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Critical Remarks on the Editions of Diego de Landa's Writings.

By Daniel G. Brinton, M.D.

(Read before the American Philosophical Society, Jan. 7, 1887.)

No document bearing upon the ancient Maya civilization of Yucatan surpasses in importance the work written by Diego de Landa, the second Bishop of the Diocese of Mérida, who was a resident of Yucatan from 1549 until 1579, the year of his death. The description of the country and its inhabitants which he composed has been preserved to us in one MS. copy, now in the library of the Royal Academy of History, at Madrid. In the winter of 1863–4, the late Abbé Brasseur (de Bourbourg) transcribed a portion of it, and published it with notes, and a translation into French, the following summer, under the title, *Relation des Choses de Yucatan de Diego de Landa, etc.* (Paris, Arthus Bertrand, 1864). As it contained the signs of the calendar, and what purports to be the alphabet of the Maya hieroglyphic writing, as well as much material relating to the customs of the natives, Landa's *Relation* at once took a leading position among Americana.

The well-known peculiarities of the Abbé Brasseur, however, the freedom with which he dealt with his authorities, and the license he allowed his imagination, have always cast an atmosphere of uncertainty about his work,* and hence it was a decided

* This general distrust with reference to the particular instance of the Landa MS. has been very vigorously expressed by Dr. P. J. J. Valentini in his article on the Landa alphabet, in *Proceedings of the American Antiquarian Society* for 1880, p. 91.

satisfaction to have published at Madrid, in 1884, under the competent supervision of Don Juan de Dios de la Rada y Delgado, a literal, faithful copy of the original text. Unfortunately, it appears simply as an appendix to the Spanish translation of M. Leon de Rosny's work on the hieratic writing of Central America, and is issued to the limited number of 200 copies, all large folio. It is therefore both difficult to obtain and needlessly expensive. Moreover, the editor, for fear of "distracting the reader," as he tells us, pointed out only a few of the differences between the correct text and that printed by Brasseur, so that the real value of the second edition of the text is not apparent until a long and toilsome comparison has been made.

The leading position which Landa's *Relacion* holds with reference to the ancient Maya civilization has led me to examine his words with care, and the notes I have made will, I believe, prove of value to those who are engaged in the study of this remarkable people. I shall arrange these notes in three portions, as they refer to the two texts now printed, to the Abbé Brasseur's translation with its notes, and to the hieroglyphic signs, etc., inserted in the text.

The Text.

In Brasseur's edition the text is divided into numbered sections, each with an appropriate heading. No such arrangement is in the original. What is more objectionable, many of the paragraphs and even sections as arranged by Brasseur are entirely arbitrary, and do not correspond at all with the paragraphing of the original. Sometimes they begin in the midst of a phrase, cutting it in two, and destroying its meaning.

He omits, without a word, fully one-sixth of the whole text. In his edition, p. 346, he concludes with the words, *aqui acaba la obra de Landa*, "here closes the work of Landa." No such words are in the original. On the contrary, the MS. he copied from continued with a number of chapters, one on the reason why the Indians offered human sacrifices, others on the serpents, animals, trees, etc., of Yucatan. Of these Brasseur says not a syllable. In copying he occasionally, but rarely, omitted sentences, doubtless through haste. An instance of this occurs, p. 328, where three lines of the original are dropped immediately after the word *escalera*, terminating the sentence.

He did not hesitate occasionally to alter the original when he could not get at its meaning conveniently. Thus, p. 100, he prints "pero que a parte de los españoles," whereas the original is "pero que entre los Españoles," which conveys exactly the opposite sense. Again, p. 162, lines 2, 3, he writes "otras se separavan partes de su cuerpo," where the original is "se sejavan." Oddly enough, in the note on p. 104, he claims to have altered the text from "tres fiestas" to "otras fiestas," whereas the latter alone stands in the original.

The proof-reading of Brasseur's Spanish text leaves something to be desired. On the first page I have noted three errors, *vaya* for *via*, *haz el* for *haz á*, and *hiervas* for *sierras*, which last error he carries into his translation. Others, as *llamaron* for *llevaron*, p. 20, line 1, and *alcangaron* for *alancearon*, p. 76, line 10, are not much misleading.

Of greater moment is his inaccuracy in both the spelling and translation of proper names and Maya words. I shall mention a few of these:

Taiza, p. 4. This is for *tah itza*, "the lord or ruler of the Itzas."

Ulumil Cuz y Etel Ceh, p. 6. These Maya words were understood and translated by Brasseur as two distinct names connected by the copulative conjunction *y*, *et*, *and*. This is not the case. They form one term, the correct spelling of which is *uluumil cutz yetel ceh*, "the land of the wild turkey and deer."

Cuzmil, p. 12. The "Swallow-island," *ah-cuzamil peten*, according to the *Diccionario Maya-Español del Convento de Motul, MS.*, was also called *Oycen* and *Oycib*. In these names *cen* means "ornament," and *cib*, "wax," while the prefix *oy* is an interjection.

Maya, p. 14. The form adopted by Brasseur, *Ma-ay-ha*, meaning "there is no water," is incorrect. This phrase in the Yucatecan tongue is *Ma yan ha*. For a more plausible derivation of the word *Maya*, see *The Maya Chronicles*, p. 16 (Philadelphia, 1880, vol. I of Brinton's *Library of Aboriginal American Literature*).

The names of the idols mentioned, p. 16, read in the original *Ixhunié*, and *Ixhunieta*, not *Ixbunié*, etc. The prefix *ix* in all four names is the feminine particle. The meanings are:

Ix-chel, the Lady of the Rainbow, or "of the Cheles."
Ix-chebel-yax, the Lady of the green (blue) feathers.
Ix-hun-yei, the one chosen Lady.
Ix-hun-yeta, the Lady with the one adornment.

Mochcovoh, p. 18. The *Covohes* are referred to, p. 72, as the name of the tribe near Champoton. The word *Covoh* is applied to a poisonous spider found in Yucatan, and here probably has a totemic signification. It is still, says Dr. Berendt, a common family name among the Mayas.

On p. 30, the original has *Cochnah* instead of *Cochuah;* but the latter is probably correct, being a simple compound of *coch*, broad or large, and *uah*, bread or tortilla. *Hocabaihumun* has no terminal *n* in the original. The proper form I expect is *Hoccabal-hunhun*, "cosa asentada en el suelo cada año," referring to the year-stones which were annually set up.

Tikoch, p. 52, orig. *Tiloch*. The former is correct. It means "at (the place of) the castor-oil plants" (*ti*, at, *xkoch* or *koch*, the *Ricinis communis*).

Mai, p. 42. This word means ordinarily snuff, or pulverized tobacco. Brasseur, in his note, derives from it the name Maya, forgetting that on p. 14 he had assigned a different etymology.

Tutulxiu, p. 46. On the derivation of this name see *The Maya Chronicles*, p. 109.

Ɔilan, p. 52. The proper form is *ɔiluan*, and means something filled, realized, perfected, attested, etc.

Chicaca, p. 70. Brasseur says that Cogolludo calls this province *Chavacha-Háa*. This is inaccurate. Cogolludo's words are "Choáca, que los Indios llaman Chuuachaá" (*Hist. de Yucathan*, Lib. II, cap. viii). This is a compound of *chauac*, large, great, and *ha*, water.

Vamuxchel, p. 76. The original has *Namuxchel*. The correct form may be *Namach Chel*, the distinguished Chel; or *Vamac Chel*, some one of the Chels, or, he who is a Chel.

Copo, p. 148, is the *Ficus rubiginosa* (Aznar, *Plantas de Yucatan*, p. 231).

Iztahte, p. 184, stands for *yitz tahté*, which is the native name for turpentine.

Mitnal, p. 200, is spelled by Beltran, *Arte de la Lengua Maya*, *Metnal*. Brasseur's derivation from Nahuatl *Mictlan* is probable.

Ixtab, p. 202. Compounded of the feminine prefix *ix*, and *tab*, which as a verb means "to tie to something," and as a noun, the gallows.

Uinal-Hun-Ekeh, p. 204. In the original this reads *Vinal, Hunekeh*. Of these words *uinal* is the ordinary Maya word for month; *hun* is "one"; but *ekeh* does not appear in any of the dictionaries. Perez *Dicc. Maya*, gives *Keh* as "the seventh day."

Zacab, p. 212. Brasseur explains this in a note as "une sorte de mais moulu"; but the *Diccionario de Motul*, gives *çakab*, "la caña del mais," cornstalk. The name of the deity, therefore, was "The Nine Cornstalks." On the same page, *zacah* is in the usual form *çaca*, and is pulverized roasted maize mixed with cold water. *Kanté*, on the same page, is not the cedar, as the editor supposes, which in Maya is *Kuche*, but "a tree from whose roots the natives obtain a yellow dye" (*Dicc. Motul*).

Kauil, p. 216, does not appear in the dictionaries. The Abbé's suggestion that it is an error for *Kabul* is possibly correct; or it may be for *Kaual*, which means one who is very choice in food and raiment (*Dicc. Motul*).

Batel-okot, p. 218, means "battle dance." The similarity of the Maya *batel* or *bateel*, to battle, a battle, to the English I have elsewhere noted as an odd coincidence.

Chacan-cantun, pp. 220, 222. The original has *chacacantun*, and also *Canzienal* in place of *Canziemal* in Brasseur's text.

On p. 222 and elsewhere instead of *zac-u-uayeyab*, the original text gives uniformly *zacuuayayab*.

The Translation.

Bishop Landa's writings on this subject were evidently mere memoranda, jotted down to await future arrangement and revision. The copyist contributed to their obscurity, so that passages of his *Relacion* present peculiar difficulties, some of which have led his translator wide of the mark. I shall point out some of the most notable of these.

p. 4. "tiene mucha lama"; "la plage y est tres etendue"; more correctly "a beaucoup de limon."

p. 16. "que por esto le llamaron Lazaro"; "que les Espagnols appellent de Lazare"; better "et pour cela ils l'appellent *Lazaro*."

p. 24. "seis soles" is translated "trois soleils."

p. 32. "tres cuentas de piedra buenas"; "trois objets de pierre bleu travaillés." It is not easy to see where this sense was obtained.

p. 74. The space left blank at the beginning of § xiii is unnecessary, and there is no need to supply a supposed omission. The sense is "The adelantado did not occupy the best position for one who had enemies," etc.

p. 116, line 1. The words "les parecia muy mal," do not mean "bien qu'elle leur parût mauvaise," but "ce qui les defigurait beaucoup." Later, on the same page, "cuero de venado por curtir seco," does not mean "cuir de bêtes fauves tanné á sec," but "de cuir sec de chevreuil."

p. 136. "Llamanse aora los nombres de Pilar los proprios"; "Leurs noms propres aujourd'hui sont comme Pilar," etc. This is a singular mistranslation. The baptismal font in Spanish is *pila*, and "nombres de pila" means "christened names." The meaning evidently is "they now call themselves by their baptismal names."

p. 158. Speaking of the wooden idols which descended from father to son, Landa says they were considered the most valuable part of the heritage, "tenidos por lo principal de la herencia." This Brasseur translates "ils y avaient la plus grand confiance."

On p. 174 there are two important errors. Line 2, "los quales llaman *holcanes*" does not mean "à l'appel des *holcans*," but "qu'on appellait *holcans*"; and "que á essos holcanes sino era en tiempo de guerra no davan soldada," means that the holcans did not receive pay except in time of war, and not at all "Quant aux holcans, ils n'amenaient point la milice hors du temps de la guerre."

Equally incorrect is the translation of the description of the manner in which the natives wore their mantle, p. 186. But it will not be profitable to continue pointing out such slips. I have said sufficient to show that Brasseur's translation must be carefully compared with the Spanish text before it is accepted.

A very curious error in translation occurs on pp. 48 and 172, but this time it must be charged to the account, not of the Abbé, but of the Bishop himself. On p. 48, bottom, there is the extraordinary statement that as an article of defensive armor the natives wore "jacos fuertes de sal y de algodon," "strong jackets (made) of *salt* and cotton!" And this is repeated, p. 172, with the specific addition that these jackets were "quilted doubly with *salt for grinding!*" No wonder the Abbé was nonplussed by this outrageous assertion! (See his note to p. 49.) The explanation is interesting. The word in the Maya language for salt is *taab*, while that for a twisted strand or cord is *tab*, the only difference being in the length of the vowel. Evidently Bishop Landa, or the person from whom he derived his information, mistook the native description of these quilted jackets. They were of cotton and *twisted cords* (*tab*), the layers of the former being quilted to the latter. The historian of Yucatan, Father Cogolludo, refers to them, stating that they were called by the Mexicans (Nahuas), *ichcavipiles*. This is a sound Nahuatl word, found in Molina's *Vocabulario*, and shows that the same defense was known and employed by the Aztecs. It was also familiar to the tribes of Maya lineage in Guatemala.

The Maya Characters.

A close comparison of the various Maya characters printed in Brasseur's edition with those in the Madrid copy proves that in the main his tracings were accurate.

The Calendar beginning on p. 240 reveals, however, a number of minor differences. All of Brasseur's characters tend more to the circular form than those in the later edition which are approximately quadrangular. Occasionally points of detail differ considerably, as for instance, on p. 240, the signs *Ix* and *Cib*. The lines for the month signs are much fainter and sharper in Brasseur, and that of the month *Minan* is incomplete, lacking a bracket-shaped appendage to the left.

The Katun-wheel on p. 312 in the Madrid edition has the inscription in its centre. The Maya words should read *u uazaklom Katun*, "their return the Katuns," *i. e.*, the return or revolution of the Katuns. Brasseur translates the Spanish rendering of this, "gerra de los Katunes" by "la guerre on le jeu des Katuns." The word *gerra* means neither game nor war, but is dialectic for *gira* or *giro*, from *girar*, to turn around.

In the important matter of the alphabet on p. 320, Brasseur makes only one serious error, that is, that he places the first form of the letter b (No. 4 of his list) lengthwise instead of upright. He was led into what I think was another error by the disposition of the letters in the MS. As the Madrid edition gives a photo-lithograph of the two pages of the original text containing the alphabet and its explanation, we are in a position to examine it satisfactorily. The figures are arranged in three parallel lines across the page, and the two figures for *u*, stand, the first at the end of one line, the second at the beginning of the next. From their evident connection with the sign for the sky at night, I am of opinion that they belong together as members of the same sign. Or did either member of the pictographic composite serve as indicating its phonetic value?

The designs of buildings as given by Brasseur, pp. 328, 332, 342, are much neater and more regular than in the original, where they are simply out-lined with a pen neither steady nor skillful. The disposition of the parts is, however, the same in both.

From these remarks it will be seen that Don Juan de Dios de la Rada y Delgado has laid students of Maya culture under positive obligations by this new and complete edition of Landa's most important work, and it should find a place in those public and private libraries which aim to have at all a complete list of consulting Americana.

THE FACIAL NERVE IN THE DOMESTIC CAT.

BY T. B. STOWELL, PH.D.

(Read before the American Philosophical Society, November 5, 1886.)

Introduction.

The embarrassment of the student of comparative anatomy will be greatly relieved, and his progress will be proportionately facilitated, if he has access to a complete description of the structural characters of a typical form. The anatomy of the cat furnishes a desirable and practical standard for comparison—at least for the Mammalia. Special reasons for accepting and adopting this standard have been presented elsewhere. (Anatomical Technology, **34**, p. 55.)

The osteology and the myology have already been described (**34**, **B.C.**). The neurology has been given only in part; the anatomy of the brain has been published by Wilder in the Anatomical Technology (**34**), and in numerous papers by the same author before scientific bodies. (For the bibliography see Anatomical Technology.)

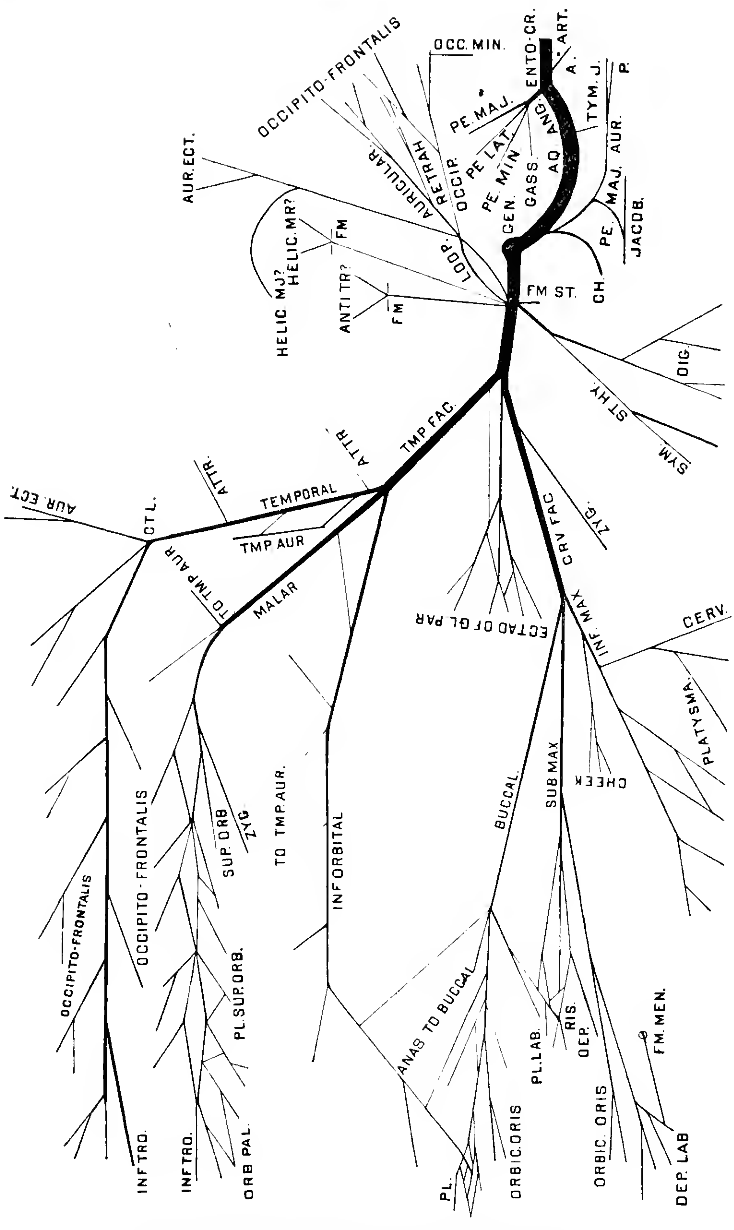

Diagram of the Facial Nerve.—Stowell.

It has seemed desirable that the nerves of the cat be described with the same fullness of detail that has been given to the bones and the muscles.*

The Vagus (**27**) and the Trigeminus (**A.**) nerves have been described; the present study of the Facial nerve is now offered as a contribution to comparative neurology. It has been the author's aim to present the relations and the distribution of this nerve, based upon repeated dissections, so as to insure, as far as practicable, the elimination of individual variation.

Preparation.

The cats were injected with the "starch injection mass" recommended in the Anatomical Technology (**34**, p. 140); both arteries and veins were injected, to facilitate identification and to insure accuracy. Alcoholic and recent specimens were used. Most of the work has been done under a magnifying power of 15–25 diameters, with the hope that no anastomotic or terminal filaments should escape notice.

NERVUS FACIALIS.

Synonymy.—Portio dura (of the seventh pair), Par septimum seu faciale, Communicans faciei nervus, Sympatheticus minor, Ramus durior septimæ conjugationis, Respiratory nerve of the face, Nervus facialis, Facial nerve.

Anatomical Characters.—This nerve is distributed to the muscles which give expression to the face, viz., the muscles of the palpebral, the nasal, the maxillary, the mandibular and the inter-maxillary regions; to two of the principal muscles of the ectal ear, viz., attrahens aurem and retrahens aurem, and to the small muscles of the cartilage (pinna); it gives filaments to the middle ear, directly to the stapedius muscle, indirectly to the tensor tympani and those structures innerved by the tympanic plexus (Jacobson's nerve); it supplies the scalp (occipito-frontal muscle) and the ectal muscle of the cheek and neck (platysma myoides); it communicates with the several divisions of the trigeminus nerve upon the face, and with ganglia of the trunk, viz., with the Gasserian ganglion by a small fascicle, with the spheno-palatine through the great petrosal root of the Vidian

* For the study of individual structure the elaborate and expensive work of Straus-Durckheim (**B.**), and the more accessible reduced copies of his outline plates by Professor Henry S. Williams (**C.**), possess excellent features. The Anatomical Technology by Wilder and Gage (**34**) is all that can be desired in a manual which is designed "to furnish those who intend to pursue human, veterinary or comparative anatomy, with explicit directions for dissection and for the preparation and preservation of anatomical specimens, and with a correct and clear account of the principal parts of an accessible and fairly representative mammal of convenient size" (Preface, 2d ed.). Directions for dissection and manipulation are so explicit in this manual that it seems unnecessary to describe the methods followed in the preparation of this paper. No work known to the writer, except perhaps Mivart's (**18**), assumes to present in detail the nervous system of the cat; the wide discrepancy between his text and the nervous system of American cats has been mentioned elsewhere (**A**; The Nation, June 2, 1881; Science and the Athenæum, June 4, 1881).

nerve, with the otic through the small petrosal, and with the submaxillary through the chorda tympani; it is joined by a considerable fascicle from the auditory nerve near the ectal origin (this is the origin of the chorda tympani, according to Sapolini), by a branch from the glosso-pharyngeal and the vagus nerves; it anastomoses with the superficial cervical and the minor occipital nerves. It is not given to the temporal muscles, although its terminal filaments form dense plexuses upon their ectal surfaces.

Physiological Characters.—This nerve controls facial expression, the movements of the ectal ear and the auditory ossicles; it has a direct action upon the salivary glands. (Sapolini ascribes speech to the chorda tympani, and thinks that the further action of the facial nerve upon the tongue is to govern its movements in deglutition). I do not know that its action upon the auditory nerve has been demonstrated. Its anatomical relations suggest a modifying influence upon the trigeminus, the glosso-pharyngeal and the vagus nerves.

SPECIAL DESCRIPTION.

Proximate Roots.—The union of the proximate roots of the facial nerve may be traced along the ventrimesal border of the sensory root of the trigeminus nerve caudad of the pons.

The dorsal root bends around the caudal root of the trigeminus, crosses its lateral and dorsal faces, and enters the cerebellum with the medipeduncle.

The cephalic root is ventrad of the caudal root of the trigeminus and caudad of the medipeduncle; a portion is reflected dorsad to the cerebellum with the prepeduncle; the larger portion dips into the floor of the epicœle, and may be traced cephalad to the region of the post optici.

The caudal root separates from the cephalic as it passes ventrad of the root of the trigeminus; it lies ventrad of the caudal root of the trigeminus, and passes obliquely meso-caudad to the floor of the metacœle.

Ectal Origin and Entocranial Relations.—The facial nerve takes its ectal origin from the latero-cephalic border of the trapezium, meso-cephalad of the auditory nerve (**27**, Figs. 1, 2; **34**, Fig. 116, and Pl. II, Fig. 3). The distribution of the cerebellar artery is such that the ectal origin is surrounded by arterioles; a small twig from the medicerebellar artery (**D**) and a venule pass between this nerve and the auditory.

The ento-cranial course is laterad with the auditory nerve; it traverses the ental meatus auditorius with that nerve, its position being dorsad.

Just ectad of the arteriole which separates the facial and the auditory nerves a small ramus apparently unites these nerve trunks, or rather is an accession to the facial nerve. Is this the intermediary nerve of Wrisberg (*portio inter durum et mollem*)? Sapolini maintains that in man this is the origin of the chorda tympani, which he names the thirteenth cranial nerve. He traced this nerve to the geniculate ganglion, and found that the nerve of Wrisberg and the chorda tympani were one and the same nerve. (From a résumé of Sapolini's monograph by Dr. Burnett, published in the Medical Times, February 24, 1883, and reprinted in the Medical Record, March 31, 1883, p. 362.)

Intercranial Relations.—The facial nerve traverses the serpentine flexions of the aqueductus Fallopii to the foramen stylo-mastoideum. The course in the aqueduct is first laterad for 2–3 mm.; an abrupt change in direction at this point forms an angle which is directly mesad of the fossa occupied by the spherical tensor tympani muscle ; peripherad of the angle the course arches first dorsad (the concavity being ventro-laterad), then laterad (the concavity being ventrad) for 5–7 mm., and lies caudad of the tensor tympani muscle.

About 10 mm. peripherad of the ental meatus auditorius there is a considerable expansion in the aqueduct, about 2 mm. in length ; in this fossa a reddish swelling rests upon the facial nerve. This is the ganglion geniculatum, or intumescentia ganglitormis.*

From this point the course is laterad to the stylo-mastoid foramen.

At the angle (Fig. Ang.) a considerable twig 2 mm. in length is given off, which traverses a foramen to the ental surface of the cranium, where it divides into four ramuli, which become respectively the mesal root of the great superficial petrosal nerve, the small superficial petrosal, a ramulus to the sympathic plexus in the carotid rete arteriale, and a fascicle to the eminence on the caudo-lateral angle of the Gasserian ganglia. At a point caudad of the stapedius muscle a fascicle, the tympanic nerve, is sent to that muscle. (It is not clear but that this fascicle has its origin in the geniculate ganglion instead of the nerve trunk.)

Caudad of the geniculate ganglion the fallopian aqueduct arches latero-caudad (the concavity being mesad). In this canal, immediately caudad of the ganglion, are two fasciculi separated by a slender arteriole. These are the chorda tympani and the united anastomotic branch to the glosso-pharyngeal and the vagus nerves with the long root of the petrosal nerve, q. v. The geniculate ganglion embraces these united nerves and the trunk of the facial.

About 5–8 mm. peripherad of the ganglion, where the arch reaches its ventral angle and begins to curve cephalad (the concavity being dorsad), the anastomotic branch bends ventri-mesad, and 5 mm. peripherad it bifurcates to join the petrosal ganglion of the glosso pharyngeal nerve and the jugular ganglion of the vagus. This is a portion of the auricular branch of the vagus. This point of separation is also the origin of the long root of the great petrosal, q. v.

