with an insulating coating of gutta percha was laid across the Straits of Dover, and Great Britain was telegraphically united with the Continent of Europe. This pioneer cable, though so soon destroyed by friction, lasted long enough to prove the practicability of submarine telegraphy, and was replaced in the following year by a permanent armoured cable, resembling in its essential features, those now in use.

In 1858, a proposal which at first seemed utterly absurd in its audacity, was at vast expense carried into effect, and a cable was laid across the bed of the Atlantic from Europe to America. Like the little pioneer cable from Dover to Calais, this at first proved short-lived, but as with advancing years valuable experience was accumulating, and cables of gradually increasing length being laid across minor seas, the attempt was at last repeated with perfect success, and the year 1866 saw Atlantic submarine telegraphy an accomplished practical commercial fact. Since then the work has been steadily advancing, until the familiar poles and wires are now found in the wilds of Central Australia, the deserts of Africa, the snowy wastes of Siberia, and the prairies of America, and the cables extend across all the seas from North America across the Atlantic, and through the Mediterranean, the Red Sea, and Indian Ocean, down to New Zealand, the world being bound in one vast network of wires, from north to south, and from east to west; the only part as yet untraversed being the Pacific Ocean, across which a cable is now being urgently demanded. Up to the present time, 115,000 miles of submarine cable, costing altogether, nearly £40,000,000, have been laid, while the length of land line is beyond counting. And while the telegraphic nerve system of the globe has been so rapidly extending, its capabilities in the way of rapid transmission have also advanced. In the pioneer experimental telegraph of 1837, five wires were used to convey one message, and it was considered good work to send five words per minute, now six messages may be sent simultaneously along one wire, and by the aid of the Wheatstone automatic instrument, nearly five hundred words a minute can be sent.

And to whom is this mighty development due? Like most great inventions, it is the aggregate result of the labours of many. It was long expected and many years in preparation. Men of theory and men of practice alike aided, the former patiently investigating phenomena of apparently no practical interest; the latter appreciating and applying principles, which in the absence of their more contemplative brethren, they could never have discovered. Thales of Miletus, and Gilbert of Colchester, laid the foundation;

Galvain, Volta, Oersted, Ampere, Coulomb, Weber, carried on the work; Ronalds, Cooke, Wheatstone, Davy, Steinheil, Morse, and others, commenced the practical application; Field, Sir W. Thompson, Fleming, Jenkin, John Pender, and others, showed how it was possible to work a submarine cable even across the Atlantic Ocean, while innumerable workers of less note, gave valuable assistance by perfecting details and adding to the ever growing stock of experimental knowledge. And so it is, that a great invention is like a coral reef, the aggregate results of the life long labours of multitudes of workers, the majority of whom are soon forgotten, and every one of whom is in a thousand ways dependent on those who preceded or assisted him.

And what will be the ultimate effect of this wondrous system of communication? One thing is certain, and that it has already revolutionised commerce by enabling the wants of one part of the world to be instantaneously known in every other part. Another is, that it has facilitated in an enormous degree, the government of large empires from one centre. Fifty years ago, it took months for intelligence to travel from distant parts of the British Empire to its metropolis. The greatest disasters, physical or political, might occur in Canada, India, or Australia, and weeks or even months would pass before the news reached London, and months more before assistance could be sent. But now, if the remotest part of the empire be menaced, the fact is immediately known at head quarters, and measures taken accordingly. Thus, by the aid of the telegraph, the whole empire can act in unison in meeting a common danger. May we not look forward to the day when the whole world shall be federated, when war shall be abolished, when general questions shall be decided at one central metropolis, into which information is continually pouring, and from which commands are constantly proceeding to the most distant parts of the earth with the speed of lightning. And what of the effect of the telegraph upon the development of the human mind? What this will be we can hardly yet imagine. For thousands of years, even the noblest and wealthiest of men lived in a narrow groove. Their attention was occupied with the small affairs of their own little sphere. The most stirring events, the most startling changes might occur a few hundred miles away, but the news if it arrived at all, came so late and in so imperfect a form, that people failed fully to realise what had happened. To the average citizen, everything beyond a radius of a very few miles was nebulous, unreal, mysterious. But now all is changed; the telegraph and the newspaper acting in concert, supply full, complete, and prompt intelligence of the public events of the whole civilized world to the humblest member of the community, while the facilities of travelling enable a thousand persons to see the great and famous cities of the world, when one saw them a half century ago. Is it not reasonable to suppose that when these favouring influences, which can hardly be said to have been in action to any great extent until the last twenty years, have had full play for a century, the average human intelligence will be stimulated and human sympathies broadened to an extent beyond all present imagining? The day was when the world was divided into small communities, distrustful of each other, when the word stranger was synonymous with enemy, when kindness, honesty, and truthfulness were supposed to be duties only within the small circle of the family or tribe, and when the traveller to other lands often paid the penalty of his curiosity with the loss of his life or liberty. The day is coming and that right speedily, when all men shall be brothers, when information, sympathy, and assistance in time of calamity shall flow to the farthest ends of the earth; and in bringing about this great and glorious consummation, the electric telegraph will have been one of the most potent agents.

I have spoken somewhat fully about the telegraph, owing to its Jubilee being practically coincident with that of the present reign. But there are other branches of applied science which, if they did not exactly originate in the eventful year 1837, have, nevertheless, advanced tenfold more during the Jubilee period than they had ever done before.

An excellent Encyclopædia in the University Library, bearing date 1828, speaks of the locomotive engine as a slow clumsy machine, quite in the experimental stage, and of which the utmost that could be hoped, was that it might possibly replace horses in the laborious operation of moving heavy merchandise and minerals, while the writer becomes quite scornful at the expense of certain foolish enthusiasts who imagined that a future greatly improved locomotive might come into competition with that grand old British institution—the stage coach. But a year later it was demonstrated to the British public by actual trial, that it was possible to convey passengers with comfort and safety, at the incredible speed of 20 miles per hour, or twice as fast as swift coaches on the best roads. That day constituted the real birthday of the vast passenger railway system of the world. For some years, however, progress was not very rapid. The engines were small and feeble, and capable of attaining a fair speed and carrying a payable load on very level railways only. By 1837, however, the weight of engines had advanced to about half of that of the average locomotive of the present day, while the proportions and details of the machine were gradually being assimilated to those with which we are familiar. As the locomotive improved in power and efficiency, so railways, though at first confined to level districts, before long extended into hilly and even mountainous parts, needing steep grades, and curves of a sharpness at first deemed impracticable ; the speed also increased, until the public, who had been at first incredulous as to the modest rate of 20 miles per hour, began to complain as to the tardiness of trains travelling at double that pace. It will thus be seen, that railways may not unreasonably be regarded as having passed out of the experimental stage and commenced to assume their present position of commercial and social importance at a date roughly approximating with Her Majesty's accession to the throne.

At that time the mileage of British railways was only 200, while now it is not far short of 20,000, while in other lands the total length of lines, of which hardly any existed in

1837, is counted by hundreds of thousands of miles. Practically next to the effect of instantaneous conveyance of information upon our commercial and social relations and mental development, we may place that of rapid and convenient transit of goods or passengers by land or sea.

Steam navigation achieved its early successes long before 1837, but up to that date steamers were practically confined to rivers, estuaries, and local coasting service, one vessel with auxiliary steam power had, it is true, crossed the Atlantic in 1819, but nothing further had come of the experiment. In 1838, however, Trans-Atlantic navigation with full-powered steamers, as distinguished from sailing vessels provided with small auxiliary steam power, commenced in earnest, and from that day to this, the size and speed of Atlantic steam liners has increased, until instead of vessels of 1300 tons propelled by paddles driven by engines of 450 horse-power, at a speed of seven or eight knots per hour, we have screw steamships of six times the tonnage and twelve times the power, travelling at more than double the speed. This great advance in velocity has been due to a combination of causes—first, increased size, which is advantageous because the resistance of the water being mainly due to surface friction, increases only in proportion to the surface, and not in proportion to volume. Consequently, a two-fold increase of linear dimensions involves only a four-fold increase in resistance, while it secures an eight-fold power of carrying machinery and fuel; secondly, some advantage has no doubt accrued from improvements in the form of vessels; but thirdly, the most notable gain has been due to improvements in engines and boilers. Instead of working at a pressure of only about 20 lbs. above the atmosphere, with boilers filled with dense brine and coated with saline incrustations of great thickness with large heavy slow moving engines, working with but little expansion and consuming 7 lbs. of coal per horse-power per hour, we now have, thanks to surface condensation, compounding, and the substitution of the compact and quick running screw for the slow and ponderous paddle-wheel, comparatively small and light engines working at a high speed with steam of 150 lbs. per square inch, expanded most effectively in three cylinders of successfully increasing size, and not consuming more than 1½lbs. of coal per horse-power per hour. With vessels then of far larger size, and engines that obtain four times as much power from the coal consumed, no wonder greatly enhanced speed results. And the great success of Trans-Atlantic steam navigation has naturally led to the use of similar vessels elsewhere, so that now all seas are traversed by magnificent ocean steamships, and places distant from each other by the whole diameter of the earth, are brought within a little more than one month's voyage. With such vast improvements in steamers, sailing vessels are constantly falling more and more into the back ground.

In 1837 the aggregate tonnage of British steamers was less than 70,000, while that of the British ships was over 2,000,000. In 1883 the steam and sailing tonnage was equal, each being 3,500,000, while in 1885 the steam tonnage was nearly 4,000,000, and the sailing tonnage not much over 3,000,000. We may then I think fairly claim the establishment of the great ocean steam service of the world, with all its momentous consequences as having taken place entirely within the Jubilee period. Thus we see that telegraphs, railways, and ocean steam navigation, application of science to practical uses of the most enormous importance, and affecting most profoundly the social and commercial relations and mental development of the human race, all belong to the past fifty years, which period must for all future time be looked upon as in one most important respect the most remarkable the human race has yet seen.

The introduction of railways, with their necessary bridges and viaducts, &c., and the substitution of iron for wood in ship-building, together with the continually increasing use of machinery for all kinds of industrial processes, has involved a very large increase in the production of iron and steel, the amount of crude or pig iron of British origin being 1,120,000 tons in 1837, and 8,529,000 tons in 1883, while the other nations of the world, whose iron production fifty years ago was merely nominal, now supply over 12,000,000 tons per annum. This increased production has naturally led to improved processes, so that now steel, which, not many years since, was known only in small quantities as a material for swords, knives and the like, is now used in thousands of tons for rails, ships, and bridges.

There is another and very different direction in which human well-being has been enormously enhanced during the present reign. Fifty years ago, anæsthetics were unknown, and surgical operations were invested with a degree of horror which now we find it difficult to realise. The pain endured under even comparatively simple operations was so fearful that the unhappy patient not unfrequently died from the shock, while in almost every case recovery was seriously retarded. Consequently, surgical relief was had recourse to in but an exceedingly limited number of cases, and the desire to avoid unduly protracting the intolerable sufferings of the patient, led to a hurried and consequently imperfect style of operating, that most seriously impaired the prospects of satisfactory recovery.

Now all this is changed. By the aid of chloroform, ether, nitrous oxide, and other anæsthetics, including as the latest and perhaps the most remarkable, the local anæsthetic, *cocaine*, the patient is relieved of all pain, and the operation can proceed with as much care and deliberation as the dissection of a dead subject. Consequently, not only do we employ surgical aid in thousands of cases where fifty years ago it would have been regarded as utterly inapplicable, but the result of each individual operation is immensely more satisfactory than of old. The most serious surgical operation is probably that for the removal of ovarian tumour, and this is stated to have been first successfully accomplished in London in 1842. For several years the mortality under this operation was 50 per cent. Since then, however, owing to use of anæthetics, and the adoption of special precautions to secure perfect freedom from germs of disease, the mortality has been enormously reduced; one leading British practitioner having, it is stated, operated 251 times during the years 1884 to 1887 with only 2 deaths; while the labours of two English surgeons in this directions, during the past 30 years, are calculated to have added to the lives of their patients an aggregate of nearly 43,000 years. Up to the Victorian era, surgery was in its infancy; during the Victorian jubilee it has advanced to a lusty manhood. The present reign we may claim to have witnessed a development as great and beneficent in this direction as in that of rapidity and convenience in travelling, and prompt communication of information.

These then are the great practical advances, the applications of scientific investigations to ends of public utility, that must through all future history be held to distinguish the reign of Queen Victoria.

In other directions, too numerous to mention, has there been steady growth, increased efficiency, and extended application, but the above-mentioned advances are unique, startling, and epoch-making. The beautiful art of photography, the improvements in textile manufactures, the discovery of new therapeutic agents, the application of machinery in a thousand ways to lighten human labour, the general adoption of gas for lighting, and the more recent application of electricity, the invention of the telephone, the introduction of tramways in large cities, improved roads in country parts, the bridging of streams and estuaries, or the construction of tunnels beneath them, and a thousand other useful improvements are second only in importance to the more striking advances first mentioned.

In the realm of pure science, as distinguished from useful application, the three most salient facts are the establishment of the doctrines of the molecular constitution of matter, of the conservation of energy and of evolution, and with regard to these, I cannot do better than quote from a recent deliverance of no less an authority than Professor Huxley. He says: "I have said that our epoch can produce achievements in physical science of greater moment than any other has to show, advisedly; and I think there are three great products of our time that justify the assertion. One of them is that doctrine concerning the constitution of matter, which for want of a better name, I will call 'molecular;' the second is the doctrine of the conservation of energy; the third is the doctrine of evolution. Each of these was pre-shadowed, more or less distinctly, in former periods in the history of science; but, so far is either from being the outcome of purely inductive reasoning, that it would be hard to overrate the influence of metaphysical, or even theological considerations on the development of all three. The peculiar merit of our epoch is, that it has shown how these hypotheses connect a vast number of seemingly independent partial generalisations, and it has given them that precision of expression which is necessary for their exact verification, and that it has practically proved their value as guides to the discovery of new truth. All these three doctrines are intimately connected, and each is applicable to the whole physical cosmos. But as might have been expected from the nature of the case, the first two grow mainly out of the consideration of physico-chemical phenomena, while the third in great measure owes its rehabilitation, if not its origin, to the study of biological phenomena."

To dilate upon these three great doctrines would take far more time than could be spared to-night, and would need language intelligible but to few. I shall, therefore, content myself with stating that as regards the first, atoms are no longer matters of speculation as in the days of Democritus and Lucretius, but are real recognisable units, the relative weight of volume of which are well-known, while several independent but converging lines of investigation enable us to approximate to their actual size. That as regards the second, the last half century has witnessed numerous careful experiments, demonstrating that heat and mechanical energy are interchangeable, so much heat disappearing for so much mechanical work done, or so much mechanical work expended in the production of a corresponding quantity of heat.

In connection with these researches the name of Joule has acquired an imperishable fame, and his labours in this direction did not commence until some years had elapsed after Queen Victoria's coronation. Similarly other forms of energy, such as electricity in motion, sound, &c., can be obtained in return for so much mechanical work. Energy, including all these various powers as special manifestations, is constant in quantity. It may be called the currency of the universe, capable of being translated into various forms, but capable as a whole of neither increase or decrease. This doctrine is fatal to the hopes of that race of enthusiasts, even now by no means extinct, who endeavour to discover what is popularly called perpetual motion, but which really means an inexhaustible source of mechanical power. The proper appreciation of the doctrine of the conservation of energy at once shows that to hope to create or increase mechanical work by the use of complex arrangements of levers, springs, and wheels, is just as unreasonable as to hope to create or increase the quantity say of a fluid like water by simply passing it through a complex arrangement of pipes or passages—a project which, as far as I am aware, no one has yet been insane enough to expend his time and labour upon.

This great law is expressed thus by the eminent physicist, Clerk Maxwell:—"The total energy of any body, or system of bodies, is a quantity which can neither be increased or diminished by any mutual action of such bodies, though it may be transformed into any one of the forms of which energy is susceptible," and its utility in guiding both the scientific investigator and the practical mechanician is beyond all expression.

And, lastly, evolution—the grand doctrine that every thing is passing steadily through regular and orderly stages of growth and development—first dimly hinted at by early Greek thinkers, touched now and then by the scientists of the seventeenth and following centuries, but never worked out until the present half century, in which the united labours of astronomers, geologists, and biologists have impressed it so deeply upon the public mind, that whether it be in newspaper, sermon, lecture, or ordinary conversation, our thoughts and words are tinged and flavoured with it.

Darwin's great work, the "Origin of Species," saw the light in 1859, and took the whole biological world by surprise; and since then its applications in the field of biology, and its extension, in the hands of Herbert Spencer, to sociology, have been subjects of the most profound and abiding interest.

As for other scientific advances, time would fail to tell of progress in electricity, in spectrum analysis, in chemistry, and a thousand other ways. But the amount of scientific work going on at present in one direction may be roughly indicated by the statement, made on the best authority, that "more chemical analyses are now made in one day than were accomplished before Liebig's time in one year."

The present year is interesting from a scientific point of view in several other ways. One hundred years ago James Watt had but very recently perfected his famous improvements in steam engines, and was struggling to get his engines into use. Two hundred years ago exactly, Newton was engaged in publishing the "Principia," that marvellous work that ended the perplexities of astronomers, by once for all explaining the intricate motions of the heavenly bodies as a necessary consequence of the known laws of motion, and the newly enunciated law of universal gravitation. Three hundred years ago, the laws of motion had just been enunciated by Galileo, and the science of statics, that had stood still since the day of Archimedes of Syracuse had received an enormous advance through the enunciation of the proposition known as the parallelogram of forces by the Dutch Engineer Stevinus. The period 1587 to 1590 witnessed the birth of modern experimental science. Then, and not till then, did natural philosophers escape from mediæval misconceptions, and set out on a new and hitherto unsuspected road, that has led to such glorious results.

Ladies and Gentlemen,—I have on the present occasion departed from the time-honoured practice of giving a *resumé* of the scientific work of the past year, and the progress of the various local institutions. This practice, excellent and useful in its way, had through long continued annual repetition, grown somewhat monotonous and wearisome, while the great public event of 1887 suggested, and I think you will agree, justified a special departure. I shall therefore conclude by merely mentioning that the Royal Society of Victoria has held its usual meetings throughout the year; that papers of interest and value have been read and discussed; that we have welcomed to our midst the Microscopical Society, which has, as I think, most wisely decided to discontinue its independent existence and become a section of the more comprehensive body; that we have inaugurated a systematic biological survey of the waters of Port Phillip Bay, the first fruits of the results of which are open to your inspection to-night; that our joint project with the Geographical Society to explore the Antarctic regions is receiving a growing support, and will, we hope, in time be carried into effect; and lastly, that we deplore the loss, through death, of earnest and steady workers in the cause of science in the cases of Sir Julius von Haast, of Canterbury, New Zealand, whose eminent services in many branches of science had rendered his name famous throughout the world of science; of Dr. Iffla, of South Melbourne, one of the founders of the Philosophical Society, which afterwards merged into the Royal Society of Victoria, and one of the foremost promoters of the now historical Burke and Wills exploring expedition; and of Mr. A. F. Oldfield, a most industrious botanist, who did much to elucidate the flora of Tasmania and Western Australia, and who enjoyed the thorough confidence and esteem of Sir Joseph Hooker and Baron F. von Mueller. Mr. Oldfield died at an advanced age, and during his closing years suffered from the sad affliction of total blindness. But while death year by year makes havoc in the ranks of scientific men, it is pleasing to note that the gaps are as constantly being filled by young and enthusiastic workers, who carry on the labours bequeathed to them, and thus the great temple of scientific truth grows ever higher and more complete.

TRANSACTIONS.

Art. IX.—*Remarks on the Early History of the Brennan Torpedo.*

By Professor Kernot, M.A., C.E.

[See Proceedings.]

Art. X.—*Notes on Some Determinations of Chlorine in the Water of the Yarra.*

By C. R. Blackett, F.C.S.

[Read August 11, 1887.]

The opening of the Fisherman's-bend Canal, in accordance with Sir J. Coode's plan, would seem to have caused a great change in the character of the water in the Yarra-river. In 1884, Mr. Newbery made some determinations of the amount of chlorine in the water. The quantity has much increased even on the surface, but at the bottom it is now as fully charged with salt as the water of Hobson's Bay on the surface at low tide, or indeed more so.

There are several points of interest in considering the differing amounts of chlorine at high and low tide; it would seem to conclusively prove that the heavy tidal water slowly creeps up at the bottom of the stream, and that the fresh water coming down the river floats more or less upon the surface, unless when there is a vigorous churning-up by the numerous steamers which are constantly during the day moving to and fro. At the time when my samples were taken, the river was unusually still and free from traffic.

Another point arrests attention, and that is the very rapid way in which the amount of salt decreases as we ascend the stream after leaving the Paper Mills. On reaching the Gardens, at the time we took samples of the water, the proportion went down much more than was anticipated. No doubt considerable variations take place in this respect. Rain and high tides undoubtedly exercise much effect. The bed of the river is, I am informed so formed between these points which I have indicated, as to account to some large extent for this sudden diminution of the saline constituents.

Sea water is known to be impregnated with magnesium chloride. The water of the ocean and seas "is subject to some variations, according to the part where it is collected. The waters of the Baltic and Black Seas are less salt than the average." The waters of the Mediterranean in the Levant are more salt than near Gibraltar, the variations ranging from 3·5 to 4 per cent. A complete analysis of our Australian sea water has not yet been done, but would be both a useful as well as an interesting piece of original work.

I may add that the removal of the Falls and cutting of the new channel has not been an unmixed evil from a sanitary point of view. The antiseptic power and the precipitating influence of chloride of sodium in the Yarra should have an effect on the contaminations constantly entering it. Some little time ago there was a great outcry about stenches on the Yarra, but those bad smells arose chiefly from the operations carried on for the construction of Princes Bridge. The contractor pumped the water out of the lagoons in the vicinity of the bridge, and this water was highly charged with decayed organic matter. Moreover, the water from the lagoons had filtered into the river, and had left decayed organic matter in the earth through which it passed, and this earth had been disturbed, and smelt very badly. But the public has been under the impression that the Yarra itself was in a worse state than it had been in for many years. Since the operations I have referred to have been concluded, one can walk along the banks of the Yarra without having his olfactory nerves offended. The Yarra must naturally be contaminated, but it is no longer a public nuisance. I hope, however, that efforts will be made to keep the Yarra as free as possible from contamination, for I do not wish to minimise the dangers arising from the pollution of the stream.

Yarra Water taken September 30, 1884, by Mr. Cosmo Newbery.

1. Above Princes Bridge—surface	..	7·2	per gallon
2. ,, ,, ,, bottom	..	7·71	,,
3. Opposite Paper Mills—surface	..	8·17	,,
4. ,, ,, bottom	..	9·08	,,
5. Above Falls Bridge—surface	..	9·08	,,
6. ,, ,, bottom	..	53·15	,,
7. Below ,, surface	..	19·08	,,
Surface Falls Bridge ..	..	7·72	
Bottom ,, ..	..	36·8	
,, ,, ..	..	278·9	
Spencer-st. bottom ..	..	306·24	

Estimation of the amount of Chlorine (combined) in the Water of Yarra River at various places, at High Tide and Low Tide. May 23rd, 26th and 27th, 1887. Grains per Gallon.

No.	Place.	Chlorine	=	Na Cl.	High Tide, 2.34 p.m.
1	Spencer-st. ..	170·4	=	280·6	Surface
2	,, ..	1316·0	=	2169·0	Bottom, sp. gr. 1025·1
3	Falls Bridge, West ..	31·5	=	51·9	Surface
4	,, ,, East ..	1300·8	=	2127·0	Bottom ,, 1025·0
5	,, ,, East ..	32·0	=	52·7	Surface
6	,, ,, East ..	1290·8	=	2123·9	Bottom ,, 1023·8
7	Paper Mills ..	16·0	=	26·36	Surface
8	,, ,, ..	1240·4	=	2042·9	Bottom ,, 1023·0
9	Botanical Gardens ..	2·8	=	4·61	Surface
10	,, ,, ..	42·0	=	69·17	Bottom ,, 1002·0
21	Johnston-st. ..	2·3	=	3·78	Surface
22	,, ..	2.3	=	3·78	Bottom & Bottom =
23	Dight's Falls, below	2·3	=	3·78	S ,, ,,
24	,, ,, above	2·0	=	3·29	
					LOW TIDE
11	Spencer-st. ..	118·0	=	194·34	Surface
12	,, ..	1244·0	=	2048·8	Bottom, sp. gr. 1023·8
13	Falls, West ..	36·3	=	59·78	Surface
14	,, ,, ..	1295·0	=	2132·86	Bottom ,, 1024·8
15	,, East ..	26·0	=	42·82	Surface
16	,, ,, ..	1176·0	=	1936·87	Bottom ,, 1022·5
17	Paper Mills ..	9·7	=	15·97	Surface
18	,, ,, ..	11·0	=	18·11	Bottom
19	Gardens ..	2·6	=	4·28	Surface
20	,, ..	3·5	=	5·76	Bottom
25	Johnston-st. ..	2·4	=	3·95	Surface
26	,, ..	2·4	=	3·95	Bottom
27	Port Melbourne ..	1052·8	=	1733·9	Sp. gr. 1018·0
28	Heads ..	1470·0	=	2421·0	,, 1027·5
29	Yan Yean ..	2·0	=	3·294	

Art. XI.—*Notes on Certain Metamorphic and Plutonic Rocks at Omeo.*

By A. W. Howitt, F.G.S.

In writing on the subject of the Metamorphic Rocks at Ensay * I said that the conclusions to which their study had led me were also those to which I had been brought by the examination of similar phenomena in the Omeo district, where the relations of the sedimentary, metamorphic, and plutonic rocks may be observed and studied on a much wider scale. In the present paper, I desire to bring under notice certain observations which I have made on the relations of the metamorphic and plutonic rocks in one part of the valley of the Livingstone Creek.

These notes refer only to a part of the Omeo district, that is to say, to a strip of country extending from the Tongeo Gap in the Great Dividing Range to near the junction of the Livingstone Creek, with the Mitta Mitta River at Hinnomunjie.

The road from Ensay and from the valley of the Tambo River ascends the Great Dividing Range from Tongeo, by way of the Tongeo Gap, at an elevation of 2800 feet above sea level, and thence follows the slopes of the eastern side of the Livingstone Valley to the township of Omeo, at about 500 feet below the elevation of the Gap.

To the right-hand of the Tongeo Gap, in going to Omeo, are the Bowen Mountains, rising to some 1500 feet or more above it. These mountains are almost wholly composed of highly inclined and more or less altered sediments, which have, in places, still retained the familiar facies of the older palæozoic or goldfields series of this district. The wide sloping valley falling from them towards Livingstone Creek is composed of varieties of regional metamorphic schists together with masses of intrusive granites and quartz diorites, the former being the most prevalent.