Chorda Tympani.—This nerve, or the nervus tympano-lingualis, has its origin and course as given above ; it continues cephalad in the canal, accompanied by a slender arteriole ; it bends dorsad to enter the tympanum through the *iter chordæ posterius ;* it crosses the tympanum about

*The author has not at this date completed experiments to satisfy himself as to the relation of this body ; whether the relation is one of position only or one of structure—that is, whether it is a ganglion of the facial nerve, or is peculiar to the great superficial petrosal nerve and merely rests upon the facial.

the middle of the malleus, somewhat mesad of the bone, and emerges through a minute foramen, the iter chordæ anterius, into the glaserian canal, thence along the canal to the ecto-cranial foramen ; it lies ventrad of the otic ganglion and the dental branch of the mandibular nerve, ectad of the external carotid artery, passes between the pterygoid muscles, and joins the lingual nerve at an acute angle about 5–10 mm. peripherad of the foramen ovale.

Nervus petrosus superficialis major.—The great petrosal nerve has a fourfold origin. The principal root may be traced to the geniculate ganglion with the trunk which is directed caudad from that body ;* the next in size comes direct from the petrosal ganglion of the glosso-pharyngeal nerve, and is a division of Jacobson's nerve ; the third is a branch from the trunk of the facial, at the angle ; and the fourth is a slender filament from the tympanic plexus (Jacobson's). The united trunk lies in the glaserian canal, and emerges from its ventral hiatus, enters the caudal foramen of the Vidian canal, which is about 5 mm. cephalad, traverses the canal, and at the middle of the foramen lacerum anterius becomes the petrosal root of the Vidian nerve, whence it is related to the spheno-palatine ganglion.

Nervus petrosus superficialis minor.—This branch from the interosseous portion of the facial nerve is one of the four divisions of the ramulus given off at the angle ; about 2 mm. peripherad of its origin it enters an enlargement (plexus?) about .5 mm. in diameter ; this enlargement is joined by the tensor tympani nerve ; the petrosal nerve traverses the glaserian canal and joins the otic ganglion at the ventral hiatus.

Ecto-cranial Relations.—The ecto-cranial trunk emerges from the foramen stylo mastoideum ; its course is cephalad and dorsad, and lies ectad of the post-auricular artery. (It often lies entad of a branch artery to the parotid gland.) At the foramen of exit, or just peripherad, the nerve divides into branches ; its relations and distribution are given accordingly. The primary rami ventrad are the digastric and the stylohyoid ; cephalad are the cervico-facial and the temporo-facial ; dorsad and caudad are the auricular.

N. digastricus.—The digastric nerve is a small ramus from the ventral border of the facial nerve at its foramen of exit ; it lies entad of the stylomastoid artery, around the cephalic border of which it bends abruptly and takes its course ventrad ; it extends along the dorsal border of the proximal end of the digastric muscle, which it penetrates about 5–8 mm. from its origin ; its terminal filaments supply the proximal end of the muscle. (I do not find an anastomotic branch to the glosso-pharyngeal nerves, as is the case in man.)

N. stylo-hyoideus arises from the ventral border of the facial nerve, in common with the digastric, or remains in the trunk-sheath to be given off about 1–2 mm. peripherad ; it penetrates the stylo-hyoid muscle at its

* This trunk becomes the anastomotic branch to the glosso-pharyngeal and the vagus nerves, the chorda tympani and the long root of the petrosal nerve.

proximal third, and is distributed throughout the muscle; it often communicates with the cervico-facial nerve about 10 mm. peripherad of its origin. As it crosses the post-auricular artery it gives two or three filaments to the sympathic plexus around this blood-vessel.

Cephalic Division of the Nerve-Trunk.—As the common trunk emerges cephalad from the foramen of exit, it lies dorsad of the stylo-mastoid artery (a small twig from the post-auricular), and crosses the lateral border of the post-auricular artery; at the dorsal border of the artery the trunk divides into the cervico-facial and the temporo-facial rami. (In some instances this trunk seems to give origin to the stylo-hyoid nerve.)

N. cervico-facialis.—This is the cephalic and ventral ramus of the common trunk; it is ectad of the carotid artery and the facial vein, entad of the submaxillary gland, and upon the ectal surface of the masseter muscle. At the cephalic border of the submaxillary gland it divides into three rami, the infra-maxillary, supra-maxillary and the buccal.

The first branch of the cervico-facial trunk is given off at the origin of this nerve; it lies ectad of the carotid artery, and is directed dorsad and laterad upon the ectal surface of the parotid gland; about 12 mm. from its origin, ectad of Stenon's duct, it bifurcates, each division again branching into two or four ramuli and terminating in the dermal muscle ectad of the gland (Platysma myoides). A few filaments may be traced to the zygomatic muscles.

This branch receives a considerable accession from the temporo-facial nerve near its origin; some of the filaments seem to terminate in the substance of the parotid gland.

5–8 mm. peripherad of the origin of the cervico-facial nerve a second fascicle is sent to the zygomatic muscles.

N. infra-maxillaris.—This is the ventral division of the cervico-facial nerve; it lies ectad of the facial artery and the facial vein; 5 mm. peripherad of its origin it divides into several ramuli which anastomose freely and terminate upon the platysma. A large fascicle joins the superficial cervical nerve from the cervical plexus.

N. supra-maxillaris.—This is the middle division of the cervico-facial nerve. (It often arises as a branch of the buccal nerve, given off at the border of the orbicular muscle at the angle of the mouth; its distribution is constant.)

Its general course is toward the angle of the mouth; it lies ectad of the facial artery and vein; it forms a dense plexus upon the ectal surface of the ventral lip; the ventral ramuli supply the muscle between the foramen mentale and the mandibular symphysis (M. depressor labii), and anastomose with the mental branch of the mandibular division of the trigeminus nerve; its filaments are also given to the orbicular muscle (M. orbicularis oris).

N. buccalis is the dorsal branch of the cervico-facial nerve; it gives several anastomotic filaments to the infra-orbital branch of the temporo-facial nerve; it joins the plexus at the angle of the mouth (Plexus labialis); a ramuscle is inflected around the angle of the mouth and anastomoses with the buccal branch of the mandibular division of the trigeminus; it reaches the following muscles: the buccinator, the orbicular, the zygomatic, the risorius and the depressor anguli oris; it continues mesad along the dorsal lip between the superior coronary artery and the vein just dorsad, and at the lateral border of the arteriale rete, just dorsad of the canine tooth, the infra-orbital and the buccal nerves anastomose and form a plexiform swelling for 3–5 mm.; from this united nerve fibres diverge to the levator muscles and to the muscles upon the nasal cartilage.

N. temporo-facialis.—This is the dorsal division of the cephalic trunk as it crosses the post-auricular artery; it is considerably larger than the cervical division (N. cervico-facialis); it lies ectad of the external carotid artery, entad of the ventral lobe of the parotid gland and the adjacent lymphatic gland, and upon the ectal surface of the masseter muscle. Entad of the parotid gland, and 10 mm. peripherad of origin, it divides into three rami—the ventral, or infra-orbital; the middle, or malar; and the dorsal, or temporal (the malar and the temporal often remain in a common sheath for 10–12 mm., forming the temporo-malar trunk).

N. infra-orbitalis.—This, the ventral division of the temporo-facial nerve, emerges from the cephalic border of the parotid gland just dorsad of Stenon's duct; its course is arched toward the angle of the mouth, about midway between Stenon's duct and the zygoma, and lies upon the ectal surface of the masseter muscle; it sustains anastomotic relations with the malar nerve and the temporo-auricular division of the trigeminus nerve. At the ventral border of the zygomatic muscle it gives anastomotic filaments to the cervico-facial nerve, as described; it lies ectad of the zygomatic muscles and dorsad of the superior coronary artery. At the angle of the mouth it gives filaments to the dorsal part of the orbicular muscle; in its course along the dorsal lip it supplies the levator muscles, the muscle at the base of the vibrissæ and the muscles which move the nasal cartilage; it joins the buccal nerve to form the plexiform enlargement in the rete arteriale dorsad of the canine tooth, as already described (v. N. buccalis).

N. malaris.—This is the middle and large division of the temporo-facial nerve; the central portion is covered by the parotid gland; entad of the gland it communicates freely with the temporo-auricular nerve. At the dorsal border of the gland it is apposed to the cephalic temporal artery, and continues along with the artery just caudad of the supra-orbital ridge (the tension of the muscle will dispose the nerve cephalad or caudad of the artery). The principal divisions of the nerve make a dense plexus upon the ectal surface caudad of the supra-orbital ridge; the terminal filaments are given to the occipito-frontal muscle over the frontal region where they anastomose with filaments of the supra-orbital nerve. At the lateral angle of the eye, where a fascicle joins the supra-orbital, a slender nerve is given off to the zygomatic muscles. The nerve trunk may be traced along the supra-orbital ridge to the mesal angle of the eye, where it joins the infra-trochlear nerve.

N. temporalis.—The temporal branch of the temporo facial nerve lies close to the basal cartilage of the ectal ear and entad of the parotid gland. The central portion communicates with the temporo-auricular nerve and sends filaments to the attrahens muscle.

At the dorsal border of the gland, and at the ventral border of the long triangular cartilage which is directed meso-cephalad from the dorsal angle of the ectal ear, and which is embedded in the occipito-frontal muscle, the nerve divides; one portion, passing ectad of the cartilage, is distributed to the occipito-frontal muscle in the pariëtal region; the other, passing entad of the cartilage and along its ventral border, joins the supra-orbital plexus already described.

N. post-auricularis.—This nerve emerges from the stylo-mastoid foramen, and takes its course dorso-caudad in a groove upon the ectal surface of the mastoid process. The central 5 mm. form a loop around the post-auricular artery, one division lying ectad and the other entad of the vessel. These may be described as the auricular and the occipital portions.

The auricular portion, at the peripheral end of the loop, lies apposed to the ectal or caudal division of the artery,* and is distributed to the lateral border of the occipito-frontal muscle. A ramulus from this nerve is given to the retrahens muscle.

The occipital portion lies between the two branches of the post-auricular artery and is distributed to the caudal part of the occipito-frontal muscle; it communicates with a branch of the minor occipital nerve (N. occipitalis minor).

Ramuli to the Ectal Ear.—A ramulus from the auricular nerve is directed toward the tip of the ear; 10 mm. from its origin it gives off 4–5 ramuli, which supply the dermal muscle of the latter half of the ectal ear (probably the platysma); the nerve follows an arteriole around the caudal and the dorsal borders of the ectal ear, and bending around the cephalic margin just distad of the attrahens muscle, it supplies a muscle (helicis major?) upon the ental surface of the ear.

From the ental surface of the facial nerve at the stylo-mastoid foramen a considerable fascicle is directed dorsad close to the proximal cartilage of the ectal ear and entad of the auricular muscles; it penetrates the cartilage and terminates in a muscle (helicis minor?) upon its ental surface mesad of a projection from the ental surface of the ear near the external meatus.

A third ramulus takes its orgin at the stylo-mastoid foramen; it is ectad of the post-auricular artery, and crosses the base of the second arteriole, which is sent dorsad from the post-auricular; it follows a small arterial twig about 6–8 mm., when it perforates the auricular cartilage with the

* The artery divides just peripherad of the loop.

arteriole, and terminates upon the thin muscle (anti-tragicus?) at the base of the ear centrad of the folds which extend from the external meatus to the marginal "pocket" of the ectal ear.

SUMMARY.

Anatomical.

PROXIMATE ROOTS.—The dorsal root proceeds from the cerebellum with the medipeduncle.

The cephalic root has one ental origin in the region of the floor of the epicœle or the post-optici part of the mesocœle, and another in the cerebellum, whence it proceeds with the prepeduncle.

The caudal root originates in the caudal portion of the floor of the metacœle.

ECTAL ORIGIN.—This is from the latero-cephalic border of the trapezium; it is separated by an arteriole and a venule from the auditory nerve.

THE EXIT is by the meatus auditorius entalis, dorsad of the auditory nerve, through the aqueductus fallopii, and emerges from the foramen stylo-mastoideum.

PRINCIPAL ECTOCRANIAL DIVISIONS AND THEIR DISTRIBUTION.—Nervus digastricus is distributed to the musculus digastricus; N. stylo-hyoideus to M. stylo-hyoideus; N. cervico-facialis to the MM. platysma, orbicularis oris ventralis, depressor labii ventralis, depressor anguli oris, risorius; N. temporo-facialis to the MM. orbicularis oris dorsalis, buccinator, zygomatici, levatores labii dorsalis, orbicularis palpebræ, occipito-frontalis, attrahens aurem; N. auricularis to the MM. occipito-frontalis, retrahens aurem, helicis major, helicis minor, antitragicus.

COMMUNICATING RAMI.

Ento-cranial.—The facial nerve receives an accession just peripherad ot the arteriole which separates it from the auditory; this is probably the intermediary nerve of Wrisbery, or the root of the chorda-tympani (Sapolini's thirteenth cranial nerve).

Inter-cranial.—The facial nerve communicates with the spheno-palatine ganglion by the great superficial petrosal root of the vidian nerve; with the otic ganglion by the small superficial petrosal nerve; with the sympathetic plexus by the lateral petrosal nerve; with the Gasserian ganglion of the trigeminus by an anastomotic filament from the ramus at the angle in the aqueduct; with the petrosal ganglion of the glosso-pharyngeal by a large fascicle from the geniculate ganglion; with the jugular ganglion of the vagus by the same fascicle; with the lingual branch of the trigeminus by the chorda tympani; with the stapedius muscle by the tympanic nerve; with the tensor tympani by filaments from the small superficial petrosal nerve.

Ecto-cranial.—The facial nerve communicates with the superficial cervical nerve by the infra-maxillary branch; with the mental nerve (mandibular division of the trigeminus) by the infra-maxillary; with the buccal nerve (trigeminus) by the buccal branch; with the auriculo temporal (trigeminus) by the infra-orbital branch; with the supra-orbital nerve (trigeminus) by the malar branch; with the supra-orbital and auriculo-temporal by the temporal branch; with the great auricular nerve (spinal) by the auricular branch; with the small occipital nerve (spinal) by the occipital branch.

There seems to be no anatomical relation between the facial nerve and the masseter muscle, although the nerve ramuli make a complex network over the ectal surface of the muscle.

Physiological.

The facial is the motor nerve of the face; it excites contractility in the muscles of the middle ear, the ectal ear (except M. attolens aurem), the cheeks, the scalp, the lips, the nostrils, the eyelids and the neck (platysma). Through the vidian nerve it modifies the movements of the muscles which are controlled by nerves whose immediate origin is the spheno-palatine ganglion. Its action upon the salivary glands through the chorda-tympani is generally accepted; further investigation may confirm Sapolini's theory that the chorda-tympani controls speech. Its anastomotic relations with the branches of the trigeminus suggest that much of the motor function in structures supplied by that nerve may be referred to the facial. It is intimately related with the glosso-pharyngeal and the vagus nerves. Its relation to audition is unknown.

DESCRIPTION OF THE DIAGRAM.

The diagram is not drawn to a scale. No attempt has been made to represent the nerves in perspective. To secure simplicity, it has been necessary to change the relative proportions and directions of nerves which intersect or lie in planes at considerable inclination

A., the accession from the auditory nerve, the intermediary nerve of Wrisberg and root of the chorda-tympani (Sapolini); *Ang.*, the angle in the interosseous trunk; *Antitr.?*, the thin muscle upon the ental surface of the ectal ear, which has been provisionally identified as the antitragicus; *Aq.*, the intercranial trunk in the aqueductus fallopii; *Art.*, the twig from the anterior cerebellar artery which separates the facial and the auditory nerves at their ectal origins; *Attr.*, the filaments to the M. attrahens aurem; *Aur.*, the anastomotic branch of the petrosal ganglion of the glosso pharyngeal nerve and to the jugular ganglion of the vagus; *Auricular*, the auricular division of the post-auricular nerve; *Aur. Ect.*, the ectal ear; *Cerv.*, the anastomotic filament to the superficial cervical nerve; *Ch.*, the chorda tympani; *Cheek*, filaments to the muscle ectad of the parotid gland; *Crv. fac.*, the cervico-facial division of the facial nerve; *Ctl.*. the position of the long triangular cartilage at the base of the ectal ear; *Dep.*, filaments to the M. depressor anguli oris; *Dep. lab.*, to the M. depressor labii ventralis; *Dig.*, the digastric nerve; *Ento-cr.*, the ento-cranial trunk; *Fm.*, the position of the small foramina in the cartilage of the ectal ear through which the nerves pass to the ental muscles; *Fm. men.*, foramen mentale; *Fm. st.*, foramen stylo-mastoideum, the foramen of exit of the facial nerve; *Gass*, the anastomotic filament to the caudo-lateral eminence upon the Gasserian ganglion; *Gen.*, the geniculate ganglion; *Gl. par.*, the parotid gland; *Helic. mj.*, the helicis major muscle (provisional); *Helic. mr.*, the helicis minor muscle (provisional); *Inf. max.*, the infra-maxillary nerve; *Inf. tro.*, the infra-trochlear branch of the trigeminus; *J.*, ramus to the jugular ganglion; *Jacob.*, Jacobson's nerve; *Occip.*, the occipital branch of the post-auricular nerve; *Occipito-frontalis*, filaments to the occipito-frontal muscle; *Occ. min.*, to the small occipital nerve; *Orbic. oris*, to the musculus orbicularis oris; *Orb. pal.*, to the orbicularis palpebrarum; *P.*, ramus to the petrosal ganglion; *Pe. lab.*, the lateral petrosal branch to the sympathic plexus; *Pe. maj.*, the short root of the great superficial petrosal; *Pe. maj.'*, the long root of the same; *Pe. min.*, small superficial petrosal; *Pl.*, the plexus in the rete arteriale dorsad of the canine tooth; *Pl. lab.*, the plexus at the angle of the mouth; *Pl. sup. orb.*, the supra-orbital plexus; *Retrah.*, to the musculus retrahens aurem; *Ris*, to the risorius muscle; *St. hy.*, the stylohyoid nerve; *Sup. max.*, the supra-maxillary nerve; *Sup. orb.*, the supra-orbital branch of the trigeminus nerve; *Sym.*, the filament to the sympathic plexus around the artery; *Tmp. aur.*, the auriculo-temporal branch of the mandibular division of the trigeminus; *Tmp. fac.*, the temporo facial division of the facial nerve; *Tym.*, the tympanic branch to the stapedius muscle; *Zyg.*, filaments to the zygomatic muscles.

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James R. Ludlow. By Richard Vaux.

(Read before the American Philosophical Society, January 7, 1887.)

The American Philosophical Society in recording its tributes to the memory of its deceased members is sensibly impressed by the reflection that the propriety of their election to its membership had been signally confirmed by the learning and attainments manifested in their life-work.

Knowledge is advancing to the circumference which bounds the human mind. Science is laboriously engaged in finding out the reason of things. Philosophy in the library is exercising its capacities, and elsewhere testing its ability to demonstrate them. Out of these sources our Society is filled with vital force. Those who augment and increase its value are within the compass of our commendation.

The preparation of this paper is the practical exemplification of this axiom. It is dedicated to the memory of the Hon. James R. Ludlow.

On the 3d of May, 1825, in the City of Albany, in the State of New York, James R. Ludlow was born. His father, the Rev. Dr. John Ludlow, was a minister of the Old Dutch Reformed Church. This venerable Society had an historical character. Its influence in the earlier days of New York was marked, and much yet remains. The Dutch settlers of that Province were earnest, sincere, sluggish, but patriotic people. The Patroons were noted men in their time. The Van Rensselaer Manor was historical. The Patroons, Van Rensselaer, even to a late period were esteemed and respected in social circles.

The anti-rent excitement half a century ago, was evolved out of the relations between these manors and the tenants.

The Rev. Dr. Ludlow was an educated, cultivated gentleman. He was professor of languages in the Theological Department of the New Brunswick, New Jersey, School of the Dutch Reformed Church.

In the year 1834 Dr. Ludlow came to Philadelphia and was elected Provost of the University of Pennsylvania, in which post he served for nearly twenty years.

When Dr. Ludlow came to this city, his son James entered the University of Pennsylvania and graduated with distinction in July, 1843.

He then became a student of law with the Hon. Wm. M. Meredith. It may not be out of place to say of Mr. Meredith that he was one of the ablest lawyers of this country. Well read in all branches of learning, with a brilliant wit, his fame was the growth of inherent ability and marvelous culture. Without industry, he absorbed knowledge. His reading was general, his memory phenomenal.

On the admission of James R. Ludlow to the bar on July 24, 1846, he entered on the practice of his profession in this city. Earnest, faithful, industrious, he began to establish a professional character that promised success.

In 1850 he was appointed Assistant District Attorney of the United

States and earned high repute for his conduct of some of the Government cases. He learned rapidly the science of the law, and mastered its practical details.

In 1856 he was named as a candidate for the District Attorneyship of Philadelphia. His reputation had grown, his professional standing was assured.

In 1857 he was nominated for Judge of the Court of Common Pleas of Philadelphia County, and elected, and in November, 1857, took his seat on the Bench. His term of ten years expired in 1867, and he was reelected.

By the Constitution of the State of Pennsylvania, which was amended in the year 1873, the Courts of the County of Philadelphia were re-organized. By this organic law, four Courts of Common Pleas were established. Each had a President Judge and two Associates. Judge Ludlow became President Judge of Court of Common Pleas, No. 3.

In 1877 Judge Ludlow was again elected without opposition. He held that position until his death. His judicial life began in 1857, and ended, by his death, in 1886. Thirty years of judicial labor was the training he received. He gained the respect and confidence of his fellow-citizens. They appreciated his honesty, impartiality, his courage and his learning.

As a Judge, his reputation was substantial. In the law and equity sides of the Court he was admittedly a safe and conservative administrator of the high trust conferred on him. His conscientiousness was proverbial. He possessed and developed the highest courage in the impartiality with which he adjudged the questions he was called upon to determine. It may be said he died the victim of continuous, conscientious labors. He investigated and examined, and came to his conclusions after patient study of the law involved in the decisions of those cases, the importance of which made severe demands on his time. He took nothing for granted. He believed his duty required his best efforts, and was not satisfied that errors inconsiderately made might be possibly corrected in a court of review.

It may be said of Judge Ludlow, that in dealing with the science of the criminal law he became an authority in this country. His tastes led him to study physiology and psychology. To facilitate his labor he attended the lectures in the medical school of the University of Pennsylvania. He therefore became well informed in medical science. In administering the criminal law, his opinions were regarded as a settlement of those principles in which a knowledge of these sciences was necessarily involved.

It became a professional fashion to plead insanity to indictments for murder. The first tentative efforts to introduce this defence seem to have been so successful as to encourage its adoption. The Courts, leaning to the doubt as to the mental condition of the accused when put in issue on a trial, created a demand for medical evidence in support of this plea.

It became important to the administration of justice that a rigid enforcement of the law should be secured.

To relieve one guilty of murder from the just penalty of his crime, by the interposition of a scheme to confess the act and avoid the conviction, by the assertion that the accused was insane, needed to be subjected to the test of scientific investigation. Medical experts who look up the specialty of mind diseases made of it a sort of avocation.

There ought to be a significant distinction between an "expert" and a "witness." This distinction is not always made in these trials. An "expert" is almost always called as a witness, while his function as an "expert" is to give merely professional opinions. Many of these experts, so called, were too ignorant to do more than cast suspicion on the value of any medical testimony. It was not long before the intelligent of both professions became disgusted with this expert system of building up a theory of want of mental responsibility for acts committed.

Judge Ludlow was one of the first of the Judges in Philadelphia to defeat the purpose for the use of these medical experts.

In the Commonwealth vs. Sayres, he laid down the principles which should govern the investigation of insanity as a plea against a conviction of murder. The Supreme Court of Pennsylvania confirmed Judge Ludlow's law in this case.

His opinion in this case became recognized authority. The Insane Asylum at Utica, New York, published that opinion as canon law on this subject.

The case of the Commonwealth vs. Taylor, 1884, was perhaps the most important of all the cases which were subjected to judicial determination. To those best informed as to the character of the prisoner, there was no doubt of his entire responsibility for the crime of murder of which he was convicted and afterwards hanged.

The insanity plea was fully discussed, and the Supreme Court on appeal finally settled the law on this subject in the Commonwealth, by endorsing Judge Ludlow's opinion in Taylor's case. From that opinion we make the following extract as indicating his views and asserting the law as now settled:

"I do not intend to review the law as settled by our Supreme Court in Sayres' Case, 7 Norris, 291, upon the subject of insanity.

"I tried that cause, and the charge then delivered was before the appellate tribunal. On the trial of this case I quoted from that charge freely, and added the words contained at the end of the ninth reason for a new trial of record.

"My object was to draw a line of distinction between what may be called *legal* and *medical* insanity, between acts which an eccentric, angry, jealous, sentimental and revengeful man may do, when medically and scientifically, in one sense, insane, and when by every *legal* test that man is a responsible being, and for the protection of society must be held so to be.

"It is quite possible for one to commit a violent act, when by reason of very many causes, his brain is not in a healthy condition, is in fact diseased. He knows the circumstances by which he is surrounded, is perfectly able to attend to his own affairs, distinguishes right from wrong, and yet by reason of an unhealthy brain, is abnormally swayed by passion, sentiment and emotion, and in a fit of anger, jealousy or revenge, kills another.

"When an expert, in answer to the question

"'Suppose a case to arise, in which the diseased condition of the brain produces jealousy, anger, or revenge; is that man insane?' Answered, Yes. I then remarked: 'That is the sort of insanity the Supreme Court declares shall make a man responsible.'

"That opinion is yet entertained. If the expert had answered, 'Yes, if satisfied that this diseased or unsound state of mind existed to such a degree, that although he (the prisoner) could distinguish between right and wrong, yet, with reference to the act in question, his reason, conscience and judgment were so perverted as to render the commission of the act in question a duty of overwhelming necessity,' we could then understand the difference between an opinion based upon scientific metaphysics, under cover of which every wicked man may be declared to be insane, and a clear cut, well defined rule of law, which requires every man to be a responsible agent, and adopts rules to test that responsibility, which every one can understand and apply, and which will in practice rarely, if ever, consign to the gallows a really insane man.