From near the Tongeo Gap, and running in a direction which approximates to N. 30° W., that is to say, to the mean strike of the lower Silurian formations, there is a more or less well-marked contact of the plutonic and altered sedimentary

* "The Sedimentary, Metamorphic, and Igneous Rocks of Ensay." Transactions Royal Society of Victoria, vol. xxii, p. 64.

rocks, which crosses Livingstone Creek just below the northern end of the Hinnomunjie Morass, and thence extends probably to the Mitta Mitta River, if not beyond. The total distance of the contact which I have observed is not less than ten miles.

Speaking generally, the rocks on the north-east side of this contact are varieties of metamorphosed sediments, which, at a distance from it, still retain the outward semblance of the alternating argillaceous and arenaceous beds of the Silurian formations, while near to the contact, they are in places so metamorphosed as no longer to be recognisable when seen in hand samples. On the south-western side of the contact the rocks are almost wholly crystalline intrusive rocks, mostly granites, and with, in places, small areas of gneiss.

This contact represents a great fault, the amount of down-throw on the north-eastern side having brought the sedimentary strata within the influence of the intrusive rock masses. It is not possible to say how much has been the amount of down-throw, for there is not any standard which may be taken for reference. The sedimentary rocks have been almost completely denuded for long distances on the south-western side of the contact, and those that remain in the nearest localities, as for instance on Mount Livingstone, or in Mountain Creek, are so much metamorphosed as to afford no measure of comparison. Nor can any data be obtained from the relative position of the contact planes in those places and at Wilson's Creek or Hinnomunjie Morass.

The sections and diagrams which accompany these notes, together with the analytical examinations of the rocks collected, will give further insight into the interesting features of this locality.

Hinnomunjie Morass.—The line of contact, as I have already said, crosses Livingstone Creek at a short distance below the Hinnomunjie Morass, and thence extends, I know not how far, towards or beyond the Mitta Mitta River. The line of contact is not a regular one when locally examined, yet, when traced for some distance in its course, it will be found to maintain a general direction approaching to north-west. Moreover, on looking across the undulating country crossed by it, the difference in outline of the schist hills on the one side, and of the granite hills on the other, is often quite perceptible to the accustomed eye. The local irregularity in the contact line is due to the protuberance of the granites into the tracts of schist, in promontory-like extents, which are again connected with lesser masses, or with dykes and veins which pass across or between the beds of schist. Moreover, there are numerous places where greater or less extents of granitic rocks have been exposed in the schist areas, especially in the Wilson's Creek district, by denudation at distances of more than a mile from the granite contact.

The manner of the contact between the granites and the schists will be understood from the following descriptions :—

The first sample of contact which I shall note, is situated about a mile from the northern end of the Hinnomunjie Morass, in a small gully which runs down to Livingstone Creek from the west side. The actual contact has been laid bare in a horizontal section. The schists are nearly vertical, on a strike of N. 55° W. They are greyish in colour, and the less quartzose beds are micaceous and glistening, and very frequently nodular in character. Irregular veins of quartz follow the strike, or cut across the beds. The granites which are on the western side of the contact extend from it into the schists, and also pass as dykes between the beds, or appear as apparently isolated masses at a distance, surrounded by them. The intrusion of the granites does not appear to have much bent or contorted the beds of schist, which, however, are cut off across the strike, as well as being in places detached in portions from the main mass.

The essential features of this contact are given in Fig. 1, Plate I., and I collected examples of the schists, and of the granites, as to which the following details will give information :—

The first samples illustrate the micaceous and the quartzose beds which alternate with each other just as do the argillaceous and quartzose beds of the local Silurian sediments. The first sample is of a grey-coloured, very fine grained mica schist. It is much corrugated on a small scale, and is distinctly nodular. Under the lens one can make out colourless mica in small flakes, some black mica in less amount, and also some minute crystals of black tourmaline. Examined as a thin slice under the microscope, the main mass of the rock is seen to be of muscovite mica, intermixed with a brown magnesia mica. In places the muscovite is the sole mica; in others the magnesia mica preponderates, and there are also places where the plates of both of the micas are larger than the average. Throughout the whole slice there are very numerous small prisms of tourmaline, which are translucent in tints of brown, the O ray being brown and the E ray being almost colourless. The prisms are mostly arranged with their C axis in the plane of the slice, and therefore, I observed but few cross sections. So far, however, as I could observe, the prisms are mostly six-sided, and are hemi-hedrally terminated. The size of the prisms varies from ·08 inches down to ·02 inches in length, and from ·04 inches to ·01 inches in width. Many of the crystals are much eroded, and also include what appear to be small masses of quartz.

The second sample examined is of a somewhat fissile grey coloured schist, tinted in places with ferruginous stains. The foliations are glistening with minute plates of muscovite, and under the lens one can observe, in addition to them, flakes of brown mica, and numerous prisms of tourmaline of minute size. There are slight traces of nodular structure in this schist. An examination of a thin slice of this rock shows that it is composed of a considerable amount of quartz in grains, intermixed with flakes of muscovite and magnesia mica, the latter being strongly pleochroic. There are great numbers of minute tourmaline crystals distributed throughout the slice. In places the magnesia mica preponderates over the muscovite, as was the case in the sample last described. The principal, if not the only, difference in the two samples, is that in the latter quartz is in considerable percentage, and that the magnesia mica occurs in crystals and not in overlapping plates. As I have shown in Fig. 1, Plate I., portions of the schists have been detached, and are included in the granite. In order to see what changes had been effected by the action of the magma upon such fragments of the sedimentary rocks, I examined one such sample (*c* in Fig. 1, Plate I.) with the following results:—

The hand sample is a finely crystalline rock, having in places a schistose arrangement; but taken as a whole, it much resembles some of the very crystalline dark-coloured varieties of hornfels. Under the pocket lens it can be made out to be a mixture of quartz grains, and very numerous minute, splendent, rather short prisms of tourmaline of a black colour. In a thin slice under the microscope, this rock is seen to be composed of quartz grains and very numerous crystals of tourmaline, which is transparent in tints of brown. These crystals do not lie in any definite direction in the slice, although they form bands in it, thus producing a schistose appearance. They are mostly short and rather stout, prismatic crystals, three, six, or nine-sided, and hemi-hedrally terminated. The dimensions of these crystals are about the same as those last described. They are, and especially the larger ones, much eroded and cavernous, and include numerous particles of quartz. The crystals are pleochroic, the E ray being nearly colourless, while the O ray is a dark golden brown. These observations were further confirmed by an examination of a number of these beautifully splendent crystals which I isolated by means of hydrofluoric acid. The main mass of this rock is composed of numerous grains of quartz, with a few small grains of triclinic felspar.

It seems to me that this rock represents a portion of schist in which the bases have been converted into tourmaline, with also an access of silica as quartz.

The Muscovite granite at this contact varies much in grain. In some parts, the constituent minerals are up to an inch across, while as to others, all that can be said is, that it is slightly coarser than that of the average rocks of the neighbourhood.

I separated samples of the felspar, mica, and quartz for examination.

The felspar is yellowish in colour. In places, it is somewhat intergrown with quartz, after the manner of "graphic granite." Under the pocket lens it also shows those irregular veinlets of a second felspar on OP (001), and $\infty\bar{P}\infty$ (010), which indicate a microperthite. I found on examining a thin slice prepared from the most perfect cleavage (OP), that this felspar is a well-marked example, the albite veins being very characteristic, as well as the twinned structure of the microcline, which is the form of the potassa felspar.

A slice from the less perfect cleavage (∞ ∞) showed me also the familiar appearance of irregular veinlets of albite, traversing the slice at angles between 60° and 65° to the trace of the perfect cleavage. A second set of veinlets were also interposed in the plane OP, and which in places connected with the other series. The inclusions in this felspar are confined to grains of quartz, and rarely plates of muscovite. Through the kindness of Mr. J. C. Newbery, C.M.G., Mr. Jas. C. Fraser most obligingly made the subjoined quantitative analysis of this felspar in the laboratory of the Technological Museum:—

ANALYSIS No. 1.—MICROPERTHITE.*

$Si.O_2$	...	...	...	62·13
$Al._2O_3$	...	...	...	24·35
$Fe._2O_3$	...	...	...	tr.
$Na._2O$	...	...	...	6·66
K_2O	...	...	...	8·31
H_2O	...	...	...	·50
				101·95

The mica is the usual silvery coloured muscovite found in these rocks, in plates, and in irregularly shaped crystals, having an hexagonal, that is to say, a modified rhombic outline. When least altered, the cleavage plates have a slightly smoky tint by transmitted light. The optical characters of this mica are as usual, and it is according to Reusch's test, a mica of the second order.

I subjoin a quantitative analysis of this mica:—

ANALYSIS No. 2.—MUSCOVITE.

Fl	...	...	...	·15
$Si.O_2$	...	...	...	44·67
$Al._2O$	...	...	...	37·44
$Fe._2O_3$	...	...	...	·48
$Fe.O$	...	...	...	·91
$Ca.O$	...	...	...	·26
$Mg.O$	...	...	...	·42
K_2O	...	...	...	10·90
$Na._2O$	...	...	...	1·24
H_2O	...	...	...	3·76
				100·23
Hygroscopic Moisture			...	2·18
Sp. gr.		...	...	2·758

The quartz of this granite is somewhat glassy in appearance, and contains numerous fluid cavities without bubbles. It shows cloudy obscuration when examined by polarised light, indicative of strain.

* The grains of free quartz were picked out from the sample before analysis.

The less coarse parts of this granite mass, though still large in grain, is of such a texture that a fairly correct estimate of its composition can be made by examining a thin slice of good extent.

I found in it muscovite in broad crystals, with irregularly bounded planes parallel to the C axis. Some individuals included grains of quartz. The felspar is in less amount, being mainly orthoclase, with a smaller proportion of plagioclase, which occurs in ill-formed crystals with irregular twinning. The quartz is in large amount, and of the same character as that spoken of before. In the mica, felspar, and quartz there are numerous small spheroidal masses of black opaque iron ore, which is probably of secondary origin. This rock is, therefore, to be classed as a coarse-grained muscovite granite.

Another interesting exposure of the contact is laid open in a gully somewhat nearer to the Hinnomunjie Morass. Here the surface details are supplemented by a vertical section in the banks of the gully immediately adjoining. This exposure is, I think, a little to the eastward of the general line of contact, if one may assume that at this spot it is at the extreme western extremity of the masses of schist. But the schists and the granites are so much interlocked that it is not always safe in the absence of a detailed survey to speak with certainty as to any particular spot in this line being the main contact. The schists are here surprisingly regular in their strike and dip considering their relation to the granites. They are alternations of somewhat narrow micaceous and quartzose beds. They are always at a high angle of dip, and frequently vertical on a strike of near N. 45° W. Fig. 2, Plate I., represents diagrammatically the relations of these schists, and of the granites which are in contact with them. It will be seen that the granites have come up as veins or dykes between the schist-beds, and that at the principal contact these intrusive rocks are massive, and fill a space which was once occupied by the schists which are, as I have represented, cut off sharply, and in places are more or less included in the intrusive rock.

In proceeding across the strike of the schists, beyond the line of section and in a north-easterly direction, the granite veins decrease in number, and the schists are less altered, until at perhaps a distance of a mile they have much the normal appearance of the argillaceous schists of Reedy Creek.

The mineralogical characters of these schists will be understood better from the following examples. The letters prefixed to the descriptions refer to those appended to the diagram Fig. 2, Plate I.

(*a*) Nodular mica schist striking N. 30°-40° W. The beds at this place are not all of them nodular, and they vary also in colour and in the relative amounts of quartz and mica. This sample I examined in a thin slice. I found the main mass of the rock to be a mixture of brown magnesia mica, and of colourless muscovite in small overlapping plates. In this are very numerous short, stout, light-coloured crystals of tourmaline from ·004 x ·002 inches down to ·0015 x ·001 inches in dimensions. There is a considerable amount of black iron ore scattered throughout the slice. No quartz is visible in the several slices examined. I have to thank Mr. Jas. C. Fraser for the subjoined analysis of this rock :—

ANALYSIS NO. 3.—MICA SCHIST.

$Si.O_2$	...	...	...	58·87
$Al._2O_3$	...	...	...	16·95
$Fe._2O_3$	...	...	...	8·62
Fe.O	...	...	...	3·93
Ca.O	...	...	...	·97
Mg.O	...	...	...	2·32
K_2O	...	...	...	5·98
Na_2O	...	...	...	1·48
$Li._2O$	...	...	...	tr.*
B_2O_3	...	...	...	tr.
				99·12

A second sample from the same place (*a* Fig. 2, Plate I) is of one of the quartzose beds. In the hand sample it is a somewhat fissile schist of a greyish to yellowish colour, and the foliations very glistening with plates of muscovite. Under the lens can be seen plates of rather pearly mica, very little brown magnesia mica, and numerous crystals of tourmaline can be made out. Under the microscope a thin slice of this rock shows a far greater amount of quartz than there is in those beds of which the last described is a sample. With the quartz grains there is a colourless mica, and there are numerous tourmaline crystals of somewhat larger size than those in the last-mentioned rock. These crystals lie mostly

* Determined by spectroscope only.

in the micaceous foliations, and are generally broken across. The principal difference between this rock and the last one described is in the scarcity comparatively of magnesia mica, and in the large amount of quartz in grains of various sizes.

The subjoined analysis was kindly made for me in the laboratory of the Technological Museum, by Mr. Jas. C. Fraser:—

Analysis No 4.—Quartzose Mica Schist.*

$Si.O_2$	72·60
$Al._2O_3$	9·03
$Fe._2O_3$	10·00
$Fe.O$	1·05
$Ca.O$	·50
$Mg.O$	3·12
K_2O	2·44
Na_2O	2·62
H_2O	·50
	101·86

I selected a third sample from a quartzose bed adjoining a dyke at *c*, Fig. 2, Plate 1. It is composed of rather large rounded to angular grains of quartz, full of inclusions, and with fluid cavities without bubbles. The inclusions are mostly minute rounded flakes of dark brown mica, such as I have frequently observed in quartzose hornfels at Swift's Creek and in other parts of North Gippsland. Besides the quartz there are flakes of muscovite in less amount than the numerous small, greenish-coloured prisms of tourmaline. In order to complete the comparison of varieties of these schist beds, I selected a fourth example, being one taken from close to the contact at the place marked (*e*) in the diagram section, Fig. 2, Plate I. This sample is strongly nodular, but otherwise much resembles in appearance the second example at (*a*.) Judging from the example of a thin slice, this rock is composed of quartz in angular grains, scattered through a ground mass of muscovite mica. Fluid inclusions are common in the grains of quartz, which differ much in size. Tourmaline crystals of minute size are also numerous, arranged parallel to the foliations. Most of these crystals have, as in other samples, been broken across the

* I found the specific gravity of a sample of this rock to be 2·723.

prism. These samples of the schists sufficiently describe the character of all the beds shown in the section, the only difference being that some are more nodular than others, or that in places the quartzose beds predominate over the micaceous ones, or *vice versâ*.

An inspection of the diagrams given, which sufficiently well copy the reality, shows that the schists have been invaded by the granites, which, in places, fill spaces at one time occupied by the schists, and in other places, at further distances, have penetrated between the beds and more rarely across them. Where the contact line is well marked, the schists are cut across, and the granites abut against the truncated ends, and also include fragments of the beds which have been detached, and have become surrounded by the magma. The general character of these granites in mass is a rather coarse crystalline, or crystalline granular compound of felspar, muscovite, and quartz, analogous to that described previously at *p*. The dykes and veins which lie between the schist beds are, however, as a rule, much coarser in structure than the granite masses, and may, in some cases, be rightly designated as Pegmatite. But since this name has, to some degree, become associated with the conception of dykes which are not, strictly speaking, igneous and intrusive*, it may be well to use the general term "muscovite granite." These dykes vary in the locality taken as an illustration from 6 inches up to 36 inches in width. With the larger ones I found quartz veins to be associated, thus recalling the "plutonic quartz veins" which I have spoken of elsewhere †. In this locality these veins seem so far to have proved entirely barren of gold or ores of metals. In Fig. 1, Plate II., I have sketched one of the dykes of muscovite granite which occur in the section described. I chose this dyke for the reason that it represents the fair average sample, while at the same time it is, in parts, not too coarse in texture for a thin slice for microscopic examination. It is composed of felspars of two kinds, muscovite mica and quartz. The potassa felspar is in

* Kalkowsky remarks as follows :—"Es ist nun aber zu beachten dass solche Pegmatite fast stets 'gang granite' sind, also massen deren anogene Entstehung zehr zeifelhaft ist die viel mehr durch mancherlei chemische und mechanische Processe unter uns unbekannten Verhält nissen gebildet worden sein mögen."—*Elemente der Lithologie*, p. 66.

† Notes on the Area of Intrusive Rocks at Dargo. Transactions Royal Society of Victoria, Vol. XIII., p. 152.

comparatively large irregularly-shaped masses, without any striation, and obscuring in partial fields. As there is no trace of cleavage, and as there are no bounding planes developed, observations as to the angle of obscuration could not be made. The percentage of potassa in the subjoined analysis renders it, however, most likely that these felspars are as I have classed them. Besides these larger individuals, there are also smaller fragments of the same. The other felspar is a plagioclase in much wasted crystals. The only obscuration angles which I could measure with any confidence, gave 2° approximately on OP (001), and 11° on $\infty\bar{P}\infty$ (100.) The mode of twinning resembles that of oligoclase.

Muscovite mica is in large crystals which have been much corroded at the sides. Where the section cuts the crystal at a slight angle with the base, the slice has a peculiar mottled-appearance, due to the overlapping of numerous consecutive cleavage plates. But where the section coincides with the basal cleavage, the slice is optically perfectly homogeneous, and polarizes with uniform tint of colour. There are no inclusions, and the mica seems to me to be of the same period of formation as the felspar, but to be younger than the quartz. The quartz is in large masses, filling in all spaces, and including portions of broken up felspars of both kinds, and also small flakes of muscovite. I made a quantitative analysis of a portion of this dyke which was apparently but little decomposed, but also somewhat more quartzose than the part examined under the microscope :—

ANALYSIS NO. 5.—MUSCOVITE GRANITE.

$Si.O_2$	76·10
$Al._2O_3$	15·95
$Fe._2O_3$	tr.
$Ca.O$	·23
$Mg.O$	·11
K_2O	3·27
$Na._2O$	2·90
H_2O	1·16
	99·72
Hygroscopic Moisture ...	·18
Sp. gr.	2·673

At (*e*) in the section Fig. 2, Plate I., there is a close-grained dyke of a dark-greenish colour, lying between the schists, and about three feet in thickness.

When examined in a thin slice, I observed that it was extremely altered from the usual character of such dykes in this district, and of the original structure but little remained. In parts there had been an extensive deposition of quartz in irregularly-formed concentric radial crystals, forming masses which, when rotated between crossed nicols, showed strong traces of a black cross. Here and there in the portions outside these quartz masses, I could trace the outlines of former lath-shaped crystals of felspar, scattered among numerous groups of grains and tufts of a dark-green mineral, which I did not find to be sensibly dichroic. Were it not for this, I should be inclined to consider it one of the chlorite groups of minerals. Mr. Jas. C. Fraser found in an examination of a sample of this rock, ·05 per cent. of boracic acid. All that I can say is, that it probably in its original condition was a diabase porphyrite, and that it seems to have been subjected to metamorphism at the same time with the schists enclosing it.

Before speaking generally as to the conclusions to be drawn from a consideration of the phenomena observed at the contact of the granites and the mica schists in the two localities now described at Hinnomunjie Morass, it will be well to review slightly different, and yet analogous appearances, in connection with another part of the same contact, which can be studied at Wilson's Creek, at a distance of several miles south east from the locality which I have now described.

Wilson's Creek rises in the Bowen Mountains, and in the spur, which runs from it in a north westerly direction over Mount Cook, towards Livingstone Creek. It crosses the line of contact of the granites and schists about a mile and a half above its junction with Livingstone Creek. Thus the upper part of its course is over the metamorphosed schists, and the lower over the granites.

In Fig. 3, Plate I., I have given a diagrammatic section along that part of its course which covers the most important features.

In the following descriptions, the letters used at the commencement of the several paragraphs refer to that section :—

(*a*.) Spotted schists dipping N. 60°, E. at 70°. These beds conform in their strike and in their alternation of quartzose and fine-grained beds, with the less altered formations in the same sequence in the Bowen Mountains, which can be again followed across their strike still further to the eastward, to where in the Tambo Valley, between Tongeo and Bindi, they have all the familiar facies of the Silurian strata of the district. I regard these schists as being metamorphosed lower palæozoic sediments, and in all probability of lower Silurian age.

Under the microscope, I found a thin slice prepared from one of the fine-grained beds, to be a minute mixture of small flakes of a colourless alkali mica, with a very little magnesia mica of a yellowish colour, and a small amount of quartz in grains of minute size.

Throughout the whole mass, there is much graphite distributed in minute specks, which in places are aggregated into small masses. Of this rock I made the subjoined quantitative analysis:—

ANALYSIS No. 6.—MICA SCHIST.

C	3·32*
P_2O_5	·10
$Si.O_2$	64·00
$Al._2O_3$	19·82
$Fe._2O_3$	3·50
Ca.O	·32
Mg.O	2·14
K_2O	4·41
$Na._2O$	1·10
H_2O	2·23
	100·94
Hygroscopic Moisture ...	·85
Sp. gr.	2·651

I also examined a quartzose schist which adjoined the above. I found it to be composed mainly of grains of quartz, some of which contain numerous fluid cavities. Surrounding, and lying between the quartz grains are small ragged flakes of magnesia mica, which are much bleached in colour, and

* As this percentage of graphite appeared to me to be high, I made a second determination for control, which gave 3·40 per cent. The graphite which separated, on treating the finely powered rock with pure hydrofluoric acid and sulphuric acid, and boiling the residue with water, was apparently in a pure state, but on ignition for nearly two hours left a considerable ash.

as is usual in such cases, this is associated with an exclusion of iron, which has been deposited as magnetite adjoining them and also in neighbouring fissures. Muscovite is in rather more amount than the other mica in lath-shaped flakes. In this mass are some minute crystalline grains, which are colourless, have a wrinkled surface, strong marginal total reflection and polarize with red and green tints of the first order of colours. I found one such crystal which had a prismatic form, and which obscured parallel to the sides. These data seem to indicate zircon.

(*b*.) The schists here are a little more altered, and have micaceous nodules. They are vertical on a strike of N. 80° W.

(*c*.) Rather coarse schists having a gneissose appearance. The strike is probably N. 60° W., the beds being vertical. In a microscopical examination, I found this rock to be composed of much quartz in grains, alkali mica in aggregates of small flakes, together with a little brown magnesia mica.

A dyke crosses the beds at this place. The ground mass of the rock was probably felspathic, but it is now greatly altered into a pale green-coloured fibrous chlorite. In this ground mass are a few much altered felspars, in which no striations are distinguishable in more than traces. There are also chlorite pseudomorphs after some mineral, possibly augite. This dyke may be a porphyrite, but it is so much altered that a satisfactory diagnosis is not to be arrived at.

(*d*.) At this place the schists are in a still more altered condition than those seen last on the line of section. They have an appearance resembling that of a fine-grained gneiss, and they strike N. 45° W. A sample of one of these schists, when examined as a thin slice under the microscope, I found to be composed of quartz and mica in about equal amounts, but in places the former predominates slightly, while in other places the contrary is the case. The quartz is in angular grains of the character usual to some metamorphic schists. It has very few fluid cavities, but it includes numerous minute oval or rounded microliths of a brown colour, which appear to be mica. The mica in this rock is of two kinds, first a colourless alkali mica either in individual crystals or in masses of flakes or small scales, which are then surrounded by brown magnesia mica.

Throughout the slice there are masses of iron ore, which in some instances are clearly aggregates of imperfect crystals. These masses also include flakes of muscovite.

(*e.*) The schists at this place are very massive, no bedding being visible and only indistinct foliation in the rock. I found a sample, of which I prepared a thin slice, to be very micaceous, most of the mica being a yellowish or colourless alkali mica, the colourless portion being either in plates or else in plumose or fan-shaped groups of plates. The yellowish-coloured mica is fibrous, or is in small scales, and it fills in spaces. This yellow fibrous mica also surrounds other minerals, and seems to be due to later alteration, and has some resemblance to damourite. There are also numerous patches of pleochroic brown mica in which I observed in places minute crystalline inclusions, round which there is a dark to black halo which disappears when the slice is rotated, so that the traces of the basal cleavage are perpendicular to the plane of the polarizing nicol. The pleochroism of the halo is only visible in the vertical sections of the mica, and not in those which are parallel to the basal cleavage, in which the inclusion is surrounded and concealed by a permanent circular opaque black patch. In these latter sections the dark halo is seen, but it undergoes no change in rotating the slice. In connection with these phenomena are to be noted numerous crystals and grains of iron ore, or possibly ilmenite, although in no case did I observe any of the characteristic alteration products of that mineral.* Many of these crystals of ore can be recognised as being hexagonal, but in most cases the outlines of the crystals are eroded or worn away; other cases are where there are mere skeletons of crystals, part of the form being indicated merely by minute black grains in rows. These ores are connected in some cases with the brown mica, and with the halos surrounding the microliths of which I have spoken. These observations suggest that the pleochroic halos may be due to local molecular aggregation of iron in the mica.†

As is usual in other parts of the district, there are two alternating varieties of these schists, one of which is more quartzose than the other.

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* Minute portions of iron ore which I extracted from the powdered rock did not give me any reactions for titanium when examined with fluxes before the blowpipe.

† Rosenbusch notes these occurrences in mica, and suggests the above explanation in his "Physiographie der Mineralien," 2nd edition, p. 192.

The main mass of a slice prepared from a sample of the quartzose variety I found to be composed of almost equal sized grains of quartz and felspar, the former being the more plentiful. There are also here some grains of quartz of much larger size than the average, and these are all much broken. All the quartz grains, large and small, have numerous fluid cavities, and also include numerous small reddish-brown flakes of mica.

By far the greater number of the felspar grains are simple, and appear to be orthoclase. The few which are compound I consider to be oligoclase near to albite, if not indeed the latter. They much resemble similar felspar grains which occur in some of the quartzose schists at Ensay.

In the mass of the rock which is thus composed of quartz and felspar there is an amount of mica equal perhaps to one-fifth of the whole. The greater part of the mica is a yellowish to light-brown magnesia mica, not strongly pleochroic, the remainder being muscovite. The mica lies between and around the grains of quartz and felspar, and has, as it seems to me, been formed later than either of them. A few yellowish tourmaline crystals, with a few small grains of magnetite, (?) complete the composition of this rock.

It is to be noted that in these schists, which adjoin an intrusive mass or large dyke of aplite, felspar and tourmaline appear, and that the schists generally have assumed a structure and composition differing in a marked manner from those at (*a*) which were taken as a starting point, because they were a fair example of the mica schists which extend from the Bowen Mountains across towards Hinnomunjie, and which are perhaps also representative of the metamorphism of those strata generally anterior to that further alteration which was produced by the granites.

(*f*.) There is here an exposure of a mass of granite. The surrounding schists are much contorted, and are spotted and micaceous. The sample of schist which I examined from this place is fine grained, and composed of numerous grains of quartz, among which are small flakes of a brown mica and of muscovite. The mica has in places a parallelism, and thus produces the appearance in the slice of foliation. A few light-coloured grains of tourmaline complete the rock. The granite is rather light-coloured, and is composed of felspars, mica, and quartz. The principal felspar is orthoclase in irregularly bounded crystals, which in some cases include veinlets of a second felspar, thus being a microperthite. In one instance I found the felspar intergrown with quartz in the "graphic" manner. Some of the orthoclase felspars are quite fresh, while others are converted into pinite pseudomorphs, accompanied by the usual large plates of muscovite mica which I have observed in such cases in some of the Ensay rocks. That these pseudomorphs are after potassa felspar is shown by portions remaining centrally in one or two cases still unaltered. A few triclinic felspars occur also in smaller crystals, having small obscuration angles. Some of the crystals of muscovite are probably original, whilst others are certainly secondary, as, for instance, the micaceous aggregates of the pseudomorphs.

Brown, strongly pleochroic magnesia mica appears also to be one of the earlier-formed minerals, as it is extensively eroded, and has ragged edges, portions of which have, in places, been detached. The same pleochroic halos surrounding minute crystals, of which I spoke a few pages back, appear here also under the same conditions. Here also such of the minute included crystals which I could examine had a prismatic habit, with rounded edges, and a longitudinal obscuration. Their comparative rarity and their minuteness, so far, have prevented me from isolating any for separate examination, and their real nature must therefore still remain uncertain. This granite mass is about thirty paces across on the line of section, and then the schists continue much broken up, disjointed, and in places decomposed.

(*g*.) The schists at this place are very massive, and are traversed by small veins of aplite and of quartz. They are jointed, but the bedding is obscure, if not obliterated. In a hand sample the rock is buff-coloured, with a schistose structure, and under the lens it has the appearance of being a rather minute mixture of yellowish-coloured felspar, quartz, and mica. Under the microscope I found this rock to resemble in its structure that described at (*e*), but it is rather coarser in grain, and with fewer felspars as compared to the quartz grains. The felspars form connected veins of varied width, separating the quartz grains into rude foliations connected with each other. Muscovite mica occurs in crystals among the felspars, and seems to be one of the earlier-formed minerals. There are also a few light-coloured flakes of magnesia mica, and a few greenish prisms of tourmaline complete the composition of this rock.

(*h.*) At this place the schists are much jointed, and the foliation is not marked; yet, on looking at the rocks in mass, they can be seen to be contorted in structure. A rude foliation dips at 52° to N. 20° E. There are traces of granite veins with schorl. The hand sample of this rock is of a light buff colour, with a schistose character produced by alternations of light and dark-coloured foliations. Examined by means of the pocket lens, the light-coloured portions appear to be a minute mixture of felspar and quartz, and the dark-coloured portions to be the same with a large proportion of a dark-coloured mica. Throughout this surface larger plates of muscovite are visible.

This preliminary diagnosis is borne out by an examination of a thin slice. The main mass of the rock is composed of quartz and mica, with a somewhat less amount of felspar in grains. In places these grains are aggregated together, and are surrounded by grains of quartz larger in size. These felspar aggregates suggest that they are the broken fragments of one individual. The grains of quartz are much separated by flakes of muscovite and of magnesia mica, the latter being much chloritised. This chlorite polarizes with faint tints. The quartz grains include fluid cavities, and also numbers of minute, rounded, brown and colourless microliths. Iron ores and a few broken and cavernous crystals of tourmaline complete the list of component minerals.

(*i.*) The schists here are thick bedded, dipping S. 65° W. at 78°. In a hand sample the appearance is much that of the last described rock, but it is rather darker in colour, and perhaps not quite so minutely crystalline.

In a thin slice the rock is seen to be mainly composed of interlocking grains of quartz, which are full of rounded microliths, both of a brown colour and colourless. Brown mica flakes are plentiful among the grains of quartz. In places, what may be called the ground mass of the rock, is not quartz, but felspar, in which are included the quartz grains. Most frequently this felspar has been converted into an aggregate of minute flakes of mica of a yellowish colour. In addition to these components there are a few yellowish-coloured tourmaline crystals, which, as in other samples of these rocks, have been eroded and wasted since their crystallisation.

(*k.*) The schists at this place dip N. 20° E. at 81°, and are traversed by small aplite veins. The sketch, Fig. 3,

Plate II., gives roughly the features of these beds. A sample from the bed marked (*a*), which I examined in a thin slice, I found to be foliated by alternate bands of brown pleochroic mica and quartz in crystalline grains. The interspaces are filled by a mixture of flakes of brown mica and a lesser number of flakes of muscovite, or else filled by small masses of pinite, with relatively large plates of muscovite. As in other rocks in this section, the brown mica contains, but not in all cases, minute inclusions surrounded by pleochroic halos. In addition there are also grains of orthoclase among the quartz grains.

A second sample which I examined was from one of the finer-grained beds (*b*), which, here as elsewhere in this district, alternate with those which are quartzose. I found it to differ from that last described. It has a well-marked foliated structure. The greater part of the slice has, at one time, been a ground mass of orthoclase felspar, in which were included grains and irregular patches of quartz, thus producing a structure resembling that which is termed "graphic" in the granites. In the greater part of the slice the felspar has been converted into a colourless or slightly yellow alkali mica, while, in other places, the felspar is still unaltered. This felspar appears to be orthoclase. The areas of felspar and quartz or of mica and quartz are separated by foliations of brown mica with a little muscovite. In places the foliations bulge out round small masses of felspar and quartz with a little mica, simulating, on a small scale, the so called "eyes" in some rocks. In some of the felspar areas there are places where the brown mica preponderates, in others, it is the muscovite together with small grains of quartz. A few small crystals of tourmaline are scattered throughout the mass. There are also a few scattered crystals of iron ore, having traces of hexagonal outlines. Most of these are in the neighbourhood of the brown mica, of which some individuals have pleochroic halos.

In this rock the felspar and quartz appear to have crystallised almost simultaneously, forming a ground mass in which are the micas and the iron ores.

(*l.*) The schists, which up to this place were much as last described, become here more massive, but with traces of bedding, and an apparent strike of N. 40° W. They are also traversed by small winding veins of aplite and quartz.

(*m.*) The rocks at this place are massive and much jointed, and are traversed by a strong dyke of "graphic granite," nine to ten feet in thickness, and striking N. 10° E. There is also here a strong dyke of basic rock on the same strike, which I did not further examine.

The crystalline granular character of these rocks raises a doubt whether they may not be, in fact, members not of the schist group in a metamorphosed condition, but of the granites. Yet their resemblance in some respects to portions of the most altered of the schists which I have described, and the absence of any defined contact, cause me to hesitate as to the class to which I should assign them. I shall again refer to this, after describing the remainder of the section, and I now proceed to give some data as to the mineral composition of these rocks at (*m*).

The dyke of "graphic granite" is a good example of one of the extreme forms in which the granites of this neighbourhood not infrequently occur. It seemed to me to be worth further examination. It is light-coloured, or of a light yellowish tint. It has a platy structure in places, due to a tendency to split along the cleavages of the felspars, which are similarly oriented over considerable spaces, for instance, over several inches square. The larger part of the rock seems to be felspar, and the lesser part quartz, in grains and in veinlets, producing in the planes of separation those figures which have given a name to this kind of rock. Where there are fissures traversing the rock, secondary muscovite has been produced.

Examined in a thin slice, I found this rock to be composed of microcline and quartz, with a very little secondary muscovite mica. The microcline is twinned in the well-known manner, and contains portions which are not twinned, and which re-act with polarized light, as does the monoclinic potassa felspar. Albite is in considerable amount, and occurs in veinlets, in small twinned crystals in the microcline, and more rarely outside of it. The quartz has no crystalline form, but is in irregularly-shaped masses, such as are well known in graphic granite. The rock is traversed by fissures which have been filled partly by the comminuted felspar, and partly by secondary muscovite resulting therefrom. Round some of the quartz grains there are radiating cracks and disturbances of the microcline twinning, indicating strains.

On these data, this rock may be described as a graphic granite, and from its occurrence as a dyke at this place, may be considered allied to, but, in all probability, younger than the aplites.

A quantitative analysis which I made of this rock is given below :—

ANALYSIS No. 7.—GRAPHIC GRANITE.

$Si.O_2$	...	...	...	70·91
$Al._2O_3$	...	...	...	15·32
$Fe._2O_3$	...	...	...	tr.
Ca.O	...	...	...	·58
Mg.O	...	...	...	·07
K_2O	...	...	...	10·07
$Na._2O$	...	...	...	2·31
H_2O	...	...	...	·51
				99·77

Hygroscopic Moisture	...	·15
Sp. gr.	...	2·564

(*n*.) Here are massive crystalline granular rocks with aplite veins. A strong dyke of this rock traverses them, dipping probably N. 20° E. about 40°. A hand sample from this place is very fine grained and siliceous, and has no resemblance to the thick-bedded schists which I have described at (*i*.) These rocks resemble some of the crystalline granular parts of the bedded schists, but are themselves only faintly schistose in places ; whilst in others there are crystalline granular patches of small size, whose composition of felspar and quartz, with but little muscovite, approximates in appearance to aplite, while it shades off also into the surrounding rock. I must leave for future determination the exact relations of these rocks to the schists on the one hand, and to the intrusive granites at no great distance on the other ; but I may point out that it may be possible that we have here an instance in which the sediments under the influence of the exudations from the plutonic magma have more or less, in re-crystallising, assumed their character. I have long since seen, and have pointed out, that large masses of the lower parts of the Silurian sediments must have been absorbed by the plutonic magmas.

(*o*.) From (*n*) to this point there are but few rocks visible, and they are all of a massive appearance. A sample collected at (*o*) proved, on examination as a thin slice, to be interesting. There is in it a ground mass, which is formed in places of orthoclase felspar, which surrounds and includes rounded or sub-angular grains of quartz, and this is analagous to the structure of the rocks lately described. In places the quartz also surrounds portions of felspar. Most usually the felspar has been converted into small flakes of alkali mica, which lie at various angles to each other. The result simulates portions of mica schist enclosing quartz grains. On the whole this rock is very quartzose, the grains being angular to rounded, and in places showing strain. Between the grains, and also bordering the felspar, there are in places small flakes of brown mica which extend down into fissures, and which are, therefore, probably secondary in formation. There are in this rock hexagonal and imperfect crystals of iron ore, and also a few scarce crystals which I refer, upon grounds before stated, to Zircon.

At about two hundred yards from this spot is the boundary of the Granites, and there being on the one side massive rocks with faint traces of foliation, and on the other well-marked porphyritic granites. I have here marked on the section a second possible contact (x'.) In order to compare the doubtful rocks with the porphyritic granites which they adjoin on the north-east side, I made a quantitative analysis of both samples. The first to be described is the one on the north-east side—that is to say, on that side on which the schists are found. The sample is a rather fine-grained, crystalline granular rock, dark grey in colour, with in places lighter portions, giving it a slightly schistose appearance.

An examination of a thin slice of this rock gave me the following results, and I found it to be composed of the following minerals :—

(*a*.) Orthoclase in eroded crystals, most of which have been much altered to muscovite, which either is scattered through the crystal or entirely replaces it. In parts the orthoclase crystals have been broken up, and much of the resulting *debris* has gone to produce mica. The orthoclase was formed before the triclinic felspars, which have been altered in an analogous manner to the former. The low extinction angles of the plagioclase indicate albite or oligoclase. Muscovite occurs not only as alteration products replacing felspars, but also as larger flakes and crystals of an earlier formation. Intergrown with the muscovite, but also independently of it, is a brown pleochroic magnesia mica which, where unaltered, is much corroded and "tattered," and where altered, has been converted into a pale-coloured chlorite. As is very common in this chloritisation, the process has also eliminated iron ore. The greater part of the rock is composed of quartz grains, which have been crystallised last of all.

The subjoined analysis is of this sample :—

Analysis No. 8.

P_2O_5	·06
$Si.O_2$	69·79
$Al._2O_3$	16·47
$Fe._2O_3$	·53
$Fe.O$	2·97
$Ca.O$	·73
$Mg.O$	1·95
K_2O	3·44
$Na._2O$	1·68
H_2O	·99
	98·61
Hygroscopic Moisture ...	·49
Sp. gr.	2·720

Close adjoining this rock is the boundary of the granites, which are porphyritic with orthoclase felspars. A sample which I collected close to the boundary is a light-coloured crystalline granular rock, of medium texture, containing two micas, felspars, and quartz, and with porphyritic crystals of rather greasy-looking orthoclase.

A quantitative analysis of this sample is as follows :—

Analysis No. 9.—Granite.

P_2O_5	·05
$Si.O_2$	68·87
Al_2O_3	16·62
$Fe._2O_3$	·43
$Fe.O$	2·72
$Ca.O$	·71
$Mg.O$	1·60
K_2O	6·48
$Na._2O$	1·80
H_2O	·74
	100·02
Hygroscopic Moisture ...	·21
Sp. gr.	2·762

An examination of a thin slice of this sample by the microscope shows that it is composed of two kinds of mica, two felspars and quartz, and that, therefore, in accordance with the classification of Rosenbusch, which I follow, it is a granite.

The crystals of orthoclase are larger than those of the accompanying plagioclase. They are also more converted into mica. Instances occur of intergrowth with quartz. Various stages of alteration can be followed out in this slice, from a conversion of the edge of the crystal more or less into muscovite, to the complete conversion into that mica. Intermediate stages show portions of felspar still intact. In one eroded crystal, the section of which was approximately parallel with OP (001), I observed a number of angular fragments of plagioclase. These had the appearance of being parts of a former whole, and if so, would indicate more than one generation of triclinic felspars. For the plagioclase crystals in this rock, which are subordinate in number to those of orthoclase, are better formed, are smaller, and are less altered, and may, therefore, be considered as formed at a later period than the orthoclase. The obscuration of these triclinic felspars indicate oligoclase rather than albite.

In one or two instances I observed the environment of a simple crystal by a margin which was twinned. Muscovite mica is in a few large crystals which appear to be of an older generation than the remaining small flakes, or aggregates of flakes, which are certainly alteration products. Yet even some of the larger flakes of muscovite extend into the felspars.

The magnesia mica is brown in colour, and distinctly pleochroic. It was one of the earlier-formed minerals, but is present only in small amount. The crystals are in places crushed and broken, and the isolated flakes are tattered or torn across, and in the latter case I observed, where the fracture was filled in with minute flakes of muscovite. This mica has in some cases dark pleochroic halos surrounding microliths such as I have before described.

An inspection of the two analyses, Nos. 8 and 9, shows a great similarity of composition, and this, together with the mineral composition of the two rocks and their proximity to each other, strongly suggests the conclusion to which I have before referred, that the crystalline granular rocks shown between the letters (x) and (x') in the section may, perhaps, be unusual forms, in which the intrusive rocks have crystallised. For the present I must leave this in a state of doubt.

At this point the diagram section terminates, but the granites extend westwards, without break, along the course of Wilson's Creek, to its junction with Livingstone Creek, and thence to the hills on the western side. When examining these hills, I found that the granites still extended, with slight alteration of composition, and that in places they assumed a gneissose structure. But I did not, within a distance of about two miles from Livingstone Creek, meet with even any traces of such schists as those which I have described as being on the north-eastern side of the contact. How far to the west the granites extend, I am at present not able to state.*

The porphyritic structure of the granites of Wilson's Creek is well marked, and on the western side of Livingstone Creek the felspar, which is the porphyritic mineral, is in places remarkably fresh and unaltered. I examined one of these felspars, with the following results:—

ANALYSIS No. 10.—ORTHOCLASE *(Microperthite).*

$Si.O_2$	...	...	...	63·60
$Al._2O_3$	...	...	...	20·20
$Ca.O$	...	...	...	·31
$Mg.O$	...	...	...	·15
K_2O	...	...	...	8·05
$Na._2O$	...	...	...	6·43
H_2O	...	...	...	·52
				99·26

In this felspar the optic axial plane is perpendicular to the plane of symmetry, with horizontal dispersion, as is usual in orthoclase.

In a thin slice prepared from a basal cleavage plate, the main field obscures parallel to the edge P.M., but there are places which obscure at an angle of about 3° from that direction. Small interpositions of quartz and of a second felspar are in veinlets, and also in the direction of the prism, ∞ P. (·110). The felspar veinlets are probably albite, and do not differ from analogous interpositions in some of the

* This examination does not refer to the country south of the junction of Day's Creek with Livingstone Creek.

microperthites, except in so far that they are very minute and in small amount. When the slice is placed in such a position that the plane of vibration of the orthoclase is parallel to that of the polarizer, the nicols being crossed, and the field therefore obscure, the space surrounding any one of the quartz inclusions depolarizes the ray, and permits light to pass. But in the space thus illuminated a black cross shows, whose arms are parallel to the ortho and clino-diagonals respectively. On rotating the slice some 3° from this position, the arms of the cross close together into a black bar having that direction, the field still being light. These appearances indicate that the felspar surrounding the quartz grain is in a state of strain.

A slice prepared from the second cleavage, namely, parallel to the clino-pinnacoid, shows the familiar appearance of minute veinlets of the second felspar (albite), which cross the trace of the perfect cleavage at an angle approximating to 65°. The potassa felspar in this slice obscures at 5° 20′ referred to the same datum.

These appearances explain the occurrence of soda in the analysis, although the percentage found is larger than I should have expected from the inspection of the two slices which I prepared.

The felspar is an orthoclase, intergrown with a proportion of albite, after the manner of the microperthites.

It will now be advantageous to summarise the results to which these descriptions of the rocks lead me, first commencing with the schists:—

The schists which I have described occur only on the north-eastern side of the contact, and extend thence for some miles towards Hinnomunjie, the Omeo Plains, and the Bowen Mountains. On the south-western side of the contact there are no schists similar to these, but such as can be found are of a more gneissose structure, with only subordinate traces of mica schist.

When the country is examined for a distance from the contact on its eastern side, the inference seems to be justified that the schists are the metamorphosed representatives of a sequence of sedimentary formations, which can be seen in their least altered forms in the Bowen Mountains; more especially on the eastern sides of these mountains, where, between Tongeo and Bindi, they have the appearance of the Silurian formations, and are at any rate in a highly inclined position, and stratigraphically inferior to the Devonian formations at Bindi.

The general appearance of the regionally metamorphosed members of this sequence of beds, as seen at the Omeo Plains and at the upper part of Wilson's Creek, is that of a series of fine-grained and sometimes nodular or spotted mica schists, approaching phyllites in places, and which alternate with fine-grained to coarser quartzose beds, all being tilted at high angles of dip, on an approximately north-western strike. This amount of metamorphism decreases towards the Bowen Mountains, and increases towards the fault. It becomes especially marked near the contact, or where, as at Wilson's Creek, there are outlying patches of the intrusive rocks. The distance to which the increased amount of metamorphism extends, varies. It may be taken at about a quarter of a mile, at Hinnomunjie Morass, while at Wilson's Creek it is not less than a mile. This increased alteration is shown also by the presence in almost all the samples which I examined from the altered zone, of microscopic crystals of tourmaline in great numbers. The general change in the schists, which may be attributed to the action of the intrusive granites, seems to have been at Hinnomunjie Morass a more complete crystallisation of the previously (regionally) metamorphosed sediments, in larger plates of muscovite and biotite micas, and the production of numerous crystals of tourmaline.

Analagous alterations occur at Wilson's Creek at a distance of a mile from the contact, but are there partly due to the influence of strong masses of granite outlying from the contact. The changes seen in proceeding towards the contact at Wilson's Creek, are the appearance of grains of felspar in increasing numbers; the formation in portions of the schist of what I am inclined to term a "ground-mass" of orthoclase and quartz, and the increasing silicification of the rock.

Finally, there are for some little distance from the margin of the porphyritic granites, a set of crystalline granular rocks, which in some respects resemble both series, and as to which I am unable at present to determine to my own satisfaction, whether they are re-crystallised schists re-acted upon by the granitic exudations, or abnormal forms of the intrusive rocks.

Certain distinctions may therefore be made between the metamorphic rocks in this locality. The first group includes the regionally metamorphosed schists on the eastern side of the contact; the second group includes the more strongly metamorphosed mica schists, with tourmaline crystals and the gneissose schists at Wilson's Creek. The alterations in the second of the above groups I attribute to metamorphism produced by the intrusive granites, and by the younger porphyritic rock-masses connected with them. Thus in one sense the metamorphic rocks adjoining the contact might be not inappropriately spoken of as "contact schists," if it is desirable to limit the use of the term "regionally metamorphic," to those schists whose peculiar mineral and physical composition, and structure, are the result of dynamical metamorphism.

The intrusive rocks in the area herein dealt with are granites, whose western extent I have not determined. This mass of granite has associated with it marginal masses and strong dykes of muscovite granite, passing in places into aplite. These are clearly younger than the main granite mass, as are also other dykes of pegmatite, aplite, and graphic granite, which are found at the contact or beyond it in the schist area. The granites, therefore, taken as a whole, including all the above varieties, represent an intrusion of plutonic rocks of several consecutive ages of the same period of plutonic invasion, and the series is increasingly acid, the later dykes being mainly of orthoclase (microperthite) and muscovite, or of orthoclase and quartz. Finally, the veins and even strong dykes of crystalline quartz, or of quartz and tourmaline (schorl) which are associated with these granites, represent the last portions of still fluid (uncrystallised) magma.

The line of contact is an irregular one, although the general direction is constant, and approaches the mean strike of the lower palæozoic formations. The invasive rocks protrude into the schist tract in promontories, and appear within it in isolated patches laid bare by denudation, but which no doubt, are connected below with the main granite mass. Thus when we picture to ourselves this mass adjoining the schist contact, and the numerous surface outcrops and veins of granite in the schists, we must see that these all represent a much larger extent of granite subterraneously, which at one time as a magma, invaded the schists both horizontally from the contact and vertically from below, where it "corroded" its way upwards into the schist masses. An inspection of the contacts laid bare by denudation, shows that the intrusive masses now occupy spaces which at one time were filled by sediments, but that their action has not at all times been one of forcible intrusion, for at Hinnomunjie the schists are cut off, but not contorted. At Wilson's Creek, however, their action seems to have been accompanied by more violence and also with greater metamorphic effect, and this may have been due to there having been at that place stronger plutonic activity. For at rather over a mile in a south-west direction from the contact at Wilson's Creek, there is situated a rocky hill, known locally as the Frenchman's Hill, which marks the site of a considerable eruption of igneous rocks younger than the granites, but I believe connected with them. To this younger plutonic magma I attribute the metamorphic action which I observe in some of the granites, and perhaps, also the "finishing touches" in the schists nearest to it. As the granites and the granite dykes penetrated the schists and metamorphosed them, so did the quartz-bearing and quartzless porphyries of the Frenchman's Hill, penetrate in masses and in dykes, both the granites and the schists, and re-act upon them.

It remains to remark upon the gneisses which, in some places, as for instance at the junction of Wilson's Creek, and in a gully on the western side of Livingstone Creek, and nearly opposite Day's Creek, form part of the granitic rocks. These gneisses are in fact merely structural forms of the granites, and are strictly analogous to the gneisses, which in the Swift's Creek area and elsewhere, are often the margins of the intrusive masses. They probably result from pressure upon the consolidating magmas, and it is between gneisses of this class and the plutonic masses that a complete passage can be traced. Where, however, such gneissose forms of the intrusive rocks occur near to contacts with the regional schists in the Omeo district, there appears, unless under most favourable surface conditions, and with the most careful inspection, to be a continuous sequence from the granitic rocks to gneiss, and from gneiss to mica schist, and finally through less altered rocks to the normal lower palæozoic sediments. It is evident that under such conditions, it is only in places where the streams have laid bare a series of such rocks, that the break between the schistose forms of the igneous rocks and the schistose forms of the metamorphosed sediments can be seen and recognised. Examinations elsewhere in places where the actual sequence of the rock formations is obscured by surface accumulations have led to the erroneous belief, which for long I also shared, that there is at Omeo a passage from the granitic rocks to the lower palæozoic sediments, and that therefore the former are the completely metamorphosed forms of the latter.

Where the granitic rocks have no margin of gneiss at their contact with the sediments, and where the latter have undergone very great molecular recrystallisation, the difficulty of a true diagnosis is very great, and questions arise which may require possibly to be revised by the light of more extended examination and research.

In the present investigation, my attention has been attracted more by the appearances suggestive of chemical action producing changes in the sediments, than of alterations brought about by dynamical metamorphism. The effects observed are such as may, I think, be attributed in part to mineral exudations from the plutonic magmas, as also to the volatile emanations therefrom, such as Fluorine or Boron, which have evidently been strongly active at the contacts, and under the exceptional conditions which must have obtained there, have produced a recrystallisation of the already regionally metamorphosed schists. Such results were more marked in the district which I have described in this paper, than those which could be attributed to the compression and dislocation of rock masses subjected to shearing strain. These latter phenomena can be studied better in other parts of the Omeo district, and would properly orm the subject of a separate memoir.

The general conclusions to which the study of the phenomena noted in this paper has led me may be briefly stated as follows :—

(1.) The contact referred to represents an extensive fault, with a downthrow on the north-east side of undetermined depth.

(2.) The schists on the north-east side most probably represent some of the regionally metamorphosed lower palæozoic sediments (Silurian).

(3.) The schists were let down within the influence of the plutonic magmas which invaded them, both horizontally from the contact and from below upwards.

(4.) The regional schists were probably phyllites and fine grained mica schists, and by the further action of the invading granites, have been converted for some distance from the contact into mica schist, tourmaline schist, and forms of gneiss.

(5.) The numerous masses and veins of crystalline quartz which occur at or near the contact, as well as the veins of quartz associated with mica (muscovite), with felspar (microperthite), and with tourmaline (schorl), must be regarded as emanatous from the consolidating granites, and, therefore, as of plutonic origin, and thus, so far as the quartz veins concerns, to be distinguished from the auriferous quartz veins of the district.

(6.) The period of geologic time at which the granite magmas invaded the schists cannot be stated with precision, but it may be broadly stated that it was probably synchronous with the period of plutonic activity in the Gippsland Alps—that is to say, at the close of the Silurian or the earlier part of the Devonian periods.

DESCRIPTIONS OF PLATES.

Plate I.