"It is hardly probable in this enlightened age that one whose insanity is difficult of detection, and whose case may therefore be real, as well as mysterious, will ever be unjustly punished. When courts and juries deal with cases of insanity, they can and should only be governed by plain principles, readily applicable to facts as proved, and not indulge in impracticable theories, often subtle, and to the ordinary mind incomprehensible, which lead to the acquittal of the guilty, and to the final destruction of that security which society demands."

It is fortunate for medical and legal science, that a check was imposed on the vagaries of experts on mental disease.

The closest and best informed student of mental phenomena must know that it is impossible to establish and formulate any certain rules to make a reliable diagnosis as to special mental maladies. Abnormal mental conditions develop themselves to the recognition of educated and experienced observation. Inherited traits, latent physical causes, morbid moral alienations may express themselves in forms which indicate the existence of some irrational mental conditions. In such cases the theorist accepts a conclusion of insanity. But under which of the terms used to describe this disease it can be classified, is only to be known by the results of practical personal observation of those familiar from long experience with the various characteristics of these maladies. A theoretic opinion is of little value. Mental disturbance may exist, and become apparent under certain forms, to the expert, when if by long and close observation of those familiar with mental disease the responsibility of the individual for acts cannot be doubted. When, therefore, it becomes a question of the responsibility of a person for his acts, a theory is too often misleading.

Judge Ludlow, in his opinion in Taylor's case, has drawn the distinction with the force of scientific truth when he says, Scientific metaphysics, as applied to mind disease, may suggest medical insanity. Whatever medical insanity may be, it is now clearly determined to be the law in Pennsylvania that insanity to be a defence in murder must be determined by legal principles. Responsibility for crime is now to be determined by legal tests. Medical insanity resting on scientific metaphysics may be accepted as authority by medical experts, but before the law, legal insanity can only be recognized.

This enlightened and learned Judge, worn out by judicial labor, ended his days on the 20th day of September, 1886, in the 62d year of his age, with a high reputation, gained and earned in the thirty years of devotion to the conscientious discharge of his high trust.

It is due to the character of James R. Ludlow, that the American Philosophical Society should enroll his name among those of its members who worthily obtained and richly merited by his life-work the honorable distinction of its membership.

Contributions from the Chemical Laboratory of the University of Pennsylvania.

No. XXIX.

CONTRIBUTIONS TO MINERALOGY.

By F. A. Genth.

(With one phototype plate and three wood-cuts.)

(*Read before the American Philosophical Society, March 18th, 1887.*)

I. On the occurrence of Tin Ores in Mexico.

The ores which are the subject of the following investigation were received in January, 1885, from Mr. John L. Kleinschmidt of San Miguel del Mesquital in the State of Zacatecas, Mexico,* to whom I am greatly indebted for this gift, and for highly interesting observations, regarding

* I have just learned from Mr. Kleinschmidt that he has returned to Hillsboro', Jefferson Co., Mo.

their occurrence. They are all from the Sierra de Catatlan, in the State of Durango, and comprise the following:

No. 1. Ore from Mina del Diablo. "Clace 1ª, Cristal."
" 2. " " " " "Clace 2ª.
" 3. " " " de San Antonio.
" 4. Washings received from Mr. W. Schlemm.
" 5. Ore from Mina Varosa.
" 6. Stream tin ore, marked "Superior de Placer."

The central body of the Sierra de Catatlan, in which the mines which have furnished these ores are situated, consists of quartz-porphyry, which, in some places, is traversed, in a net-like manner, by small veins of tin ores. About one mile from the Mina del Diablo doleritic rocks occur.

Nos. 1 and 2. The vein of the Mina del Diablo has been traced for about one mile in length, it has a thickness of from eighteen inches to two feet, is almost perpendicular, and perfectly separated from the porphyry by argillaceous selvedges. It consists of a decomposed white clayey material, containing druses of quartz with tin ores. In a pocket was found a white clay in which crystals and crystalline aggregations (No. 1), and also finer ore (No. 2), were intermixed. On washing, this pocket yielded about 54 per cent of clean ore, the crystals and crystalline aggregations were picked out from a large quantity of clay, and weighed about 650 grms, yielding nearly 50 grms in well defined shape.

This occurrence is completely exhausted; the deeper and harder portions of the vein contain tin ores, but not any of these peculiar crystals. A qualitative examination of the crystals as well as of the finer ores, although different in form, showed the composition of mimetite, mixed with more or less cassiterite, small quantities of porphyry, quartz, hematite, clay, etc. Many interesting specimens of cassiterite, mostly of a red variety, were picked out from the mimetite crystals and crystalline aggregations; they all showed such an unusual appearance that it was desirable to obtain a larger quantity from the second-class ore. The finer portion was separated by a sieve of 16 meshes to the square inch, and 500 grms. of the siftings treated with hydrochloric acid until all the mimetite was dissolved. The residue was treated with Thoulet's solution, which gave in the heavier portion a little over 15 grams of cassiterite with a few crystals of hematite, while the lighter consisted principally of quartz, with little feldspar, fragments of porphyry, kaoline, etc.

A fuller description and analyses of the various minerals and varieties from the Mina del Diablo will be given in the sequel.

No. 3. The San Antonio Mine has furnished in a seam, six inches in thickness, a length of ten feet, and a height of eight feet, an ore in the form of pulverulent or very friable, earthy yellowish masses, with darker, somewhat more ferruginous streaks. There were only a few very small particles of the red variety of cassiterite present, most of it being of a yellowish color. A partial analysis gave:

SnO_2	=	31.27
Bi_2O_3	=	6.10
As_2O_5	=	10.13
PbO	=	8.58
Al_2O_3 } Fe_2O_3 }	=	11.39
SiO_2	=	14.20
Sb_2O_5, ZnO, MgO, CaO, by diff.	=	12.64
Ignition	=	5.69
		100.00

A portion of the ore, after washing off the lighter particles and removing the little friable lumps, which showed but a few pseudomorphous crystals of mimetite composition, by a sieve of 16 meshes to the inch, a yellowish sandy powder was obtained, which was analyzed. It was first treated with dilute nitric acid for the determination of chlorine, and then dissolved as far as possible in hydrochloric acid.

The solution contained :

Cl	=	0.070						
SiO_2	=	1.235						
P_2O_5	=	0.075						
As_2O_5	=	14.290						
Sb_2O_5	=	0 263						
SnO_2	=	3.860						
Bi_2O_3	=	5 190						
CuO	=	0.195						
PbO	=	9.482						
ZnO	=	3.940						
Fe_2O_3	=	4.955						
Al_2O_3	=	7.630						
MgO	=	0.200						
CaO	=	2.120						
			=	53.505				
The insoluble contained :								
Quartz	=	10 640						
SnO_2	=	19.300	=		0.129	=	16	
As_2O_5	=	1.844	=		0.008	=	1	
Sb_2O_5	=	1.040						
PbO	=	0.198						
Fe_2O_3	=	2.945						
Al_2O_3 with traces of ZnO, Bi_2O_3, MgO, CaO	=	3 208	=	39.175				
Ignition	=	7.320	=	7.320				
				100.00				

The ores from both mines are melted together with other tin ores, and yield a crude metal, which, after some purification, furnishes a tin, very well adapted for soldering, notwithstanding the considerable quantities of lead and arsenic which it contains.

No. 4. The washings from the Catatlan mountains, which Mr. Kleinschmidt received from Mr. W. Schlemm, are highly interesting. They consist of a fine sand, the particles rarely over 1^{mm} in size.

There were no lead ores present, but cassiterite, mostly in the red variety, but also minute quantities of the yellow, interesting forms of hematite and alterations of the same, a few crystals of topaz, many minute crystals of durangite, quartz, etc.

No. 5. The ores from Mina Varosa are exclusively of the yellow variety.

No. 6. The Placer ores are both of the red and yellow varieties, the former largely predominating, also pieces showing bands of the yellow alternating with a brown variety.

For comparison several other varieties of Mexican cassiterite were examined which were kindly presented by Messrs. Clarence S. Bement, Joseph Wharton, Prof. Carlos F. de Landero, and Dr. Joseph Leidy, to all of whom I am greatly indebted for their liberality; I am also under great obligations to Professors Gerhard vom Rath and George A. Kœnig, for generous aid rendered in the preparation of this paper.

1. *Cassiterite.*

As already indicated, cassiterite occurs in Mexico principally in two varieties, the most abundant of which has a red color, while the other is yellow.

a. Red variety.—Occurs in various shades of red, from bright hyacinth red, brick-red to brownish red, to brown and brownish-black. The powder is from pale to brownish brick-red. The general appearance of the red cassiterite proves that the dioxide of tin was in solution from which it has been deposited upon whatever substances it came in contact with, so that numerous imitative shapes were produced. Thus, we find it as incrustations in plate-like masses which formed upon quartz or porphyry, or in reniform, mammillary, or botryoidal aggregations, frequently in perfect stalactites, which are sometimes not over 0.5^{mm} in length, often hollow, radiating from the centre, often in forms resembling sponges, roots, clubs, &c.; sometimes granular and compact, especially larger masses, which closely resemble compact hematite, towards the exterior frequently assuming a fibrous structure which may end in distinguishable crystals. The outside of the stalactites is frequently covered with exceedingly minute crystals which, however, are so small and irregular that their form can only be determined in very few cases without a microscope. Some microscopic groups of crystals obtained from the Ore No. 2 from Mina del Diablo, most of them not over 1^{mm} in size, are composed of an aggregation of apparently hexagonal plates of a bright hyacinth-red color with rounded edges, some show flat hexagonal prisms, upon quartz or porphyry, a few also are groups of minute hematite crystals, together with those of hyacinth-red cassiterite. The most remarkable and only specimen which is large enough to distinguish its form with the naked eye came from the pseudomorphs of mimetite composition of the Mina del Diablo.

It is a little group of $7^{mm} \times 5^{mm}$ in size, composed of dark hyacinth-red crystals. There may be ten or more little crystals present, but only a few are perfect enough to show the form, but even these have somewhat curved faces and are not smooth enough and are too much interrupted to allow of an accurate measurement. They are slightly barrel-shaped, apparently hexagonal prisms with hexagonal pyramid and basal plane; the largest is 3^{mm} high and of about the same diameter.

The specific gravity of the group was found to be = 6.496, which is evidently too low, probably on account of the presence of a nucleus of quartz or porphyry around which the crystals may have formed.

The question presented itself, whether the observed forms were really hexagonal, in which case the dioxide of tin would be dimorphous, or, whether they were resulting from the twinning of tetragonal forms. In order to obtain a conclusive answer, I submitted this group, and also crystalline sands from the washings, received from Mr. Schlemm, to Prof. Gerhard vom Rath, in Bonn.

I am greatly indebted to him for his aid in this matter, which was exceedingly difficult to determine on account of the great minuteness of these crystals, so that only one of so much experience and perseverance as he has could attempt to solve this important question.

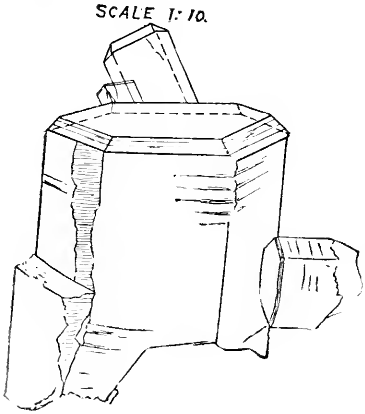
He found nearly 135° for the angle made by the *apparent* basal plane and face of the hexagonal pyramid, which closely corresponds to the angle produced by the first and second tetragonal pyramids of cassiterite. For one prismatic edge he found 112½° (must be 120° in the hexagonal system), and this angle, too, is the ordinary angle of the geniculated edge of cassiterite twins. Furthermore, he was enabled to pick out crystals from Mr. Schlemm's sands, with which approximate measurements of the angles between the basal plane and the six planes of the *apparent* hexagonal pyramid could be made, which gave: 134° 10′, 135° 15′, 135°, 134°, 135°, and 134½°, in agreement with the above measurements, as closely as could be expected.

He writes in his last note, under date of October 26th, 1886, referring to the small group of crystals: "You may consider the determination as *quadratic* beyond question, assuming an hexagonal habitus by repeated twinning."

The twin combination resembles figure 162, page 159, in J. D. Dana's "Mineralogy," 1868. I am indebted to Dr. Kœnig for the accompanying drawing, illustrating my group of crystals:

Besides the localities mentioned, I have received the red cassiterite from Coneto, in the State of Durango, Comanja and Paso de Sotos, in the

State of Jalisco. Professor G. vom Rath, in his "Geologische Briefe aus Amerika" (Sitzungsberichte der Niederrheinischen Gesellschaft für Natur und Heilkunde in Bonn, July 7th, 1884), mentions it as woodtin, implanted in red porphyry in the Valle San Francisco, San Luis Potosi, also between Sta Rosa and La Fragua, in Guanaxuato, and at Sain Alto and several other localities in the Sierra Zacatecana.



The following analyses of the red variety were made : *

1. Bright brick-red, fine granular, somewhat reniform, the surface assuming slightly fibrous crystalline appearance. Durango ; from my Cabinet, I, a and b.

2. Reniform, curved lamellar, the laminæ from 0.1 to 1^{mm} in thickness, separate on breaking with smooth surface slightly granular, brick-red ; powder bright brick-red. Coneto, State of Durango ; from Mr. Joseph Wharton, II.

3. Large pebble, somewhat granular, of the appearance of compact hematite, powder brick red. Durango ; from Mr. Clarence S. Bement, III.

4. A mass which had deposited as an incrustation upon quartz or a siliceous rock, of a thickness of 20^{mm}, with fine crystalline fibrous structure, being flat on the bottom and reniform on the surface. Dark brown, a fresh fracture reddish brown, powder brownish brick-red. Coneto, State of Durango ; from Mr. Joseph Wharton, IV.

5. Stalactitic, granular, the surface covered with minute crystals, color and powder bright brick-red. Minute crystals of hematite were implanted which were separated by a magnet (this hematite being slightly magnetic) ; from the ores No. 1 of Mina del Diablo, V.

6. Botryoidal, dark brown, on fracture paler reddish-brown, with a slightly fibrous structure ; color of powder terra cotta ; from Guanajuato, State of Guanajuato, from Mr. Clarence S. Bement, IV.

* *Artificial Pyrite*.—In the analysis it was found to be most convenient to render the cassiterite soluble by fusing with a mixture of sodium carbonate and sulphur, at first at a very low temperature, and then for about ten minutes at low red heat. There was rarely more than a few milligrams of cassiterite left unacted upon which yielded readily to a second fusion. Thus all the tin and arsenic, and the greater part of the iron dissolved in water as sulpho-salts of sodium. In two instances in Analyses III and V b, I was interrupted in my work and the fusion at a low temperature was continued for five or six hours. When the mass was treated with water it dissolved with a yellowish-red color without dark green tint, and the washings also did not indicate that any iron sodium sulphide had gone in solution. The insoluble residue, however, showed the iron in the form of octahedral crystals or clusters of crystals of pale brass-yellow *pyrite*.

	I. a	I. b	II.	III.	IV.	V. a	V. b	VI.
Sp. Gr.	6.820	——	6.591	6.911	6.535	6.714	6.712	6.581
SnO_2	92.51	92.84	93.98	93.01	92.09	86.99	86.81	92.26
Fe_2O_3	4.18	4.12	5.62	5.82	5.45	11.56	12.73	4.58
As_2O_5	trace	trace	——	——	2.11	trace	——	1.25
CuO	——	trace	——	0.07	——	0.11	——	trace
ZnO	——	——	——	——	——	——	——	0.57
SiO_2	lost	2.70	0.23	1.07	0.66	0.57	0.52	0.44
Ignition	0.38	0.34	0.21	0.27	0.07	0.20	0.34	0.26
		100.00	100.07	100.21	100.38	99.43	100.40	99.36

b. Yellow variety.—It occurs like the red in imitative shapes, and evidently has been formed under similar conditions.

The color is from a pale brownish-yellow, honey yellow to a reddish brown, sometimes greenish-yellow, variegated in bands of paler and darker colors. Globular, reniform, frequently curved lamellar, in many cases the laminæ readily separating. Several of the reniform masses from 25 to 35^{mm} in size are really stalactites which have formed upon some unknown irregularly-shaped substance which has weathered out, leaving a cavity, others are flat and have deposited upon quartz, of which some remnants may often be seen. Fibrous, radiating.

The most interesting and apparently purest specimens came from Mina Varosa; it is also associated with the red variety in the Placer ores No. 6, rarely in microscopic botryoidal concretions in the sand from Mr. Schlemm, and also in the ores of the San Antonio mine, forming about one-fifth of the whole mass.

The following analyses have been made:

1. Globular, radiating from the centre; powder cream color. Mina Varosa, State of Durango, VII, a and b.

2. Reniform and lamellar, concentrically fibrous; powder cream color. Mina Varosa, VIII.

3. Flat, brownish-yellow, banded, fibrous, radiating, powder dark cream color; from the Placer ores No. 6, IX.

4. Laminated, reniform, fibrous, brownish-yellow; powder brownish cream color; from Dr. Joseph Leidy, X.

	VII. a	VII. b	VIII.	IX.	X.
Sp. Gr.	6.160	6.219	6.509	6.199	6.496
SnO_2	84.20	84.30	92.50	89.90	93 13
Fe_2O_3	1.31	1.55	0.22	0.10	0.20
As_2O_5	9.85	10.34	4.56	5.80	3.18
CuO	trace	trace	0.16	0.20	0.09
ZnO	3.05	2.95	1.89	2.43	2 71
SiO_2	0.35	0.30	0.24	0.55	0.43
Ignition	0.39	0.57	0.26	0.40	0.32
	99.15	100.02	99.83	99.38	100.06

The analysis of the heavier portion of the ore from the San Antonio mine shows 3.86 per cent of dioxide of tin which went into solution by treating the same with chlorhydric acid. As cassiterite is not acted upon by acids, it is difficult to perceive in which form this tin existed. Dissolving in the presence of a neutral solution of auric chloride gave not a trace of reduced gold, therefore neither tin nor arsenic were in the form of the lower oxides.

There is a sufficient amount of arsenic pentoxide present to combine with all the bases; the lead is evidently in the form of mimetite of which the calculated percentage would be 12.58 per cent, the zinc is probably there as adamite, and the amount of zinc oxide found would give 6.96 per cent of this mineral; no arsenate of bismuth has yet been distinguished as a mineral, but there can be no doubt that the bismuth in the San Antonio ore is present as Bi_2O_3, As_2O_5, H_2O, the salt which Salkowski has first described and analyzed (Journ. für Praktische Chemie, 104, p. 172), the bismuth oxide found would give 7.94 per cent of the hydrous arsenate.

The insoluble portion of the San Antonio ore contains 19.300 per cent of SnO_2 and 1.844 per cent of arsenic pentoxide. The atomic ratio between these would be = 16 : 1. To this I shall refer again further on.

The different varieties of cassiterite show a considerable variation in their specific gravity which, in part, is probably owing to cavities produced in the process of their formation. The arsenical varieties have all a lower specific gravity.

The analyses show that the red varieties are dioxide of tin, contaminated with ferric oxide, and only exceptionally containing an appreciable quantity of arsenic pentoxide, while the yellow varieties contain very little ferric oxide, but a far higher percentage of arsenic pentoxide and also invariably an admixture of zinc oxide.

It is difficult to perceive how these constituents in such variable quantities could be present in apparently perfectly pure and often highly crystalline minerals.

Excepting analysis V, in which the ferric oxide is double the amount of the average of the other analyses of the red varieties, which may be owing to the fact that the little crystals of hematite which have been observed being only slightly magnetic, were not completely separated by the magnet, they give the atomic ratio between $Fe_2O_3 : SnO_2 = 1 : 9$ and $1 : 12$. Although the ferric oxide cannot be extracted from the stannic oxide by chlorhydric acid, I cannot favor the idea of a definite compound existing between these oxides, and consider them only as mechanical mixtures. The high percentage of arsenic pentoxide, especially in the apparently purest and highly crystalline globular variety from Mina Varosa, and the constant presence of zinc oxide are very surprising. It suggests the idea that there might be a zinc salt of one of the complex inorganic acids consisting of tin dioxide with arsenic pentoxide. A calculation of the molecular ratios of these constituents gave for:

Analysis	VII—As_2O_5	:	SnO_2	:	ZnO	=	1	: 13	:	0.84
"	of San Antonio ore,					=	1	: 16	:	?
"	IX—As_2O_5	:	SnO_2	:	ZnO	=	1	: 24	:	1.2
"	VIII— "		"		"	=	1	: 31	:	1.1
"	X— "		"		"	=	1	: 44	:	2.36
"	IV— "		"		"	=	1	: 68	:	——
"	VI— "		"		"	=	1	: 123	:	1.4

This shows no rational proportions in the constituents of the cassiterite, and there is no other conclusion than that both arsenic pentoxide, ferric oxide and zinc oxide are admixtures of the tin dioxide, which is easily explained, if we bear in mind the tendency of this latter substance which at the time of its formation, precipitated and retained these oxides.

c. *Cassiterite, pseudomorphous after hematite.*—It has already been stated that little red crystals of cassiterite are sometimes found associated with those of hematite. From the sands of Mr. Schlemm a few highly interesting, but unfortunately very small specimens were obtained.

One, about 1^{mm} in size, consists of perhaps a dozen modified crystals of hematite, with the basal plane predominating, in which latter twin groups of pseudohexagonal red cassiterite are implanted ; the occurrence reminds one of rutil which frequently occurs in a similar manner upon the hematite (Eisenrose) from St. Gothard.

Another specimen consists of a group of tabular crystals, radiating from a centre, the whole group 3^{mm} in diameter, which is almost completely altered into reddish-brown brilliant cassiterite, leaving a small core of about 0.5^{mm} in size of unaltered hematite. About ten other pieces of the same kind, although far less perfect, have been observed.

d. *Cassiterite, pseudomorphous after magnetite?* — A little group of crystals from the ores of the Mina del Diablo— 5×3^{mm} in size, consists of crystals which are apparently isometric octahedrons, together with some botryoidal aggregations. The crystals are almost black, but mostly show an uneven surface, a color between brownish-yellow and yellowish-green and a waxy lustre, owing to a subsequent coating of reniform, botryoidal cassiterite upon the crystals. A fracture of the crystals shows the dark brownish-red color and lustre of the red cassiterite. The original mineral may have been magnetite. Only three of such minute groups have been found.

Of great interest in connection with these pseudomorphous forms of cassiterite are the observations of Mr. Wm. Semmons (published in London in the December number, 1883, of the Natural History Notes), who describes the coating of bismuthinite (Bi_2S_3) at the Fowey Consols Mine of Cornwall with thin layers of brownish cassiterite. In a letter dated London, August 19th, 1886, Mr. Semmons gives me fuller details about this occurrence as follows :

"The bismuthine (bismuthinite Dana) in this mine is found :

"1. As brilliant untarnished crystals.

"2. Crystals with a slight deposit of cassiterite on them.

"3. With the cassiterite coating the bismuthine in concentric layers, *wood tin.*

"All *wood tin,* the bismuthine having been carried away.

"You doubtless are familiar with the remarkable pseudomorphs of cas- "siterite after quartz which received for a short time the name of stannite "or silicate of tin from the late John Garby," &c., &c.

I should mention also the very interesting observation of microscopic crystals of cassiterite in the black zincblende of Freiberg, Saxony, described by Dr. A. W. Stelzner, and Dr. A. Schertel (Jahrbuch für Berg und Hüttenwesen im Königreich Sachsen auf das Jahr, 1886). The cassiterite in the variety "Nadelzinnerz" occurs associated with quartz crystals and sometimes implanted in the same, in minute and microscopic crystals and groups of crystals. Most of the forms are simple combinations of prisms and pyramids, and have no resemblance with the Mexican specimens. The whole occurrence indicates a simultaneous formation of the zincblende and cassiterite.

2. *Hematite.*

Both localities, the Mina del Diablo, and that in the Catatlan mountains from which the sands of Mr. Schlemm were obtained, furnished minute, sometimes very perfect, crystals of hematite, occasionally grouped in the form of "eisenrose." The crystals from Mina del Diablo are larger, at times from 2 to 3^{mm} in diameter and have the basal plane oR more fully developed.

The crystals from the sands of Mr. Schlemm are very minute, and I am indebted to Prof. G. vom Rath for the following information :*

Contrary to the general rule these very minute crystals, from 0.25 to 1^{mm} in size show a holohedral development with the second hexagonal prism $\infty P2$, striated parallel to the basal edge, prominent. The second pyramid $\frac{2}{3}P2$ (π in Miller's mineralogy, π : oR $= 137^\circ 49'$) dominates the polar development of these crystals. As combinations appear a more acute second pyramid $\frac{4}{3}$ P 2 (n in Miller, n : oR $= 118^\circ 53'$), R and $-\frac{1}{2}$R. oR appears from a mere point to a relatively large extension. Ironblack, powder brownish-red ; slightly magnetic.

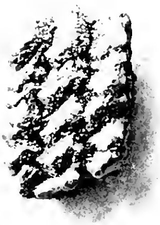
As already mentioned under cassiterite, that hematite is sometimes found in part or wholly altered into cassiterite.

* I have sent to Prof. vom Rath the crystals of hematite, above referred to, also the peculiar pseudomorphous crystals with mimetite composition and the first specimens which I had received of the vanadinite and descloizite from Oracle, in Arizona. He has taken such an interest in these occurrences that he communicated the results of his investigations to the "Niederrheinische Gesellschaft für Natur und Heilkunde zu Bonn," at the meeting of January 11th, 1886, which have been published by this Society. In the following pages I shall refer to these communications, as l. c.


1 a


2 a


3 a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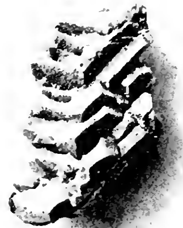
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7


8

Mimetite Pseudomorphs.