Fig. 1. Diagram section (horizontal) near Hinnomunjie Morass, about 200 feet in length, at the contact of the muscovite granites with mica schists. (*a*) Alternating beds of micaceous and quartzose schists striking N. 55° W. (*b*) Muscovite granites. (*c*) Tourmaline schist.

Fig. 2. Diagram section (horizontal), about 400 feet in length, near Hinnomunjie Morass, across the contact of the muscovite granites with the mica schists. (*a* and *f*) alternating micaceous and quartzose beds striking N. 30°–70° W. (*b b′*) Dykes of muscovite granite. (*c*) Dyke of metamorphosed basic igneous rock. (*d*) Dyke of muscovite granite, Plate II., Fig. 1.

Fig. 3. Diagram section (vertical) at Wilson's Creek. (*a*) Spotted fine-grained mica schist, alternating with quartzose beds dipping N. 60° E. at 70°. (*b*) Similar beds, but more altered and disturbed. (*c*) Gneissose schists, strike probably N. 60° W. (*d*) Schists resembling a fine-grained gneiss in contact with strong dykes

Plate. I

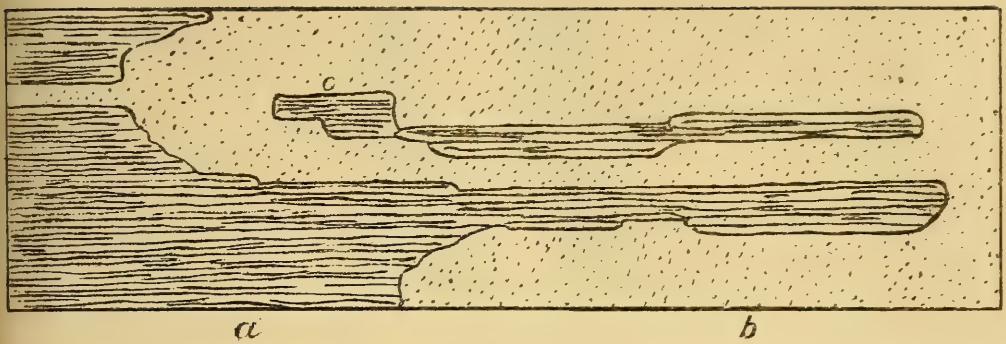

Fig. 1

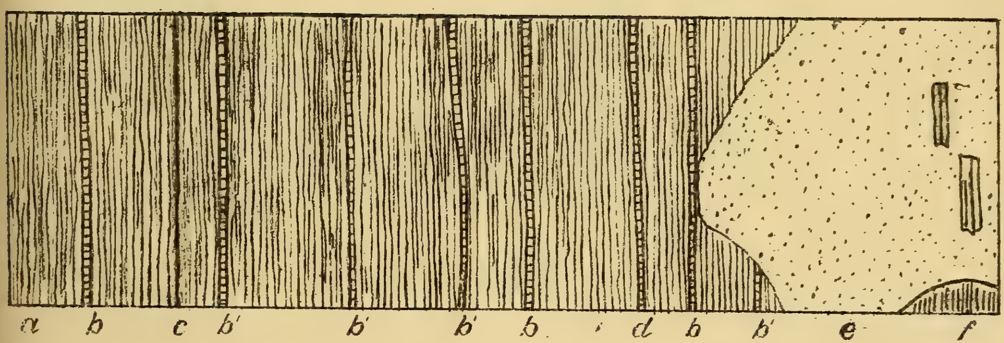

Fig. 2

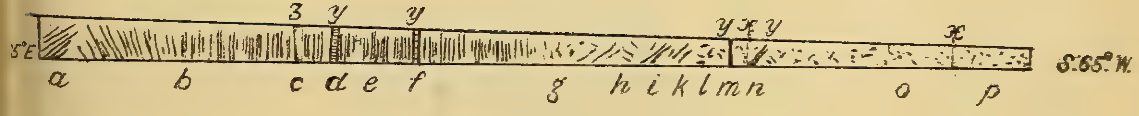

Fig 3

Plate. II

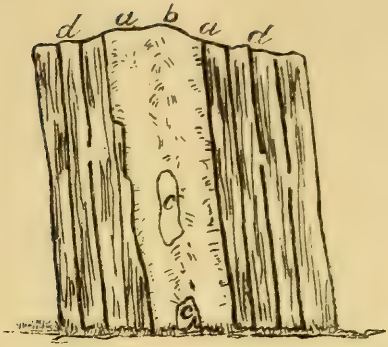

Fig. 1

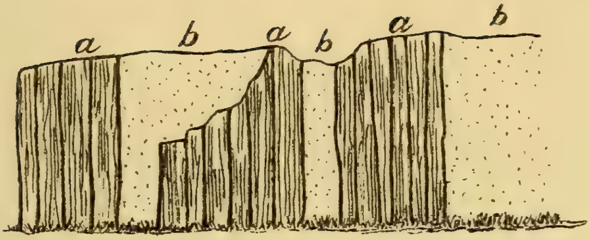

Fig. 2

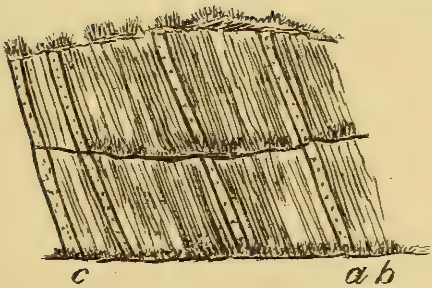

Fig. 3

of muscovite granite. Strike of beds N. 45° W., see Plate II., Fig. 2. (*e*) Rather massive, much altered schists. (*f*) Spotted and micaceous schists, much contorted, and in contact with a large mass of muscovite granite. (*g*) Massive schists traversed by veins of aplite and quartz. (*h*) Schists having a rude foliation, dipping N. 20° E. at 52°. (*i*) Thick-bedded schists, dipping S. 65° W. at 78°. (*k*) Rather massive schists in alternating micaceous and quartzose beds, with veins of aplite, dipping N. 20° E. at 81°. (*l*) Very massive schists, traversed by small winding veins of aplite and quartz. (*m*) Massive rocks, much jointed, and having a crystalline granular structure, traversed by a dyke of graphic granite. (*n*) Massive crystalline granular rocks traversed in places by veins of aplite or muscovite granite. (*o*) Quartzose crystalline granular rocks. (*p*) Porphyritic granite. (*x* and *x′*) probable contacts. The rocks contained between these two points are of doubtful character. (*y*) Dykes of muscovite granite, aplite, and graphic granite. (*z*) Basic dyke.

Plate II.

Fig. 1. Dyke of muscovite granite (pegmatite) near Hinnomunjie Morass. (*a*) Mainly felspathic, with a little quartz and muscovite. (*b*) Coarse crystallisation of orthoclase, and quartz with bunches of muscovite. (*c*) Rather translucent crystalline quartz. (*d*) Fine-grained mica schist.

Fig. 2. Contact of schists and muscovite granite at Wilson's Creek. (*a*) Gneissose schists striking N. 45° W. (*b*) Muscovite granite.

Fig. 3. Outcrop of schist, see Plate I., Fig. 3—(*k*). (*a*) Rather quartzose mica schist. (*b*) Nodular mica schist (*c*) Band of aplite. The schists dip N. 20° E. about 80°

Art. XII.—*Remarks on a New Victorian Haloragis, and on the occurrence of the Genus Pluchea within the Victorian Territory.*

By Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., &c.

[Read September 8, 1887.]

Haloragis Baeuerlenii.

Very tall, glabrous; leaves comparatively large, all opposite and of equal form, somewhat decurrent into the short stalk, lanceolar, crenate-serrulated, faintly veined, the apex of the serratures deciduous, leaving a callous base, the upper leaves not much smaller, and never alternate; flowers, at least in part, axillary and solitary; two of the calyx-lobes deltoid, the two others dilated, or truncate-rhomboid; tube of the calyx, when fruit-bearing, expanded into four broadish, conspicuously-veined membranes, of these, on each side of the somewhat compressed tube two approximated; styles four, very short; stigmas beardless; fruit rather large, four-celled, pendant from a stalklet of half or nearly its length; pericarp spongy; seeds irregularly developed.

Between rocks in ravines on and near the summit of Mount Tingiringi, at an elevation of about 5000 feet; W. Baeuerlen. This remarkable and seemingly quite local plant attains a height of five feet, the stem finally gaining an inch in thickness. Branches spreading; branchlets opposite, quadrangular, as well as the young shoots often of a reddish tinge. Leaves mostly from one to two inches long and from one-third to half inch broad, flat, gradually narrowed into the acute apex, dark-green above, somewhat lighter colored beneath; the leaves of young shoots pinnati-lobed in their lower portion. Pedicles, so far as seen, solitary in the axils, but perhaps also sometimes racemosely arranged, as would appear from remnants of flowering summits of branchlets. Stamens as yet unknown, only fruit-bearing specimens having been obtained. Fruit roundish-ovate in outline, from hardly one-quarter to fully one-third inch long, the four surrounding membranes two and two confluent with the broadest lobes of the calyx, and decurrent much beyond the fruit-cells, the latter small in proportion to the pericarp. Matured seeds not available yet.

This species shows most affinity to H. racemosa, from the mild coast-region and low hills of South-western Australia, the only other congener (unless H. alata and H. monosperma), which attains to great height; but the leaves are generally shorter, their denticles rather curved inward than spreading and soon getting blunt; the floral leaves often at least do not become much diminished in size; the fruit is proportionately broader, its longtitudinal membranes are more expanded and not almost equally distant, while its endocarp is harder. Whether the petals are gradually much acuminated and generally longer than the stamens, as those of H. racemosa, remains yet to be ascertained. The last-mentioned species should also be placed into the section of oppositi floræ. Mr. W. Webb found it on Mount Lindsay (Mrs. M'Hard) near the Blackwood River. In various respects our new sub-alpine plant is allied also to H. scordioides, H. alata and H. Gossei. Now an apt opportunity is afforded to point out, that the genuine H. alata from New Zealand and the Chatham Islands cannot be regarded as absolutely identical with the East Australian plant, admitted under that name into the Flora Australiensis, in as much as the small blunt and often downward-bent appendages at the angles of the fruit in the legitimate species do not occur in any of the Australian specimens seen by the writer of these remarks; besides, the leaves of our plant are longer and narrower, also more decurrent into the stalk, while the floral leaves are more reduced to bracts; indeed the Australian plant verges closely to H. serra, but has four styles, as also a four-celled and four-seeded fruit; either as a variety or as a distinct specific form it might be distinguished under the name *exalata*.

H. cordigera has been traced to the Serpentine River (F. v. M.); the fruit is shorter than the calyx-lobes, and not rarely bearing hairlets.

H. scoparia bears a fruit roundish-ovate, compressed, beyond the base upwards slightly quadrangular, much longer than the calyx-lobes, two-celled and two-seeded.

H. hexandra was seen by the writer of these lines near King George's Sound and the Shannon; the leaves, when fresh, are carnulent.

H. odontocarpa extends to the Gascoyne River (Forrest), to Youldeh and Oudabinna (Tietkens), to the Elizabeth River (Giles), to the Lachlan River (Tucker).

H. serra ranges to the Clarence River (Beckler), Hunter River (Miss H. Carter).

H. exalata was obtained at Mount Dromedary (Reeder), on the Burnett River (Hely); the leaves are paler beneath; the stigmas are not conspicuously bearded.

H. rotundifolia varies in height from one-half to four feet; it is perennial, like nearly all its congeners; we know this plant now from Karri-Dale (Walcott), the Shannon, the Collie, the Preston, and the Serpentine Rivers (F. v. M.) The leaves are sometimes not at all larger than those of H. micrantha, to which species this plant bears some resemblance in the capillary branchlets of the panicle and in the minute fruits.

H. scordioides has an irregularly wrinkled, truncate-globular, somewhat quadrangular fruit, not much longer than the calyx-lobes.

H. micrantha has been sent from Walcha by Mr. Crawford.

H. depressa occurs on Mount Field, at elevations from 3 to 4000 feet, also on Mount Kosciusko (F. v. M.)

H. teucrioides has been found in New England (C. Stuart), in Yorke's Peninsula (Tietkins), near Streaky Bay and Fowler's Bay (Mrs. Richards), in Kangaroo Island (Prof. Tate).

H. tetragyna reaches the Tweed (Hickey), the Dawson River (O'Shanesy), and the Darling Downs (Lau).

H. leptotheca is contained in our collections now, also from King's Sound (Hughan), Yeldham Creek (Armit), Trinity Bay (Fitzalan). H. acanthocarpa, to which Bentham joins H. leptotheca, seems rather to constitute a form of H. tetragyna, which latter would, early in the century, be much more readily accessible to Brogniart than the intra-tropical H. leptotheca.

H. elata extends to the Castlereagh River (Woolls), Macquarie River (Betche), Darling River (Burkitt), Lachlan River (Tucker), Gawler Range (Ryan), Condamine River (Hartmann), Bogan (Morton), Dawson River (O'Shanesy). Contrary to what the specific name would imply, this plant seldom attains a height of two feet; some of the leaves assume occasionally quite a lanceolar form.

H. rudis is often erect, but seems never a tall species; the branchlets are remarkably robust; the leaves have a particularly thick pale margin.

H. nodulosa was gathered by the writer at the Greenough and Irwin Rivers; eastward, it extends to Israelite Bay (Miss Brooke), and Esperance Bay (Dempster).

H. paniculata occurs on the Collier, Preston, and Blackwood Rivers (F. v. M.)

Haloragis pycnostachya.

Erect, rather dwarf; beset with spreading soft hairlets, leaves firm from lanceolar to rhomboid-ovate, flat, serrulated, almost sessile, the lower opposite, the upper scattered; flowers in dense terminal spikes; bracts ovate-lanceolar, foliaceous, about as long as the flowers or somewhat longer; flowers singly sessile in each axil; calyx-lobes four, almost deltoid, much shorter than the four outside short hairy petals; stamens eight; stigmas conspicuously bearded; fruit small, subtle-downy, somewhat quadrangular, rough from two transverse rows of minute granules, above the upper row contracted and streaked, usually one-celled and one-seeded. Near Israelite Bay (Miss Brooke). Differs from H. confertifolia in the longer and less dense vestiture, in much larger and less crowded stem-leaves, in broader and shorter calyx-lobes, in more noduligerous and upwards more conspicuously contracted fruits, the latter reminding of those of H. nodulosa.

H. heterophylla must include also H. ceratophylla, according to the respective drawings by De Caisne, and by Bauer; it belongs more particularly to the coast-regions, while H. aspera pertains chiefly to the inland country, and thus not occurs in Tasmania. Further, the H. pinnatifida (A. Gr. non J. H.) seems a state of H. heterophylla; Endlicher derived his plant from Shoalwater Bay; his description accords fully with the earlier one given by Brogniart, except the remark on the supposed unisexuality of individual plants, pronounced evidently from imperfect material. Our collections show this species to inhabit the following localities beyond those already recorded: Gordon River (Miss Oakden), Mount Lofty (Tepper), Barossa Range (Dr. Behr), Wannon River (Sullivan), Emu and Creswick Creek (Rev. W. Whan), Loddon, You Yangs, Snowy and Hume Rivers (F. v. M.), Genoa (Baeuerlen), Paramatta

(Woolls), Moona (Crawford), Hunter River (Miss H. Carter), Clarence River (Beckler), Richmond River (Miss Edwards), New England (Stuart), Armidale (Parrot), Tweed (E. Hickey), Brisbane River (Leichhardt), Comet River (O'Shanesy), Georgina River and Gainsford (Bowman), Warrego and Maranoa (Barton), Burdekin River (F. v. M.), Mount Surprise (Armit). The flowers are sometimes fascicled, and occasionally supported by long floral leaves. Forms with particularly long and narrow leaf-lobes, seemingly also belonging to this species, bear much resemblance to Meionectes. At the whole it is less robust than the following:—

H. aspera was originally in 1836 collected by Sir Thomas Mitchell on the Murrumbidgee; it has a wide range, thus is known from the Upper Darling River (Wuerfel), Warrego (Mrs. Cotter), Barcoo (Schneider), Charlotte Waters (C. Giles), James and Finke Rivers (Kempe), Evelyn Creek (A. King), Mount Everard (E. Giles), Musgrave Ranges (Forrest), Eucla (Carey). Any endeavour to separate H. glauca specifically from H. aspera, would prove futile; for unison the latter name is preferable. Under the name sclopetifera a plant is separable from H. aspera, either as a variety or perhaps as a distinct species, on account of its verrucular calyx, which when fruit-bearing, is copiously beset at the summit with narrow dilated and often simply or doubly-hooked excrescences, its leaves are from linear-lanceolar to broad-linear; it is known only from Norman River and Spear Creek (Th. Gulliver), and from Aramac Creek (Dr. Poulton).

H. acutangula extends to Point Sinclair; its leaves are rather flat and often somewhat denticulated.

H. salsoloides has staminate and pistillate flowers on distinct plants, as first observed by Messrs. Haviland and Deane, who found this rare species at Double Bay, consociated with Casuarina nana; it is often only half-a-foot high, even when fruiting, and then somewhat reminds of Tillaea recurva. Specimens from any mountain region never came under the writer's notice.

H. Gossei was found near the Finke River (Rev. H. Kempe), at Ularing (Young), at Alice Springs (Ch. Giles), in the glen of Palms (E. Giles), on the Mulligan River (Cornish), Field River (Winnecke), Nickol, Cane and Ashburton Rivers (Forrest), Exmouth Gulf (Carey); occasionally the fruits are tetramerous.

H. trigonocarpa was obtained at the Gascoyne River by the Hon. John Forrest, and a variety with linear leaves at Lake Austin by Mr. H. S. King.

H. digyna is now known also from Israelite Bay (Miss Brooke), Eucla (Oliver), and Lake Bonney (F. v. M.); its calyx-lobes occur sometimes of deltoid form, and they number not rarely like the petals styles and fruit-cells three or four; but, though the fruit may be quadrangular, it is only one or two-seeded. From H. digyna cannot be held apart as a species H. mucronata. Sometimes the fruit produces callous extrusions, thus far reminding of the inner sepals of Rumex; the margin of the petals turns sometimes bluish.

H. pityoides occurs on the Arrowsmith River (F. v. M.); it is Drummond's plant 706; the calyx-lobes are almost deltoid, the fruit is sometimes densely beset with hairlets. H. pusilla is closely allied to the foregoing.

H. monosperma forms somewhat leafy spikes to the length of three inches; according to specimens sent by Mr. G. MacRae; the petals are almost white, gradually pointed, not prominently keeled, and fully to one-quarter inch long; thus, as far as blooming is concerned, it proves the most conspicuous among its many congeners, so far approaching the Loudonias, to which it bears similarity also in tall growth, while it verges to the Serpiculas in carpologic characteristics; but the fruit of a few other species may ripen also only one seed, notably those of H. tetragyna in India, as pointed out by Mr. C. B. Clarke in Sir Joseph Hooker's *Flora of British India, II.*, 431, and as noted already by C. Koenig.

H. trifida will likely prove a Myriophyllum, while the H. cyathiflora, to judge from Fenzl's descriptive notes, may possibly be a gyrostemonous plant.

In concluding these short references to Australian Halorageæ, it might yet be observed that the genus Meionectes can no longer be maintained, after what we more recently have learned of the numerical inconstancy of the floral divisions in several species of Haloragis. Indeed, Meionectes became impaired in its generic position already by the discovery of a dimerous species as well of Loudonia as of Myriophyllum, and Bentham also noticed before that his Haloragis tennifolia was closely connected with Meinoctes Brownii. In placing that plant under Haloragis now, the generic name serves aptly for specific signification.

Pluchea conocephala.

Eurybia conocephala, F. v. M. in the Transactions of the Victorian Institute, I., 36.

Dwarf-shrubby, much branched; leaves small, obovate or spatular-cuneate, flat, entire, as well as the branchlets grey velvety; flower-headlets sessile, singly terminating branchlets imperfectly dioecious; involucre at first almost hemiellipsoid-cylindrical, at last obverse conical; involucral bracts in several rows, rounded-blunt, near the upper end somewhat velvet-downy and fringy-ciliate, the outer bracts abbreviated, the lowest verging to an oval form, the inner bracts gradually elongated, narrowly elliptical-cuneate, and finally beyond the middle recurved; receptacle minute; flowers few within each involucre and extending considerably beyond it; corolla of the perfect staminate flowers slightly dilated above the middle, those of the most developed pistillate flowers thinly cylindrical, the five lobes of either rather long, comparatively narrow, hardly spreading; style glabrous; achenes narrow-cylindrical, scarcely angular, quite glabrous; bristlets of the pappus numerous, almost biseriate, nearly equal in length, almost plumously ciliate. In arid calcareous tracts of country from the Wimmera, Darling, and Murray Rivers, extending westward as far as Eucla, the northern limits of the species remaining hitherto unascertained.

When the writer of these observations discovered already in 1848 this remarkable plant, he placed it in the Cassinian genus Eurybia (since reduced to Olearia and later still to Aster), on account of great external resemblance to Aster pimeloides, though at the time some abnormal characteristics, such as the absence of ligulate corollas, were recognised and subsequently recorded. The plant is now transferred to the mainly tropical genus Pluchea, of which it is the most southern species, although Pluchea Eyrea was traced, in 1851, also so far south as the apex of Spencer's Gulf. For including this plant in Pluchea it is however needful to extend somewhat the limits of that genus, in as much as each individual plant seems to produce within its involucres one only of the two states of flowers, as only few flowers occur in each involucre, as the flowers with imperfect anthers produce also a five-lobed corolla, as the bristlets of the pappus are very copious, therefore not uniseriate, and moreover, long ciliated. Some degree of diœcism is however characteristic also of P. tetranthera and P. baccharoides, while pappus-bristlets in a single or in more than one row, and with various extent of denticulation or even ciliation, occur together in some other genera of Compositæ, for instance, in Senecio. The remarkable narrowness of the stigmata in our species, as well as their structure, are quite in accord with Pluchea, so also the sagittate base of the anthers, although the latter is reduced to extreme minuteness. This Pluchea, however, connects the genus evidently with the exclusively American Baccharis, and a section in Pluchea, as Natho-Baccharis might be established for it. The involucral bracts of P. conocephala arise all closely together from the exceedingly small receptacle; the corollas when dry are dull and dark-coloured towards the summit, but may be purplish when fresh; those of the staminate flowers being shorter than those of the others; the filaments are comparatively short; the terminal plate of the anthers is almost semi-lanceolar; the stigmas of the flowers with rudimentary anthers are fully exserted, those of the other kind of flower much enclosed and thicker than in many other species; the achenes are comparatively long. The pappus is almost that of Pterigeron. Additionally it may also here be noted, that Eurybia rudis is transferable to Erigeron, in which genus it should form a distinct section.

Art. XIII.—*Notes from the Biological Laboratory, Ormond College.*

I. *Observations on the Movements of Detached Gills, Mantle-lobes, Labial Palps, and Foot in Bivalve Mollusks.*

By D. McAlpine, Esq.

[Read October 13, 1887.]

The present paper will only deal with the results of these observations, without giving any detailed description.

It has long been known that the gills, for instance, of bivalve mollusks, exhibit ciliary motion in a very marked manner, but it has not hitherto been observed, that an entire gill, or portion of a gill, when detached from the body is capable of moving visibly and at a measurable rate of speed. It does seem strange, no doubt, that a large and important portion of the body, such as the gill, firmly fixed during life, and playing the part of a stationary engine, by creating currents in the water by means of its cilia, should become when detached, a locomotive engine, and the energy formerly spent in creating currents, now apparently utilized in driving the gill itself. And the wonder is not lessened, but increased, when we consider that the sea mussel, provided with such organs, capable when detached, of roaming about pretty actively, is one of the most inactive of animals in the adult state, even rooted to the spot where it lives by means of its byssus. Not only does the gill move thus, but other parts as well, all of them being richly provided with cilia. In fact there are four principal portions of the sea mussel which exhibit this independent movement when detached, viz., the mantle-lobes, the labial palps or tentacles, and the foot, as well as the gills.

It is generally known that cilia retain their activity even after the death of the animal, and that ciliary motion may be beautifully seen in detached pieces of any of the parts mentioned, but the point now to be insisted on is, that there is visible and measurable movement in these parts when detached. And there is at least a threefold interest attaching to an investigation of this sort.

There is first of all the peculiarity of detached portions of an animal comparatively high in the scale, retaining to a certain extent independent vitality, moving about and often rotating, as we shall see, in a certain definite manner and direction. Such an appearance is always interesting, whether it be the detached portion of a hydra, or of an earthworm, the wriggling tail of a lizard, or the detached leg of a spider.

Then there is a further interest when it is known that this movement in the mollusk is due, in whole or in part, to the action of cilia, for it may throw light upon the action of the ciliated epithelium of our own bodies, say of the lining membrane of the nose or of the windpipe.

And lastly, it will be interesting to determine the functions of the parts when attached to the body, judging from their behaviour when free, and see if such movements can throw any light upon their actions when in organic connection with other parts.

It was while examining the gills of the sea mussel in the ordinary course for medical students, at the Biological Laboratory, Ormond College, that a clue was obtained to the independent motion of the gills, and afterwards of the other parts as well. At first the movement was thought to be microscopic, only to be determined by a micrometer, but I soon found out that it required the largest of plates to allow free scope to the movements of translation and rotation.

For convenience, the subject will be considered under a fourfold heading, and in the order named :—

I.—Labial palps, inner and outer.

II.—Gills, inner and outer.

III.—Mantle-lobes.

IV.—Foot.

And a further division into four sections is necessary, each dealing with one special part of this particular enquiry :—

(*a*) Nature, direction, rate, and duration of movement in each of the above four parts when detached and free to move.

(*b*) Bearing of the observed movements on the probable functions of the parts concerned.

(*c*) Motive power employed in producing the movement.

(*d*) Effects of re-agents, &c., on movement.

Only the first section will be dealt with now.

Before proceeding a step further, it will be necessary to be agreed as to the position from which the moving parts are to be viewed, since it is impossible to have them detached and observed in motion in their natural position. If the valves of the shell are separated in the usual way, by inserting a knife at the ventral surface and passing it round the posterior end until the posterior adductor muscle is cut through, then if the two valves are spread out flat, with their pointed ends directed anteriorly, the right and left valves will be just reversed from our own right and left. This is the position from which our observations will be made as to the direction of movement. Further, in describing movements of rotation it will be found very convenient to use the terms *right-handed* and *left-handed*, as is done in connection with the rotation of the plane of polarization. So when rotation occurs in the direction of the hands of a watch, as seen by the observer, it will be called right-handed, and when in the opposite direction, left-handed; and the Labial Palp, for instance, according to its rotation, will be spoken of as right-handed or left-handed.

I.—Labial Palps.

1.—*Inner Palps.*

If a Palp is detached as near its base as possible, and laid on a plate with the liquid from the shell, then its motions are easily observed.

The movement is one of regular rotation, the palp revolving about one end in a steady manner, and in a definite direction. There may be forward, or backward, or lateral movement combined with this, but when once the palp has fairly become accustomed to its free condition of existence, rotation is its characteristic movement. This rotatory motion is probably due to the fact that the basal (cut) end is destitute of cilia, and so there is a tendency to turn round that spot as on a pivot. The palp, however, can also rotate upon its tip, and we can hardly account for making it the pivot on purely mechanical grounds.

The right and left inner palps detached turn *inwards*, the left turning to the left, while the right turns to the right. If there are obstacles in the way, such as dirt-particles in the water, or solid bodies of any kind, then the sensitive tip, ever, seemingly, on the alert, soon backs out and clears away from it, even although it should involve a change of course. Thus, I have seen a palp, when placed in a dirty liquid, turn backwards for a short distance, until it had shaken itself clear of adhering rubbish, and then go forward in its regular course, as if nothing had happened. If either palp is reversed, then it might be anticipated that the direction of movement would be also reversed, but as the result of several trials it was found that the direction was the same, the left inner being *right-handed* and the right inner *left-handed.*

Numerous continuous observations were made, over extended periods of time. It generally happened that the rate was slow at first, then gradually quickened, attained its maximum speed, and finally declined. The greatest speed attained was found to be a complete revolution in $1\frac{3}{4}$ minutes. *Left.*—For 15 recorded revolutions, the slowest was 17 minutes, the quickest $2\frac{1}{2}$ minutes, and the average 6 minutes. The first revolution took 11 minutes, and the last (recorded) 17 minutes. If a *partial* average be taken, including from the 4th to the 12th round, when the rate was comparatively regular, it would give 3 minutes per round. The left reversed, performed 12 revolutions at an average rate of 8 minutes. The motion was very steady, and after the first round, which took 16 minutes, the rate was either 7 or 8 minutes. A second specimen tried, performed 12 revolutions at an average rate of $6\frac{1}{3}$ minutes. The first round took $10\frac{1}{2}$ minutes, and afterwards they varied from $7\frac{1}{2}$ to 5 minutes. It is always to be understood that the palp continued revolving after the recorded observations. *Right.*—For 26 recorded revolutions, the slowest was 60 minutes, the quickest $1\frac{3}{4}$ minutes, and the average $8\frac{1}{3}$ minutes. It commenced with a revolution in 5 minutes, about the middle (14th) attained to the quickest in $1\frac{3}{4}$ minutes, and ended with the slowest in 60 minutes. A partial average for the more steady rounds, comprising from the 6th to the 19th inclusive, gave $2\frac{1}{2}$ minutes per round. The record was closed for the right after completing 26 rounds, when it became perfectly still, as if exhausted. It was still sensitive, however, as it quivered on being touched with a pin, and next morning it had shifted its position. The right reversed, moved very slowly, although it rotated in the usual manner by making the base the pivot. The first round occupied an hour, but deducting time stuck, it only took 28 minutes; the second round 22 minutes, and the third 20 minutes. Another specimen was tried, and in 12 revolutions gave an average rate of $5\frac{1}{6}$ minutes per round. The first round took $7\frac{1}{2}$ minutes, the last $8\frac{1}{2}$ minutes, and the intermediate rounds from 4 to $5\frac{1}{2}$ minutes.

2.—*Outer Palps.*

The movements generally resemble that of the inner palps. The outer palps appear to be capable of more sustained effort than the inner, as indicated by their more regular rotation for longer periods. The tip appears to be exceedingly sensitive. It might be thought from their general resemblance to the inner, that the direction of movement would be the same, but it is just the reverse of the inner of the same side. Thus the right rotated to the left, or outwardly, while the left rotated to the right, also outwardly. While this is the normal direction, I observed that it was occasionally reversed. This change might last for a few rounds, and then the original normal direction would be resumed. That the direction can be changed, and the original resumed again is rather an important observation, showing that the arrangement is not altogether a mechanical one, which causes the palps to move in a particular direction, like the hands of a clock.

The rate happened to be more regular than in the inner. This is evident from the fact that I was able to observe their movements over extended periods of time and through a number of rounds (50) without their movements becoming feeble or sluggish.

Left.—The left was observed for 20 rounds moving to the right with great regularity. The average was 7½ minutes to the round, the slowest being 9½ minutes, and the quickest 6 minutes. It commenced at the rate of 6 minutes per round, and with a steady pace, varying from 6 to 9 minutes. The 20th round was performed in 7½ minutes. The movement still continued when I ceased recording.

Right.—The right was observed continuously for 50 rounds, and for given periods of time the rate was pretty constant. The general average was 5 minutes to the round; the slowest record was at the commencement, with 25 minutes to the round, and the quickest was 2 minutes. The partial average for the 20 best continuous rounds, from the 13th to the 32nd inclusive, was 3 minutes, and the middle round of the whole (25th) was 2 minutes. The palp was going at the rate of 4 minutes to the round, when I left off observing, and the 51st round took 5½ minutes. Both left and right continued to move for some time afterwards, as I observed them for 25 minutes rotating as usual.

In this series of observations, extending over 4 hours, there was no variation in the direction, the left always revolving to the right, after being fairly started, and the right always to the left. But in a second continued series of observations, there was considerable variation in the rate and regularity, and a change in one of them once in the direction of movement.

An outer and inner palp were laid out at 11 p.m. to test how long they would retain movement, and next morning both were found moving. The morning after both again were found to have moved, and on the evening of the same day the inner palp moved visibly, while the outer was sensitive, but not motile. Hence one of the palps, at least, retained its power of movement for 48 hours, but this duration was afterwards completely eclipsed by the palp of the fresh water mussel *(Unio)*, which actually continued to rotate for eight days.

A comparison may now be profitably instituted between the outer and inner palps as to direction and rate of movement, taking the partial average as a fair one.

TABLE I.

Left.		Direction.		Average Rate.
Outer	-	Left-handed, outward	-	7½ mins. per round.
Inner	-	Right-handed, inward	-	3 ,, ,,
Right.				
Outer	-	Right-handed, outward	-	3 ,, ,,
Inner	-	Left-handed, inward	-	2½ ,, ,,

The outer rotate outward, the inner rotate inward, and this suggests a difference of function which we shall see actually exists. But it is also suggestive of some difference of structure or relative position, and the latter is found to be the case.

There is not any important difference in the rate of speed, except with the left outer, and its inherent slowness is borne out by two series of observations. No general conclusion can be drawn from the fact, but it remains that the left outer is fully twice as sluggish as the others when detached, and even regularly so, for each quarter round was frequently two minutes, thus completing a round in eight minutes.

II.—Gills.

The gills will be named as in the following scheme :—

Gills	Left	Inner.
		Outer.
	Right	Inner.
		Outer.

The left and right gills were first experimented on as a whole, *i.e.*, taking inner and outer of same side together. Next, inner and outer were observed separately, and lastly, small portions were taken.

As regards the power of movement possessed by the gills, perhaps, no more striking illustration could be given of it, than the fact, that either a single gill or a small portion of it, can travel along a moist surface even when held vertical, and if the plate is turned upside down, the gill still continues to move.

Dr. Carpenter, in his well-known work on the microscope, in referring to the ciliary motion exhibited by the gill of the sea mussel under the microscope, has remarked, "Few spectacles are more striking to the unprepared mind, than the exhibition of such wonderful activity as will then become apparent in a body, which to all ordinary observation, is so inert." But if he had only looked beyond his microscope, and applied ordinary observation, he would have seen the spectacle of the moving gill, the wonderful result of the lashing of the cilia.

It is also remarkable that in a sedentary animal like the mussel, more than one-half of its body by weight, when detached and free to move, is capable of independent motion. I took three mussels of average size, and after allowing them to drain sufficiently, weighed the entire body as taken from the shell. Then the gills, mantle-lobes, and labial palps were detached and weighed, and it was found that $\frac{7}{12}$ths of the soft body by weight could move about.

The movement is both translatory and rotatory. The former being a gliding movement, with the free ventral margin always behind. The direction is always that of the cut surface, and the rotation as a rule, takes place with the posterior end as a pivot.

As the result of numerous determinations at different times, I have found that the gills, both inner and outer, move at an average rate forward, of two minutes to the inch. They frequently cover an inch in 1 minute, and are sometimes much slower, but on the whole I have found them time after time, in succession, doing an inch in 2 minutes. The average rate for a small piece is the same as for the entire gill. The rate of the vertical ascent is more variable. The right inner gill ascended an inch three times in succession, respectively in 9, $10\frac{1}{2}$, and 11 minutes, thus giving an average of 10 minutes to the inch. The left inner did the same in 14, 13, and 10 minutes respectively, thus giving an average rate of $12\frac{1}{3}$ minutes to an inch. Both gills travelled horizontally at the regular rate of 2 minutes to the inch. The quickest vertical ascent was made by a right outer gill doing 1 inch in 7 minutes. The average rate when turned upside down was $2\frac{1}{2}$ minutes to the inch. Left inner gill, detached on the evening of the 2nd, was found moving visibly with cilia in active movement on the evening of the 4th, so that in this instance, motion continued for at least 48 hours.

III.—Mantle-lobes.

The right and left mantle-lobes are just lateral expansions of the integument, arising dorsally from the body-wall, and attached ventrally to each valve of the shell by the thickened muscular margins, which are pigmented posteriorly and provided with tentacular processes. The inner surface only of the mantle is ciliated, and the direction of the ciliary current is outward and backward. On the thin membranous body of the mantle, the current is towards the exterior, while on the thick muscular margin it is towards the posterior end of the body. The movement is rotatory, for although there is a certain amount of forward movement, it only occurs, as it were, in the course of the rotation.

The entire left mantle-lobe was detached and placed in water, with its outer or non-ciliated surface uppermost. It began to glide away at once, but soon rotated upon its posterior end, turning towards the cut surface. It completed a round in 4 hours 20 minutes, and the quarter rounds were successively 1 hour 5 minutes, 1 hour 17 minutes, 1 hour 21 minutes, and the last in 37 minutes.

Right and left mantle-lobes were next taken and divided, each into two portions, the brown tentacular muscular margin being separated from the remainder. The brown marginal portion did not move just at first, but afterwards it travelled considerably. The whitish muscular margin, with the thin body of the mantle-lobe, moved visibly, the muscular margin taking the lead and dragging the rest along. The white and brown portions continued moving the day after being detached, and both were found to be sensitive, though not moving, 48 hours after being detached. The pigmented portion is particularly sensitive to stimulation, readily responding to the prick of a pin.

IV.—Foot.

The foot is a thick muscular brownish tongue-shaped body, ventrally situated, and its tip directed anteriorly. From the posterior end, which is comparatively uncoloured, the byssus for attachment is given off. By virtue of its secreting this byssus, the foot is the fixing organ of the mussel, but the free portion of the foot is capable of great expansion and contraction, and is really a very active member. When the valves gape a little it can protrude itself beyond the mouth and outside the shell, or it can turn itself round and project behind, or when the shell is firmly closed it may protrude on the ventral surface. The foot is richly ciliated, there is a slight notch at the free end, making the tip slightly bifid.

If the free portion of the foot is detached and laid in water sufficient to cover it, movement will take place. The movement is of two kinds—translatory and rotatory—the former being the normal one. The direction of translation is straight forward and away from the cut surface. The tip always led the way, and it might sometimes diverge a little to the right or left, but the general trend was a direct straight line. The direction of rotation, with the dorsal surface uppermost, was right-handed. The rate of rotation was, a complete round in 6 hours 47 minutes.

The rate of translation was fairly tested in a specimen, with dorsal surface uppermost, which moved 6 inches in 5 hours 55 minutes, or at the average rate of 1 inch per hour. With such a slow rate of movement, it is, of course, impossible to say exactly when movement ceases. Accordingly I have taken the safe plan of giving duration up to a time *after* which a little movement was known to occur. A specimen was thus known to retain its power of movement for at least 73 hours, or about 3 days.

Thus the wonderful result is arrived at, that in the common sea mussel, which has been known and studied for so long, there is a latent power of independent movement in detached parts, which has hitherto escaped notice.

It is one of the marvellous surprises of Natural History to see the seeming biological paradox of parts when attached to the living body apparently inert, but when detached from it, in active motion. The gliding gill and the rotating palp, the moving mantle-lobe and the creeping foot, show what a stock of vital energy must be stored up in the soft-bodied mollusc imprisoned within the walls of its shell.

Similar comparative observations have been made on the fresh water mussel and the oyster. Even detached portions of the frog have been found to move, and it will be a genuine surprise to physiologists to learn, that the heart of the frog, so long and so much investigated, has likewise a wonderful power hitherto unnoticed, that of travelling about when detached from the body, having covered a distance of half-an-inch in 10 minutes. These and other matters will, however, require separate treatment.

Art. XIV.—*Rainfall and Flood Discharge.*

By G. R. B. Steane.

[Read November 5, 1887.]

The subject of maximum Flood Discharge is one of considerable importance to the engineering profession, particularly to those upon whom falls the responsibility of constructing drainage outlets, culverts, bridges, &c. Though the subject has been practised for thousands of years and there have been millions of opportunities for observation, the bulk of the opportunities have been lost, owing to the fact that the surrounding circumstances have not been observed, and the information has not been published.

A few engineers have paid attention to the matter of river discharge and published the information, but on the whole, I think, the subject has been neglected. I know of very many instances where costly works have been constructed to answer certain purposes and have failed, causing damage to many times the value of a proper structure. As an evidence of the difference of opinion held by authorities, I cannot refrain from referring to evidence given at an enquiry held on the Cootamundra disaster, where five engineers gave different opinions—one said the culvert was not sufficient to take $\frac{1}{3}$ inch of rain in 24 hours, and another said it would take 28 inches of rain in 24 hours. Matters being thus, I need no other excuse for referring to this subject.

Mr. Beardmore, in his Manual of Hydrology, has devoted a section to discharge from rivers, and gives a list from many sources. Mr. L. de A. Jackson in his Hydraulic Manual, devotes a space to it. Mr. Neville in his work also devotes a space to it.

As a preliminary to the subject, I submitted a paper to this Society, Notes on Hydrology, in June 1883. In June 1885, in Section A, I also submitted a paper on Rainfall and Flood Discharge, and with the hope of preparing a paper worthy of submitting here, I posted more than 150 circulars to engineers, but failed to elicit any data. I have, therefore, to submit this paper, bald as it is, with the hope that other information may be supplied by those who may have had better opportunities for observing. I claim a little indulgence for introducing matters of an elementary character with the data I submit.

The amount of discharge depends on many circumstances. The amout of rain ; size of area, especially the nature of the area varying from rock to beds of sand ; the form of the area ; inclination of surface, whether dry or soaked. I propose only to deal with the maximum discharge, and that due to the rainfall only ; the maximum discharge depends on the maximum rainfall.

The rainfall has been observed as to the total daily fall in many places, but the same attention has not been paid to the amount in times of short duration (B), and the area over which that rain falls. We have records such as an inch in fifteen minutes, but no evidence of the extent of such rains. The maximum discharge must take place from any watershed, when with the maximum rainfall over the whole area, it has continued long enough for a drop from the extreme distance to join drops from the whole of the area at the outlet. Hence the time the water takes to travel the longest distance must be an element in the discharge, and we must approximate the rain which falls in that time. Supposing it to be such a length as to take an hour to travel, we must approximate the rain—suppose it an inch.

The next, and a difficult and serious matter in the estimate, is the soakage. During the average time that the discharge at any instant has been travelling, soakage has been taking place, and the amount of soakage varies much more than the rain. I have no doubt that parts of sandy areas, such as Caulfield and Brighton, will absorb water faster than any rain that ever fell.

For the purpose of arriving at the form a simple formula should take, it appears to me to be necessary to assume quantities which cannot be fixed. The rainfall, for instance, I assume to vary as the cube root of the time:—1 inch in ¼ hour, 2 inches in 2 hours, 4 inches in 16 hours, 8 inches in 5½ days. The observed quantities I give at the end (A). If the total maximum rain be assumed to vary as $\text{time}^{\frac{1}{3}}$, the rate of fall will vary as $\frac{\text{time}^{\frac{1}{3}}}{\text{time}} = \frac{1}{\text{time}^{\frac{2}{3}}}$ Assume the watershed a constant narrow width, and assume the water to flow at a constant rate, which though not true, the tendency is to equalise, as the grades near the extreme limits are generally steeper. The area will vary as the time the water has to travel, and the discharge will vary as $\frac{\text{area}}{\text{time}^{\frac{2}{3}}} = \frac{\text{area}}{\text{length}^{\frac{2}{3}}}$

Then, if we assume length to vary as $\sqrt{\text{area}}$, $1 = a^{\frac{1}{2}}$, as for similar figures and substitute we obtain discharge varies as $\text{area}^{\frac{2}{3}}$. This takes no account of soakage, or varying inclinations.

That is, that the maximum discharge will depend on the area, and inversely on some power of the length, and this is the form that I have adopted.

For small areas of clay and rock, and tolerably impervious surfaces in larger areas, I have for the present adopted the following in the same form:—

$$\text{Discharge cubic feet per second} = \frac{\text{area sq. chains} \times 181}{\text{length chains}^{1\cdot23} + 1800}$$

The co-efficients for which I have obtained from the following three recorded observations:—

Maximum discharge 4 feet per second from 4 acres, length 7 chains.

Bendigo Creek 4100 feet per second from 10,000 acres, length 7½ miles.

Coliban 10,000 feet per second from 64,000 acres, length 22 miles.

The first two are my own, the last was obtained from a report on the Coliban works, which also mentioned a reported discharge of 32,132, but this I think doubtful. I should like, if I could obtain the necessary data, to obtain co-efficients for various average character of watersheds. I need hardly remark that this formula would be inapplicable for very absorbent ground or sandy areas.

We may also estimate the discharge in a more direct manner.

Let $Rt^{\frac{1}{3}}$ = rainfall for any period, $\frac{R}{t^{\frac{2}{3}}}$ = rate of fall, for instance so many inches per hour, where t is the time the water takes to travel the length of the watershed. If we put S for hourly soakage, as it will take less than t for the average time for the whole of the water to reach the outlet, it may be t^x or $\frac{t}{x}$, and knowing that 1 inch rain per hour represents very nearly a discharge of 1 foot per second per acre, we arrive at the following :—

$$\text{(acres) area} \left(\frac{R}{t^{\frac{2}{3}}} - \frac{t}{x} s \right) = \text{discharge per second.}$$

As time and the length depend on each other, substitute $\frac{l}{v} = t$, we obtain

$$a \left(\frac{R}{\left(\frac{l}{v}\right)^{\frac{2}{3}}} - \frac{l}{vx} s \right) = \text{discharge.}$$

Again, assuming $s\ v\ x$ to be constants, we obtain

$$a \left(\frac{x}{l^{\frac{2}{3}}} - ly \right) \text{ or } a \left(\frac{x}{l^x} - ly \right)$$

Which corresponds very nearly with Mr. Burge's No. 3

$$a \left(\frac{x}{l^{\frac{2}{3}}} \right)$$

The effect of soakage being omitted, hence I have adopted

$$\text{discharge} = a \frac{181}{l^{\cdot 23} + 1800} \quad a \text{ and } l \text{ in chains.}$$

The objection to this formula is, that when applied to very large areas and long rivers, the high power of the length reduces the quantity too rapidly ; I would therefore alter a and l to miles, and adopt different co-efficients.

The following formulæ are given in Mr. Jackson's "Hydraulic Manual :—"

1st. $Q = k_1\, 27\, (K)^{\frac{1}{2}}$
2nd. $Q = k_2\, 100\, (K)^{\frac{3}{4}}$
3rd. $Q = k_3\, 1300\, K\, (L)^{-\frac{2}{3}}$

Q = discharge cubic feet per second ; K area square miles ; L length miles ; and $k_1\ k_2\ k_3$ local co-efficients.

The first is most simple, but k varies so much as to make it inconvenient, and no attention is paid to the shape.

The second is a modification of Col. Dickens' formula, which was suited to Bengal, but $k \propto$ 1 to 24.

The third was deduced by Mr. Burge, of Madras.

4th. Mr. Jackson proposes $Q = k_4 \frac{B}{L}\, 100\, (K)^{\frac{3}{4}}$

I don't know the object of a numerical constant and a variable constant. (?)

5th. Mr. Hawkesley, an eminent authority, supplies a formula for the diameter of outlet pipes log. dia. inches =

$$\frac{3 \text{ log. area acres} + \text{log. length, in which sewer falls 1 ft.} + 6{\cdot}8.}{10}$$

by using Mr. Hawkesley's formula for discharge $D = C\sqrt[5]{\frac{G^2 L}{H}}$, it is easily proved that the formula 5 is constructed on the assumption that the discharge varies as $K^{\frac{3}{4}}$ without regard to form.

6th. Mr. B. Zeigler, of Zurich, supplies the following

formula $R = r \times c \sqrt[4]{\frac{s}{a}}$

r being average rain, C = coef., varying from ·75 for cities and ·31 for suburbs, s = fall in area or grade per 1000, and a = area drained, giving R resultant rain discharge, and this I find to vary as $S^{\frac{1}{4}}\, K^{\frac{3}{4}}$, but by this if $\frac{s}{a}$ under the sign becomes greater than 1, the result is incorrect. Three inches of rain with grade $\frac{8}{1000}$ and $\frac{1}{4}$ acre will give a rain discharge of 5·3 inches, evidently wrong for small areas.

Transactions of the Institute of C.E. England, 1883, on Improvement of River Broye. Mr. Gangnillet gives the form as

$$\text{discharge} = \overline{c \times \sqrt{K}}^{\,b} \text{ for floods}$$

and the maximum discharge is said to vary as a curve of an equilateral hyperbola.

Lieutenant P. P. L. O'Connell, Associate of Institute of C.E., in January 1868, argued that the maximum discharge from similar water-sheds varied as the curve of a common parabola.

On the whole, I think it may be agreed that a simple formula can only be a rough approximation.

For tolerably impervious surfaces, such as clay, a useful simple approximate formula for the sectional area of a waterway, is the following :—

$$\text{area of culvert in square feet} = (\text{area in acres})^{\cdot 62}$$

only a rough approximation.

In conclusion, I supply a few facts which have come under my own observation, a list kindly supplied by Mr. Gordon, and also a list that I have acquired from time to time from various sources. I would also direct attention to a list in Mr. Beardmore's Hydrology, and pages 94 and 95, Vol. XX. Transactions of the Victorian Royal Society 1883; and hope that some experienced in Hydrology may supply information at some future date on this, to me, interesting subject.

Some years ago, a borough was founded with a creek through its centre. It was found to be a considerable detriment. The local Council decided that it would be advisable to remove two bridges and cover over a considerable part of this creek. Their surveyor prepared a design with about 190 feet area waterway for 10,000 acres, and application was made for a Government grant; the grant was allowed subject to approval of the Government Engineers. The Government Engineers reported that the waterway was excessive, and recommended that it should be reduced by $\frac{1}{3}$. That surveyor was an obstinate man and would not cede the third. Ultimately, the plan was approved and the creek was covered, and I have seen floods over that many times a year. I pulled that culvert up and put down a new one 370 feet area. Since the time I refer to, a culvert was put down at Cootamundra, with a water-shed of somewhat similar character, but 13,000 acres instead of 10,000, with a sectional area of 52 feet. The result known, a flood—verdict, abnormal flood.

(a.)

Heavy Rain Storms.

Duration.		Rate per Hour.		Locality.		Date.
2 min.	..	6· in.	..	Sandhurst	..	28/11/82
4 ,,	..	5· ,,	..	,,	..	,,
15 ,,	..	4· ,,	..	Melbourne	..	10/3/77
20 ,,	..	5·4 ,, (?)	..	Ballarat	..	—/3/76
30 ,,	..	2·4 ,,	..	,,	..	2/3/64
75 ,,	..	2·0 ,,	..	Sandhurst	..	11/2/77
90 ,,	..	·75 ,,	..	..	..	..
24 hours	..	·15 ,,	..	Sandhurst	..	16/3/78
30 ,,	..	·2 ,, (?)	..	Beechworth	..	31/8/75
48 ,,	..	·10 ,,	..	Sandhurst	..	15-16/3/78
30 ,,	..	·19 ,,	..	Gordons	..	6/1/87
6½ ,,	..	·28 ,,	..	Ballarat	..	6/1/86
12 ,,	..	·19 ,,	..	Melbourne	..	6/1/86

(b.)

At Ontario, 10th July, 1883, 4 in. of rain fell, and extended over an area 50 miles by 20 miles. Eliptical in form.

Prof. F. E. Niphe (*Science*, p. 409, 1884), says from 47 years' observations, at St. Louis, he arrived at the conclusion that the duration of a rain was inversely proportional to the violence.

Sir J. W. Bazelgate (Journal, Franklyn Institute, 1882), says 2·64 in. rain fell in 19 hours over the whole of the London Metropolitan District.

Authority.	Watershed.	Dr'nage Area. Sq. Mls.	Disch. Cubic ft. per min. per sq. m.	Remarks.	Total Disch'ge Cubic ft. per sec.	Approx. Length. Miles.	Disch'ge from my Form'la.
Mr. G. Gordon, C.E. -	Goulburn -	3155	906	Murchison, 1870 - - -	47640	112	49070
,, ,, -	Moorabool -	1623	2957	Flood, 1852 - - - -	79986	50	65398
,, ,, -	Yarra - -	1546	2102	Flood, 1863 - - - -	54161	85	33438
,, ,, -	Campaspe -	1088	3355	Axedale, 1870 - - -	60838	50	43841
,, ,, -	Wimmera -	750	1154	Glenorchy, 1870 - - -	14425	50	30222
,, ,, -	Coliban - -	100	7250	1870 (another doubtful, 17191)	12081	20	10791
,, ,, -	Moonee Ponds -	64	4688	Flood, 1880 - - - -	5000	20	6906
,, ,, -	Bullarook Creek	22	5137	Flood, 1870 - - - -	1884	8	5500
(?) Steane - - -	Yarra - -	1584	..	..	35000	80	36698
Steane - - - -	Campaspe -	1088	..	Flood, 1870 - - - -	54000	50	43841
Mr. Culcheth, C.E. -	Barwon - -	1500	..	..	71000	80	34864
Steane - - - -	Bendigo Creek -	15⅔	..	..	4100	7½	4100
Reports - - -	Coliban - -	100	..	..	10000	20	10790
Mr. J. K. Smith, C.E. -	Elizabeth-st. City of Melb'rne	·776	..	..	410	1·25	430
Mr. Thos. Haynes, C.E.	Reilly-st. Drain	2·87	..	..	1118	2·50	1342

List of Sectional Areas of Outlets, Bridges, &c.

Areas of Watersheds, &c.