Magnified two diameters.

3. Mimetite and Pseudomorphs of Mimetite after Anglesite?

The greater portion of the ores Nos. 1 and 2 from the Mina del Diablo consists of crystals and crystalline aggregations of a white or yellowish-white mineral, rough to the touch, somewhat earthy in appearance, with a slight resinous lustre on a fresh fracture. These crystals have been picked out from a great mass of clay and are a great rarity, and even the crystalline aggregations, which occurred in somewhat larger quantities, are completely exhausted. At the Mina de San Antonio, a few but far less perfect crystals have been observed.

a. Mimetite.—Small fragments of finely granular, frequently cavernous concretions, the surface of which is coated with microscopic colorless crystals, have been found among the above mentioned ores Nos. 1 and 2. Similar crystalline coatings are sometimes observed upon the crystals, especially when in groups, which were better protected against corroding influences, and it is most likely that the whole mass of the pseudomorphous crystals consists of an accumulation of such microscopic crystals, so small, however, that a fracture would show only a compact mineral with a slightly waxy lustre. Cavities of the pseudomorphous crystals are also sometimes lined with colorless microscopic crystals. It was very difficult to observe any distinct forms; when magnified 60 diameters many hexagonal planes were seen, but only one crystal was observed which showed a short hexagonal prism, with a second hexagonal prism, a pyramid and basal plane. Several others were found of the same form without the second hexagonal prism. These crystals have a vitreous lustre and are undoubtedly *mimetite.*

b. Pseudomorphs of Mimetite after Anglesite?—The great bulk of the ore, however, is entirely different and consists of pseudomorphs which have apparently a rhombic form while their composition is that of mimetite. They are associated with stalactitic or botryoidal red cassiterite often in isolated crystals with all planes fully developed, upon it, or in crystalline groups or incrusting the same. The whole occurrence shows the more recent origin of the mimetite pseudomorphs.

Isolated crystals are rare, they are often cavernous and generally arranged in reticulated and skeleton-like groups. On a most excellent phototype plate by Mr. Frederick Gutekunst, I have given a few of the forms magnified two diameters which show best this peculiar arrangement: 1a, 2a, and 3a are the reverse of 1, 2, and 3.

Measurements of the best isolated crystals gave angles which suggested the idea that the original mineral was anglesite.

I have submitted these crystals and aggregations to Prof. G. vom Rath, who had the kindness to make the following measurements, which, together with his conclusions, he communicated, l. c. On account of roughness and imperfection of the surfaces of the crystals only approximate measurements were possible, which were made with the help of attached glass plates.

Considering the crystals as a combination of a macrodome **d** with a brachydome o, the approximately measured angles d : d in axis c = 101° 30′ and 102° 30′ and o : o in axis a = 103° 30′, 104° 36′ and 105° 30′, a form which is very close to that of anglesite, if we compare d with ½ P̄∞ (101° 13′) and o with P̆∞ (104° 24′).

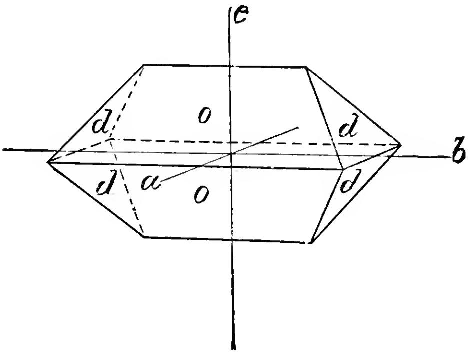


Fig. 9.

Prof. vom Rath is opposed to this view ; he would look upon it favorably if only isolated crystals had been observed, but would consider it very strange to find the skeleton-like formation and the reticulated arrangement of the aggregations in anglesite. He suggests that the primitive mineral might have been reticulated galenite, and he has been supported in this view by the late Prof. Websky, Prof. Descloizeaux and Dr. Hintze. Considering galenite as the primitive mineral, the apparently rhombic forms of these pseudomorphs would be distortions or irregular hemihedries of isometric forms, as it is well known how frequently galenite occurs in forms which have not the habitus of isometric crystals.

However, he was not able to reduce these oblongoctachedrons to normal planes of galenite, and notwithstanding the important opinions sustaining his views, Prof. vom Rath does not feel satisfied and expresses his manifest doubts by suggesting that, these forms might be pseudomorphs after a yet unknown rhombic mineral, having a tendency to occur in skeleton-like aggregations.

I have examined the reticulated galenite specimens in Mr. Clarence S. Bement's magnificent cabinet, but could not satisfy myself that the pseudomorphs under consideration could have resulted from such forms of galenite.

Reticulated galenite is of a rather rare occurrence, and such forms would not be known, if the few localities where it has been found would not furnish it. That anglesite has not been observed in such forms before, does not prove the non-existence of the same.

A suite of these pseudomorphous forms was sent by me to the Imperial

Mineral Cabinet in Vienna, and at my request, to give me his opinion, Dr. Aristides Brezina wrote me under date, Vienna, July 31, 1886 :

"The pseudomorphs are evidently after mendipite* and permit to determine the heretofore incomplete elements of this mineral with a fair approximation :

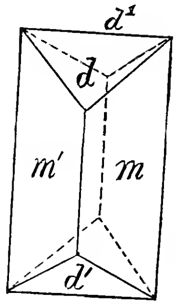


Fig. 10.

m : m' = 77° 19', mean of four measurements with the hand goniometer—mendipit measured 77° 24'.

d : d' = 102° 23', mean of four measurements with the hand goniometer—

from which it follows that the elements are rhombic.

$a : b : c = 0.8002 : 1 : 0.9948$ $\left(\frac{a}{c} = 0.8044\right)$ if m = (110); d = (101).

"At the same time the pseudotetragonal character is peculiar ; the difference of the parameters b and c lies within the errors of observation, but the habitus of the crystals speaks for the rhombic system."

I thought it best to give these different views, trusting that the future may furnish, by the discovery of the unaltered mineral, together with the pseudomorphs, the true explanation of this doubtful subject.

The analysis of these pseudomorphs shows them to be mimetite in which a small quantity of the lead is substituted by calcium. Even the purest have an admixture of clay, containing a minute quantity of dioxide of tin.

Analyses 1 and 2 were made by myself with material selected from the best crystals and apparently quite pure, 3 and 4 were made by Mr. Harry F. Keller, with apparently pure crystals.

	1	2	3	4
Spec. Grav. =	6.636	6.611	——	——
Cl =	2.47	2.38	2.43	2.43
PbO =	71.40	71.27	70.63	70.56
CaO =	0.57	0.34	not determined	
As_2O_5 =	24.97	24.58	24.82	24.57
P_2O_5 =	0.05	not det'd	0.09	not det'd
Clay with trace of SnO_2 =	0.65	0.85	1.44	1.89
Ignition =	0.37	0.47	0.60	0.49
	100.48	99.89	100.01	99.94
Less O, equivalent to Cl =	0.56	0.53	0.55	0.55
	99.92	99.36	99.46	99.39

* I have just received a letter from Dr. A. Brezina, dated: Wien, April 7, 1887, in which he admits it as an oversight to have considered the mimetite pseudomorphs as being after *mendipite*, and states that there is now nothing to prevent the acceptance of my original views that the primitive mineral was *anglesite*. F. A. GENTH.

University of Pennsylvania, April 20, 1887.

II. Vanadinite and Descloizite.

a. Mr. Charles R. Fletcher, of Boston, formerly Superintendent of the Mammoth Gold mine, near Oracle, Pinal county, Arizona, sent me about two years ago a highly interesting and fine variety of vanadinite and descloizite and subsequently, from a new occurrence, he presented me with a number of magnificent specimens of the same minerals, which, as for vanadinite, are some of the finest which I have seen, for all of which I am greatly indebted to him.

Of the first lot received I sent a small piece to Prof. G. vom Rath, who describes it (*l. c.*) as being composed of barrel shaped crystals with a brown nucleus, surrounded by a yellow coating of very fine aggregations of more recent growth, the druses and surfaces covered with exceedingly minute crystals of descloizite.

The vanadinite from this mine occurs upon quartz in crystals, varying in size from 0.1^{mm} to 8^{mm} in length, the smallest crystals are of a yellow color, which changes with their size increasing to an orange yellow, orange red, aurora red to a brownish-red, often variegated. Perfect isolated crystals are rare and generally small, they are mostly united to clusters and crystalline coatings upon the quartz; the crystals are often very much distorted and cavernous. The forms which I have been able to distinguish are the hexagonal prism with pyramid and basal plane, the latter frequently very small or entirely wanting.

Calcite sometimes surrounds the vanadinite and is again covered by vanadinite crystals.

b. A brownish-black and black descloizite from this locality covers in form of a crystalline coating in minute rhombic pyramids the reddish-white massive gold quartz, or is united to clusters of microscopic crystals upon and between the crystallized quartz. Upon these coatings of descloizite are the crystals of vanadinite, which again are covered with exceedingly minute crystals of descloizite. The yellow crystalline coating upon the brown nucleus, mentioned by vom Rath has often *no* nucleus of vanadinite, it is dull and of a yellow color throughout the mass of the hexagonal barrel-shaped crystals. Mr. H. F. Keller, who analyzed the brown and the bright orange red crystals from this locality (a, 1 and 2) found that the yellow mineral contains *no* chlorine. It is very probable therefore that the dull yellow crystals are pseudomorphs of descloizite after vanadinite.

Not enough of the descloizite could be obtained for analysis, qualitative tests however gave lead, zinc and traces of copper and manganese oxides with vanadium pentoxide.

c. A peculiar variety of vanadinite, much resembling pyromorphite, has been noticed in Yavapai county, Arizona, by Mr. J. C. Cooper, of Topeka, Kansas, who has sent specimens to the East. Mr. Clarence S. Bement kindly presented to me one, of which I have made the analysis given below (c). The crystals occur as a coating upon porous quartz, are barrel shaped prisms with basal plane, from very minute to not over 4^{mm} in size. Their color is from pale green to brownish olive green, small fragments are pale grayish green.

d. Mr. J. C. Cooper presented to me a small fragment of another variety from the same county. The crystals, not over 1^{mm} in size, are of brownish-red color, short hexagonal prisms with basal plane, on some a pyramid is slightly indicated. They cover a dark brown quartz. In some places is a very minute crystalline black coating upon the quartz, which may be descloizite.

e. A very interesting variety of a vanadate, which appears to be vanadinite, has been observed by Mr. J. C. Cooper, at the McGregor mine, Grant county, New Mexico. The specimen, for which I am indebted to him, consists of an impure, friable, earthy hematite, which is coated with crystallized calcite, frequently enveloping stalactites of the vanadium mineral, which is again covered by finely crystalline calcite. After removing the calcite by dilute acetic acid, the orange-yellow and orange-red stalactites remain. They are from 3 to 5^{mm} in length, and up to about 1^{mm} thick. When magnified 60 diameters, they show a core of some other mineral surrounded by scaly crystals of the vanadium mineral, the form of which could not be made out. A qualitative analysis showed lead oxide, vanadium pentoxide, and chlorine as the principal constituents, hence the conclusion that it may be vanadinite.

f. Prof. Albert H. Chester, of Hamilton College, N. Y., presented to me a few fragments of a yellow ferruginous quartz with a pale brownish crystalline coating, which appears to be descloizite, and upon it vanadinite in very minute crystals mixed with larger ones from 5 to 6^{mm} in length, and 0.5 to 1.5^{mm} in thickness, from Bald Mountain mine, Beaverhead Co., Montana. These crystals are hexagonal prisms with basal plane, some slightly barrel shaped, the greater portion of the crystals is of a dark greenish brownish color, their ends capped with almost transparent terminations.

g. In his Re-examination of American minerals, Am. Journ. Sc. [2], xx, 246, J. Lawrence Smith gives a description of vanadate of lead (descloizite?) from the Wheatley mines near Phœnixville, Pa., and an analysis of the same. He had only very impure material, mixed with a large percentage of wulfenite, etc., for examination, so that with the imperfect knowledge which we then (1855) had of descloizite, he expressed his doubt whether it was this species. I have examined a specimen which came from the late Mr. Charles M. Wheatley, at Phœnixville, and have no doubt of the correctness of Dr. Smith's determination.

Analyses of vanadinite. a, 1 and 2 by H. F. Keller; c by myself.

		a, 1. Brownish. From Mammoth Mine.		a, 2. Bright orange-red. From Mammoth Mine.		c. Brownish olive green from Yavapai County.
Sp. grav.	=	6.572	—	——	—	7.109
Cl	=	2.41	—	2.46	—	2.69
Fe_2O_3	=	0.48	—	——	—	0.04
CuO	=	——	—	——	—	0.18
PbO	=	77.49	—	77.47	—	77.96
V_2O_5	=	16.98	—	17.16	—	18.64
As_2O_5	=	3.06	—	4.30	—	trace
P_2O_5	=	0.29	—	trace	—	0.72
		100.71		101.39		100 23
Less O, equiv. to Cl.	=	0.55		0.56		0.61
		100.16		100.83		99.62

h. Variety of Descloizite, Cuprodescloizite, Ramirite, Tritochorite.— In 1883, Samuel L. Penfield (Am. Journ. Sc. [3] xxvi, 361) published the description and analyses of a mineral from Mexico as a variety of descloizite; at about the same time, C. Rammelsberg (Berl. Acad., Berl., 1883, 1215), under the name cuprodescloizite gave his analysis and description of the same mineral from San Luis Potosi in Mexico. In a pamphlet, "La Ramirita, nueva especie mineral, Mexico, 1885," D. Miguel Velasquez de Leon gave the same mineral the name ramirite, with an engraving showing its appearance and an analysis of the same.

In his paper Mr. Penfield referred to the great similarity of the appearance and the results of the analyses of his mineral with those of Frenzel's tritochorite. About two years ago Prof. F. W. Clarke presented to me a specimen of ramirite from San Luis Potosi, Mexico, and a year ago I had an opportunity to purchase, from Dr. A. E. Foote, a number of pieces which gave such an abundance of very pure material that I thought a re-examination desirable on account of great discrepancies in the amounts of water and the pentoxides of arsenic and vanadium as well as cupric oxide.

The mineral occurs as an incrustation from 1 or 2 to 10^{mm} in thickness, radiating fibrous to fine columnar. The form of the individual crystals cannot be distinguished, they are united into groups resembling the arrangement of cockscomb barite or prehnite. The color is dark yellowish-brown, and the surface has a dark color, and a velvety appearance; the fracture has a resinous lustre. Powder pale yellow. The spec. grav. = 6.203.

The analyses gave :

	1	2	3	Mean.	Ratio.	
Ignition =	2.59 —	2.65 —	2.62 —	2.62	0.146	
PbO =	54.89 —	54.35 —	54.31 —	54.52	0.244	
CuO =	6.34 —	6.78 —	6.63 —	6.58	0.083	} 0.240
ZnO =	12.70 —	12.84 —	12.56 —	12.70	0.157	
As_2O_5 =	3.63 —	3.57 —	3.70 —	3.63	0.016	
V_2O_5 =	19.77 —	19.75 —	20.45 —	19.99	0.110	} 0.125
P_2O_5 =	0.13 —	not determined	—	0.13	0.001	
	100.05			100.17		

For comparison I give the mean result of three analyses of Penfield, Rammelsberg's analysis of cuprodescloizite, Velasquez de Leon's analysis of ramirite and Frenzel's analysis of tritochorite.

	Genth.	Penfield.	Rammelsberg.	V. de Leon.	Frenzel.
H_2O =	2.62 —	2.70 —	2.52 —	—— —	——
PbO =	54.52 —	54.93 —	54.57 —	54.275 —	53.90
CuO =	6.58 —	6.74 —	8.26 —	8.690 —	7.04
ZnO =	12.70 —	12.24 —	12.75 —	11.250 —	11.06
As_2O_5 =	3.63 —	3 82 —	0.28 —	3.610 —	3.76
V_2O_5 =	19.99 —	18.95 —	22.47 —	19.850 —	24.41
P_2O_5 =	0.13 —	0.18 —	0.17 —	1.830 —	——
FeO =	—— —	0.06 —	——	Mn_2O_3 = 0.150 —	——
	100.17 —	99.62 —	101.02 —	99.655 —	100.17

My analyses agree very closely with those of Mr. Penfield and give exactly the formula of descloizite Pb_2 [HO] (VAs P)O_4 + $(ZnCu)_2$ [HO] (VAsP)O_4.

In Rammelsberg's analysis the greater portion of arsenic pentoxide has evidently been weighed with the vanadium pentoxide.

In De Leon's analysis the determination of water is omitted, while otherwise the results agree with ours although the copper oxide is about two per cent higher.

The physical characters of the mineral and some of the determinations of the trichorite agree so closely to cuprodescloizite that it would be desirable if Dr. Frenzel would repeat his analysis.

III. Pyrite pseudomorphous after Pyrrhotite.

In a highly interesting and important paper on "Natural solutions of gold, cinnabar and associated sulphides, by Geo. F. Becker" (Am. Jour. Sciences [3] xxxiii, p. 199 ff), the author shows the solubility of gold, cinnabar, pyrite and other sulphides in alkaline solutions containing sulphydrates, and suggests that these minerals, found at Steamboat Springs and Sulphur Bank and similar occurrences, have been deposited from such solutions.

Several months before this paper appeared, Mr. John F. Blandy sent me from the mines near Sulphur creek, Colusa county, California, a number of specimens, containing gold in minute arborescent crystals, and crystalline coatings upon quartz and chalcedony in a dark gray shale from the mines at that locality, also cinnabar and pyrite, which evidently have been deposited under similar circumstances as those mentioned by Mr Becker.

The pyrite is remarkable. It occurs in the same dark shale as the gold and appears in tabular hexagonal crystals, rarely reaching 1^{mm} in diameter. A few isolated crystals are very perfect, mostly however they are grouped together or one upon the other. Their color is pale brass yellow, they show very little lustre upon the basal plane, which is rather rough, but bright metallic lustre upon the prismatic planes.

A qualitative analysis showed them to be pyrite in composition, the form is that of pyrrhotite, they are therefore pyrite, pseudomorphous after pyrrhotite.

IV. Hessite.

An interesting variety of hessite has been found at the West Side mine, Tombstone, Cochise county, Arizona, and I am indebted to Mr. Samuel W. Cheyney for specimens for the same.

It is found in vein-like strings or patches in quartz, associated with cerargyrite in small crystals and crystalline coatings, a bluish green and a siskingreen mineral in too small a quantity for investigation, and minute grains of native gold. Color dark iron black; spec. gr. = 8.359.

Soluble in nitric acid without separation of gold.

In analysis 1, 0.61 p. c.; and in analysis 2, 3.98 p. c. of quartz were deducted, and gave :

		1		2
Ag	=	62.87	—	62.34
Pb	=	0 28	—	0 30
Fe	=	37.34	—	37.05
Se	=	trace	—	trace
		100.49	—	99.69

It is remarkable that no gold is combined with the tellurium, although metallic gold is associated with this hessite.

V. Tapalpite.

Prof. Carlos F. de Landero has given an account of the occurrence, the properties and the composition of tapalpite from the Sierra de Tapalpa (Boletin de la "Sociedad de Ingenieros" de Jalisco, Tom. v, Num. 3). From an analysis of it which Prof. C. Rammelsberg had made he came to the conclusion that the composition of this mineral is represented by the formula : Ag_2 S. Bi_2 Te_2.

This being exceedingly improbable, and a re-examination very desirable, Prof. C. F. de Landero has placed me under great obligations for specimens of this rare species, which have furnished the material for the following investigation :

It occurs at the San Antonio mine in the mineral district of San Rafael, Sierra de Tapalpa, Sayula Canton, State of Jalisco, Mexico.

It has a finely granular structure and a pale steel-gray color, inclining to lead-gray. Lustre dull metallic; soft.

Associated with pyrite, galenite, quartz and a silicate of aluminum and calcium, and so much intermixed with them that it was impossible to obtain pure material for analysis. The purest that could be selected was free from pyrite, but contained about 7 to 8 per cent of galenite and the same quantity of quartz and silicate. The specific gravity, which was found to be = 6 739, was approximately calculated for the pure mineral, and gave — 7.744.

Portions from two pieces, A and B, apparently equally pure, were analyzed. A by dissolving in nitric acid; B by fusion with sodium carbonate and sulphur—the sulphur in B was determined by fusion with sodium carbonate and nitrate, lixiviation with water and five times repeated evaporation with hydrochloric acid in order to reduce the tellurito tellurous acid and precipitation of the sulphuric acid by barium chloride. The tellurium was always weighed as tellurous oxide.

The portion A gave :

		1		2		Average.		Ratio.		
Ag	=	38 81	—	38.36	—	38.59	—	0.357	=	3
Pb	=	7.22	—	7.26	—	7.24	—			
Bi	=	24.97	—	25.13	—	25.05	—	0.119	=	1
Cu	=	0.23	—	0.19	—	0.21	—			
Te	=	17.43	—	lost	—	17.43	—	0.136	=	1.15
S	=	7.93	—	8.54	—	8.24	—			
S required for 7.24 Pb to form PbS					=	1.12	—			
S in tapalpite					=	7.12	—	0.226	=	1.85

$$Ag : Bi : (TeS) = 0.357 : 0.119 : 0.362 = 3 : 1 : 3$$

$$= Ag_3 Bi (STe)_3 \text{ or } 3 Ag_2 (STe). \quad Bi_2 (STe)_3$$

The above average analysis and the atomic ratio of the constituents found give the following percentages :

Ag	=	43.76	—	6 Ag	=	648	=	43.76
Bi	=	28.41	—	2 Bi	=	420	=	28.36
Te	=	19.76	—	2.3 Te	=	294.4	=	19.88
S	=	8.07	—	3.7 S	=	118.4	=	8.00
		100.00				1480.8		100.00

The portion B gave :

		1		2		3		Average.	Ratio.
Ag	=	39.54	—	39.34	—	39.35	—	39.41	0.365
Pb	=	6.13	—	6.28	—	6.25	—	6.22	
Bi	=	22.00	—	21.43	—	20.97	—	21.37	0.102
Cu	=	0.17	—	——	—	——	—		
Te	=	lost	—	18.53	—	18.53	—	18.53	0.145
S	=	7.16	—	——	—	——	—	7.16	
S required for 6.22 Pb to form PbS							=	0.96	
S in tapalpite							=	6.20	0.194

Ag : Bi : (TeS) = 0.365 : 0.102 : 0.339 = 3 : 0.84 : 0.93

This ratio makes it probable that the portion B had a slight admixture of telluride of silver.

Deducting galenite, &c., the analysis would give the following percentage :

Ag	=	46.09
Bi	=	24.99
Te	=	21.67
S	=	7.25
		100.00

Imperfect as these results may be on account of the noticed admixtures, there can be very little doubt that tapalpite is a normal sulpho-telluro-salt of silver and bismuth. Rammelsberg gives no lead in his analysis, and may have had purer material at his disposal ; it is to be hoped that such may be obtained for a subsequent investigation.

VI. Allanite.

A variety of allanite, closely resembling that from East Bradford, Chester county, Pa., and like the latter easily decomposed into a brown earthy powder, has been sent to me by Mr. J. A. D. Stephenson, who discovered it several years ago near Statesville, N. C.

The pure has a brownish-black color and a pitchy lustre. Associated with it are small zircons.

Mr. Harry F. Keller has made the following analysis :

Sp. Grav.	=	3.63	
SiO_2	=	31.685	
Al_2O_3	=	17.330	
Fe_2O_3	=	7.052	
Ce_2O_3, Di_2O_3, La_2O_3	=	18.990	of which about 5 per cent Ce_2O_3, the rest mostly Di_2O_3.
Y_2O_3, Er_2O_3	=	1.120	
FeO	=	10.110	
MnO	=	1.025	
CaO	=	10.785	

MgO	=	0.540
Na_2O	=	0.210
K_2O	=	trace
H_2O	=	1.460
		100.307

VII. Willemite.

A few specimens of this rare mineral have been discovered by Mr. J. C. Cooper, of Topeka, Kansas, at the Merritt mine, Socorro county, New Mexico.

It occurs in very small hexagonal prisms, the largest not over 0.5^{mm} in size, associated with barite, quartz, mimetite, wulfenite, cerussite and a blue coating of a cupreous mineral. The willemite crystals are sometimes isolated, colorless, or black with a colorless top, mostly in coatings or ridges of aggregations of crystals filling cavities in the barite and quartz. They show only the prismatic and basal planes, the prismatic sometimes slightly striated longitudinally. In druses of quartz the microscopic willemite crystals are united to clusters, the individual crystals barrel-shaped, with deep longitudinal striation terminating in a serrated basal plane or in a point.

The mimetite, which is associated with the willemite, is of a bright honey yellow color, crystallized in slender hexagonal prisms with pyramid, often without the basal plane, also united to clusters, which, on breaking, present a radiating structure.

The wulfenite has a reddish-orange color, the crystals are tabular, and show pyramids of the first and second order.

It was difficult to obtain a sufficient amount of the willemite, and only by selecting a larger quantity of the purest material, and partial crushing and washing off the lighter particles and purifying the heavier by picking, I succeeded in getting enough to leave no doubt about the accuracy of the mineralogical determination.

The analyses gave :

		1		2
Spec. grav.	=	4.098	—	——
Barite	=	0.69	—	0.69
SiO_2	=	29.16	—	28.72
PbO	=	2.04	—	1.98
CuO	=	0.50	—	0.48
Fe_2O_3	=	0.10	—	0.04
Zno	=	66.79	—	66.59
Ignition	=	1.18	—	1.18
		100.46		99.68

Analysis 1 gave 91.53, and analysis 2, 91.18 per cent willemite. Lead and copper are probably present as carbonates.