Locality.	Area—Acres.	Section.	Remarks.
Maher's Bridge, Bendigo Creek -	14,500	Bridge, 230 ft.	Flooded.
Back Creek Bridge, Sandhurst -	2,700	,, 103 ft.	Often flooded.
Golden Gully ,, -	600	Culvert, 33 ft.	Bad inlet, often flooded.
Cricket Ground ,, -	230	,, 19·3 ft.	Too small
,, ,, ,, -	230	,, 25 ft.	A new one lower down—enough.
Adelaide Gully ,, -	280	,, 23 ft.	Flooded, but rarely.
Hargreaves Street ,, -	65	,, 12 ft. to 13 ft.	,, ,, ,, a long Culvert.
Barkley Street ,, -	8	Channel, $2\frac{1}{4}$ ft.	Great fall—filled.
Long Gully ,, -	1,200	Bridge, 66 ft.	Overflowed.
New Chum ,, -	205	Bridge, 28 ft.	Never flooded.
Vine Street ,, -	48	Culvert, 5 ft.	Often too small.
Dowling Street ,, -	112	Culvert, 20 ft.	Good fall. Filled, but not over.
Bye Wash Park ,, -	112	Footbridge, 22 ft.	Overflowed. Bye wash bridged over.
,, ,, ,, ,, -	85	,, $15\frac{1}{2}$ ft.	Overflowed slightly.
Plenty River - - - -	38,400	440 ft.	Overflowed. Mr. Taylor authority.
Spencer Street, Melbourne - -	98	Culvert, 8·3 ft	A. K. Smith. Length 58 chains Enough to date, 1864.
Thomas Street, Sandhurst - -	3·7	Culvert, 1·2 ft	A box 25 ft. long 20 in. x $8\frac{1}{2}$ in. Good outlet. Sometimes small.

List of Sectional Areas of Outlets.

Areas of Watersheds and Estimated Discharges, &c.

Locality.	Area—Acres.	Section.	Estimated Discharge, Ft. per S'cond	Estimated Discharge Ft. per S'cond per Acre.	Remarks.
Pakington Street, St. Kilda -	12	15 in. pipe	7	·60	Long pipe. Several ft. head. Too small.
Charles Street ,, -	20½	15 in. ,,	11½	·51	Level crossing. Good fall. Too small.
Wellington Street ,, -	15	15 in. ,,	10·3	·68	,, ,, Rarely small.
Chapel Street ,, -	500	Channel	50 at flood	·10	Sandy area a portion.
Argyle Street ,, -	62	5 ft. Culvert	25	·40	Flooded.
Chapel Street ,, -	67	17 in. pipe	17	·25	Short pipe, good head. Often small.
,, ,, ,, -	2000	42·4	300	·15	Filled, large area in Caulfield (Main drain).
Union Street ,, -	234	Channel	140	·60	
Westbury Street ,, -	50	5 ft. Culvert	40	·80	Not filled.
Swanston Street, Melbourne -	188	12·3 ,,	86	·46	Overflowed.
,, ,, ,,	188	14 ,,	98	·52	Never overflowed.
Elizabeth Street ,, -	497	Channel, &c.	410	·82	A. K. Smith authority.
Bourke and Russell Sts., Melb. -	10	15 in. pipe	11·5 including overflow.	1·14	23/12/85. Good fall. Good inlet and head. Too small.
Hargreaves Street, Sandhurst	65	13 ft. Culvert	65	1·00	Long culvert. Has overflowed.
Bendigo Creek ,,	10,000	297	4100	·41	Grade 1 in 220.
,, Myrtle St. Bridge ,,	9500?	266			Not overflowed.
,, Golden Sq. ,, ,,	9000?	245			Overflowed. Bad approach.
,, Booth St. ,, ,,	9000?	240			Overflowed a little.
,, Laurel St. ,, ,,	9000?	228			Overflowed.
,, Maple St. ,, ,,	9000?	288			Not overflowed.
,, Alder St. ,, ,,	7500?	220			Overflowed.

Art. XV.—*Experiments on the Range of Action of the Digestive Ferments.*

By James Jamieson, M.D.

[Read November 5, 1887.]

No subject in the whole range of physiology has had more attention given to it, than that of digestion. Especially since Dr. Beaumont published the results of his observations and experiments on St. Martin, there has been almost an uninterrupted series of investigations into the properties of the digestive juices, and the ferments contained in them. But in spite of the excellent work done, there are still points left unsettled, this being true especially of the active constituents of the pancreatic juice. It has long been known that the pancreas forms a secretion possessed of very powerful digestive properties, and these of a very mixed kind. It has been proved to be capable of digesting all three of the chief ingredients of food, viz., the albumens, the fats, and starch, though there has not been much progress made in the direction of isolating, in a pure state, the ferments which exert these actions. Pancreatine, or pancreatic extract, is assumed to contain at least three distinct ferments—*trypsin*, the solvent of albuminous substances; *steatopsin*, that which emulsifies fats, and splits them up into their constituents; and *amylopsin*, the ferment which converts starch into sugar. Of these, only the first has been obtained in the separate state, and in a tolerably pure form; but of them all it is known, that they exert their special actions best, if not only, in alkaline or neutral media. The pancreatic juice itself is alkaline in reaction, and complete neutralisation of the acid contents of the stomach, when poured into the small intestine, is secured by the further help of the bile which is also strongly alkaline. But, while it has been sufficiently shown that the pancreatic secretion, in the fresh state or in the form of an extract, does convert starch into sugar, and albumen into peptones, in an alkaline mixture, there has been almost no exact enquiry into the influence exerted on it by acidulation of the media in which it may be called upon to act. And yet this is by no means an idle enquiry. For although within the body, under normal conditions, an alkaline, or at least a neutral reaction of the chyme may be secured, almost immediately after it has passed out of the stomach, there is sufficient practical reason for desiring to know whether the activity of the pancreatic ferments is stopped by the presence of an acid, and if so, in what degree of concentration. For these ferments have now entered largely into commerce, and are used in various ways as helps to digestion. It is important to know the limits to the range of their action, so that agents which are powerful for good, when rightly used, may not be misapplied. And further, it is interesting to know the fate of such agents, when subjected to conditions other than those they ordinarily meet with; whether, that is to say, their powers are only kept in abeyance temporarily, or are completely destroyed.

Experiments with the view of testing these points have become possible, only since good and reliable forms of these ferments have been prepared, and the importance of having them tested is increased by the fact, that they are now largely used in practical medicine. The first of these uses is in the preparation of artificially digested food, for administration in cases where digestion is greatly impaired, or where for any reason it is desired to spare the labour to the stomach involved in carrying on the process of digestion. For this purpose, the pancreatic ferments have a marked superiority over pepsin, which acts only on albumens, and does so only in acid solutions. But when it is proposed further to give these pancreatic preparations internally, as a help to digestion, the question is at once raised, whether there is not simple waste in doing so, there being considerable grounds for supposing that their powers are in complete abeyance in the presence of the acid of the gastric juice. And even supposing that this abeyance of activity is proved to come about in the stomach, there remains the further question, whether the ferments themselves are actually destroyed by continued exposure to the action of the acid and pepsin of the gastric juice, or are capable of resuming activity when an alkaline reaction is again brought about in the duodenum. It was for the purpose of testing these points that the following experiments were devised. The preparation tested was the article of well-established activity, known as zymine, a powder containing the mixed ferments formed by the pancreas. In the stomach there may be found a variable amount of acid *(hydrochloric acid)*, according to the stage and activity of digestion, and the character of the food; but there is good reason to suppose that it readily reaches the proportion of 1 part in 500 of the mixed contents of the stomach. A considerable time, as much as three or four hours, may elapse before the extreme degree of acidity is reached; but there can be no doubt, after the observations of Beaumont and others, that an intensely acid secretion is poured out as soon as the lining membrane of the stomach is stimulated by the contact of food.

The first series of experiments consisted in heating a mucilage of 10 grains of arrowroot in 20 cubic centimetres of water, for two hours, at 95° F., under different conditions as regards reaction and presence or absence of the ferment :—

I. Mucilage heated alone for two hours, still remained thick, and would not filter.

II. Mucilage heated, as above, with addition of 2 grains each of zymine and bicarbonate of soda. In a few minutes there was distinct thinning of the mixture, which at the end of the time was quite liquid, and filtered easily.

III. Mucilage, with 2 grains of zymine only. The result was the same as in No. II., though the mixture had a very slight acid reaction.

IV. Mucilage, with $\frac{1}{10000}$ part of hydrochloric acid, and 2 grains of zymine.

V. The same, but $\frac{1}{5000}$ part of acid.

VI. The same, but $\frac{1}{1000}$ part of acid.

Even with No. IV., there was some retardation of the solvent action, while with No. V., and still more with No. VI., there was a considerable amount of the swollen starch left in clotty pieces at the end of two hours.

VII. and VIII. To test this effect further, and with reference both to the amylolytic and tryptic elements in the mixed ferment, 10 grains of zymine were heated for two hours at 95° F., in 40 c. ctrs. of water, containing $\frac{1}{1000}$ part of hydrochloric acid. The mixture was then divided into two equal parts, to one of which was added pressed fibrin, 10 grains, and to the other, 10 grains of starch boiled in 20 c. cs. of water. Each of these was again kept for a full hour at 95° F., but little if any solvent action was observed at the end of that time.

It was thus made clear that the action of the mixed ferment is almost completely checked in the presence of hydrochloric acid, in the proportion of 1 part per 1000, and to a considerable extent when the acid was present in the strength of 1 to 5000.

IX. For the purpose of discovering whether loss of power was only temporary, or if the ferment had been permanently injured; the mixtures of starch and acid (Exps. IV., V., and VI.) were rendered alkaline, by the addition of 2 grains of bicarbonate of soda to each, and again kept at 95° F. for two hours. In that which had contained only $\frac{1}{10000}$ of the acid, there was complete liquefaction, while in those which had contained $\frac{1}{5000}$ and $\frac{1}{1000}$ respectively, there was slight breaking down of the clotty particles, but no great change. In both of these, therefore, there had been permanent injury to the ferment, though it did not seem to be completely destroyed.

X. For the purpose of discovering whether this destruction would be effected by the presence of pepsin in the acid mixture, the following experiment was carried out. Zymine (10 grains) was heated for two hours at 95° F., in 40 c. ctrs. of water, with 10 grains of Fairchild's scale pepsin, acidulated to the strength of 1 in 1000. At the end of that time the mixture was divided into two equal parts, each of which was rendered slightly alkaline with bicarbonate of soda, and heated again for an hour with 10 grains of pressed fibrin, and the mucilage of 10 grains of starch respectively. It was found that both the fibrin and the starch were almost completely dissolved. This difference from the experiment before detailed (IX.), was due probably to the larger amount of zymine present, 5 grains instead of 2. It was made clear that the pepsin, as such, had not acted at all on the zymine, though placed under very favourable conditions for doing so.

For the sake of completeness, the following counter-experiment was tried:—

XI. Five grains of pepsin were kept at 95° F. for 2 hours, along with 5 grains of zymine and 2 grains of bicarbonate of soda. Hydrochloric acid was then added in sufficient amount not only to neutralise the soda, but to leave an excess equal to 1 part in 500 of the mixture. To this was then added coagulated white of egg in thin slices, and the whole kept for 3 hours at 100° F. At the end of that time the albumen was not appreciably altered ; while similar slices, treated in the same way with fresh pepsin and hydrochloric acid, 1 in 500, were found, at the end of 3 hours, to be completely dissolved. The quality of the pepsin being thus shown to be good, it follows that the treatment to which it had been subjected had had a destructive influence on it. Whether this was owing chiefly to the action of the bicarbonate of soda, or to that of the zymine, remains, of course, undetermined, though the probability is that the latter supposition is the correct one.

As this question did not enter into the scope of the original inquiry, though it is of great interest, it had to be left, the investigation having proved sufficiently laborious.

The general conclusions are :—

I. That the pancreatic ferments are not merely temporarily inhibited in their digestive action by small quantities of hydrochloric acid, but are permanently injured, when the strength of the acid reaches the proportion of 1 to 1000, or even 1 to 5000, for 2 hours.

II. That pepsin does not seem to have any power, in association with the acid, in bringing about or even hastening this destructive action.

III. That, on the contrary, the trypsin of the pancreatic secretion seems to bring about the destruction of pepsin in slightly alkaline solutions.

I have to acknowledge my great obligations to Mr. Frederick Dunn, public analyst, for assistance in the way of carrying out the practical details of the experiments. Without that assistance, indeed, I fear that the inquiry would scarcely have been carried out at all.

Art. XVI.—*The Anatomy of Megascolides Australis.*

By Professor W. Baldwin Spencer.

[Received October 6, read November 10, 1887.]

The following is an abstract of the full paper which, with illustrations, is in course of publication as a separate monograph. Since it was written and read before the Society, a short account of the macroscopic anatomy ot the same worm has been published in the Journal of the Linnean Society of New South Wales by Mr. Fletcher, whose paper was read in September, one month before the reading of this paper. The papers were written quite independently of one another, and, as far as the macroscopic anatomy of this interesting worm is concerned, are in almost perfect accord.

Professor M'Coy's description in the *Prodromus of the Zoology of Victoria* (Decade 1, Pl. 7), contains the first account published of the worm, and deals merely with its external anatomy. In this description the worm is placed in the family *Lumbricidæ,* and thus close to the common earth-worm, a mistake which would appear to have been due to the counting of the annuli as segments.

Mr. Fletcher does not seem to have recognised the worm from Professor M'Coy's description, and himself giving a perfectly correct one, placed it in his genus *Notoscolex,* containing several other species, so that in his recent paper the worm appears under the name of *N. Gippslandicus.*

The worm lives in deep burrows, principally by the sides of creeks in Gippsland. The burrow is devoid of "castings" at its mouth, is of about the diameter of ¾ to 1 inch, and contains a slimy fluid ; but only in very rare cases any trace of leaves dragged into it. With care, the animal, whose presence can easily be recognised by a peculiar gurgling sound made when retreating through its burrow, can be dug out. It has been described as brittle, but though it easily tears, the word "brittle" is most inapplicable, as it stretches to a very great amount before even tearing. Its odour, as pointed out by Prof. M'Coy, is very characteristic, resembling somewhat that of creosote.

The body varies in length from three to six feet, or even longer, and contains upwards of 500 segments. Anteriorly, it is somewhat swollen and hard, due to the very strong septa internally. The anterior segments contain from two to four annuli, which are often incomplete and slightly irregular. The segment boundaries are clearly marked, and posteriorly to about the 18th segment each one shows in the median dorsal line a large " dorsal pore," through which, in contraction of the body, the cœlomic fluid is pressed out in little jets. In the middle and posterior regions of the body the septa are inserted into the body-wall somewhat anteriorly to the line bounding the segment externally. Segments 13 to 20 are usually of a dark purple colour, are provided with an especially strong development of nephridia, and have externally to the muscle layers a strongly-marked development of glands. Ventrally, a portion which, as described by Professor M'Coy, is evidently equivalent to the cingulum of other worms, is found on the 17th, 18th, and 19th segments, where it forms three white prominent ridges, in the middle one of which are the male apertures. The whole of this region is called clitellum by Mr. Fletcher.

The setæ are arranged in four pairs in each segment, but cannot be seen in front of the 13th segment.

The paired external openings of the receptacula seminis lie between the 8th and 9th and the 9th and 10th segments, the oviduct openings close to one another ventrally on the 14th segment, and the male on two small papillæ in the part of the cingulum on the 18th segment, and correspond in position to the internal two pairs of setæ, which here cannot be seen macroscopically. No nephridio-pores can be detected.

Septa.

The first clear septum bounds anteriorly the fifth segment. Posteriorly, as far as the 16th segment, the septa are very thick, strong, concave anteriorly, and bound to one another by numerous connecting strands of muscle. Behind this they become membraneous until the hinder end of the body is reached, where they become again more muscular and have very definite supporting strands, radiating from the walls of the alimentary canal. This strong anterior and posterior development gives the worm great power of rapid swelling of its body so as to become very tightly jammed against the burrow walls, and renders it difficult to extract the worm from its hole. The posterior end especially seems to have a strong power of suction.

Alimentary Canal.

The mouth is overhung by the ridged prostomium, and leads into the strong muscular pharynx, extending back to the 5th segment.

There is a good development of salivary glands which microscopically appear to resemble nephridia in structure.

The 5th segment contains the short œsophagus and longer gizzard, then follows the long intestine which, in segments 12 to 18, contains a series of very vascular dilatations, and from the 19th runs backwards to the terminal anus. Its walls are very distinct, yellow-brown in colour, and consist internally of an epithelium of deep cylindrical cells, with large nuclei and nucleoli, external to these a layer of circular muscle fibres, then a series of longitudinal fibres, and then a layer of cells whose thin internal ends send processes between the longitudinal fibres, and perhaps deeper still whilst their external parts are filled with yellow-brown granules. The cells contain large nuclei, and are to be regarded simply as modified cells of the membrane lining the body cavity. There is no structure present representing the typhlosole.

Nervous System.

This resembles that of the ordinary worm, save that the distinction into ganglia and connecting commissures is not so clearly marked. Sections show clearly its double nature, and the arrangement of the large ganglion cells on the ventral and lateral aspects, and of the fibres in a double longitudinal band dorsally and internally. Dorsally are three, and at times, even four, of the so-called giant-fibres present. Each one, however, is very distinctly *not* hollow, but has the form of a solid homogeneous rod, surrounded by a considerable amount of ensheathing connective tissue. Three pairs of lateral branches pass off in each segment, and in sections can be traced towards the surface till they spread out on the internal side of the circular muscles in the body-wall.

Circulatory System.

A dorsal and ventral vessel are present. Lateral vessels, or "hearts," connect the two in the 13th to 6th segments inclusive, and from the 14th segment forward a lateral vessel is present on each side, and a small supra-intestinal branch in each segment. Posteriorly there is no direct connection between the dorsal and ventral vessels, and the former gives off two pairs of branches in each segment to the walls of the alimentary canal, in which they come to lie just externally to the cylindrical epithelium.

Around the dorsal vessel posteriorly is a curious ensheathing structure which gives off more or less solid diverticula into the body cavity. These processes are filled with distinctly nucleated, somewhat granular, polygonal cells. The nature and function of this structure is as yet unknown. In each segment it opens into the cœlom close to the anterior septum.

Nephridia (of Two Kinds).

(1) Very numerous, and varying in number in different segments. They are especially numerous in the 13th to 20th segments, and are scattered irregularly over the body wall. Each consists ot a much coiled duct which is clearly *intra-cellular*, and surrounded by connective tissue very rich in blood vessels. These nephridia have no internal openings. (2) A series of larger nephridia in the middle and posterior regions, one pair in each segment, with distinct ciliated funnels opening internally. *All the nephridia are connected with a network of ducts lying beneath the cœlomic epithelium, from which others pass off to open externally, so that there are many irregularly arranged nephridio-pores in each segment. There seems to be one main duct continuous from segment to segment on each side ventrally.*

Reproductive Organs.

(1) *Female.*—Ovaries paired and attached by short stalks to the septum bounding anteriorly the 13th segment. The two ciliated rosettes are in the same segment, and the oviducts leading from them open externally on the 14th segment.

The Receptacula seminis are large, prominent, paired, sac-like structures in the 8th and 9th segments. A curious muscular slip runs up each side of the sac, which opens by a very short stalk with a small indication of a cæcum. Distally, the sac tapers considerably.

(2) *Male.*—Testes, small paired bodies, very similar macroscopically to the ovaries in the 10th and 11th segments. A similar pair of bodies may be found often in the 12th segment. The ciliated external openings of the vasa deferentia are very clearly marked, but the ducts themselves can only be traced backwards in sections. The ducts are remarkable in that they never unite with one another, but run back in the body-wall parallel and close to each other till they reach, and separately enter, the duct leading from the prostate gland to the exterior. The prostate glands are largely developed in the 18th segments, and from them the paired ducts run down to open externally on the small papillæ.

The *vesiculæ seminales* vary in development in different specimens. They form white, solid, racemose bodies, in which the spermatozoa are seen in various stages of development. They may be found connected with the faces of the septa, in the 11th, 12th, 13th, and 14th segments, and can always be distinguished macroscopically from the testes and ovaries by the definite position and size of the latter.

Art. XVII.—*Description of some Hitherto Unknown Australian Plants.*

By Baron von Mueller, K.C.M.G., M.D., Ph.D., F.R.S.

[Read December 12, 1887.]

Acacia Baileyana.

Arborescent; branchlets prominently angular, somewhat furrowed, glabrous or beset with short spreading hairlets; leaves bi-pinnate, almost sessile or on very short stalks, glabrous or the main-rhachis bearing hairlets when young, as well as the branchlets and flower-stalks somewhat whitish from ceraceous bloom; pinnules usually in three or four or sometimes in two pairs, oval or broad-elliptic in outline, almost sessile, a very conspicuous depressed glandule between each pair; leaflets in from four to twenty closely approximated pairs, sessile, rather short, linear, flat, blunt at the base, slightly acute at the apex, their carinular venule faint; rhachcole greenish-margined; headlets of flowers small, in elongated almost glabrous axillary and also paniculate terminal racemes; bracts minute, ciliolated, their upper portion suddenly roundish-dilated; calyx bluntly short-lobed, hardly half as long as the deeply five-cleft corolla; fruit straight, broadish, almost flatly compressed, smooth, rather elongated, at both ends blunt, along the anterior side dehiscent; pericarp cartilaginous-chartaceous; seeds oblique-pendent, ovate-elliptic, much compressed, black, with hardly any lustre, their areole on each side large; arillar appendage pale, cymbous-semiorbicular, less than half as long as the seed; funicle comparatively short, slightly twisted.

A small tree of particularly graceful aspect; leaves crowded; well developed pinnules about one inch long; leaflets generally from $\frac{1}{16}$ to $\frac{1}{20}$ inch broad; headlets on very thin stalklets of double or triple their length, containing from 10 to 18 flowers; fruits mostly from 2 to 3 inches long and about half an inch broad, dull-brownish outside; seeds scarcely a quarter of an inch long.

This species seems always to have been passed as *A. polybotrya;* but it differs essentially from that species in glabrous leaves, with usually less numerous and always shorter pinnules, the form of which gives a very peculiar aspect to the plant; in smaller and particularly narrower leaflets, with hardly any intervening spaces between them; in highly developed glandules on the rachis; in glabrous thinner and often also longer stalks of the headlets of flowers, with still smaller basal bracts; in deeper lobed corolla; in broader fruit not constricted between the seeds, further in probably larger arillar appendage, so far as can be judged from comparison of fruit of *A. polybotrya*, available here in a young state only. Stature, bark, wood and odour of flowers of the two trees may also be quite different. The height of the tree, so far as known, seldom exceeds 15 feet; the bark is of a greyish or slaty colour and smooth; the flowering time is about the earlier part of September.

The species is named in honour of Mr. F. M. Bailey, from whom flowering branchlets were received, taken at Brisbane from a tree in Bowen's Park, the origin of which could not with certainty be traced. Somewhat later, fruiting specimens were sent by the Rev. Dr. Woolls, who got them from Mr. H. D. Coker of Brookfield, through Mr. John Dawson of Humberstone; he found this rare species only near Cootamundra on one of the sources of the Murrumbidgee and near To-morrow on a tributary of the Lachlan River on stony ridges up to an elevation of about 1600 feet. It must, however, be rare, as no other material pertaining to this species occurred formerly in the Museum Collections of Australian Plants, formed by me here since 1847. Quite recently *A. Baileyana* has been found also near Wagga Wagga by Messrs. Garland and Deane. *A. polybotrya* has a rather wide range, inasmuch as it is now known also from the vicinity of Keppel-Bay (Rev. Jul. Tenison Woods), from the sources of the Condamine River (E. Bowman), and from Drummond's Range (P. O'Shanesy). The bark is locally used for tanning; the flowers are pale yellowish.

Adjoined are some notes of unrecorded localities of various *Acacias*:—

Acacia triptera—near the Upper Darling River (Rev. H. Milne Curran).

Acacia cochlearis—Upper Kalgan River (F. v. M.), near Hampton Range (J. Forrest), near Esperance Bay and Russell Range (Dempster), near Cape Arid (Maxwell); also in Drummond's Collection 289. *A. latipes* seems a variety.

Acacia lanigera—Hume River (Ch. French, jun.)

Acacia genistoides—between the Gascoyne and Ashburton Rivers (E. Giles).

Acacia tenuifolia—near the Cann River (Edwin Merrall.)

Acacia rupicola—Wirrabara (J. R. Love), Kangaroo Island (Tepper).

Acacia oxycedrus—Lake Leake (Prof. Tate).

Acacia leptoneura—Sources of Swan River (Miss J. Wells), between the Murchison River and Juin (E. Giles); also in Drummond's collection under 303.

Acacia rigens—Gawler Ranges (C. Ryan), Murrumbidgee (F. v. M.)

Acacia scirpifolia—Upper Darling River (Rev. J. Milne Curran).

Acacia lycopodifolia—Thompson River (J. W. Birch), Macdonnell Ranges (E. Giles), Roebuck Bay (Martin), DeGrey River (Carey).

Acacia galioides—Dangar's Creek, Cape and Flinders Rivers (Bowman), Newcastle Range (Armit.)

Acacia Baueri—Richmond River (Fawcett), Fraser's Island (W. Hill).

Acacia bruniades—Minto's Craig (Rev. B. Scortechini).

Acacia conferta—Severn (C. Hartmann), Comet and Callan Rivers (O'Shanesy), between Clermont and Gainsford (Bowman), Lake Elphinestone, (Mrs. Dietrich.)

Acacia vomeriformis—near Ballarat (D. W. Spence), near Meredith (S. Johnson), Upper Ovens River (Mrs. M'Cann).

Acacia lineata—near the junction of the Ovens and Murray Rivers (C. French), near Cobar (Rev. J. M. Curran).

Acacia fasciculifera—Severn (C. Hartmann), between the Dawson and Burnett Rivers (F. v. M.)

Acacia falcata—Comet River (O'Shanesy), Mount Dromedary (Reader).

Acacia penninervis—New England (C. Stuart), Severn (Hartmann).

Acacia microbotrya—near Stirling's Range (F. v. M.), Irvin River (Miss Guerin).

Acacia vestita—Gulgong (Dr. Barnard).

Acacia stipulosa—King's Sound (A. Hughan), Fitzroy River (Maitl. Brown).

Acacia sclerophylla—Murrumbidgee (Tucker), Lachlan River (F. v. M.)

Acacia excelsa—Darling Downs (Law), Comet River and Blackwater Creek (O'Shanesy), Severn (Hartmann), Port Denison (Fitzalan), Walloon (Bowman), Flinders River F. v. M.)

Acacia binernata—Myall River (Fawcett).

Acacia alpina—Mount Bogong (J. Stirling), Mount Hotham (Rev. E. W. Nye).

Acacia cyperophylla—near Cobar (Rev. J. Milne Curran).