VIII. Hisingerite, pseudomorphous after Calcite.

Many years ago the late Julius E. Raht, of Cleveland, Tennessee, sent me a suite of minerals from the Ducktown mines, which he was then working. Among them was a specimen composed principally of the ores of that mine, pyrrhotite and chalcopyrite with a small admixture of zoisite, which was covered with crystals of calcite, in part altered into a dark brown mineral with resinous lustre. The calcite is in the form of irregular hexagonal prisms, showing planes of a scalenohedron, the smaller ones terminating in acute scalenohedrons. The largest crystals are about 20^{mm} in length and 10^{mm} thick. They all contain a nucleus of unaltered calcite, the hisingerite surrounding the core of calcite is from 2 to 4^{mm} in thickness. With a small quantity (0 2236 grm.) of fairly pure material I made an analysis, the results of which show that the pseudomorphous mineral belongs probably to hisingerite, gillingite or thraulite, if they are not all more or less pure varieties of the same species.

The analysis gave :

Loss by ignition	=	23.70
SiO_2	=	24.42
Fe_2O_3	=	49 02
ZnO	=	1.17
CaO	=	1.83
MgO	=	0.41
		100.55

University of Pennsylvania, March 16, 1887.

Synopsis of the Batrachia and Reptilia obtained by H. H. Smith, in the Province of Mato Grosso, Brazil.

By E. D. Cope.

(Read before the American Philosophical Society, March 18, 1887.)

The Naturalist Brazilian Exploring Expedition commenced its work in the province of San Paolo. From the neighborhood of Sao Joao do Rio Negro a collection of Batrachia and Reptilia was forwarded to the writer, and a list of them was published in the Proceedings of this Society, 1884, p. 185.* Mr. Smith then went into the interior, crossing the mountains into the province of Mato Grosso to Cuyabá, on the headwaters of the Paraguay river. After a short sojourn at this town, he selected for resi-

* In this collection there occurs a species of Pseudis which I had identified with the *P. paradoxa*. In comparison with the type of the *P. mantidactyla* the specimens turn out to belong to that species, as supposed by Dr. Boulenger.

dence the village of Chupada, thirty miles north-east of Cuyabá, and near the headwaters of the Xingu, an important tributary of the Amazon. The species embraced in the following list were obtained at or near this town. I reserve any general remarks to the close of the paper.

BATRACHIA.

Anura.

Arcifera.

1. Bufo margaritifer Laur. Abundant.

2. Scytopis allenii Cope. Proceeds. Amer. Philosoph. Soc., 1869, p. 162 Several specimens, representing a color variety, which lacks the lateral dark band.

3. Hyla melanargyrea, sp. nov.

Vomerine teeth in two small patches entirely between the choanæ, and scarcely reaching to the line of the posterior borders of the latter. Manus palmated to the discs of the third and fifth digits, but not to that of the third, and marking the basal third of the second ("first"). Pes webbed in much the same way; the web reaching the discs of the second, third and fifth digits, the middle of the penultimate of the first, and the base of the penultimate of the fourth.

The head is short, entering the length of the head and body, three and two-thirds times. Hind leg extended measuring the orbit with the heel. Hind foot short, equaling length of femur from groin. Fore-arm and foot, and tarsus and foot, with a free posterior edge, which has regular dermal thickenings, which give it a serrate appearance. The humerus is bound to the side by a dermal sheet which crosses the axilla to the middle of the posterior border of the former. Trace of a posterior dermal fold on the tarsus. No dermal process on the heel. Skin of upper surfaces with small scattered warts, which are most numerous and prominent on the sides. A pectoral fold from axilla to axilla.

The head is obtuse and depressed, with canthus rostralis not evident, and muzzle rather wide, and not prominent, but with vertical profile. Nostril terminal; side of muzzle as long as long diameter of orbit. Tympanic membrane round, three-fifths diameter of eye slit. Tongue subround, with an open notch posteriorly.

Color above, blackish gray, like a stain of dilute silver nitrate, with slightly darker areas included in darker lines. One of these is a large triangle whose base extends from one superciliary border to the other, and whose truncate apex is between the scapulæ: another is a large transverse area across the sacrum, which extends downwards and backwards on each side. Between these areas are several smaller ones on the back, and there is a large area on the side posterior to the axilla. An area encloses each canthus rostralis, enclosing with the large triangle a ⊥-shaped area of ground-color. There is a dark gray spot on the lip in front of the orbit, and a narrow one descending from the posterior part of the orbit. A dark line extends from the orbit above the tympanic drum to the axilla. Posterior side of humerus and axillary web, black, the color produced in an angle towards the middle of the thorax on each side. Groin, femur except lower surface, inferior side of tibia and hind foot, anterior face of tarsus and web of inner three toes, pitchy black. A row of five or six small, silvery gray spots on the superior surface of the femur and surrounding the vent. With this exception, the superior surfaces of limbs light gray with darker gray cross-bands with black edges; three on the tibia.

	M.
Length head and body	.039
" " to posterior line of tympana	.0095
Width " at " " " "	.013
Length of anterior limb anteriorly	.0265
" " " foot	.011
" " posterior limb from groin	.0575
" " " foot	.026
" " " " without tarsus	.016

This species belongs to the same group as the *Hyla marmorata* in the general characters of skin and coloration. It is however of more slender form, and has less extensive palmation. The color differs in the absence of the yellow, which is so conspicuous in the *H. marmorata*, and in other respects.

Three individuals.

4. Hyla velata, sp. nov.

Size small; head short, wide, muzzle obtuse, not prominent, not long as the diameter of the eye. Nostril terminal. Tympanic membrane not very distinct, diameter not more than one-third that of the eye-slit, in some specimens one-fourth. Canthus rostralis not distinct, vomerine teeth between choanæ, not projecting posterior to the line connecting them. Tongue subround, with an open median notch behind.

The length of the head to the line connecting the posterior borders of the tympanic membranes, is contained in that of the head and body three and a half times. The hind leg when extended marks the end of the muzzle with the heel. The skin of the upper surfaces is smooth. An extension of the skin of the sides binds the humerus by its proximal half. There is a web between all the fingers which does not reach the discs of the third and fifth, being less than a half palmation. The web of the pes does not quite reach the discs of the digits excepting the fourth, where it leaves two and a half phalanges free. No dermal fold on the tibia or fore-arm.

Color above golden-brown, with a large patch finely dusted with dark brown, with a narrow dark-brown border, extending from between the eyes to the middle of the back, and sending a broad branch down to the middle of each side without defined inferior border. The outlines are contracted at the suprascapular region, leaving a wide band of the paler ground color between it and a black line posterior to the eye. A very convex crescent-shaped area extends forwards from the posterior parts of the iliac region on each side, presenting a convexity forwards on the sacrum. Lips, sides, humerus and femur thickly dusted with brown, and without other spots or marks. Fore-arm and tibia with dark-brown cross-bars; on the latter narrow, and four in number. A pale border on external edge of foot from heel. Inferior surfaces cream-colored, immaculate.

	M.
Length of head and body	.023
" " " to posterior line of tympana	.0068
Width " " at " " " "	.0084
Length of fore leg	.014
" " " foot	.006
" " hind leg	.0385
" " " foot	.017
" " " " less tarsus	.009

There is a good deal of affinity between this species and the last. The differences are as follows: In *H. velata* the posterior legs are longer, and the manus is less palmate. There are no dermal borders on the limbs. The femur is unspotted, and the black color so conspicuous in the *H. melanargyrea* is absent. The dimensions are strikingly different, the species just named having nearly twice the linear measurements of the *H. velata*.

Four specimens.

5. Hyla nigra, sp. nov.

Habit moderately slender; heel reaching end of muzzle. Length of head to posterior borders of tympana, enters length of head and body three times. The urostyle and pelvis are rather short, the former equaling the length of the head to the line of the posterior border of the orbits. The muzzle is slightly acuminate when viewed from above, and projecting beyond the mouth in profile. The canthus rostralis is concave, and the orbit is just as long as the muzzle. Nostrils subterminal. Tympanic drum round, one-fourth the diameter of the orbit, and bounded above by a dermal fold. Vomerine teeth in two fasciculi between the nares, their posterior edges a very little behind the borders of the latter. Tongue subround, with an open notch in the free border.

Digits of manus entirely free; the fourth quite long, and the fifth exceeding the third in length. Second digit opposed to third. Dilatation of fourth digit just fitting within border of tympanic disc. Toes webbed to the dilatations of the second, third and fifth digits, and to the base of the antepenultimate phalange of the fourth and first.

Skin with numerous short longitudinal and not very prominent warts on the superior surfaces of the head and body. No distinct axillary membrane.

Superior surfaces uniform black. Gular region, inferior surface of thigh and tarsus dusted with dark brown. Posterior part of side, front and hind face of femur and inferior face of tibia, more or less closely marbled with brown on a white ground, the brown predominating on the posterior face of the femur. The brown dusting extends across the inferior surface just behind the axillæ. Concealed surface of pes and web, marbled dark brown and white. The coloration is peculiar in that the superior surfaces of the humerus and tibia are colored like the rest of the body.

	M.
Length of head and body	.034
" " " to posterior line of tympana	.010
Width " " at " " " "	.013
Length of fore leg, on front	.022
" " " foot	.011
" " hind leg, from groin	.057
" " " foot	.026
" " " " minus tarsus	.010

This species approaches the genus Scytopis in the very narrow fronto-parietal frontanelle.

6. HYPSIBOAS BOANS Daudin.

One specimen rather smaller than usual. The femur is brown posteriorly, with small scattered yellow spots.

7. HYLODES CONSPICILLATUS Günther.

Hylodes guentheri Steindachner. Verh. Zool. Bot. Gess. Wien., 1864, p. 246, Pl. xvii, fig. 1.

Numerous individuals, all with the posterior face of the femur unicolor.

8. PALUDICOLA NATTERERI Steind.

A very abundant species, always without tarsal spur as described by Steindachner. The lumbar gland is black with a white border, and the groin below it and the posterior face of the femur is beautifully marbled with black on a white ground. Vomerine teeth none. Tongue subcylindric.

9. PALUDICOLA KROYERI R. & L. *Liuperus sagittifer* Steind.

Three specimens, two with the oblique longitudinal bands described by Steindachner, and the other unicolor above, having only the black lateral band extending from the end of the muzzle.

10. PALUDICOLA SALTICA, sp. nov.

Characterized by the great length of its posterior legs. It has the form of the North American Acris, and is probably like it, a great jumper.

Muzzle narrowly acuminate, and projecting a little beyond the lip border. No canthus rostralis; nostril looking partly upwards, half way between end of muzzle and orbit. Interorbital space not wider than eyelid. Tympanic membrane not distinguished. Tongue diamond-shaped with rounded angles, extensively free and entire behind. No vomerine teeth.

Hind legs long; when extended the muzzle marks a little beyond the middle of the tibia. Second finger shorter than third. Toes with a dermal margin. Two metatarsal tubercles, both small, the internal larger and subconical, and giving origin to a dermal fold which extends to the middle of the tarsus. No tarsal tubercle. Skin of upper surfaces and sides with numerous small warts. Inferior surfaces smooth.

Color of adult dark-brown on superior and lateral surfaces, of younger individuals gray. The median dorsal region is marked with a wide black or dark-gray tract with undulating borders from between the eyes to the end of the urostyle, and this is again divided in many specimens by a median white band which extends from the vent to the end of the muzzle. In the adult the femur has one, and the tibia has two blackish cross-bands, and the superior edge of the tibia is pale-colored on its distal fourth. Posterior face of femur, and superior face of humerus, pale-brown. Posterior foot with numerous brown cross-bands. Below white (inferior surfaces of hind legs possibly yellow in life); the lower lip black all round, the color advancing towards the throat on each side. This mark is present on all the specimens.

	M.
Length of head and body	.020
" " " to posterior line of tympana	.007
Width " " at " " " "	.007
Length of fore limb	.012
" " " foot	.005
" " hind limb from groin	.0413
" " " foot	.020
" " " " without tarsus	.013

One adult and several young specimens. Readily distinguished by its very long hind legs, peculiarly shaped head, etc.

11. Paludicola mystacalis, sp. nov.

Size small. Heel of extended hind leg reaching to front of orbit.

Muzzle a narrow oval as viewed from above, a little longer than the diameter of the orbit, and not projecting beyond the lip-border. Canthus rostralis indistinct. Interorbital space wider than eyelid. Gape of mouth wide. Tongue narrow, extensively free, entire behind. Nostrils two-fifths way from end of muzzle to orbit. Tympanic disc concealed. Second finger ("first") shorter than third, which is in turn a little shorter than fifth. Two large palmar tubercles. Terminal phalanges not shorter nor expanded at the extremities, but obtuse. The close contact of the third, fourth and fifth metatarsals gives the foot a narrow form, especially as the first and second digits are short. The other digits, especially the fourth, are quite slender, with elongate narrowed terminal phalanges as in Leptodactylus. No dermal margins. Skin generally smooth; no discoidal ventral fold.

Color of superior surfaces and sides, black. A broad white band extends from each eye to the groin; it is distinct in the young, obscure in the adult. It is bounded below by a black band which widens near the axilla. A white line extends on the middle line from the extremity of the muzzle near the end of the urostyle. In the young it sends off a little branch on each side to the eyelid. The upper lip is marked as follows: A white vertical bar marks the middle of the premaxilla; two bars are below the nostril, and two larger ones below the eye. A short distance behind the latter a white stripe commences and extends to the axilla. The superior face of the femur is pale longitudinally; the posterior face is brown, with a pale longitudinal band in the centre. Under surfaces white, except that the throat and breast are faintly brown spotted. The femora are similarly brown spotted in an oblique tract from the anus to the anterior aspect of the knee.

	M.
Length of head and body	.0172
" " " to line of tympana	.0057
Width " " at " " "	.0052
Length of anterior limb	.009
" " " foot	.0047
" " posterior leg from groin	.0267
" " " foot	.0135
" " " " minus tarsus	.009

But three specimens of this species was obtained by Mr. Smith, and these are of small size. All their parts are, however, fully ossified, and its characters developed.

12. Paludicola ameghini, sp. nov.

No lumbar gland nor tarsal tubercle, nor vomerine teeth. Skin covered with large flat warts irregularly arranged.

Muzzle short and acuminate; no canthus rostralis; muzzle not projecting in profile. Nostril half way between its extremity and the orbit. No membranum tympani. Interorbital space a little wider than eyelid. Second finger shorter than third. Extended hind limb reaching with the heel half way between orbit and nostril. Two metatarsal tubercles small but distinct, a diagonal fold extending from the internal to the middle of the tarsus. Toes with narrow dermal margins, and a short web at the base. Soles smooth. General form robust.

Color of superior surfaces and sides, a lighter or darker lead-color. There is a dark band extending from one superciliary border to the other, and there are indirect cross-bands on the hind legs. Very indistinct light bars on upper lip. Below white, the border of the lower jaw densely marbled with blackish. Posterior face of femur dark, with a longitudinal pale line near the inferior side.

		M.
Length of head and body	....	.0155
" " " to line (posterior) of tympana	....	.0055
Width " " at " " " "	....	.005
Length of anterior leg	....	.009
" " " foot	....	.004
" " posterior leg	....	.0258
" " " foot	....	.012
" " " " less tarsus	....	.008

This species belongs to the group of *P. marmorata* of Boulenger's system. Two specimens.

Dedicated to my friend Dr. Florentine Ameghino, the distinguished naturalist of Buenos Ayres.

13. Leptodactylus gracilis D. & B.

One rather large individual.

14. Leptodactylus brevipes, sp. nov.

Form rather stout, legs short. The heel of the extended hind leg reaches to the middle of the orbit, and the foot is as long as the rest of the leg measured to the groin.

The outline of the head from above is an acuminate oval. The muzzle projects a little beyond the lip when viewed in profile. The top of the head is flat, but the canthus rostralis is so obtuse as to be scarcely noticeable. The nostril is almost terminal, and as far from the orbit as the diameter of the latter. The tympanic membrane is round, and is equal to two-thirds the orbit in diameter. The vomerine teeth are in two short, nearly transverse patches, well behind the internareal palatal space. The tongue is a wide oval, slightly emarginate behind.

The second, fourth and fifth fingers are equal in length. The toes contract to their extremities, and have a membranous border on each side and a rudimental web at the base. The external border of the external toe is continued along the external edge of the sole of the calcaneum, terminating near a small, round tubercle. The internal tarsal tubercle is an oval, attached by one side. There is an obtuse dermal ridge extending along the inner edge of the tarsus.

There is a strong dermal fold above the tympanic membrane, which is deflected towards the humerus. Another ridge extends from the eyelid to above the axilla. Another ridge commences a short distance from the end of the last mentioned, and ceases just above the groin. Skin of superior surfaces with numerous small warts, below, except adjacent parts of femora, smooth. A discoidal fold of abdominal integument. All the ridges and warts of the upper surface might readily disappear on prolonged preservation in weak alcohol.

The color of the upper surfaces is a blackish brown, which does not extend on the sides, but forms a dark band from the eye through the tympanum to near the shoulder. There is a paler band across the front between the eyelids, bounded posteriorly by the base of an indistinct dark triangle, which is darker than the rest of the back. The lips are clouded, and there is a vertical pale line on the end of the muzzle, and a similar one on each side of it below each nostril. The ground color of the legs is gray. The humerus is uniformly pale, but the fore-arm is blackish speckled. There are four wide blackish cross-bands on the femur, and three on the tibia. Femur behind closely marbled with black on a dirty whitish ground. Inferior surfaces straw-color, with indistinct brown speckles on inferior face of tibia, femur, and lower jaw. The sole is blackish from the heel, and there are five blackish cross-bands on the outside of the foot. Groin marbled with black, and a few shades in the axilla.

	M.
Length of head and body	.054
" " " to posterior line of tympana	.015
Width " " at " " " "	.020
Length of fore leg	.025
" " " foot	.011
" " hind leg from groin	.074
" " " foot	.031
" " " " less tarsus	.024

Though allied in important characters to the *L.* (*Crossodactylus*) *gaudichaudii*, the differences are numerous, to judge from the description given by Boulenger (Catal. Bat. Sal. B. M., p. 249). The well-developed vomerine teeth, the terminal nostril, the weak tarsal tubercles and the ventral discoidal fold are some of these.

One specimen.

15. LEPTODACTYLUS GLANDULOSUS, sp. nov.

Small ; extended hind leg reaching middle of eye. Toes without dermal margins. Vomerine teeth in two transverse fascicles well behind the line connecting the choanæ.

Muzzle narrowed, somewhat prominent, rounded transversely and without distinct canthus rostralis. Nostril two-fifths the distance from the extremity of the muzzle to the eye. Tongue oval, entire posteriorly. Tympanic drum one half diameter of eye-slit. First finger not longer than second. Metatarsal tubercles two, both very small. Palm and sole tubercular, the latter rough with pointed warts. Interorbital width equal that of eyelid. Skin smooth, excepting two rows of glands or glandular warts, one on the upper part of the side, extending from above the humerus to the groin, and the other above it, which terminates in a number of low warts on the posterior iliac region. Numerous similar warts on the side below the inferior glandular ridge. A groove from the eye above the tympanum towards the humerus bounds the lower side of a glandular dermal thickening.

Color blackish, dark-brown, or light-brown above, with a median whitish line which is wanting from the anterior part of the body or head. The lighter specimens have numerous dark-brown spots on the lighter ground above. Several light vertical lines on the lip. Femur behind obscurely and finely marbled. The concealed edge of the tibia and tarsus dark cross-banded on a light ground. Below dirty white, dusted with brown on the legs, sides and gular region, and frequently on the abdomen also.

	M.
Length of head and body	.024
" " " to posterior line of tympana	.0075
Width " " at " " " "	.0082
Length of fore leg	.0115
" " " foot	.0045
" " hind leg from groin	.032
" " " foot	.0155
" " " " minus tarsus	.0102

Fourteen specimens.

FIRMISTERNIA.

16. ENGYSTOMA OVALE Schn.

17. DENDROBATES BRACCATUS, sp. nov.

Small. Second digit of manus ("first") much longer than third ("second"). Skin tubercular. Muzzle overhanging lip, but not much produced, truncate on superior view, about as long as diameter of orbit. Nostril nearly terminal. Tympanic disc less than half diameter of eye. Interorbital space much wider than eyelids. Tongue cylindric, entire. When the fore leg is extended, the muzzle marks the middle of the fore-arm. The muzzle marks the heel of the extended hind leg. Digital expansions of foot smaller than tympanum, and larger than expansions of fingers. The tuberosities of the upper surfaces are not prominent and in a soft specimen they have disappeared entirely. Skin of back very porous; no distinct glandular folds.

Black above, with a white line extending from one groin to the other, over the tympanic drum, on the edge of the eyelid, and round the end of the muzzle. Sides of head and body black; a narrow white line commencing below the nostril and extending to the humerus. Behind the humerus a large pink spot, followed by a wide irregular light band to the groin. A large pink spot in the groin and extending over the adjacent part of the femur. This spot is sometimes obscured by dark bands running across it. Limbs dark colored above, the posterior face of the femur similar, sometimes a bright spot under the knee. Under side of tibia with pink areas enclosed by black boundaries. Borders of abdomen and front of femur with small black dots. In some specimens there is a trace of two pale lines on the back about equidistant from each other and from the superior lateral lines.

	M.
Length of head and body	.022
" " " to posterior edges of tympana	.007
Width " " at " " " "	.007
Length of fore leg	.014
" " " foot	.006
" " hind leg	.0305
" " " foot	.015
" " " " less tarsus	.0098

This species agrees in most of its characters with the *D trivittatus* Spix., but is very much smaller, not measuring half its linear dimensions. As the specimens are, according to Mr. Smith, adult, they must be regarded as specifically distinct. It is also related to the *D. hahneli* of Boulenger,* but differs in the considerably shorter posterior limbs.

The singular manner in which this species carries its larvæ is described by Mr. Smith in the American Naturalist, for April, 1887. The latter are carried, closely packed, embedded in a coating of gelatine, on the back of the parent. This constitutes a method of nursing distinct from any of those enumerated by Mr. Boulenger in his recently published table.

It approaches nearest the habit of the *Pipa monstrosa*, which also carries the young on the back. But, as is well known, the skin itself and not a gelatinous secretion, encloses the eggs and retains the young until the metamorphosis is complete in that species.

Several larvæ accompany one of the specimens of this species, which are stated by Mr. Smith to have been adhering to its back when it was taken. They do not resemble those of Pipa, but rather those of a Rana or Bufo. The branchial opening is on the left side, and no limbs are developed. The tail is long. The mouth is not peculiar. The decurved lower lip is present, and is furnished with two transverse series of bristle-teeth. A single series of the same extends entirely across the superior labial region, above the upper horny jaw. The papillæ are rather long, and extend all round the inferior lip, and for a short distance on each side at the lateral end of the upper lip; the series presenting an entering angle opposite the mouth.

This species is described and figured† by Steindachner in the Verhandl. der k. k. Zoolog. Botan. Ges. in Vienna, 1864, p. 258, who refers it to the *D. trivittitus* ("*nigerrimus*"), under the impression that the specimens before him are not adult. He states that the latter were labeled *Dendrobates braccatus*, by Dr. Fitzinger. This name is not adopted by Steindachner, but I use it in order not to simplify the synonymy.

18. Prostherapis brunneus, sp. nov.

Viewed from above the end of the muzzle is rounded, but it is angulated at the nostrils. In profile it is vertical, as is also the loreal region.

* Proceeds. Zoöl. Soc. London, 1883, p. 636. Pl. lvii, fig. 4.

† Plate xiii, fig. 2.

Canthus rostralis obtuse. Muzzle longer than diameter of orbit; nostril marking two-fifths distance from ear to orbit. Interorbital space wider than eyelid. Tympanum concealed. Tongue obovate, extensively free and e tire behind.

Digital enlargements distinct; two metatarsal tubercles small and subequal. Second ("first") finger equal to second. Skin with numerous small low glandular warts, easily obscured by stretching. The heel of the extended hind leg reaches the front of the eye.

Color of superior and lateral surfaces brown; a darker brown tract commences between the eyes and extends to the middle or end of the urostyle, with contractions of width on the nape and in front of the sacrum. A nearly black band extends round the end of the muzzle on the side of the head and body to the groin. Only one, a wide brown band across femur, between which and the anal region is a pale space. The inner edge of the band becomes a blackish spot in front near the groin. One brown band across tibia; several bands on tarsus. Femur brown with many light points posteriorly. Inferior surfaces unspotted white.

	M.
Length of head and body	.019
" " " to line of tympana	.006
Width " " at " " "	.006
Length of anterior leg	.0108
" " " foot	.004
" " posterior leg from groin	.0265
" " " foot	.0125
" " " " minus tarsus	.0074

Numerous specimens, mostly young.

The discovery of this species is of much interest, as it gives the genus Prostherapis a continental distribution. First detected in the extreme north-west of the Colombian district, it has been identified by Boulenger next from Ecquador,* and later from northern Peru.† To the present time the latter is the most eastern locality known for it.

LACERTILIA.

19. Anolis fuscoauratus D. & B. One specimen.
20. Anolis binotatus Peters; Boulenger, Catalogue. Abundant.
21. Polychrus acutirostris Spix. Abundant.
22. Scartiscus caducus Cope. Two specimens.
23. Microlophus spinulosus Cope. Abundant.
24. Ecphymotes torquatus Spix. Not rare.
25. Hoplocercus spinosus Fitz. One specimen.
26. Tupinambis teguexin L.
27. Ameiva surinamensis L. Abundant.

* Catl. Batr. Sal., Brit. Mus., 1882.
† Proc. Zoöl. Soc. London, 1883, p. 635.

28. CNEMIDOPHORUS OCELLIFER Spix. Three.
29. PANTODACTYLUS SCHREIBERSII Wiegm. Two.
30. CERCOSAURA OCCELATA Wagl. One.
31. EMŒA FRENATA Cope. Abundant.
32. AMPHISBÆNA ALBA L. Abundant.
33. LEPIDOSTERNUM MICROCEPHALUM Wagl.

OPHIDIA.

TORTRICINA.

34. TORTRIX SCYTALE L.

ASINEA.

35. BOA CONSTRICTOR L.
36. APOSTOLEPIS ERYTHRONOTUS Peters; *Elapomorphus erythronotus* Peters, Monatsberichte K. Akad. Wiss., Berlin, 1880, 222.

Subspecies LINEATUS Cope.

This form agrees exactly in pholidosis with Peters' description, above cited, of specimens from San Paolo, but differs much in coloration. It presents five longitudinal brown lines on the upper surface which mark the third and fourth, the fifth and sixth, and the median rows of scales respectively. In the adult, the line on the fifth and sixth rows is obsolete. The inferior surfaces are immaculate, except that the black collar is visible on the sides of the neck, from below. In the form *erythronotus*, the gastrosteges have black centres, according to Peters.

37. RHYNCHONYX AMBINIGER Peters, Monatsber. Berlin Akad. Wiss., 1869, p. 437.

Subspecies VITTATUS Cope.

This form differs from the typical form described by Peters, in having longitudinal color bands. These are dark-brown, and are located on the fourth, sixth and median rows of scales respectively, occupying only the middle of each row. The space between the sixth rows of opposite sides is pale brown; external to the sixth row and below, dirty white. The entire coloration is so like that of the young of *Apostolepis erythronotus lineatus*, as to be a case of mimetic analogy.

The present specimen confirms the correctness of the locality given by Peters.

38. TANTILLA PALLIDA, sp. nov.

Postocular plates two, labials seven, the posterior elevated and separated from the pariëtal by one and a part of another temporal. Postnasal and preocular plates well separated.

Characters normal. Postnasal bounded below by first labial, behind by second labial, which reaches frontal. Preocular deeper than long. Third and fourth labials bounding orbit, the latter also bounding inferior postocular below. Fifth labial higher than wide; the sixth of equal height, which equals the middle; the seventh largest of all, a little higher than wide (or long). A large temporal bounds the fifth and sixth above, and a narrower one the seventh above, by its anterior third. Inferior labials seven, the fourth much the largest; the first of opposite sides separated by the symphyseal. Postgeneials shorter than pregeneials. Frontal with produced posterior angle; pariëtals elongate. Gastrosteges 148; anal 1–1; urosteges 57.

Color very pale brown above, white below. Top of head black; a broad black collar incomplete below, and connected with the head color on the middle line. A white spot on labial below nostril; another below and behind orbit, which extends to the last superior labial, and connects with the pale collar. Edges of scales on sides, brown-dusted.

Total length 285; of tail 65mm., or a little less than one-fourth the total. One specimen.

39. Rhadinæa occipitalis Jan. *Enicognathus occipitalis* Jan., Iconogr. Gen. des Ophidiens Livr., 16; Pl. 1, fig. 1. Two specimens.

40. Apoprophis almadensis Wagl. Abundant.

41. Opheomorphus brachyurus, sp. nov.

Form robust, tail remarkably short, constituting less than one-sixth the total length. Head wider than the neck, muzzle rather short.

Rostral plate rounded, visible from above. Internasals as long as prefrontals, the median sutures of both not continuous, but each oblique to the middle line. Frontal narrowing behind; the pariëtals not longer than the frontal, emarginate at the point of union posteriorly. Loreal plate much higher than long. Preocular narrow, not or barely reaching frontal. Postoculars two, the inferiors quite small. Temporals 1–2. Superior labials eight; the third narrowed; fourth and fifth entering orbit; the last three large, the seventh higher than long. Inferior labials ten, sixth largest. Geneials unequal, the posterior pair short. Scales small, poreless, in 19 longitudinal rows. Gastrosteges 153; anal 1–1; urosteges 39. Measurements, No. 1, total length 371mm.; tail 55mm.; No, 2, total 435 mm.; tail 67mm.

Color, above bright green; below pale yellow. No markings. On the superior labial plates the green and yellow pass into each other.

This species is allied to the *Opheomorphus typhlus*, but has a relatively much shorter tail. It is a much more robust snake than the *O. jægeri* and it does not possess the brown dorsal stripe of the latter.

Two specimens.

42. Opheomorphus meleagris Shaw; subsp. doliatus Wied.

A large specimen in the which the black annuli are so wide as to nearly meet on the dorsal region, leaving only traces of the ground color between them. I have often had occasion to observe that this annulate coloration characterizes adults as well as young.

43. Liophis reginæ L., var. with unicolor pariëtals.

44. Erythrolamprus venustissimus Wied.

45. Dipsas cenchoa Linn.

46. Sibon annulatum Linn.

47. TACHYMENIS STRIGATUS Gthr. *Tomodon strigatus* Günther; *Tachymenis hypoconia* Cope, teste Boulenger.
48. OXYRRHOPUS TRIGEMINUS D. & B.
49. OXYRRHOPUS RHOMBIFER D. & B.
50. OXYRRHOPUS PETALARIUS Linn.
51. LEPTOGNATHUS TURGIDA Cope; var. in which the top of the head is uniform blackish.
52. SPILOTES CORAÏS Linn.
53. HERPETODRYAS CARINATUS L. Abundant.
54. DRYMOBIUS PANTHERINUS Merrem.
55. DIRRHOX LATIVITTATUS, sp. nov.

The generic name Dirrhox is proposed as a substitute for Callirhinus Girard, a name used by Cuvier for a genus of seals. The type is *Dirrhox patagoniensis* Girard, which is described in the report of the U. S. Exploring Expedition under Commodore Wilkes (1858, p. 139). It is a terrestrial form of Philodryas with two loreal plates one above the other. The name was first proposed in my catalogue of the Batrachia and Reptilia of Central America and Mexico, Bulletin U. S. Nat. Museum, No. 32, 1887, Index. At the same time (l. c.) I propose the generic name Atomophis for the *Philodryas trilineatus* of Burmeister (*Dryophylax burmeisteri* Jan.), in which the loreal plate is wanting.

The *Dirrhox lativittatus* is a handsome species of moderately slender proportions, and with the head little distinct from the body. The scales are in nineteen longitudinal series, and each has a single apical pit. Muzzle rather narrow, rounded and not truncate, the apex of the rostral plate appearing on a view from above. The internasals are as wide as long, and the prefrontals a little longer than wide. The frontal has concave lateral borders, and is about as wide as the superciliaries, and as long as the occipitals. The nasals are subequal, and the loreals are placed the one directly above the other. The inferior is parallelogrammic and horizontal, while the superior is shorter and a little higher behind than before. The oculars are 1–2. The preocular is much wider above than below, and reaches the frontal. The superior postocular is larger than the inferior. The temporals are 1–2–3. The superior labials are eight in number, the fourth and fifth forming the inferior boundary of the orbit. Inferior labials eleven, the sixth largest, and in contact with the postgeneials, which latter are a little longer than the pregeneials. Gastrosteges 184; anal divided; urosteges 82.

The ground color above is a pale brown, which changes to olivaceous on the head. A narrow black line passes from the eye along the superior edges of the posterior labial plates, and immediately behind them widens out into a brown band, which soon occupies three and two half rows of scales, beginning with the first row. This extends to the vent where it covers two and two half rows, and still narrower to the end of the tail. A brown dorsal band commences in irregular spottings, a length of the head behind the same, and soon becomes solid, covering three and two half scales to opposite the vent. It then contracts and continues to the end of the tail. A narrow black band extends from the gular region to the end of the tail across the ends of the gastrosteges, and is separated from the brown lateral band by a yellow stripe. Inferior surfaces unspotted, but shaded delicately with dusky. The centres of the scales of the first and second rows on the neck have a black central line, as have several scales on the throat and gular region. Some small black spots on the fourth, fifth and sixth superior labial scuta.

Total length, M., .668; length of tail, .153; of mouth to canthus, .016.

This very pretty species resembles the *Atomophis trilineatus* Burm., and the *Philodryas tæniatus* Peters. Besides the peculiarity in the double loreal plates, it differs from the former in the rounded muzzle. It is obliquely truncate in the species of Burmeister. According to Jan's figure the latter has the seventh superior labial a little longer than high, while in the *D. lativittatus* it is higher than long. The inferior lateral yellow stripe in the *A. trilineatus* is not black-bordered below. In the *Philodryas tæniatus* the preocular plate is scarcely visible from above; there are only seven superior labials, and the scales are said to be without pits.

56. Philodryas nattereri Steindachner. Sitzungsber. d. K. K. Akad. Wissensch. Wien, 1870, p. 20; Pl. vii, figs. 1–2. Not rare.

57. Philodryas viridissimus L.

58. Philodryas olfersii Licht.

Proteroglypha.

59. Elaps lemniscatus L.

Solenoglypha.

60. Bothrops brasiliensis Latr. Abundant.

61. Bothrops neovidii Wagl. Three specimens.

62. Crotalus terrificus Laurenti. *C. cascavella* Wagler, in Spix Serp. Brazil.

Several individuals, all alike and differing in color from the true *C. durissus* Linn. (*C. horridus* D. & B.). This is a brown snake with brown dorsal rhombs with narrow yellowish borders. The *C. durissus* is a yellow snake with brown dorsal rhombs which have yellow centres, the brown being little more than a border. The *C. terrifica* is figured by Seba, and by Wagler as above.

CONCLUSIONS.

The collection made by Mr. Smith is productive of a good many interesting results, especially to the knowledge of geographical distribution. Such are the great extension of the range of the anurous genus Prostherapis among Batrachia; of Anolis and Scartiscus among lizards; and of Rhynchonyx and Dirrhox among snakes. The rediscovery of a few species brought from the same region a half century ago by the Austrian, Johann Natterer, is of considerable interest. Such are the species *Paludicola nattereri* and *Philodryas nattereri* Steind. Other rare species only seen in this collection for the second time, are the *Rhynchonyx ambiniger* Peters, *Rhadinæa occipitalis* Jan., *Leptognathus turgida* Cope, and *Scartiscus caducus* Cope. The number of species known and previously unknown, is as follows:

	New.	*Total.*
Batrachia	9	18
Lacertilia	0	15
Ophidia	3	29
	—	—
	12	63

APPENDIX ON A LEPTOGNATHUS FROM SAN PAOLO.

Leptognathus garmani, sp. nov. *L. catesbeyi* Cope, Proceeds. Amer. Philos. Soc., 1884, p. 193, not of Duméril and Bibron.

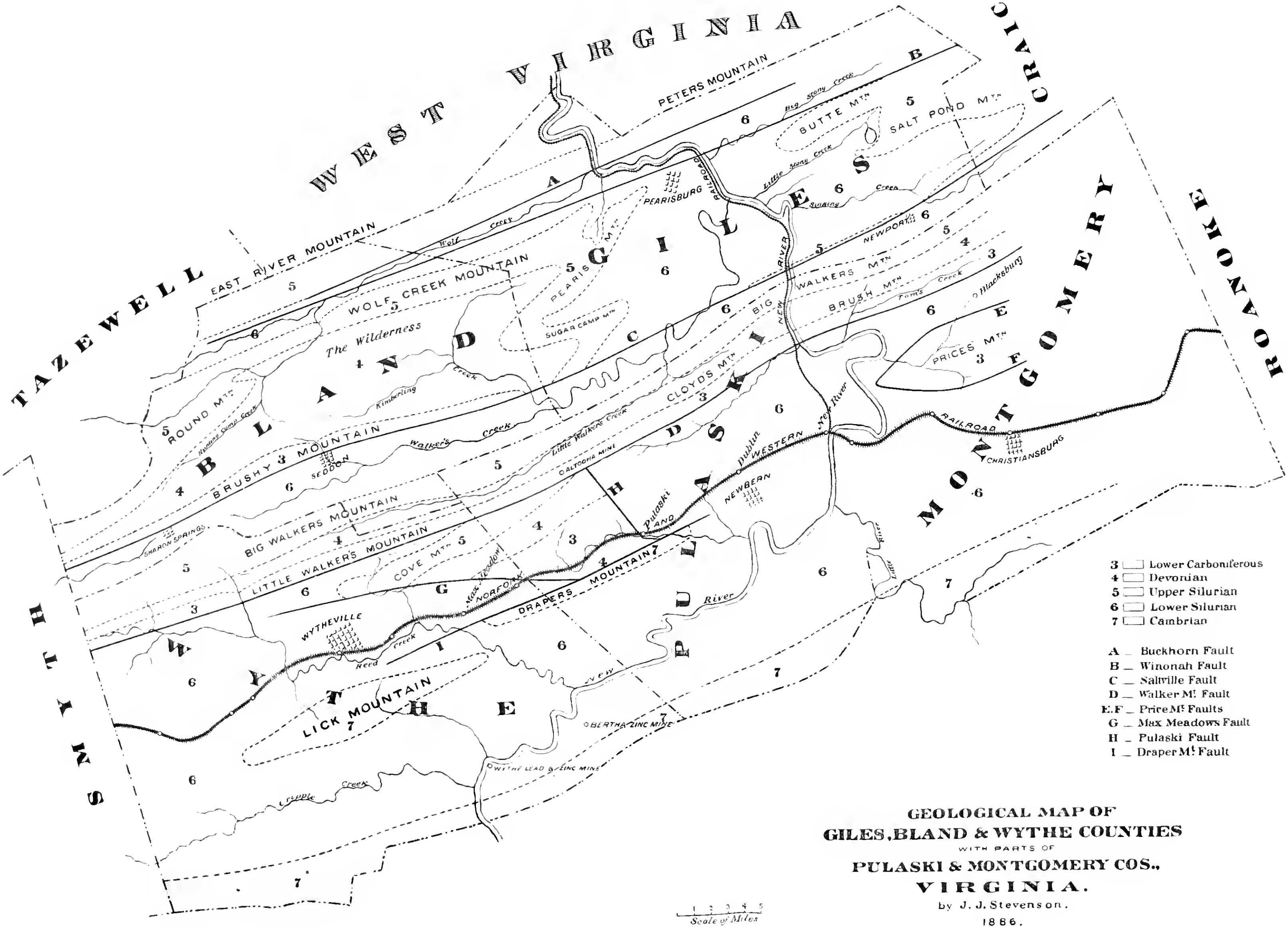
Renewed examination of the specimens on which the above determination was based, shows the determination to have been erroneous. A species from San Paolo has been named by Dr. Boulenger *L. ventrimaculatus*,* but the present snake, although resembling that species, does not belong to it.

Fifteen rows of scales, the median larger, but not maintaining its character as far as the occipital scuta. One pair of normal geneials, which are short, and are followed by two pairs which are arranged en chevron, the angle directed forwards. The anterior chevron leaves a triangular space between it and the normal geneial, to be filled by a triangular plate on each side. Seven superior labials, the seventh largest, the sixth next in size, and both longer than high. The fifth supports only the postocular, and the fourth the eye, so that the third only enters it by a corner on one side. Loreal a little longer than high. Oculars 0–2 ; nasals distinct ; temporals 1–1–2. Internasals less than half prefrontals ; the latter wider than long. Frontal wide as long, presenting angles both anteriorly and posteriorly, and about two-thirds as long as the large pariëtals.

Color light-brown, covered with numerous wide black cross-bands, which narrow towards the gastrosteges, and are sometimes divided on the middle line, one-half alternating with the other. The centres of the spaces of ground color are darker than the margins, and sometimes contain a black spot. Top of head blackish-brown, with a T-shaped mark in lighter brown extending from the occiput to the anterior superciliary region, and a brown cross-bar across the anterior part of the prefrontals. Inferior surfaces yellow, with two irregular series of small brown spots, one on each side of the middle line. The ends of the dorsal black spots involve the ends of the gastrosteges. Gastrosteges 158 ; anal entire ; urosteges 59. Total length 478 mm. ; of tail 105.

Sao Joao do Rio Negro ; H. H. Smith. One specimen. The species is dedicated to the able naturalist of Cambridge, Mr. S. W. Garman.

* Ann. Magaz. Nat. Hist., 1885, p. 87.



GEOLOGICAL MAP OF
GILES, BLAND & WYTHE COUNTIES
WITH PARTS OF
PULASKI & MONTGOMERY COS.,
VIRGINIA.
by J. J. Stevenson.
1886.

A Geological Reconnaissance of Bland, Giles, Wythe and portions of Pulaski and Montgomery Counties of Virginia.

By John J. Stevenson, Professor of Geology in the University of the City of New York.

(*Read before the American Philosophical Society, March 18, 1887.*)

Introduction.
I. The Faults and Folds.
II. The Groups, with comparative notes.
III. The Area north from Walker mountain, Bland and Giles counties.
IV. The Area south from Walker mountain, Wythe, Pulaski and Montgomery counties.

INTRODUCTION.

The region described in this memoir, embracing Bland, Giles, Wythe and portions of Pulaski and Montgomery counties of Virginia, is the eastward continuation of the region described in the writer's previous memoirs* on the geology of Southwestern Virginia.

The examination of the area under consideration was purely a reconnaissance, and the notes in several localities must be regarded as little more than suggestions to the one who may make the detailed study on behalf of the United States Geological Survey.

The whole area is rugged. Even the Great valley, so wide in Washington and much of Smyth county, becomes broken in Wythe by the introduction of Potsdam ridges south from the railroad, while a new fault originating in Wythe county reproduces Big and Little Walker mountains in Cove and Max Meadows mountains north from the railroad. These break the valley in Pulaski county also, while the faults of Price mountain hold between them a Carboniferous area, which divides the valley in Montgomery county from New river almost to the line of Roanoke county. The whole region from the Tennessee line north-eastward to beyond the New river, as far as the writer has gone, is broken by successive pairs of Silurian and Devonian mountains separated by valleys of Lower Silurian limestone.

The Walker mountains, Big and Little, originating in Smyth county, are continuous to beyond the eastern border of Montgomery county. The latter ridge changes its name twice, becoming Cloyd's mountain as it approaches New river and Brush mountain beyond that stream; while the former retains its name to the river and thence becomes Gap mountain. Big Walker maintains its rugged features throughout and shows but two water-gaps, those made by Walker's creek and New river, which are separated by barely seven miles. Some wind-gaps exist, one of which, near

* These were read before this Society and are to be found in the Proceedings, Vol. xix, pp. 88 to 107, 219 to 262, 498 to 505; and Vol. xxii, pp. 114 to 161.

the west line of Wythe county, is thought to be available for a railroad line. Water-gaps through Little Walker are numerous, but with one exception they have been made by streams rising in the valley between the mountains or on the southerly slope of Big Walker. New river alone has made a continuous gap through both ridges. The ruggedness of Big Walker is due partly to the refractory nature of the Medina which forms its body, but more to the steep dip, which makes the mountain narrow and limits the effectiveness of erosion. The rocks of Little Walker are more easily affected by atmospheric agencies, and for the most part they have a much gentler dip.

The Clinch Mountain group, so conspicuous in the counties previously described, comes to an end in Giles county under the influence of two anticlinals and of extensive erosion on both sides of New river. The Medina outcrop, doubling over the anticlinals, forms Pearis and Sugar Camp mountains, while the Brushy mountain of Chemung and Vespertine disappears very near the line of Bland and Giles counties. But beyond New river the anticlinals diminish and the group reappears in the magnificent pile of Butte and Salt Pond mountains, the latter rising to fully 4500 feet above tide. These mountains extend eastward into Craig county, and are conspicuously visible from localities beyond Little Walker. Wolf Creek mountain, originating in Tazewell county as a loop of Clinch mountain, extends to Pearis mountain and thence is continuous with the others. The Garden mountains unite to form the anticlinal ridge of Round mountain, which gradually disappears in the broad space between Wolf creek and Brushy mountains, known as "the wilderness."

East River mountain, originating in Tazewell county, retains its name to New river, beyond which it becomes Peters mountain. Like the other Medina ridges, it is rugged and almost unbroken, the only water-gap for many miles being that of New river.

The mountains, Cove and Max Meadows, in Eastern Wythe and Western Pulaski, are short, being cut off at each end by a fault. The area occupied by them is comparatively rugged and imperfectly cleared, so that little examination was made of it. Lick mountain is about fifteen miles long and is wholly within Wythe county. It lies south from the railroad, is abrupt and almost uncleared. Draper's mountain, somewhat further east, is in both Wythe and Pulaski, and is even more rugged than Lick mountain, while its length is approximately the same. Price mountain, in Montgomery county, north from the railroad, is a short, by no means abrupt ridge, which extends from New river eastward for say eight miles, and attains its maximum at about five miles from that river.

The whole region, aside from the south-west corner of Bland county, is drained by the New river and its tributaries. That great stream rises on the Atlantic side of the Blue Ridge and flows across every fold of the great Appalachian chain until, as the Kanawha, it enters the Ohio at Point Pleasant. Its most important tributaries here are Reed and Cripple creeks in Wythe; Big and Little Reed Island, Peak and Back creeks in

Pulaski ; Walker, Wolf and Sinking creeks in Giles. Most of these streams carry much water, and for a large part of the year afford power for mills ; but the water-supply is not so regular as it was before so much clearing had been done, and floods are now too frequent. The New river, however, carries a large volume, and mills along its banks rarely suffer inconvenience.

Agriculturally the features of this region do not differ from those of the area already described, except that, as already indicated, the proportion of rich land is much less. The limestone areas are those indicated on the map by the number 6, all the other portions are sandstone or shale. Much of the sandstone region is abrupt or so rugged as to be worthless for ordinary farming purposes, but much of the shale land lies so well for cultivation that one feels more than regret because it is so thin. In seasons when the "rich" valleys yield twenty-five to thirty bushels of wheat, the "poor" valleys yield only from seven to ten bushels. The limestone areas are admirably adapted to grazing, as the grass is abundant and nutritious. The stock interests are extensive, and the cattle bring the highest price in Baltimore, Philadelphia and New York markets.

As the area described in this memoir does not reach to the West Virginia coal measures at the north, it offers a somewhat shorter list of mineral resources than do the areas previously examined. Clinton ore occurs on Big Walker, Round, Wolf creek and others of the Medina mountains, while brown hematite occurs on the southerly slope of those mountains and to some extent in the Lower Silurian limestones north from the Norfolk and Western railroad ; but nothing is known positively respecting either the quantity or the quality of these ores. Brown hematite, zinc, lead and manganese ores occur abundantly in the southern part of Wythe, Pulaski and Montgomery counties, where the production of iron, zinc and lead has long been important. Little has been done toward developing the manganese. Coal occurs in the Vespertine along Brushy mountain in Bland county ; Little Walker in Wythe, Pulaski and Montgomery ; in the Peak hills of Wythe and Pulaski ; and in Price mountain of Montgomery. It has been mined to a greater or less extent at several localities in Pulaski and Montgomery. Not a little good timber remains, but the charcoal burner at the south and the portable saw-mill at the north have done much destruction without bringing much profit to the owners.

The only outlet to market is by the Norfolk and Western railroad with its New River branch to the Pocahontas mines, seventy-six miles long, and the Cripple Creek branch from Pulaski to the rich mineral region of Southern Pulaski and Wythe counties. The topography renders construction of railroads difficult and costly, and the only easy line northward from the valley is occupied by the New River branch of the Norfolk and Western ; but an available route is said to exist from Wytheville over Walker mountain near the Wythe and Tazewell pike. As the mountains are in pairs a promising water-gap in one usually leads to an impracticable crossing of the other, and the railroad engineer often finds his wits of little service. Many routes have been surveyed in these and adjoining counties, and each new survey is an object of much interest. Some additional railroads would be an undoubted convenience, as, except the pike connecting the county towns of the Great valley, the roads are not macadamized, and the amount of labor expended on them clearly does not exceed the minimum required by law.

Those portions of this area which are underlaid by limestone are cleared and for the most part are under cultivation ; but the other portions have comparatively few settlers and are traversed by roads usually not fit for light vehicles. As a rule the people are prosperous, utilizing the advantages which are available, while they waste little of their energies in discussing the value of the mineral wealth, which is of no immediate importance away from the Great valley. The villages in the valley are thrifty, have good church buildings and are well supplied with schools. The hamlets in Bland and Giles counties are very small and have little to support them.

Lists of Altitudes.

Mr. W. W. Coe, of Roanoke, Va., Chief Engineer of the Norfolk and Western railroad, has kindly given me the following list of elevations above tide :

On main line.

Crocketts	2327
Wytheville	2230
Max Meadows	2015
Pulaski	1904
Dublin	2058
New River	1768
Central	1778
Christiansburg	2007
New River Bridge	1760

On New River Branch.

Belspring or Churchwood	1766
Summit cut, 2½ miles from New River	1914
Staytide	1640
Ripplemeade	1607
Wenonah	1559

On the river.

Mouth of Walker's creek, about	1570
Mouth of Stony creek, about	1555
Thorn's ferry	1950

Mr. Oramel Barrett, Jr., of Abingdon, Washington Co., Va., has given me the following list of elevations of points on Clinch and Holston rivers, on the line of the proposed Clinch River railroad.

Mouth of Thompson's creek	1518
Mouth of Weaver's creek	1502
Mouth of Dump creek	1480.5
Mouth of Bickley's Mill creek	1447
Mouth of Lick creek	1442
Mouth of Russell creek	1413
Mouth of Bull creek	1399
Mouth of Guest river	1373
Mouth of Little Stony creek	1332
Osborne's ford, about	1284
Railroad crossing at Dingus's	1255
Mouth of Big Stony creek	1248
Mouth of Cove creek	1226
Mouth of Stock creek	1203
Mouth of Copper creek	1196
Summit in "Big Cut," between Clinch and Holston	1579
Big Moccasin creek, below Estilville	1241
N. Fork Holston, at Holston Springs	1185
Same at mouth of Opossum creek	1176
Same at Virginia and Tennessee line	1175
Nash's ford, on Clinch, above five miles above mouth of Thompson's creek, about	1542

Some of the elevations given in this list by Mr. Barrett, differ from elevations of the same localities, as published in a former memoir. The discrepancy is due to the acceptance of a wrong determination of the locality where the work began.

I. THE FAULTS AND FOLDS

The Clinch River group of faults, including the New Garden, Stone Mountain and Abb's Valley, lie north from the area under consideration. They gradually diminish eastward in Mercer county, of West Virginia, and it is doubtful whether they pass in any case much beyond the line into Summers county, of the same State. Nothing further north than the edge of the House and Barn synclinal of the last paper was reached during this reconnaissance.