Acacia glaucescens—Apsley River (A. R. Crawford), Genoa, at 3000 feet (W. Baeuerlen).

Acacia elata—Hunter's River (Rev. Dr. Collett), sources of Barrington, Gloucester and Manning Rivers (Aug. Rudder), Apsley River (A. R. Crawford).

Acacia Mitchelli—near Portland Bay (Ch. Green), near Meredith (S. Johnson).

Acacia pentadenia—Shannon, where it attains a height of 30 feet (F. v. M.)

Acacia Gilberti—Warren River (Walcott), Blackwood River (F. v. M.); also Drummond 314.

Acacia nigricans—Porongerup (F. v. M.)

Acacia strigosa—Pinjarrah (Rev. J. S. Price), Shannon (F. v. M.)

Acacia Drummondi—Stirling's Range (F. v. M.), Blackwood River (Mrs. M'Hard), Greenough River (C. Grey); Drummond 315.

Acacia Farnesiana—Shark Bay (Mrs. Gribble.)

Acacia Bidwilli—Mitchell River (E. Palmer).

Grevillea Kennedyana.

Branchlets and leaves beset with short appressed greyish hairlets; leaves scattered or somewhat fasciculated, rigid, linear, entire, pungently pointed, revolute along the margin; flowers comparatively large, in axillary and terminal umbels; bracts fugacious; petals bright-red, about twice as long as the glabrous stalklets, only from much above the middle or near the summit reflexed, outside glabrous, inside extensively beset with tender whitish hairlets; torus elongated, almost in a straight line continuing the stalklet; hypogynous glandule semi-annular and also upwards protracted; pistil glabrous; ovulary conspicuously stipilate; style nearly half exserted; stigma lateral; fruit oblique-ellipsoid, pointed at the upper end, slightly granular-rough outside; seeds linear- or narrow-ellipsoid, channelled, greyish outside, with a short pale terminal appendage.

Between rocks on Grey's Ranges (W. Baeuerlen).

An ample shrub, attaining a height of about five feet, flowering downward even to near the base of the stem. Leaves mostly from $\frac{2}{3}$ to 1 inch long, with a single groove underneath, many of the leaves spreading. Umbels sessile, the flowers exuding a mellaginous fluid. Total length of petals nearly an inch, but apparently less through the terminal curvature. Fruit turgid, about $\frac{2}{3}$ inch long.

This beautiful plant is as yet only known from a single locality; it is dedicated to Mrs. M. B. Kennedy, of Wonnaminta, who not only contributed since some years to the writers collections, but also from her and her consort's hospitable home promoted the searches of the discoverer of this plant. In its affinity the newly found species approaches *G. acuaria,* but the leaves are much thicker and deeply grooved beneath, the flowers are much larger, the torus is proportionately far more extended, and the ovulary is not unilaterally and suddenly protruding as that of *G. acucaria,* whereby already quite a different form of fruit is indicated. In general aspect our new plant is not dissimilar to *G. Huegelii,* the leaves of which however are always dissected, the flowers corymbously arranged, the petals outside, as well as the stalklets, invested with appressed shining hairlets, but inside glabrous, the style is less emerged and the fruit shorter, broader and compressed.

This seems an apt opportunity of bringing under notice the fruit of *G. anethifolia,* recently sent from the vicinity of Cobar by the Rev. J. Milne Curran. It is about $\frac{1}{3}$ inch long, suprabasally fixed to the slender stipes, oblique-ovate, turgid, slightly rough, but glabrous outside; the seeds are concave-convex, pale, oval and without any conspicuous expanding membrane.

Some other hitherto unrecorded notes on *Grevilleas* are added:

G. pterosperma occurs as far south as Lake Albacutya (Mr. Ch. French).

G. cirsüfolia was found on the summit of Mount Lindsay by Mr. W. Webb.

G. floribunda was noticed on the Severn by Mr. C. Hartmann.

G. ericifolia was gathered on the Ovens River by Mr. J. C. Martin, and near Mount Elgin by Mr. St. El. Dalton.

G. longistyla grows on the Upper Hunter River, according to Mr. L. Stephenson. As many as 21 segments have been counted on some of the leaves.

G. juncifolia was brought from the Berkeley Ranges by Mr. Adolph Wuerfel, from the Mulligan River by Mr. Cornish; from near the Darling and Lachlan Rivers, by Mr. Tucker.

G. Dryandri is now also known from near Port Darwin, through Mr. Holtze.

G. gibbosa extends to the Upper Thomson River (Mr. R. C. Burton). This species mediates the transit to the genus *Hakea,* its pericarp and seeds bearing much resemblance to those of *H. cycloptera* and *H. platysperma.*

G. trinervis has been detected in New England, near Walcha, by Mr. R. Crawford.

G. ramosissima has been sent from the Upper Lachlan River by Dr. Lauterer; from near Omeo by Mr. James Stirling; from near the Upper Ovens River by Mrs. M'Call; from near the Hume River by Mr. M'Kibbin.

G. Goodii was collected by Mr. Armit near the Robertson and Perry Rivers; fruit woody, broad-ovate, about ¾ inch long, pointed; seeds without any expanding membrane.

G. annulifera was traced to Shark Bay as well as *G. lencopteris* (F. v. M.)

G. striata was noticed as far south as Cobar by the Rev. J. M. Curran.

G. mimosoides advances eastward to the Palmer River, according to Mr. Wycliff.

G. Victoriæ was collected at Tooma by Miss Campbell.

ART. XVIII.—*Two Hitherto Unrecorded Plants from New Guinea.*

Described by BARON VON MUELLER.

ELAEOCARPUS SAYERI.

Tall-shrubby and straggling or finally arborescent; branchlets slender, as well as leaf-stalks and inflorescence much beset with greyish short soft hairlets; leaves comparatively small, firm, conspicuously stalked, mostly ovate-lanceolar and gradually long acuminated, rounded at the base, remotely serrulate-crenulated, almost glabrous, their costular venules prominent beneath, the ultimate venules closely reticular-connected; racemes short; flowers comparatively small; stalklets recurved, slender, longer than the flowers; petals about as long as the sepals, whitish, upwards broader, beset with appressed shining hairlets particularly outside, acutely fringed at and towards the summit; stamens from 12 to 22, slightly invested with minute hairlets; filaments about half as long as the cells of the anthers; terminal bristlet of the latter conspicuously curved; pistil beset with a somewhat velvet-silky vestiture; ovulary attenuated gradually into the conical-filiform style, two-celled; torus conspicuously raised. On Mount Obree, at an elevation of about 7000 feet (Cuthbertson and Sayer).

E. Munroi, which among the numerous congeners comes nearest to the new species above defined, differs in tall arboreous stature, want of general vestiture, leaves much paler beneath, larger flowers, more slender style and possibly also in fruit. *E. Græffei* is separated from the new Papuan congener by much larger leaves, quite short pedicels, somewhat broader sepals, almost glabrous petals and stamens, as well as by the thinner style.

Through recent access to better material it has been ascertained, that the Papuan plant, formerly regarded as a variety of *E. Armhemicus*, constitutes a distinct species, to which now the name *E. Reedyi* has been given; it differs from *E. amoenus* already in smaller flowers on shorter stalklets with almost glabrous petals and anthers, lesser number of stamens and very short filaments; a very similar species occurs in New Caledonia.

Dendrobium Cuthbertsoni.

Dwarf, tufty, except the calyx-tube glabrous; roots elongated, filiform, flexuous; stems very short, leafy; petioles clasping, towards the base dilated; leaves small, broad-linear, narrowed towards both ends, rather acute; flowers solitary, terminal, relatively large, lightly carmine-red, on conspicuous pedicels; bract ample clasping; calyx-tube slender, somewhat papillular-rough; calyx-lobes and lateral petals of about equal length; the lateral calyx-lobes deltoid-semilanceolar; their prolongation quite descending, about twice as long as the lobes, narrowly conic-cylindrical, rather blunt; upper calyx-lobe lanceolar-ovate; lateral petals cuneate-obovate; labellar petal somewhat shorter than the two other, likewise membranous, orbicular-ovate, very concave, entire, almost smooth, darker red upwards, scantily conspersed with stalked glandules; gynostemium hardly half as long as the labellar petal, upwards gradually blunt-dilated and incurved, dorsally terminated by a minute narrow and acute denticle; anther dull-purplish; pollen-massules pale-lilac, equal-sized in each pair; fruit slender.

On Mount Obree, at elevations from 6000 to 8000 feet (Cuthbertson and Sayer).

Whole plant only about two or three inches high; leaves flat, seldom above an inch long, often shorter, so far as seen not exceeding $\frac{1}{8}$ inch in breadth. Total length of flower nearly one inch. Ripe fruit not obtained.

This decorative species is dedicated to the leader of the expedition, sent this year by the Victorian Branch of the R.G.S.A. to New Guinea. It differs as well from *D. puniceum* as *D. cerasinum* in solitary still larger flowers, with broader, blunt and subtle-venulated petals.

Art. XIX.—*The Production of the Tides, Mechanically Considered.*

By T. Wakelin, Esq., B.A.

[Read December 15, 1887.]

Let us suppose the earth to be composed of grains of sand, all separate, not one grain in actual contact with another. Let us further suppose, for a moment only, that the force which *draws* them, as is supposed, towards the moon, acts equally on every particle—on every grain of sand. In this case the earth will keep its form, whatever form it may have.

Now let us take, in part, the actual case. The grains of sand composing the earth on the side nearest the moon are drawn by a greater force than are the grains composing the earth on the side farthest from the moon. This force—the gravitative force of the moon on the earth—varies inversely as the square of the distance from the moon's centre, supposing the moon to be a perfect sphere, and knowing that the attractive force of the moon may be considered as concentrated at the moon's centre. I only wish here to deal with the principle of the moon's action in producing the tides, or rather one of the principles. I have been unable to find any work in Wellington which treats of the Dynamical Theory of the Tides, or of anything relating to it, except what is contained in Newcomb's "Popular Astronomy," and I wish here, therefore, to keep to the direct action of the moon, as it is generally understood.

Let us consider the action of the moon on three portions of the earth:—(*a*) the portion nearest the moon; (*b*) the portion in the centre of the earth; and (*c*) the portion of the earth farthest from the moon. The first portion (*a*) is drawn by a greater force than the second—the central portion (*b*), and it therefore bulges towards the moon. The second portion (*b*) is drawn by a greater force than is the third portion (*c*), and this last portion, therefore, is left a little behind, and bulges away from the moon. These two bulgent portions are the two tides. The force producing these two tides is measured by the *difference* of the accelerations produced by the moon in the respective portions of the earth considered—*a*, *b*, and *c*.

The total mass of the moon is about one-eightieth of that of the earth, and her mean distance about 240,000 miles (Newcomb). The moon is thus distant about 60 semi-diameters of the earth. Whatever may be the earth's attractive force on a small mass at its surface, the moon's attractive force is $\frac{1}{80}$th of $\frac{1}{60}$th of $\frac{1}{60}$th of this force—the earth's attractive force. The *tide-producing* force of the moon (in part) is, however, only as the difference between $\frac{1}{80}$th of $\frac{1}{59}$th of $\frac{1}{59}$th and $\frac{1}{80}$th of $\frac{1}{61}$st of $\frac{1}{61}$st of the earth's attractive force on a small mass at its surface. The calculation is too tedious to go through, and it is only required to have some idea of the magnitude. It will suffice here, therefore, to say that the tide-producing power of the moon is very much less than a millionth of the power of the earth to draw a small mass at its surface towards its centre.

The *tide-producing* force of the moon being so small compared to the power of the earth to draw a mass at its surface towards its centre, how can it possibly pull up from the surface of the earth a portion of its liquid surface? It is impossible for a very small force to lift up a small mass when there is a vast force pulling it down. The moon, however, certainly produces the tides. The only question is, how?

Now, water is slightly compressible, and the pressure of the upper portion of the oceans is very great on the lower portions. If this pressure were weakened, as by the action of the moon, the elasticity of the water would cause the ocean to swell up where the pressure was relieved. If my memory serves me rightly, Mr. Murray, of the "Challenger Exploring Expedition," in a lecture at Edinburgh, estimated that if the force of gravity of the earth were to be suspended, the waters of the ocean would swell up, raising the water-level over the earth by 500 feet. Now the *tide-producing* power of the moon reduces the force of gravity of the earth, and thus relieves the pressure of the water of the ocean under the moon. The ocean, owing to the elasticity of the water, swells up, and a tide is produced.

Is the elasticity of the water sufficiently great to produce the actual tide of, say four feet in the open ocean?

The relief of pressure here producible by the moon is less than one-millionth of the pressure produced by the force of gravity of the earth acting on the oceans, the tide thus producible would be less, therefore, than one-millionth of 500 feet. This would be a mere ripple on the actual tide.

When the weight of air over any place is greater than the average for that place at that time of the year, it produces, if on the ocean, a hollow in its surface, and of course there must be a corresponding rise around this hollow. Now, the moon weakens the force of gravity of the earth under the moon (and on the opposite side of the earth also), and the weight or pressure of water under the moon is less than the weight or pressure of water at places on the earth (oceanic regions) at right angles to a line drawn from the moon's centre to the earth's centre. The greater pressure of water at places a great distance from the vertical moon will therefore cause a hollow there and a rise, wave, or tide under the moon, that is, if the action of the moon could immediately produce its full effect. Time must, however, be allowed to overcome the inertia of the water. The rise, or tidal wave of water therefore follows some time after the vertical moon.

The reasoning in this paper therefore shows :—First, that it is impossible for the slight attractive force of the moon to lift up a body of water *directly against* the vastly greater force of gravity of the earth drawing this water down. Second, that it is the greater weight of water at a great distance from the moon's vertical, so to speak, that makes a hollow there, and a corresponding rise nearer the moon's vertical.

Obituary.

Samuel Walker McGowan.

Mr. McGowan was born on the 4th of January, 1829, at Kingston, Ontario, Canada, where he received his early education. He studied for the legal profession for four years at Toronto, until the death of his father in 1847. He then attended lectures on natural science, and learnt the Morse system of telegraphy under its inventor, Professor Morse, from whom he received high testimonials. He then served successively in the Toronto and Buffalo Electro-magnetic Telegraph Company, the Montreal Telegraph Company, and the New York, Albany, and Buffalo Telegraph Company until 1852, when, upon the advice of Professor Morse, he came to Melbourne, where he landed early in 1853. He brought with him materials and instruments for establishing a telegraph company; but the Government having decided to assume the management of the local telegraphs, he tendered for their construction; his offer was accepted, and the work was so satisfactorily performed, that he was appointed to the charge of the Telegraph Department, which he retained till his death, on the 18th April, 1887. He was also Deputy Postmaster General since the amalgamation of the Post and the Telegraph Departments in 1885. In 1886 he received twelve months' leave of absence on full pay, with the view of obtaining all the latest information in Europe and America respecting telegraphs and telephones. He returned to Melbourne in April 1887, with abundant materials for a voluminous report. He had suffered at the commencement of his return voyage from an attack of congestion of the lungs. Upon his arrival, however, he felt well enough to resume duty, but served one day only, when he had a relapse, and rapidly became so much worse, that he had an operation performed on the morning of the 18th of April, and died about 9 o'clock the same evening.

He was an able, energetic, and conscientious public officer. Besides organising and managing from the commencement the whole telegraph service of Victoria for 34 years, he also acted as Captain of the Torpedo Corps, and served on the Council of the Royal Society at various times since 1862, where his valuable assistance and counsel were highly appreciated. Here his loss was felt more than in the country at large, for many of his colleagues were privileged to be his intimate friends.

Edmund Samuel Parkes.

Mr. Parkes, though for many years a member of the Royal Society, was too entirely devoted to the claims of his profession to admit of his taking an active part in its proceedings, further than by occasional attendance at the Council's Conversaziones; he was, however, known and respected by many members of the Society and of its Council.

He began his business life in the office of a leading firm of London shipbrokers. From that he passed into the London and Westminster Bank, where he acquired the experience and knowledge which he applied to such good purpose in his subsequent career. He afterwards joined the Alliance Bank of London, as Manager, and on leaving it he received a flattering testimony of the estimation in which his services were held. In 1867 he accepted the appointment of Inspector in the Bank of Australasia in Melbourne, where he became General Inspector in 1871, and Superintendent in 1876. He enjoyed the highest reputation as a banker among bankers. He was unfortunately killed in the railway collision which occurred on the 11th of May, at Chapel Street, Windsor, being so severely injured that he only survived about three hours. He was fifty-three years of age. He had lost his wife within the year preceding, and left a numerous family.

Sir Julius Haast, K.C.M.G., F.R.S., D. Sc. Camb.

Julius Haast, who was a Member of the Academy of Sciences, Paris, &c., and Honorary Member of the Royal Society of Victoria, was born at Bonn on the 1st of May, 1824. He emigrated to Auckland, N.Z., in December 1858, where his scientific career as Government Geologist included important researches in geology, geography, zoology, botany, and meteorology, records of which are preserved in the scientific journals of New Zealand. In 1886 he proceeded to Europe as Commissioner for New Zealand at the Indian and Colonial Exhibition, and afterwards visited most of the principal cities of Europe, obtaining thence valuable contributions for the Canterbury Museum. His lamented death took place unexpectedly on the 16th of August, 1887, at Christchurch.

Solomon Iffla, L.R.C.P. Glasgow.

Dr. Iffla was born in Jamaica in 1821, but was for some years at Philadelphia, U.S.A., before going to Scotland, where he received his medical education, graduating at Glasgow in 1844. He soon afterwards came to Australia, and settled first in Adelaide, where he practised his profession for a short time. He then came to Melbourne, where he established himself first in Stephen Street, and then in Collins Street, and was for several years known as a successful practitioner and magistrate. He was one of those who met at the Mechanics Institute on the 17th June, 1854, and founded the Philosophical Society of Victoria, in which he served in various years as member of Council, Treasurer, and Vice-President. In the end of 1861 he left town and settled at Wood's Point, where he was appointed Coroner, Registrar, and Public Vaccinator, and followed professional pursuits also. When the glory of Wood's Point waned, Dr. Iffla returned to Melbourne, and became a citizen of South Melbourne, where he not only enjoyed a good practice, but took an active part in municipal, magisterial, and political affairs, and was mayor of the city when the new Town Hall was opened by His Excellency the Marquis of Normanby, in 1881. He was also an official visitor of the Yarra Bend and Sunbury Lunatic Asylums. He had travelled a good deal, and his extensive information, genial manners, and instructive conversation contributed to secure for him the high esteem of a large circle of friends. He had been for some time in delicate health, and took a trip to Queensland to recruit it. Shortly after his return, however, he had an attack of congestion of the liver, which unfortunately terminated fatally on the 14th of September, 1887.

Balfour Stewart, F.R.S.

In common with the scientific world at large, our Society has to lament the loss of Professor Balfour Stewart, F.R.S., on the 22nd December, 1887. It is long since he was a member of the Royal Society of Victoria, but it is pleasing to note the fact that he was an original member of both the Victorian Institute and the Philosophical Society of Victoria in 1854, which bodies were combined in 1855, under the name of the Philosophical Institute of Victoria, which, in 1859, received the Royal permission to take the title of the Royal Society of Victoria. The second paper read before the Philosophical Society of Victoria was by Mr. Stewart, on the 10th September, 1854, "On Certain Laws Observable in the Mutual Action of Sulphuric Acid and Water." Of this only an abstract was published. Two other papers of his appear in the first volume of its Transactions for the same year, one "On the Influence of Gravity on the Physical Condition of the Moon's

Surface," and the other "On the Adaptation of the Eye to the Nature of the Rays which Emanate from Bodies." The Society soon after lost his services, as he returned to England to enter upon his subsequent brilliant scientific career, the leading achievements of which are epitomised by Prof. P. G. Tait in "Nature" for the 29th December last. Some twenty years before his death he was severely injured in a railway accident, from the effects of which he never completely recovered. Professor Tait knew him better, it is presumed, than any one in Australia, and he concludes his notice thus :—"Of the man himself I cannot trust myself to speak. What I could say will easily be divined by those who knew him intimately, and to those who did not know him, I am unwilling to speak in terms which, to them, must certainly appear exaggerated."

1887.

PROCEEDINGS.

ROYAL SOCIETY OF VICTORIA.

[N.B.—The remarks and speeches in the discussions are taken down verbatim by a short-hand writer, and transcribed by a type-writer, for reference and reproduction, if required; and therefore, more is seldom given herein than an indication of their general drift. If any person should wish to refer to the verbatim report, he can apply to the Secretary to the Society, who will give him an opportunity of transcribing it; or if he reside at a distance, so much as he requires will, upon payment of the cost, be forwarded to his address.]

11*th August*, 1887.

Present: the President, Professor W. C. Kernot, in the chair, and forty-two members and associates.

The President read a letter from the Secretary of the Royal Society of South Australia, dated 6th, stating that the idea of having special meetings in connection with the Exhibition there had been abandoned, as the Government would make no reduction in railway passes. It conveyed a cordial general invitation to the members of the Society to visit Adelaide.

He next read a letter from the Field Naturalists' Club, reporting the passing of a resolution in favour of vesting Wilson's Promontory and adjacent islands and waters in a Board of Trustees, to preserve the flora and fauna and fisheries, and as a resort for public recreation. The co-operation of the Royal Society was earnestly requested.

Mr. Lucas and Mr. White moved that the proposal be adopted. The Victorian Academy of Arts had endorsed it.

Mr. Blackett and Mr. Griffiths thought more information desirable, and moved that the question be referred to the Council. Carried.

The President then vacated the chair, which was taken by Mr. White, Vice-President, and gave an account of the early history of the Brennan Torpedo. This invention had been purchased by the Imperial Government for £110,000. The President had acted as the inventor's consulting engineer, and he explained by means of a model the method of its propulsion at the rate of 25 miles an hour for more than half a mile. The first trial satisfied every expectation. It could be turned right or left by the same means that effected its progression. The trials in Melbourne were satisfactory, and the torpedo was then taken to England and subjected to various tests during nearly seven years before it was purchased. The President could not say why—since the sale —a full description, with drawings of this torpedo had been suffered to appear in *Engineering* of 24th June and 1st July.

Mr. Blackett commented on the extraordinary fact of the publication of the secret, which had been carefully kept until after the sale.

Mr. Blackett then read "A Note on Some Determinations of Chlorine in the Water of the Yarra."

Discussion ensued, in which Mr. White, Mr. Ellery, Mr. Griffiths, the President, and Mr. Blackett took part.

Mr. A. W. Howitt then read his paper, "On Certain Metamorphic and Plutonic Rocks at Omeo." After a question from Mr. Griffiths, to which Mr. Howitt replied, it was resolved that the paper be printed at once.

The reading of Baron von Müeller's "Description of a Victorian Haloragis," was postponed, and the meeting adjourned.

Thursday, 8th September.

Present: the President, Professor Kernot, in the chair, and twenty members and associates.

The President reported that the Council had considered the proposal of the Field Naturalists' Club to reserve Wilson's Promontory as a national park, and recommended the Society to co-operate with the Field Naturalists' Club in urging its reservation upon the Government. A large scale map of the Promontory, presented by Mr. W. H. Steel, C.E., was laid upon the table.

Baron von Mueller recommended that a portion of South-east Gippsland should also be reserved. He had travelled all over it in 1853, and he thought that the native plants and animals should be preserved from destruction by the proposed reservation. Part of the Promontory was then occupied by stockholders.

The President said that the Council had consulted a gentleman who had recently been all over the Promontory, and found that none of it was now in occupation. He thought that not only this, but many other national parks should be carefully preserved.

Mr. RUSDEN said that the proposal demanded careful consideration. The reservation would be useless unless a sufficient staff of caretakers were provided to protect animals, birds, fisheries, and plantations, which would involve considerable expense. If this were done, the reserve would become a very important and valuable one.

The question was then postponed for further consideration.

The PRESIDENT reported that the recommendations of the Antarctic Exploration Committee were receiving the consideration of Her Majesty's Government, and were probably then being entertained by the British Association. He read a letter from Captain Wharton, Admiralty Hydrographer, presenting a new admiralty antarctic chart.

On the motion of BARON VON MUELLER a vote of thanks to the Hydrographer was agreed to.

BARON VON MUELLER hoped that the present season would not be lost. He understood that Sir Allen Young was willing to accept the leadership of the expedition in a few weeks, and he trusted the British Government would grant £5000, which, with £5000 from the Colonies, would suffice for a reconnoitering expedition.

BARON VON MUELLER then presented his paper on a "Victorian Haloragis and a Pluchea," which, being of a purely technical character, was accepted as read. (See Transactions, Art. XII.)

BARON VON MUELLER said, instead of reading my paper, which is of an entirely technical character, I shall only make a few remarks, especially as my essay is in process of being incorporated in our Transactions.

The specimen in my hand, the Haloragis Baeuerlein, represents a plant entirely new to the flora of the Colony of Victoria. It was found just on the boundary line near the source of the Genoa River, by Mr. Baeuerlin. It is noteworthy, that it is not particularly allied to any indigenous species from New South Wales or Tasmania, as might be anticipated, but to one in West Australia. There are some remarkable facts in connection with the geography of plants, which have in instances like the present one, great significance. It is rather an attractive plant, and it has come before me more particularly, while, on special request from the Field Naturalists' Club, I am elaborating the key to the system of Victorian plants, so that during my investigations, those forms which were not known before, had to be inserted. This one was discovered while a special effort was made last year to get the Eastern part of Gippsland phytologically further explored.

The second plant, the Pluchea Conocephala, which I have the honour of submitting, was collected as far back as 1848 by myself, on the Murray River. The species is not ornamental, but highly interesting. The plant for a long time was only imperfectly known, and thus my original view of its affinity remained adopted; but while some additional material was coming in, I was in a better position to investigate it, and found it belonged to the almost tropical Pluchea, not yet on record as represented in Victoria. That genus was named in memory of an amateur naturalist, the Abbé Pluche, who lived about the middle of the last century.

I would remark, that the printing of the key to Victorian Plants has actually commenced. I am aware that I have tried rather sorely, the patience of those particularly interested in this work; but the fact is this, the method which the Hon. Dr. Dobson more especially desired to be adopted is a very difficult one, requiring great care, much time, and circumspect toil in working out. It is in accord with the system, brought out first by the celebrated Lamarck, at the end of the last century. The method is so difficult, that unless very great caution is exercised, it is liable to mislead, or to render the search for the names of plants even bewildering; therefore its practical application has very seldom been attempted, and more particularly not over a large area. The wider the area, the more difficult is the task. The Rev. Mr. Spicer has with very praiseworthy zeal undertaken such a dichotomous enumeration of the plants of Tasmania, which comprises only about half the number of our plants; but although he did not work on a very elaborate or strictly systematic plan, he experienced great difficulties. Thus I found that I had to devote far more research than I originally proposed to the work desired; but now it seems that I am gradually and successfully emerging from what I at times thought would be a hopeless task. The system to be adopted is a kind of dualism. It has to be applied to 1900 different species of plants in Victoria, nearly double as many as the plants of Great Britain and Ireland; and they have besides to be put into several hundred genera and natural orders. Indeed, it proved a very complicated effort.