The geological structure of the southern part of this area is not unknown. Two sections were made by members of the Geological Corps, under W. B. Rogers, one passing through the eastern part of Wythe and Bland counties, the other through Roanoke and Craig counties, at a few miles beyond the eastern limit of the writer's study. Prof. Rogers, in his report of 1838, gave a summary account of the Vespertine coal areas. Prof. Lesley* published notes on the geology of Wythe, Pulaski

* Proc. Amer. Phil. Soc., Vol. ix, p. 30 et seq.

and Montgomery, and Prof. Fontaine* has given interesting details respecting the Vespertine coals. Mr. C. R. Boyd, of Wytheville, Va., has published a work, dealing with the economics of South-west Virginia, in which are given many geological details, with a map which topographically is a very notable improvement on its predecessors. The writer is under obligations to these publications which will be acknowledged in the proper connection.

The general type of structure is practically the same as that found in the areas already described, and it has been well represented by Lesley, who in his memoir on Tazewell county,† gives an ideal figure, which with his permission is reproduced as Fig. 1. The upthrow side, except in the case of cross-faults, is the south-east, and the Lower Carboniferous is found for greater or less distances in contact with the Lower Silurian limestones along most of the fractures. These faults are not simple, as is well shown in the Clinch group, but subordinate and cross-faults do not appear to arise directly from those of the principal system; and whereever a fault, either principal or subordinate, was followed out, it was found to originate or to terminate in an anticlinal. The faults are not parallel, they bear no relation whatever to the folds except such as is purely fortuitous, and their direction is wholly independent of the strike. A regular fault such as the Saltville exhibits this well, the upthrow group being in contact with different groups at different localities, owing to the influence of anticlinals on the downthrow side. Some interesting facts of this kind were given in the previous memoirs; others will be given in this, going to show independence of the faults and the folds and, as the writer intimated several years ago, suggesting very strongly a difference in age.

The structure is hardly so simple as that of the counties already described and the description cannot be given in so direct a manner as that of the other counties.

The Lick Mountain Anticlinal.

Lick mountain, at a little way southward from the railroad in Wythe county, is due to a strong double anticlinal, which diminishes rapidly eastward and is soon recognizable only as a gentle fold, followed by the Valley pike north-eastward for six or seven miles in Pulaski county. It was not traced beyond New river. How far westward it can be traced in Smyth county was not ascertained. It brings up the Potsdam in Wythe county, so as to form a very rugged mountain about fifteen miles long, but eastward it sinks so as to be crossed by the Knox shales before Reed creek has been reached; thence, as far as it was followed, no beds below the Knox shales are shown on the axis.‡ Some anticlinals in the Knox limestone were seen between the Lick mountain fold and the southern edges of Wythe and Pulaski counties, but they were not followed. One is crossed by the New river, very near the Wythe lead mine.

* Amer. Journ. of Science, Jan. and Feb., 1877.

† Proc. Amer. Phil. Soc., Vol. xii, p. 490.

‡ The easterly limit assigned to these shales on the map is conjectural.

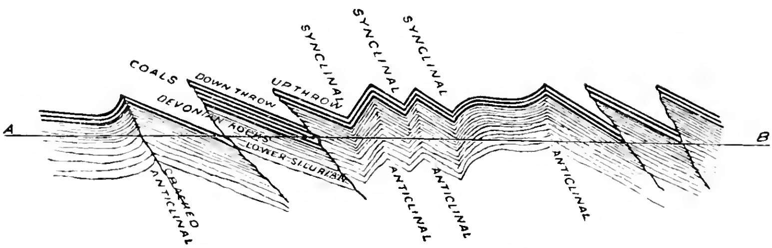


Fig. 1.—After Lesley; Ideal cross-section showing the downthrows.

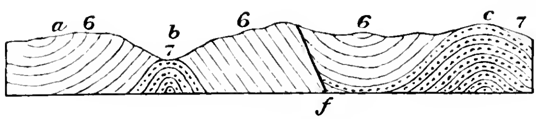


Fig. 2.—Section through Kent's Station on Norfolk and Western Railroad. *a*, Wytheville synclinal; *b*, Wytheville anticlinal; *c*, Lick Mt. anticlinal; *f*, Draper Mountain fault; 6, Lower Silurian; 7, Cambrian.

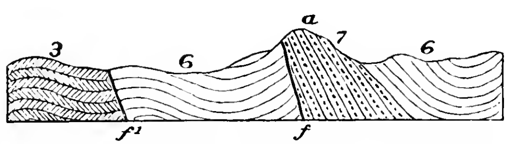


Fig. 3.—Near line between Wythe and Pulaski counties. *a*, Draper Mt.; *f*, Draper Mt. fault; *f*[1], Max Meadows fault; 3, Lower Carboniferous; 6, Lower Silurian; 7, Cambrian.

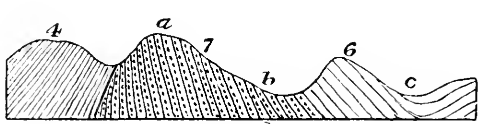


Fig. 4.—On Pulaski road. *a*, Draper Mt.; *b*, Draper Valley, *c*, Macadam road; *f*, Draper Mt. fault; 4, Devonian; 6, Lower Silurian; 7, Cambrian.

The Fault of Draper Mountain.

At a mile and a half, or perhaps a little less, south from Reed creek on the road leading from Wytheville southward over Lick mountain, the Knox Limestones are much disturbed, being thrown into several close folds. On the Valley pike, probably a mile and a half from the first crossing of Reed creek, the upper limestones of the Knox are succeeded by red shales belonging at the base of the group; the fault rapidly develops and passes along the northerly side of Draper mountain, where it brings the lower beds of the Potsdam at the south into contact with the base of the Lower Carboniferous, and further eastward with the Chemung. It quickly diminishes eastward and soon is in the Knox limestone. An anticlinal is crossed by the Valley pike very near Newbern ; it may represent the fault.

The structure of this fault is fairly well shown at several localities, but the conditions are complicated for much of the distance by two cross-faults coming the one from the north-west and the other, if the map be right, almost from the north. A section on and near the Valley pike in Wythe county is represented by Fig. 2, but the section crossing Draper mountain near the line between Wythe and Pulaski counties, as represented in Fig. 3, shows a very different condition, for here the Max Meadows cross-fault is seen. The Knox limestones certainly describe an anticlinal near the fault, but whether or not they dip away at the fault could not be ascertained. The Potsdam forms the heart of this very rugged mountain and is dipping south-eastwardly at from thirty-five to nearly sixty degrees. Further east, where the road crosses Draper mountain to Pulaski, the structure is as given in Fig. 4. The structure is distinct along this road for the Devonian shales are turned up at the fault so as to be actually conformable in dip with the lower shales of the Potsdam. The exposures along this road in descending the mountain are practically continuous, yet it will be found difficult to determine accurately the place of the fault, so closely do the shales resemble each other and so nearly exact is the conformability of dip. In all probability, the Vespertine is brought into contact with the lower beds of the Potsdam at a short distance west from the road, so that this is the most formidable fault yet noticed. The Pulaski fault cuts off the Devonian and Carboniferous, and the Lower Silurian beds are on both sides of the fault beyond Peak creek.

The Area between the Norfolk and Western Railroad and the Walker Mountain Fault.

The village of Wytheville, county seat of Wythe, is built on a ridge marking the course of the Wytheville synclinal, which, beginning certainly more than six miles westward from Wytheville, extends east-north-east to where it is cut off by the Max Meadows fault north from Max Meadows station. A well-marked anticlinal bounds it on the southerly side, which is crossed by the Valley pike near Kent's mills, three miles and a half from Wytheville, and it may be the same with that seen near Max Meadows on the railroad. It is crossed very near Reed creek on the Lick Mountain road. The dips in this portion are interesting. Within the synclinal ridge, composed of Knox Limestones, the dip is fifty to sixty degrees on both sides. The anticlinal brings up the Knox shales, which are shown on the railroad just west from Kent's mills. The south-easterly dip looking toward the Draper Mountain fault is at first very abrupt, being almost vertical for some distance along the pike, but it becomes gentler until the higher limestones have a dip of not more than twenty degrees.

The Max Meadows fault has its origin evidently in an anticlinal, which is crossed by the Wythe and Tazewell pike at say two miles and a half from the Wytheville borough line; it is crossed by Cove creek very near its forks and by the Norfolk and Western railroad at not far from three miles and a half beyond Max Meadows station. At a little distance further it must unite with the Draper Mountain fault. It cuts off the Wytheville anticlinal and synclinal at the east, while on the other side it cuts off a broad synclinal and an anticlinal which are well shown in eastern Wythe and western Pulaski and may be continuous with the Wytheville folds; but of this, one may not speak positively. The fault becomes greater as it extends south-eastwardly at an angle with the strike, so bringing Hudson, Medina, Clinton, Hamilton, Chemung and Vespertine successively into contact with the Knox limestones and shales on the opposite side.

The Pulaski fault, like the last, is a cross-fault and is the easterly boundary of the area of newer rocks held between the Walker Mountain, Max Meadows, Draper Mountain and Pulaski faults. The details of this fault were not worked out, but if the map employed be accurate, the direction from the Walker Mountain fault is almost south-south-east to Pulaski, where the course is changed to east-south-east. Evidently the line is south from Peak creek for more than two miles below Pulaski. Knox limestones are shown throughout on the easterly side of the fault, but on the opposite side are Devonian and Carboniferous rocks as far as followed. The region embraced within these faults was not worked out in detail, as much of it is not cleared; but it is evident that Cove mountain and its Devonian companion are monoclinals and there is every reason to suppose from the exposures along the railroad that an anticlinal exists in the Peak hills, the low ridge directly north from Pulaski. The limits assigned to the several groups within this area are largely conjectural.

The structure of Pulaski county east from the Pulaski fault is not shown satisfactorily along the roads, but cuts along the New River branch of the Norfolk and Western railroad make the structure clear. The Knox limestones are badly twisted for two miles and a half from New River station, but afterwards for nearly a mile they dip quite regularly to the north-west. The dip is reversed at three and a half miles and thence for a mile the prevailing dip is south-east, though there are some reversals. The dip becomes very flexuous at four miles and a half, and the same beds remain in sight thence until near Belspring station, where all exposures cease. The structure may be regarded as representing two anticlinals with irregular crests, separated by a well-defined synclinal, whose axis is somewhat more than two miles south from Belspring station. The northerly anticlinal is cut off by the Walker Mountain fault.

The faults of Price's mountain east from New river in Montgomery county hold between them a fragment of an anticlinal, the Price Mountain area of Vespertine coals. Between the Walker Mountain fault at the north and the northerly fault of Price's mountain, the Knox limestones describe a synclinal, though the few and unfortunately somewhat indefinite exposures show that it is complicated. The lower beds of the Knox limestone are brought into contact with Umbral red shales, but whether they are dipping to or from the fault could not be ascertained. The limestone on the northerly side dips northwardly at fifteen to thirty degrees, while the Lower Carboniferous rocks beyond the fault are dipping in the same direction at thirty to fifty-five degrees, the rate increasing toward the summit of the Price's Mountain anticlinal. The dip is gentler on the southerly side of the axis, rarely exceeding twenty degrees. The conditions at the southerly fault were not clear at the only point where it was crossed, further than that the Umbral shales and the Knox limestones are in contact. The eastward extent of these faults was not ascertained. They do not appear to cross New river at the west.

The Walker Mountain Fault.

This fault, following the southerly foot of Little Walker mountain, enters Wythe from Smyth county and, at the county line, brings Knox limestone into contact with the Vespertine sandstones. The line of fault is crossed by Stony fork of Reed creek at somewhat more than six miles from Wytheville, its place being shown there by a narrow valley passing in front of the M. E. Church. The church is on Umbral shales, while Knox limestones crop out on the opposite side of the bottom. The conditions are the same in Crockett's cove, but in Pulaski county for several miles they are very different. There the Lower Carboniferous beds on the northerly side must be brought into contact successively with Lower and Upper Silurian, Devonian, and possibly with Vespertine near the Pulaski fault; beyond that fault, Knox beds occur again. The fault-line passes but a little way south from the Altoona mine; is crossed by the Dublin and Pearisburg pike at half a mile, possibly a little more, north from Back creek; by New river just below the mouth of Back creek; and by the Newport and Christiansburg road at only a little way south from Tom's creek: in each case bringing the red Umbral shales into contact with the lower limestones of the Knox group.

Generally speaking, the structure in the vicinity of this fault is simple, and notwithstanding the enormous vertical extent of the fracture, the crushing and distortion are very much less than that observed near the New Garden fault in Tazewell county, the Hunter valley fault in Russell, or even the Max Meadows fault on the railroad. Where crossed by the Wythe and Tazewell pike it shows dips of thirty to forty degrees in the Lower Carboniferous, and forty to fifty-five degrees in the Knox limestones at about equal distances from the line of faulting; on the Dublin and Pearisburg road, the dip is comparatively gentle and the succession of Lower Silurian on top of Lower Carboniferous appears to be wholly conformable; a similar condition exists on New river, where the dips in the Umbral shale near the fault are only ten to fifteen degrees, while in the Vespertine further from the line the dip rises to fifty-five degrees. Here, however, the rocks on the southerly side are disturbed, and the beds are wrinkled for a mile or more. Near Tom's creek the greater disturbance is on the northerly side, where the Lower Carboniferous beds are almost vertical, though dipping toward the fault, while the Knox limestones are dipping much less sharply in the same general direction.

The structure between the Walker Mountain and Saltville faults is much less complicated than that of the next block southward. The Vespertine Coal group is exposed continuously on the northerly side of the former fault from eastern Smyth to beyond the centre of Montgomery county, and the course of the fault is so little off the strike of the beds that the thickness of the overlying Umbral shales shows very little change from Wythe county eastward. Big Walker mountain is a Medina ridge separated by a Clinton and Hamilton valley from Little Walker mountain, an Upper Devonian ridge with Lower Carboniferous sandstones and shales on its southerly slope. The dip throughout, or nearly so, is south of south-east at from ten to sixty degrees. Petty wrinkles occur in the shales, but the only material interruption of the dip on Big Walker is near the Tazewell pike, where at barely five or six miles from the Smyth county line an anticlinal evidently has its origin. This rapidly increases eastward and soon causes a considerable southward deflection in the Medina outcrop or crest of Big Walker mountain. The axis must be cut several times by Walker's creek, which flows on Knox limestone along the northerly foot of the mountain; and the fold shows no material decrease until beyond the line of Bland county; but thence to New River gap, the Medina of Walker mountain gradually approaches the Saltville fault. The interval between that fault and the Medina opposite Seddon is fully three miles, but at New River gap it is barely one mile.

The dips on the northerly side of Big Walker are comparatively gentle except for a few miles on each side of the New River gap; and it is worthy of notice in this connection that the dips throughout Big and Little Walker along the New river are much more abrupt than at any other localities. Possibly the approach of the Medina outcrop to the Saltville fault may be due as much to a thrust as to diminished strength of the Walker Creek anticlinal.

The Saltville Fault.

This interesting fault, originating in Tennessee, enters Bland county just north from the Saltville and Sharon Springs road; passes at only a few rods north from that road at Sharon Springs; less than one-third of a mile north from the cross-roads at Seddon; lies north from the road for six miles beyond Seddon; thence for two miles is south, but is again crossed so that it is only a few rods north from the forks of the road at Poplar hill, in Giles county; it is crossed by New river in Buckeye mountain, very near Scott's ferry; and by the Salt Pond and Newport road in a wind-gap through Buckeye mountain at half a mile north from Newport. The dips of the southerly side are regularly south-south-eastward, and not very abrupt, rarely exceeding twenty five degrees; those on the northerly side are equally regular except near Newport, where the Trenton shales are faulted against the Knox limestone and the former are badly twisted.

The Knox limestones are shown on the southerly side of the fault, and notwithstanding the great variations of horizons on the northerly side, there is comparatively little change on the southerly side—even less than might be expected from the influence of the Walker Creek anticlinal. The variations on the northerly side possess much interest, but being due to the Clinch Mountain group of folds cannot be described until after those folds have been discussed.

The Clinch Mountain Group of Folds.

Where first seen, in Scott county, Clinch and its associated Brushy mountain make up a broad monoclinal, showing a section from Medina on the crest of Clinch mountain to the highest Umbral rocks at the Saltville fault. The width of Upper Silurian and Devonian is barely three miles. In Smyth and Tazewell, however, a fold, the Burk's Garden anticlinal, arose at the foot of Clinch mountain, widening the area of Silurian and Devonian, and narrowing that of the Lower Carboniferous until at the line of Wythe county only the Vespertine remains. Similarly, gentle folds in Russell and Tazewell interrupt the dip at the north and the Medina outcrop is carried further in that direction, so that Rich mountain, whose crest is merely the continuation of Clinch mountain around a petty anticlinal, lies nearly a mile north from the previous line of Clinch. So the monoclinal of Scott county is interrupted by a great fold with a broad synclinal at the north as it enters Bland county. The structure becomes more complicated within Bland and Giles, but gives promise of returning simplicity as the group passes into Craig county beyond the limits of the writer's examination.

The Burk's Garden fold, which attains its greatest maximum in the cove of that name, quickly flattens, so that at the easterly end of the cove, the Medina outcrops of Garden mountain unite and that sandstone crosses the fold in Round mountain. The decrease is so rapid that within five miles the Hamilton crosses the anticlinal, which at four miles further eastward seems to have disappeared.

The Pearisburg synclinal, between the Cove and Elk Garden anticlinals in central Tazewell county, lies between the Elk Garden and Burk's Garden anticlinals in eastern Tazewell, owing to the disappearance of the Cove fold. Wolf creek, rising in Burk's Garden, flows for more than fifteen miles in this synclinal within Bland county, so that Rich mountain of Tazewell, continuous with Clinch mountain further west, becomes Wolf Creek mountain of Bland county. The disappearance of the Burk's Garden fold and the rapid growth of the Kimberling anticlinal keep this trough distinct to beyond the eastern limit of Giles county. Brushy mountain, the Devonian ridge with Vespertine foothills, continues to about the eastern border of Bland, where under the increasing influence of the new anticlinals the mountain gradually disappears.

The Kimberling anticlinal was first observed on the Seddon and Mercer county road, where, though narrow, it is distinct at not far south from the summit of Brushy mountain. To the influence of this anticlinal, most probably, is due the widening of the Vespertine area further west as shown on the road crossing Brushy mountain to Hunting Camp creek. The "Wilderness" road, leading from Kimberling creek to Rocky gap, crosses the anticlinal at say a mile* from the junction of Kimberling with No-Business creek. This fold, rapidly increasing in height, causes the broad space of Devonian shales, known as the "Wilderness," which extends from Brushy mountain northward almost to the foot of Wolf Creek mountain. It soon brings up the lower rocks and the Medina in crossing it forms a long V, with the opening toward New river. The northern arm, known as Pearis mountain, reaching north-north-eastward into the Pearisburg synclinal, terminates in a peak—the Angels' Rest—near Pearisburg, where it bends on itself and becomes continuous with Wolf Creek mountain. The southerly arm is Sugar Run mountain, pointing out in the synclinal between Kimberling and a new anticlinal, the Sinking Creek, which first appears along the Saltville fault at a little way east from the Bland county line. The Kimberling anticlinal attains its maximum elevation between Walker creek and the Dublin and Pearisburg road, whence it diminishes rapidly toward the north-east. Erosion has been effective on both sides of New river, so that for several miles Lower Silurian limestones are the immediately underlying rocks.

But the comparatively rapid flattening of the Kimberling anticlinal permits the Medina to appear in the Pearisburg synclinal with double outcrop as Butte mountain at, say four miles eastward from New river. The course of the fold and its loss of elevation are shown by the deep re-entrant angle between Butte and Salt Pond mountains. The latter is the double outcrop of Medina in the synclinal between the Kimberling and

*Many of the distances given in this memoir were determined by "dead reckoning," there being no other means of making determination in the thinly settled portions. They may be either too large or too small.

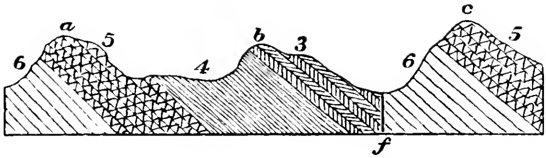


FIG. 5.—Through Sharon Springs. *a*, Garden axis; *b*, Brushy Mt.; *c*, Big Walker Mt.; *f*, Saltville fault; 3, Lower Carb.; 4, Devon.; 5, Upper Silur.; 6, Lower Silur.

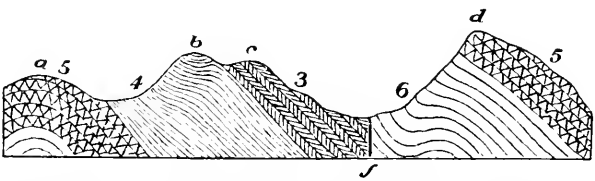


FIG. 6.—Through Seddon. *a*, Garden Mt.; *b*, Kimberling axis; *c*, Brushy Mt.; *d*, Big Walker Mt.; *f*, Saltville fault; numbers as before.

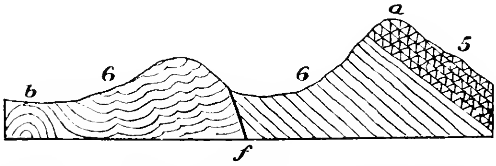


FIG. 7.—Through Newport. *a*, Big Walker Mt.; *b*, Sinking Creek axis; *f*, Saltville fault; Numbers as before.

Sinking Creek anticlinals, but it does not extend so far westward as Butte mountain, for the Sinking Creek anticlinal attains its maximum at a little way eastward from New river and Medina does not cross it until very near the easterly line of Giles county. This fold is crossed by the Salt Pond and Newport road at barely two-thirds of a mile north from Sinking creek.

For the most part the dips in the synclinals are not very abrupt; but the "Wilderness" road in crossing the Pearisburg synclinal shows Chemung with fifty degrees northerly, and almost vertical southerly dip. Northward the dip diminishes, for in Rocky gap through Wolf Creek mountain the Medina shows only twenty-six degrees. Further eastward in this trough, at the end of Butte mountain, the calcareous shales of the Trenton have been thrown into numerous and very narrow flexures. A similar condition exists in the Salt Pond synclinal on the Salt Pond and Newport road where some of the petty folds show distinct faults.

The effects produced by the Saltville fault in cutting across the southerly slope of the anticlinals are shown by the map. As the Burk's Garden anticlinal diminishes, the width of the Lower Carboniferous area increases, so that at Sharon Springs the Umbral red shales appear; but as the Kimberling anticlinal increases, the width diminishes and the whole of the Lower Carboniferous is finally lost in the fault near the Giles county line. Devonian, Upper Silurian and the upper beds of the Lower Silurian are cut off quickly at a little way further east under the added influence of the Sinking Creek anticlinal and of erosion by Walker's creek and New river, so that for several miles east and west from Poplar hill, the fault is in Knox limestone. Thence north-eastwardly to the county line, Medina is found on the northerly side of the fault, except at New River gap and for a few miles on each side of Sinking Creek gap, where erosion has cut away both Medina and Hudson.

Knox limestone is continuous on the southerly side of the Saltville fault from the Smyth county line to the end of Giles county. It is in contact with Lower Carboniferous in Bland, with Chemung, Hamilton, Clinton, Medina, Hudson, Trenton and Knox within eight miles eastward from the line of Giles county; and with Medina, Hudson or Trenton, according to extent of erosion, thence to the end of the region examined. The relations are shown in Figures 5, 6 and 7, which are merely diagrams, not actual measured sections.

The Elk Garden Anticlinal and Wolf Creek Faults.

The Elk Garden anticlinal of Russell and Tazewell counties gives rise to the Copper Creek fault in western Russell. The anticlinal continues in eastern Tazewell between Wolf Creek and East River mountains to within less than four miles of the Bland county line; but at some place between that and two miles west from Rocky gap in Bland county it gives rise to a double fault, the Wenonah, which was followed to within eight miles of the Craig county line. Another fault, that of Buckhorn mountain, originates nearly opposite Rocky gap or Wolf Creek gap, through Wolf Creek mountain, where it cannot be more than a few rods distant from the Wenonah. This was followed to somewhat less than twelve miles east from New river. But both faults must extend several miles further than the writer's examinations went.

The Wenonah fault, whose course is shown by the Valley ridge of Wolf Creek valley, is crossed by Wolf creek at a little way below Rocky gap, but not again except, perhaps, above the "round bottom;" it is crossed by New river at Wenonah; is touched by Big Stony creek at one mile from the river, and its peculiarities are well shown at three miles from the river on the road leading from Big to Little Stony creek. Where first seen, this fault is in Knox limestone and holds a wall of Medina and Clinton in its jaws. As one comes from the "Wilderness" through Rocky gap of Wolf Creek mountain, he finds the complete succession from Medina to Knox limestone; but within a mile below the gap he reaches the fault. There the creek breaks through the Valley ridge, in which Medina is shown with dip of eighty degrees, while on the lower, as on the upper side of the ridge, Knox limestone is shown against the Medina. The wall of Medina is wanting at Wenonah, where the fault shows Knox on both sides. The Valley ridge shows two sets of faults instead of one at three miles east from New river, where two lines of Medina are present.

The Buckhorn fault, whose course is shown by Buckhorn mountain and Little mountain, a ridge following the southerly foot of East River and Peter's mountain, is crossed by the Wolf Creek road after passing through the Valley ridge, nearly one mile below the Rocky gap. It is recrossed on the hill overlooking Mr. Carpenter's house at say two miles and a half from the gap. Thence, neither road nor creek touches the fault, though they approach it closely at the Giles county line. It brings Medina or Clinton into contact with Knox limestone.

The lines of faulting are not exposed. A reversed dip is shown on the north side of the Wenonah fault at one locality on Big Stony creek; and the Medina shows a flexure on the southerly side in the Wolf Creek gap through the Valley ridge; so that there is evidence of dragging at both localities. The dips in the intervals between these faults rarely exceed forty degrees and ordinarily are between twenty and twenty-five degrees. The interval is but a few rods wide at the gap through the Valley ridge, but beyond the New river it is nearly two miles. The faults disappear at no great distance beyond the limits of the writer's examination, for in the Rogers section, an anticlinal is shown along the foot of East River mountain in Craig county.