The President said that the preparation of the dichotomous key must have been a serious matter. It had been heard of as having been in progress for a long time past, and he trusted that when it was seen, it would be available to everyone. Unfortunately, the Botanical and Biological Section was rather thinly represented in that evening's meeting. The investigation of the flora of the Colony, if recorded in the Transactions, would give great value to them in the eyes of naturalists in other parts of the world.

The discussion on Mr. Howitt's paper was adjourned to the following meeting.

The PRESIDENT requested Baron von Müeller to take the chair, which he did, and the President then exhibited some models of Engine-Governors and Dynamometers, of which he conversationally explained the construction, and replied to questions and remarks from Mr. A. C. Wannan and Baron von Mueller.

Thursday, 13*th October*, 1887.

Present: the President, Professor Kernot, in the chair, and thirty-two members and associates.

Mr. Hugh Conley was elected by ballot, an associate of the Society.

The PRESIDENT announced that the usual Conversazione would be held on Friday, the 9th December.

The PRESIDENT reported that Professor Spencer was unable to attend to read his promised paper on "The Structure and Classificatory Position of Megascolides Australis," which was therefore postponed.

Mr. GRIFFITHS moved the suspension of the laws so far as necessary, to enable Mr. D. McAlpine, who was not a member of the Society, to read a paper, entitled: "Observations on the Movements of Detached Gills, Mantle Lobes, Labial Palps and Foot in Bivalve Molluscs." This was agreed to, and Mr. McAlpine read his paper (see Transactions, Art. XIII.)

The PRESIDENT remarked on the curious facts that had been described by Mr. McAlpine; others of a similar kind had before been described.

Dr. JAMIESON said that original observations were always interesting. It was, however, not uncommon to find detached portions of bodies make independent movements; he had anticipated something more from the paper. The ciliary action in question, usually took place on a fixed surface, and swept up and drove particles along the surface. When detached and placed on a fixed surface, the cilia, by their normal action, moved the unattached body along the surface. He compared this action to that of men rowing in a boat firmly anchored. They would not move the boat, but would sweep along bodies floating on the water, whereas if the boat were released, they would move the boat. The enquiry was interesting, and must have involved much time and labour. It was well known that the cilia did mechanical work in the living body, as by sweeping mucus, particles of dust, &c., out of the air passages, and it might be possible to determine the amount of power exerted by them from the range of movement produced by them in the way shown by Mr. McAlpine.

Mr. Blackett asked whether the ciliary motion had been itself observed, and whether, if so, it was proportional to the rate of observed motion.

Mr. McAlpine said the paper was a fragment, and the important part of it was to follow in a paper on the oyster. He had drawings of the palp in its natural position, but while undergoing rotation it became altered so as to be unrecognisable by comparison with the drawing. All the parts are ciliated, and the motion was in the opposite direction to the stroke of the cilia. The cilia were capable of changing directions, of reversing themselves and causing an object to move in the opposite direction. In a separate paper he proposed to treat of motion of the frog's heart.

On the motion of Messrs. White and Blackett, the thanks of the Society were voted to Mr. McAlpine for his interesting paper.

Mr. G. R. B. Steane's paper "On Rainfall and Flood Discharge," was held over for the next meeting.

Thursday, 10*th November*, 1887.

Present: the President, Professor Kernot, in the chair, and thirty-five members and associates.

Mr. J. D. Lillis, Mr. W. T. Kendall, M.R.C.V.S., and Mr. J. Cohen, M.R.C.V.S., were duly elected by ballot, members of the Society. To save time, ballot papers were used as formerly, instead of balls.

The Librarian reported the receipt of 30 scientific publications since the last meeting of the Society.

The President reported that the Conversazione would be held in the Athenæum Hall, on Friday, the 9th December.

Mr. Lucas reported progress on the subject of the reservation of the Promontory as a National Park. It was proposed that the Promontory and the adjacent islands and waters should be vested in trustees, to preserve the native fauna, flora, and fisheries, and for public recreation. The Academy of Art and the Royal Geographical Society supported the proposal of the Field

Naturalists' Club. The Council of the Royal Society had taken evidence on the subject, and unanimously passed a resolution in favour of the project. The reasons for it were, that though Victoria has small local reserves, it has no National Parks like those lately reserved in the United States and New South Wales. The Promontory is specially fitted for the purpose, by its natural definite boundaries, its diversified scenery, its accessibility by railway, the absence of vested interests, and its comparative isolation, on account of the narrow and barren sandy isthmus which constituted the approach by land to it. It was said on good authority to be adapted for the growth of kauri pine. Its reservation would give facilities for the development and protection of the fisheries. The trustees should have the power of licensing residences there.

The PRESIDENT said that Victoria should have a National Park. New South Wales had one in which the scenery was of a striking character. The Promontory included mountains 2300 feet high, and immense valleys almost impassable from the dense vegetation.

On the motion of Mr. Lucas and Mr. Griffiths, it was resolved "That it is desirable that this Society should combine with the Field Naturalists' Club and the Society of Artists, in taking steps to secure the vesting of Wilson's Promontory, and the islands and waters adjacent, in a Board of Trustees, for the purposes of a National Park and Reserve, for the preservation of the flora and fauna, for the conservation of fisheries, and for public recreation."

The motion was carried unanimously.

The PRESIDENT said that the next paper was on "The Structure and Classificatory Position of Megascolides Australis," the giant earth-worm of Gippsland. In the absence of Professor Spencer, at King's Island, he invited Mr. Lucas, with whom he had left the paper, to read it.

Mr. LUCAS said the paper was of a technical nature, and that he would read such parts as were likely to be of general interest, and leave further details to be gathered from the monograph which Professor Spencer proposed to publish on the subject. He then read portions of the paper.

The PRESIDENT said it was gratifying to find that so new and interesting a biological problem had been thoroughly worked out. The worm was one of the most curious creatures in the world, and has at last been fully described.

Dr. WILD said that it was remarkable that giant earth-worms were found only at the extremities of three Continents, viz., the Cape, at Ceylon, and in Victoria. He asked if this resembled the others?

Mr. LUCAS thought that those found at the Cape and Ceylon were not as large as Megascolides Australis, and they differed generically.

Mr. Griffiths remarked that this worm did not appear to fulfil the same function as the common worm, of bringing castings to the surface, and it appeared not to have the calciferous glands which Darwin had found to be among the most important organs of earth-worms, and necessary to dispose of the leaves which constituted their principal food.

Mr. Lucas said that wherever the burrows reached the surface, they were at right angles to it, and perfectly level. There were no castings at the mouth of the burrow. Professor Spencer represented no calciferous glands, and he had remarked on the absence of leaves in the burrows. The differences in the habits of this worm from those of others seems certain.

The President and Mr. Rosales believed that there was no limestone near the habitat of the Megascolides Australis.

After a few further remarks on the subject

Mr. G. R. B. Steane read a paper on "Rainfall and Flood Discharge." (See Transactions, Art. XIV.)

The President said the subject was one of the first importance to a civil engineer, and yet there was scarcely any subject upon which there was a greater diversity of opinion and practice. He knew bridges designed by eminent authorities, varying from an eighth of the size he considered correct to sixteen times the necessary size, and those bridges cost thousands of pounds. That was the extraordinary state of the practice. Most astonishing differences appear in the opinions of leading engineers on this subject. At Cootamundra, there were 2½ square feet of openings for every square mile. Three leading New South Wales engineers swore that the openings were abundantly large. At Melbourne, openings of 100 feet to the square mile are found, and in the country where the ground is more absorbent, there were openings of 40 square feet to the square mile. One of our Railway Surveyors allowed 40 square feet to the square mile for areas of four or five square miles roughly timbered and unabsorbent. Experience appeared to show that this was about right; but others allow less, and disasters sometimes occur costing thousands of pounds. He found a difficulty in obtaining information on the subject. Mr. Steane was working in the right direction. The diagram on the blackboard represented the beginning of an investigation which would become useful as information accumulates. Above a horizontal line, dots represent by their position the area in square feet of openings in certain structures, the history of which is known. Some are of too recent erection to be of value as data; but time will tell, and the record will be kept. Some which appear to have caused disasters are a long way below the data line. One bridge over the Upper Yarra has an opening of 80,000 square feet, while one at Melbourne thirty miles lower down the same stream draining a much larger area, has one of only 8000. How are these reconcilable?

The further discussion of the subject was postponed.

Dr. Jamieson read a paper on "Some Experiments on the Range of Action of Digestive Ferments." (See Trans., Art. XV.)

In reply to Mr. Ellery, Dr. Jamieson said an experiment was made as to whether it was good to have food given in a digested form. Young animals seemed not to thrive so well on it as on raw material. But there is no doubt that persons may be kept alive with digested food who could not get on with undigested food. Injections of digested food do better than those of undigested.

Dr. Rudall said that the new digestive ferment papain had a power of digestion greatly in excess of that of pepsine, and that promised to be a useful discovery.

In reply to Mr. White, Dr. Jamieson said that a small amount of common salt was useful, and the President said that in New Guinea it appeared to be a specific for the cure of native ailments.

ANNUAL CONVERSAZIONE.

A Conversazione was given by the Council of the Royal Society, in the Athenæum Hall, on Friday, the 9th December, 1887, and was attended by a large gathering of ladies and gentlemen.

The large hall was reserved for the display of exhibits, and the hall on the first floor was seated for the audience to hear the President's address, which he delivered at eight o'clock, and will be found prefixed to part 2 of this volume.

Professor W. Baldwin Spencer then gave an address on the subject of Megascolides Australis, illustrated with a number of specimens and large diagrams on screens. (See Transactions, Art. XVI.)

The following is a list of the exhibits shown in the large hall:—

1. Sectional Models of Steam Engines, and other Models of Machinery. Exhibited by Professor W. C. Kernot.
2. Seismograph, Thermograph and Barograph. By R. L. J. Ellery, Esq., F.R.S.
3. Two Microscopes and Microscopic Slides, Hydrostatic Balance, New Mercurial Vacuum Pumps, Spiral Balance for taking the Specific Gravity of Solids. By Mr. C. R. Blackett, F.C.S.
4. Winshurst Electrical Machine. By Professor H. M. Andrew, M.A.

4. Thoma Microtome and Knife, with Imbedded Cancer in position for section cutting; Microscope and Lamp, with Mounted Section of the same Cancer, showing Cancer-cells; Frame of Photo-Micrographs of Parasites, Fleas, Hydatid, Liver Fluke, &c.; Microphotographic Appliances complete. By Mr. W. BALL, F.R.M.S., Hon. Secretary of Section D. of the Royal Society.
6. Tabular and Mechanical Aids to Calculation, including Arithmometer, Slide Rules, Logarithms, &c. By Mr. J. J. FENTON.
7. Electric Office Indicator, and a New Typewriter. By Mr. JOHN BOOTH, M.C.E.
8. Screw Guage on a new principle, measuring to the 40 thousandth part of an inch, manufactured by Messrs. Elliott. By Mr. ROBERT BARTON.
9. New Microscope, by Zeiss of Jena, with Abbe's illuminating system, oil immersion lens of latest pattern and high illuminating power; Specimens of the Bacillus Tuberculosis, stained by the method invented by Dr. Koch. By Mr. F. W. ELSNER.
10. Katoptric Illustrations, the Sphengescope with a watch in motion; a Binocular Microscope with Crystallisations of Metals. By Mr. SYDNEY W. GIBBONS, F.C.S.
11. Harmonograph. By Mr. HENRY CORNELL.
12. Large Wheel of Life (Zoetrope) with Diagrams prepared from photographs of living animals in motion; Two Electric Clocks under shade; a Simple Device for Copying and Enlarging Drawings or Plans; Cubits Shaky Cards (an optical illusion). By Mr. HORATIO YEATES.
13. Stereoscopic Prints and Architectural Photographs. By Mr. J. H. HARVEY.

    Stereoscopic Photographs. By Mr. WALKER.

    Stereoscopic Photographs and a Revolving Stereoscope; also Negatives, Transparencies and Prints. By Mr. MUSGROVE.

    Stereoscopes and Stereoscopic Photos. By Mr. BELL.

    Exhibited on behalf of the Amateur Photographic Association of Victoria, Mr. J. H. HARVEY, Hon. Sec.
14. Impressions of Leaves of Lepidophyllum, &c., from the Coal Measures of Zwickau (Saxony); a Large Petrefaction from the Secondary Limestone Formation of Alcolea, province of Guadalajara (Spain); a large Quartz Specimen of "Hauben Quartz," from Geyer (Saxony). By Mr. H. ROSALES, F.G.S.

15. Berthon Telephone Transmitters; Berliner Telephone Transmitters; Hunning's Improved Telephone Transmitters; Thompson's Telephone Valve Transmitters; Telephone Receivers by Ader, Aubrey, Telloux, and D'Arsonval; Thompson's Telephone Membrane Receiver; Siemen's Potential Meter; Low Reading Ammeter and Voltmeter; New Standard Ohm (Paris Standard); Section of Telephone Exchange, Switchboard connected; Thirty Volt Incandescent Lamps, supplied from a Storage Battery. By Mr. George Smibert.
16. Barrow and Drum of Copper Wire; Field Insulators and Earth Plates; Vibrating Sounders; Pair of Heliographs. By Lieut. L. H. Chase.
17. Submarine Mining Apparatus. Exhibited by Capt. R. E. Joseph, on behalf of the Submarine Mining Company Corps of Engineers.
18. Model of "Ogilvie's Patent Double-wedge Storm Tiller," or Automatic Break for steering Ironclads and other hard-steering ships in heavy storms. By Capt. F. C. Rowan.
19. Centrifugal Machine for Cleaning Mercury; Centrifugal Accumulator. By Mr. Odling, C.E.
20. Apparatus used in Embryological Work; Apparatus used in the process of Section-cutting, viz., hardening of the specimens, embedding of the specimens in paraffin, cutting sections (1) by the freezing, and (2) by the "continuous series" method, preparation of the sections, and mounting of them for microscopical examination; the Third or Pineal Eye of Lizards: Specimens and Diagrams of "Megascolides Australis," the Giant Earth-worm of Gippsland. By Professor W. Baldwin Spencer, on behalf of the Biological Department of the University of Melbourne.
21. Specimens Dredged in the Inner Waters of Port Phillip; Collection of Sponges made by Mr. J. Brainbridge Wilson in Victorian Waters; Collection of Sponge Skeletons of Victorian Forms and of Victorian Crustacea and Echinodermata made by Mr. A. H. S. Lucas, B.Sc., M.A., F.G.S., and exhibited by the latter on behalf of the Port Phillip Biological Exploration Committee of the Royal Society.
22. Collection of Australian Coleoptera; Collection of Humming Birds; Collection of Rifle Birds, viz., Ptiloris Alberti, Ptiloris Paradisea, Ptiloris Victoriae; Craspedophora Magnifica. By Mr. C. French, F.L.S. of the Botanical Museum.

23 Collection of Victorian Marine Polyzoa, and Microscope. By Mr. Joseph Gabriel.

24. Pond Life; Fresh Water Polyzoa. By Mr. F. Barnard.

25. New Geological Map of Australia. Exhibited by Mr. C. W. Langtree, Secretary of the Mining Department.

26. Map of the Wilson Promontory, showing the area which it is proposed to form into a National Park for the preservation of the Fauna and Flora of Victoria. Contributed by Mr. W. H. Steel, C.E., of the Public Works Department.

27. Geological May of the Wilson Promontory. By the Royal Society.

28. New Chart of the Antarctic Regions. Presented to the Royal Society by the Hydrographer to the Admiralty.

29. Objects collected in New Guinea. Exhibited by Mr. A. C. Macdonald, Hon. Sec. Royal Geographical Society of Victoria.

30. Book entitled, "Travels in Siberia, or Official Report of the Paris Academy of Science on the Observations of the Transit of Venus in 1762." Exhibited by Mr. J. E. Prince.

31. Herbarium. By Baron F. von Mueller, K.C.M.G., F.R.S.

32. Map of the Yan Yean Water Supply System and Photographs of some of the works, were exhibited by Mr. W. Davidson, C.E., Engineer-in-charge.

Thursday, December 15th, 1887.

Present: the President, Professor Kernot, M.A., in the chair, and twenty members and associates.

Mr. Percy Wilkinson was duly elected by ballot as an associate.

Messrs. James E. Gilbert and R. E. Joseph, were re-elected as Auditors.

The President invited nominations of office-bearers for election at the Annual Meeting in March 1888, and in reply to Mr. Marks, said that Mr. Newbery hoped to return from Europe and take an active part in the work of the Society.

Four nominations for the Council were received.

The President read the reply which had been received to the address tendered by the Society to Her Majesty the Queen on the occasion of her Jubilee.

The PRESIDENT called attention to a specimen of a new and interesting acacia, forwarded by Baron von Mueller for the inspection of members.

The PRESIDENT then read the Progress Report of the Port Phillip Biological Survey Committee, and said it was evident that the Committee, judging by this very satisfactory report, was taking up the matter in a suitable spirit, and intended to do the work thoroughly.

Mr. ELLERY moved the adoption of the Report, expressing great pleasure at finding that a start had been made at such very desirable and useful work. Much had been done by a few energetic individuals, such as Dr. McGillivray, Mr. J. Bracebridge Wilson, and others. The information collected by them should be collated by the Committee in a permanent form. He hoped to see the results in the Transactions before long. Mr. Rosales seconded the motion.

At the invitation of the President, Professor Spencer on the part of the Committee, gave a short account of the work done. It was surprising how much had been done before by individuals. Mr. Wilson had a very complete collection of the sponges in the bay, which were exhibited at the Conversazione. The biological results would appear in the Transactions. The motion for the adoption of the report was then put and carried.

The LIBRARIAN reported the receipt of 85 new scientific publications.

The discussion on Mr. G. R. B. Steane's paper was then resumed.

At Mr. ELLERY'S suggestion, Mr. Steane gave a *resumé* of the paper " On Rainfall and Flood Discharge," which was read at the last meeting. (See Transactions, Art. XIV.)

Mr. ELLERY pointed out the great importance of the question, as regards roads, drainage, and water conservation. Mr. Steane had collected a large quantity of exceedingly useful information. He had shewn that in districts like Sandhurst, there was little soakage ; of other districts, very little was known of the run off, or of the differences that took place in the course of the year. This could be determined for different classes of soil. A knowledge of the intensity of rain, especially in the towns, is very desirable. In Sandhurst, rain had fallen for five minutes at the rate of six inches an hour. To learn this important datum, one or more self-registering rain gauges should be maintained in every borough. The only records at present are at the Observatory. But a thunderstorm is sometimes only a few yards in width, so that rain gauges should be multiplied as much as possible, as the engineer should know exactly what he has to contend with. He also required to learn the discharge of rivers.

Mr. NEWTON C. JENNINGS, C.E., F.R.I.B.A., a visitor for whom, at the request of Mr. Ellery, permission was granted to address the meeting, said that being a stranger in Victoria, he was diffident in speaking to the question, and regretted that he had not heard Mr. Steane's paper in full. A formula for the run off of flood waters would be of great value. To apply it to different classes of soil would be difficult; their absorbent qualities might, however, be tested. The average and maximum rainfall should be ascertained; when the soil was saturated, the run off would be greater. In India, there are large numbers of rain gauges, but not enough for satisfactory results. The police are found the most reliable persons to have charge of them. The gauges should be exactly alike, and the same height from the ground. It towns where the absorption was at a minimum, about 80 per cent. of the run off was generally provided for.

Mr. Ellery said it was certain, though unexplained, that gauges registered more the nearer the ground, irrespective of splash, for it decreased up to 30 feet, although not so much in dry seasons.

Mr. White thought the subject could scarcely be treated scientifically. If a formula were found applicable now, it may not be so in say 20 years, as physical and atmospherical conditions change, and the removal of forests would produce a difference.

Mr. Jennings said the methods of measuring the discharge of rivers was very defective. It was recently proposed to divert the main river at Rangoon. He took the discharge with floats, and with electric gauges, and at various depths he found great differences. He thought the electric gauges were the best, as they could be applied at any part of the section of the river.

Mr. Ellery thought the method employed here was very imperfect; obstructions and friction had to be taken into account.

Mr. Steane described the method used by him.

The President said the discussion illustrated well the peculiar position of engineers. They have to estimate on wretchedly inadequate data, for the expenditure of millions. He had to leap in the dark and hope for the best. Superfluous millions are spent on some bridges and culverts, and yet occasionally an accident like that at Cootamundra occurs. Men of experience in South-east Australia allow 40 square feet to the square mile of catchment, and they appear to be about right. But some formula is urgently required, and it is to be hoped that Mr. Steane will continue his important work of collecting data. A law can only be deduced from an abundance of facts.

Baron von Mueller's "Description of some Papuan Plants," was accepted as read, being purely technical. (See Transactions, Articles XVII. and XVIII.)

A paper "On the Production of the Tides Mechanically Considered," by Mr. T. Wakelin, B.A., of Greytown, N.Z., was then read by the President. (See Transactions, Art. XIX.)

Mr. WHITE said it was impossible to treat the tides dynamically. The best mathematicians had tackled the subject, but it was still said that the dynamical theory was a disgrace to science. The tides at the Port Phillip Heads differed from the Admiralty tables by four hours.

Mr. ELLERY said that Mr. Wakelin in all his papers started a speculation, but went no further.

Dr. WILD noticed that Mr. Wakelin stated that he had a difficulty in obtaining books to consult. That partly accounted for his inability to conceive how the small moon could raise the waters of the ocean against the attraction of the earth.

After a few more remarks the discussion terminated.

REPORT OF THE PORT PHILLIP BIOLOGICAL SURVEY COMMITTEE,

Presented and read on 15th December, 1887.

W. M. BALE, F.R.M.S.
REV. A. W. CRESSWELL, M.A.
A. H. S. LUCAS, M.A., B.Sc.
P. H. McGILLIVRAY, M.R.C.S.
W. BALDWIN SPENCER, B.A.
C. A. TOPP, M.A., F.L.S.
J. BRACEBRIDGE WILSON, M.A.

REPORT OF THE COMMITTEE APPOINTED BY THE ROYAL SOCIETY OF VICTORIA TO INITIATE A BIOLOGICAL SURVEY OF PORT PHILLIP.

Your Committee have held four meetings, on July 30, August 19, September 30, and November 28.

At the first meeting, all the members being present except Mr. Bale, whose duties detained him, the objects to be aimed at by the Committee were more precisely defined. It was resolved: I. That a catalogue of the existing literature relating to the fauna and flora of Port Phillip be compiled, and that annual additions should be made of such similar publications as shall appear in each succeeding year. It was decided that by Port Phillip should be indicated the salt waters inside of a straight line joining Point Lonsdale to Point Nepean. That the systematic survey should be limited to Port Phillip as thus defined, but that any results of scientific value which can be obtained in other Victorian seas should be, as far as possible, recorded. The work of compilation of existing books and papers bearing on the living forms of Port Phillip, &c., was divided amongst the Members of the Committee.

II. That Port Phillip be divided into a number of littoral and marine stations to be determined from the charts, and that the stations be numbered, and the life-forms of each explored under the direction of the Committee.

III. That a base catalogue of the plants and animals found living in Port Phillip should be prepared, each species to have appended to it the numbers of all the stations from which it is recorded.

IV. That an extended catalogue of the plants and animals should also be prepared, and that under the heading of each species all particulars observed concerning its life, history, associations, and commercial value, be inserted.

V. That the specimens obtained should be submitted for identification to competent scientists, in order to secure as far as possible absolute accuracy in the published records.

VI. That the Committee shall arrange, as opportunity arises, for the investigation of such biological questions as may be suggested by the material acquired.

VII. That the Committee shall, from time to time, furnish the Royal Society with reports of the results of their work.

Your Committee decided to ask the Council for a grant of £50, in aid of their researches, and acknowledge with gratitude the generous spirit in which their request was granted.

Mr. A. H. S. Lucas was appointed Honorary Secretary and Treasurer of the Committee.

It was decided that, *pro tempore*, the specimens obtained should be kept at the University, under the care of Professor Spencer and the Hon. Secretary.

A large order for spirit and for jars, bottles, and preservative re-agents, was given to Messrs. Felton, Grimwade and Co., and the Committee have to acknowledge the kindness of Mr. E. Bage, a Member of the Council, in aiding them greatly in their selection.

A first list of thirty-two stations was carefully drawn up by the Committee, the outer ones in accordance with the extensive previous experience of Mr. Bracebridge Wilson.

Three dredging excursions have already been made to the inner stations, viz., to Hobson's Bay, Laverton Bay, and Brighton, and some shore work has also been done by the members. Arrangements have been made for an early visit to Geelong, and the outer stations of the Bay will receive attention during the summer months. Mr. Wilson has been having his yacht repaired, and will continue his work in this field in the ensuing vacation.

A large number of animal specimens have been obtained, and will be exhibited at the general Conversazione. Great care has been exercised in preserving them in such a condition that they shall be fit for histological as well as for zoological examination. Several interesting tunicates, annelids, and alcyonatians have been taken. Mr. Wilson has recorded *Amphioxus* from the South Channel, and Mr. Lucas is engaged on a careful comparison of this indigenous specimen with the European form. *Trigonia* has been found in Laverton Bay.

Some of the number of our active workers took part in the King's Island Expedition of the Field Naturalists' Club. This to a certain extent deferred work in the Bay.

Your Committee have much pleasure in announcing that records of the work done previously on the sponges by Mr. Wilson will pass through their hands, Mr. Wilson having forwarded to the University Biological School, through your Committee, the whole of his fine and well-preserved collection.

The Committee is in communication with several eminent specialists in England and in the colonies, in order to secure their services in the identification of species.

In reviewing the work done, the Committee would point out that the preliminary arrangement of necessity involved much care and time, but they trust that the lines on which the survey has been inaugurated are broad and scientific, and that the results obtained will, in consequence, be easily classified, and of more than local value. It is, of course, during the summer vacation that most of the members of your Committee are more free from professional engagements, and we hope to be able to devote much more time accordingly to the survey, with which the Royal Society have entrusted us.

Signed on behalf of the Committee,

A. H. S. LUCAS,

29*th November*, 1887. *Hon. Sec.*

The collections of specimens of Sponges dredged in the inner waters of Port Phillip, by Mr. J. Bracebridge Wilson, M.A.; of Victorian Forms of Sponge Skeletons, and of Victorian Crustacea and Echinodermata, by Mr. A. H. S. Lucas, M.A., B.Sc., formed a prominent and interesting portion (No. 21 in list) of the objects exhibited in the large hall of the Athenæum at the Conversazione on the 9th December.

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