The House and Barn Synclinal.

Nothing was ascertained respecting the structure of this trough, which seems to be less and less complicated eastward. East River mountain is a monoclinal ridge with Medina as the backbone, and there must be a synclinal between it and the similar ridge of Buckhorn mountain. The valley between these ridges is reported to show only shale.

The Clinch Faults.

The Clinch River system of faults continue from Tazewell county into Mercer county of West Virginia, which lies beyond the area examined for this memoir. The New Garden fault passes at a little way north from East River mountain and continues eastwardly beyond the eastern limit of Mercer county, as appears from the Rogers' section; but it is greatly diminished in eastern Mercer, for there it is in Devonian rocks, whereas in Tazewell it brings Quinnimont into contact with Knox limestone. The Stony Ridge and Abb's Valley faults certainly disappear before the eastern line of Mercer county is reached, unless their course has been greatly changed, for the writer found no trace of them in Summers county, of West Virginia, where they should be found.

The extreme vertical extent of the several faults is approximately as follows:

Draper mountain	12,500	feet.
Max Meadows	9,800	"
Pulaski	9,600	"
Price mountain	10,000	"
Walker mountain	10,000	"
Saltville	10,000	"
Wolf creek	2,000	"

II. THE GROUPS, WITH COMPARATIVE NOTES.

The section is a long one, reaching from the Umbral of the Lower Carboniferous to the lower beds of the Potsdam. No detailed measurements were attempted and in most cases no effort was made to estimate thicknesses. Only the more general features are summarized here, as most of the details given in previous memoirs are equally applicable to this area.

The Carboniferous.

The Coal Measures are not reached but the Lower Carboniferous is represented by the Umbral and the Vespertine. These groups are shown in Bland county along the southerly slope of Brushy mountain; in Wythe, Pulaski and Montgomery counties, they form the foothill of Little Walker mountain; they are present in Wythe and Pulaski counties in the area between the Max Meadows and Pulaski faults; and in Montgomery, on Price mountain.

The Umbral.—Prof. Fontaine makes the thickness of the upper portion, the Umbral red shales and shaly sandstones, to be 1090 feet in Brush and Price mountains of Montgomery county, and the writer finds 996 feet in the New River gap through Brush or Little Walker mountain. In the Memoir on Lee county, &c., the writer regarded these Montgomery county shales as Vespertine, but he now feels that that identification is erroneous and that the shales belong to the Umbral or Greenbrier series. These shales are well shown on the various roads crossing Brushy mountain in Bland and especially well along the various roads crossing Little Walker, in Pulaski and Montgomery counties. They occasionally contain a thin bed of coal, which was seen on Brushy mountain, in Bland, and on the Norfolk and Western railway near Clark's summit, in Pulaski county; but the bed is of no importance. The rocks are reddish shales, mostly sandy, occasionally compacted into earthy sandstones; but in nearly all cases the bedding is irregular. So far as observed, these beds are not fossiliferous.

A silicious limestone, too impure to be used in making lime, occurs under these shales. It is said to be seven or eight feet thick on Stony Fork of Reed creek, in Wythe county: it is rather less on the railroad in Clark's summit cut four miles and a half east from Max Meadows; and is a little thicker on Brushy mountain, in Bland county. In many ways this is exceedingly suggestive of the silicious limestone which occurs at the summit of the Vespertine in Pennsylvania and it may be the representative of that rock. This limestone the writer takes to be in all probability the separating bed between the Umbral and the underlying Vespertine, but with greater affinity with the latter. Unfortunately, the only locality where measurements can be made without great expenditure of time is along New river, but there the limestone was not recognized and an arbitrary line had to be assumed for separation of the two groups.

The variations in the Umbral within South-western Virginia are not without interest. The section obtained in Lee county showed

1. Shales and sandstone with thin limestone............	705′
2. Limestone and calcareous shales	150′
3. Cherty limestone.........	200′

In Brushy mountain of Washington county on north side of the Saltville fault, the upper division retains its thickness while the lower divisions increase vastly, the measurements being,

No. 1.......................................	800 feet.
No. 2.......................................	1470 "
No. 3.......................................	605 "

But in western Smyth county, where the group is crossed by the road leading to Saltville through Brushy mountain, there is manifestly a serious decrease in thickness of the limestones, while the shales appear to have decreased very slightly. Within Bland county, in the same mountain, the red shales are found thick, but the limestone has disappeared. This is simply the condition which one should expect to find here, when it is remembered that on the north-westerly side of the Great Valley in Pennsylvania and Maryland, limestone is found almost wholly absent from the isolated patches of Umbral: similarly, with the disappearance of the calcareous matter, the fossils disappear. Prof. Fontaine came to the same conclusion with respect to the relations of these shales after comparing them with the section obtained near Lewisburg, in Greenbrier county, of West Virginia.

The Vespertine.—This great period is represented by sandstones and shales with coal beds, having in all an extreme thickness of not far from seven hundred feet. The bottom of the group is taken to be a grayish sandstone, sometimes slightly conglomerate, often with impressions of *Spirophyton*, and about thirty feet thick. It is a characteristic rock resting directly on sandy beds which mark the transition to Chemung and in which the dividing line cannot be drawn very closely. On this sandstone rests the succession of shales and sandstones, the latter varying from gray to blue or red, from compact to shaly, from good building stone to miserable rubbish. The general succession is fairly well shown in many of the smaller gaps through Brushy mountain of Smyth and Bland, as well as in the similar gaps through Little Walker in Wythe, Pulaski and Montgomery; a more accessible section is along the Norfolk and Western railroad for seven or eight miles west from Pulaski.

The change in this group is as marked as that in the Umbral. The section in Lee county shows

Reddish silicious beds, some shale................150 feet.

Some part of which must represent the Vespertine. No coal was seen here. In the North Holston section near Mendota, in Washington county, the Vespertine can only be in the concealed space of eighty feet at the bottom. But the sandy beds increase toward the north-east so that before the line of Smyth county has been reached a coal has been mined in the river bed, while the shales and sandstones form a notable foothill to Brushy mountain. At the Laurel gap, in Smyth county, the estimated thickness is about 500 feet, while in the same ridge within Bland county, the thickness appears to be approximately the same. But followed northwestward into Tazewell county, this division is found insignificant where shown among the Clinch faults, being thinner on Indian creek than in Pennington's gap, in Lee county. Along the foot of Brushy and Little Walker mountains, one finds the Vespertine very much as in South-central Pennsylvania, a mass of shales, sandstones and irregular coal beds, capped by a silicious limestone.

The feature of especial interest is the great development of Vespertine coal beds within Wythe, Pulaski and Montgomery counties. These have been worked, especially in Montgomery county, for many years, and a summary account of them was given by Prof. W. B. Rogers, in his report for 1838. Prof. J. P. Lesley gave an excellent statement respecting the beds and workings as they existed in 1860; while Prof. Fontaine has described in detail the beds of Brush and Price mountains, in Montgomery county.

According to Capt. Boyd, thirteen beds or streaks of coal occur in a vertical space of less than 400 feet within the gap made through Little Walker mountain by Stony Fork of Reed creek. The first five of these beds are embraced within a column of 100 to 120 feet, No. 1 resting on the sandstone, known as "Quarry rock," which the writer has assumed as the base of the Vespertine. The first three beds alone possess any economic interest, as no others are mined anywhere within this region.

The lowest bed is usually very thin, but on Cloyd's mountain in Pulaski, and on Brush mountain in Montgomery, it becomes of workable thickness, two and a half to three feet. The second bed has been opened near the Wythe and Tazewell pike in Wythe county; at the Altoona mine in Pulaski; at several places along Tom's creek in Montgomery, all in the foothill of Little Walker or Cloyd's or Brush mountain, as the ridge is termed in different portions of its extent. Apparently the same bed has been mined near Sharon Springs, in Bland county; and on Price's mountain, in Montgomery. It varies from nearly four feet of nearly solid coal in Wythe to twenty-two feet of shale and coal in Pulaski, and nine or ten feet of coal and shale in Montgomery. But these are extreme measurements and the bed exhibits great and sudden variations in thickness, owing to the immense pressure which the yielding material has suffered. A similar condition exists in Bland county; but the variations in Price's mountain are comparatively small. The third bed was mined systematically only at the Altoona mine in Pulaski, though it was opened in Wythe county, near the Wythe and Tazewell pike. Its thickness at these localities is said to be between three and four feet. It is not worked now.

The physical structure of the coal shows great variations, which cannot be accounted for always by supposing different degrees of pressure. The coal from the second bed appears everywhere to have undergone much greater change than either the first or the third. In Wythe county at the Boyd mine, in Pulaski; at the Altoona mine and on the Dublin and Pearisburg road; and in Montgomery county, on Tom's creek; as well as in Bland county, near Sharon Springs, the coal from the second bed appears to have been crushed into fragments, which were pressed and rubbed until they were reduced to laminæ, so loosely packed in many places as to be easily separable by the fingers. But the coal of the first or third bed may be found on the same hillside, hard enough to bear transportation, though it shows with sufficient distinctness that it too has been subjected to severe crushing and rubbing. It has been broken into fragments, which have been rubbed together until thoroughly glazed. But the rubbing did not reduce the fragments to laminæ.

This variation may be due to difference in chemical composition or to the fact that the thinner beds are not broken by shale partings. It is of interest, however, to note that notwithstanding all this crushing and rubbing, the penetration of coal layers by shale layers in the second bed is no greater than that often seen in coal beds within the very little disturbed Coal Measures area of South-western Pennsylvania and the adjacent parts of West Virginia. The crush of strata in Price's mountain has been comparatively slight, despite the faulting, though there also, it is sufficiently clear that the greater part of the crushing was endured by the coal, as being the more yielding substance.

Analyses of coals from several of the pits have been made by Mr. A. S. McCreath, the accomplished chemist of the Second Geological Survey of Pennsylvania. The results taken from his memoir on the Resources of Virginia, are as follows :

1. Guggenheim bank, Brush mountain, near head of Tom's creek.
2. Smith bank, also on Brush mountain, one mile further east.
3. Blacksburg M. & M. Co., also on Brush mountain.
4. William Perfator, also on Brush mountain.
5. William Meyers, Price mountain.

All of these are from Montgomery county :

6. Altoona mines, Pulaski county.
7. Stony Fork, of Reed creek, Wythe county, 2d bed.
8. Same locality, 4th bed.

	1	2	3	4	5	6	7	8
Water	1.228	0.816	0.615	0.725	1.080	0.236	0.466	0.620
Volatile matter . . .	11.652	11.324	12.870	12.215	9.675	9.459	16.264	17.853
Fixed carbon	73.012	75.618	70.924	72.737	74.013	49.353	55.615	59.427
Sulphur.	0.548	0.697	0.481	0.333	0.682	1.122	0.995	1.575
Ash.	13.560	11.545	15.110	13.990	14.550	39.830	26.660	20.525

The coal from several of the mines is in good repute. Much of that from Tyler's mine near New river is used as grate fuel in villages along the railroad west from New river. The Tom's Creek mines are worked and the coal is carried in wagons nine or ten miles to Bang station, on the railroad, whence, with the Price Mountain coal, it is distributed to villages in the vicinity. In spite of the great percentage of ash and the much higher cost per ton, the Tyler and Price Mountain coals are preferred to Pocahontas coal for grates, as they are practically free-burning, having very slight tendency to coke. The Altoona coal is used at the salt-works in Smyth county, and at the Bertha zinc-works in Pulaski.

A comparison of the fuel ratios is interesting. Arranged in order from north-east to south-west along the foot of Little Walker mountain we have

No. 2	15	85
No. 1	16	84
No. 3	18	82
No. 4	16	84
No. 6	19	81
No. 7	29	71
No. 8	30	70

An analysis of the Tom's Creek coal is given in Prof. Rogers' report for 1836, p. 17, which shows the ratio of

Volatile	16
Fixed	84

or the same as No. 2, of Mr. McCreath's analyses of Tom's Creek coals. These analyses show that the proportion of the volatile combustible matter decreases north-eastward, so that one is prepared to find not a semi-bituminous coal such as these, but a true anthracite in Narrowback mountain at the Dora mines further north-north-east, near Harrisonburg.

The material for comparison of the areas lying further south-east, in the Valley, does not exist. No analyses of coals in the area between Max Meadows and Pulaski have been made, so far as the writer knows; only one analysis of the Price Mountain coals by McCreath, and one of the Catawba coal in Botetourt county by Rogers, have fallen under the writer's notice; these show:

Price mountain	13	87
Catawba..........................	21	79

a very notable difference. Whether or not the specimens were taken from different parts of the same bed or from different beds cannot be ascertained.

The Vespertine coal beds attain their chief importance within the counties of Wythe, Pulaski, Montgomery, Roanoke and Botetourt, a distance along Little Walker mountain of barely 105 miles. But isolated patches of slight extent preserved in synclinals within Augusta and Rockingham counties, show that the field with beds of workable thickness extended to certainly 100 miles further north-north-east, thus giving a length directly measured of nearly 200 miles. Exposures in Wythe, Pulaski and Roanoke show that the Vespertine beds reached far into the area now known as the "Great Valley," fragmentary patches still remaining at a distance of barely twelve miles from the Archæan, while exposures in Bland and Rockingham show that the productive coal area in Virginia extended to some distance beyond the line of the Saltville fault. Certainly it was 200 miles long by fifteen miles in Virginia; and the width may have been twelve miles greater toward the south-east, reaching to the Archæan. The whole area may be estimated at beyond 5000 square miles, of which only insignificant strips and patches have escaped erosion, amounting in all to not more than 130 square miles. How much further north-eastward this area extended cannot be determined, for in Pennsylvania and Maryland the numerous folds with the disappearance of the faults have thrown the most easterly outcrop of Vespertine, to a distance from the Archæan greater than that of the Abb's Valley fault from the Archæan in Virginia. No workable coal beds occur in Pennsylvania and Maryland within the Vespertine, but what existed in that portion of the Vespertine which has been removed by erosion, we may conjecture from the conditions occurring in Virginia within the same space.

Within Virginia the coal beds diminish quickly in importance in all directions from the area already defined. South-westward, the coal-bearing division of the Vespertine diminishes and the last trace of it occurs on the North fork of Holston, near Mendota, in Washington county, where coal is said to be found in the river-bottom at low water. North-westward the coals diminish. In Lee, Wise, Russell and Tazewell counties, of Virginia, this lower division is either insignificant or wanting—but further north-west, in Greenbrier county, of West Virginia, Prof. Fontaine* found the sandstone division with strings and beds of coal, which, however, are interesting more because of their existence than because of any economical importance. The total thickness of the whole series there is about 290 feet.

No Vespertine is found in or immediately adjoining the Great valley, beyond Augusta county, of Virginia; but the petty areas preserved on the crests of synclinal ridges are among what Prof. W. B. Rogers termed the Allegheny mountains, in Hardy, Hampshire and Morgan counties, of West Virginia. There the coals are usually very thin, as they are also under the great anticlinals of Randolph and Tucker counties, of West Virginia, Allegheny county, of Maryland, Bedford, Huntingdon, and the counties further north in Pennsylvania. The coal is present in all of these, but not in such shape as to deserve more than passing notice; the thickness seldom exceeds a few inches and the large percentage of ash leads most persons to regard the coal as anthracite. Along the lines mentioned, the sandstones show a decided thickening, becoming 1100 feet or more in Bedford county, of Pennsylvania; but the thinning is very marked in a north-westward direction, as the whole thickness in Fayette county, of Pennsylvania, is barely 400 feet. There, the last westward exposure on the easterly side of the Appalachian region, it appears to contain no coal.

The Devonian.

The Devonian is represented by Chemung and Hamilton only, the Catskill and Carboniferous being absent. In Bland and Giles counties Devonian rocks occur in the "Wilderness" area of Kimberling creek, and they make up the great part of Brushy mountain, in the former county: they underlie the "Poor valley" of Walker mountain, and make the mass of Little Walker and Max Meadows mountains, while a narrow strip lies along the north side of the Draper Mountain fault in Pulaski county. Except in the "Wilderness," where the Oriskany was recognized, no line could be drawn between Devonian and Upper Silurian, the shales of the one passing interceptibly into the shale of the other.

Chemung.—The Chemung, as seen on the North Holston near Mendota, is 350 feet thick, but it is wholly absent from Stony mountain in Lee county. Eastward, or rather north-eastward in Brushy mountain, the thickness increases rapidly, so that north from Saltville, in Smyth county, it is certainly twice as great as at Mendota. On the same mountain, in Bland county, the increased thickness is noticeable even to the most careless observer, and on the road leading from Walker creek to Hunting Camp creek, the following succession was seen:

1. Sandstones with some shales.
2. Conglomerate sandstone.

* Loc. cit., pp. 44 and 45.

3. Shales and sandstone.
4. Conglomerate sandstone.
5. Shales and flags.

No effort was made to secure measurements here, as the road is tortuous and in unbroken forest, but an excellent section can be obtained by instrumental measurement, as the stream bed affords almost continuous exposures below the upper conglomerate. The flaggy sandstones between the conglomerates are bluish red and resemble closely the rocks immediately overlying the upper conglomerate; but details respecting the great part of No. 1, which includes beds of passage from Vespertine to Chemung, are practically wanting here. In the Laurel Fork gap through Brushy mountain in Smyth county, and in the Seddon gap in Bland county, these are shown to be gray to blue sandstones.

The section is similar in the Little Walker mountain gaps. On New river the distance from the "Quarry rock" to the conglomerate is not far from 900 feet, but no exposures occur in the interval along the railroad. Almost continuous exposures on the Newport and Christiansburg road show the space to be filled with gray to yellowish flags and sandstones with few shales.

At all localities the beds of No. 3 consist of more or less argillaceous concretionary sandstones passing downward into shales with bluish red or deep red flaggy sandstone. The flags, though forming a small part of the mass, are sufficiently hard to support the cliffs of this division, which are seen in many ravines. These beds are well exposed on all graded roads crossing Brushy and Little Walker mountains; along the ravine followed by the road to Hunting Camp creek, in Bland, they are shown in cliffs. There, however, the flags appear to be more abundant than at any other locality. No satisfactory estimate was made of the thickness, but as exposed along the Hunting Camp road, in Bland, it is not less than 1000 feet.

No. 5 consists of flags and shales, olive, gray, blue and drab, which are well shown at many localities.

The conglomerates are rarely shown in place. No. 2, which is not far from forty feet thick on Brushy mountain and is certainly much thicker in Little Walker, was seen in place only on the road to Hunting Camp creek, on New river and on the Newport and Christiansburg road over Little Walker, yet this conglomerate is the "backbone" of both mountains, and to its ragged outcrop is due the irregular crest of each. Its fragments are always abundant and ordinarily they are characteristic. The pebbles vary in size from a pea to a hen's egg; while in several of the layers they are flat and, curiously enough, in some parts their longer axis is almost vertical to the plane of bedding. Almost without exception these are of quartz or quartzite. The lower conglomerate was seen in place only on the Hunting Camp Creek road in Bland county, just where the road leaves the long gorge and emerges upon the "clearing." In general features it closely resembles the upper conglomerate.

In the New River section fragments with Chemung fossils are plentiful to a vertical distance of not far from 500 feet above the conglomerate, but beyond that the fossiliferous fragments become rare and soon are altogether wanting. A fossiliferous sandstone containing *Chonetes* and *Pthonia*, both Chemung forms, together with many other forms not easily recognizable on the weathered surface, was seen on the Dublin and Pearisburg pike at between 300 and 400 feet vertical distance above the supposed place of the upper conglomerate. The transition thence to the Vespertine, as shown in the excellent and almost continuous exposures along that road, is absolutely imperceptible—there is no change to the "Quarry rock," and the drawing of the line of separation at the bottom of that rock is wholly arbitrary here. But at many other localities a change occurs at about 200 feet below that rock, bringing in some bluish sandstones. Chemung forms become very abundant immediately below the upper conglomerate. Good collections can be made on Brushy mountain in Bland county along the Seddon and Mercer road, as well as along the road from Point Pleasant to Kimberling creek. Excellent localities on Little Walker are on New river and on any of the roads crossing the mountain in Pulaski and Wythe counties. No doubt good collections can be made within a mile and a half of Pulaski on the road leading over Draper mountain.

The geologist familiar with the Chemung of Pennsylvania and Maryland will recognize a familiar section here: the two conglomerates with variegated shales below them passing into the flags, while between them are the flags and shales passing through clayey concretionary sandstones to the upper conglomerate. The similarity fails above that conglomerate in that the red shales are wanting, and the passage to the Vespertine is through sandstone rather than through shale. The condition is more nearly that of South-western Pennsylvania where, as here, the Catskill is absent and the Chemung is carried directly to the Vespertine. The thickness of the section in Bland county appears to be very nearly the same with that of the section in northern Bedford county of Pennsylvania, nearly 300 miles away along the line of strike. This persistence through so great a distance makes more remarkable the entire disappearance of the group between Bland Court-house (Seddon) and Pennington's gap in Lee county, only 125 miles away at the south-west.

This group evidently reached to the south-easterly side of the "Great valley," for the beds upturned alongside of the Draper Mountain fault are within twelve miles of the Archæan.

Hamilton.—The line between Hamilton and Chemung cannot be drawn satisfactorily during a reconnaissance, as the passage from one to the other is by no means abrupt. So gradual, indeed, is the passage here, as well as in a great part of the Appalachian region, that the older geologists of both Virginia and Pennsylvania placed the series together as a single group, their No. VIII. The Hamilton shales are gray to black, and evidently represent only the lower part of the group as found further northward. They are shown in the "Poor valleys" of Walker and Cove mountains, as well as in Bland county around the foot of Round mountain. They contain little of interest.

The Upper Silurian.

No definite line of separation between Upper Silurian and Devonian could be made out except in the "Wilderness" area of Bland and Giles counties; there the Oriskany is present, which makes the boundary distinct. Upper Silurian, represented by Oriskany, Clinton and Medina, makes up the most prominent features of the district, Medina being, *par excellence*, the mountain-making rock.

The *Oriskany* was seen only in Bland county, where it is exposed at the foot of Round mountain and the Garden mountains, as well as along the foot of Wolf Creek mountain in the "Wilderness." The rock is a thin sandstone, which resists the weather so well as to make a small ridge. If this rock be present in the "Poor valley" between Big and Little Walker mountains, it must be very thin and must yield readily to the weather, as that valley was crossed on four lines, each affording good exposures, but without Oriskany. As shown in the "Wilderness" the rock is a moderately coarse gray sandstone, evidently not more than ten feet thick, and containing, in addition to the ordinary forms, impressions of large crinoidal joints.

The *Lower Helderberg* may be present in the "Wilderness," but no positive proof exists. Fragments of white chert containing a delicate *Stromatopora*, and seen near Round mountain, have much resemblance to the chert bed at the base of the Oriskany or top of the Lower Helderberg. Aside from those fragments nothing referable to the Lower Helderberg was seen in any of the "Poor valleys."

The *Clinton* forms a bench around Round mountain; on the Garden mountains; on Wolf Creek mountain and its continuation in Pearis and Sugar Run mountains; on Big Walker and Cove mountains. Everywhere it presents the same features, variegated shales with white sandstones near the ores. The "fossil" ore occurs, but little only is known respecting either its quantity or quality. It appears to be abundant, though silicious, on Wolf Creek mountain, if one may judge from the fragments where the ore horizon is crossed by the road near Wolf creek or Rocky gap.

The *Medina* is well known as the mountain-making rock. Its outcrop forms the crest of Cove, Big Walker, Garden, Round and Wolf Creek mountains; it makes a double outcrop on Pearis and Sugar Run mountains, as well as on Butte and Salt Pond mountains; while it is shown on each side of the House and Barn synclinal in Buckhorn and East River mountains.

The *Upper* or *White Medina* is very far from being coarse, though a few layers of conglomerate were observed in it. The best exposure is in the gap made by New river through Big Walker mountain, where the estimated thickness is 375 feet. For the most part the rock is white, and on long exposure the surface becomes beautifully polished. This is characteristic of the rock along an outcrop of fully 400 miles. Some brown or reddish-brown layers occur in this division, but their thickness was not ascertained. Aside from *Arthrophycus harlani* and a *Scolithus*-like form, no fossils occur in the sandstone.

The *Lower Medina*, composed of reddish sandstones and shales, is the imperfect terrace on the northerly side of the mountains, and, as was stated in a previous memoir, this is clearly the same with the Terrace group of South-central Pennsylvania, which has been identified by Lesley, and therefore by the writer in his Pennsylvania report, as the Red Medina of New York. The thickness cannot be given with any degree of certainty, as the rock passes downward without break into the Hudson ; ordinarily it is much disturbed. The best exposure in detail is on the Tazewell and Wythe pike as that road descends the northerly side of Big Walker mountain toward Sharon Springs. There, within 100 feet vertically below the White Medina, is a fossiliferous bed, six to eight feet thick, containing *Rhynchonella, Orthis, Modiolopsis, Avicula emacerata, Ambonychia radiata* and fragments of *Orthoceras*, which were collected during an examination lasting but a few minutes.

The relation to the Lower Silurian, therefore, is intimate, so intimate that the writer is more than ever convinced that there is room for doubting the accuracy of any identification which makes the Terrace group of Southern Pennsylvania the equivalent of Medina in New York.

The Lower Silurian.

The Lower Silurian is represented by Hudson, Trenton and Knox limestone. Hudson beds occur only on the steeper slopes of the Medina mountains ; Trenton is at the foot of such mountains, but within the counties described in this memoir, is rarely seen in the broader limestone valleys. The Knox limestone is the surface group in the "Rich valley" of Bland and Giles ; on both sides of New river in Giles' county ; and is the great limestone group cropping out over so much of the "Great valley" in Wythe, Pulaski and Montgomery counties.

The Hudson consists of red to yellow sandy shales, which pass with equal indefiniteness into the Red Medina (?) above and into the calcareous shales of the Trenton below. The Trenton beds are calcareous shales with streaks of impure limestone passing downwards into pure massive limestones, some of which would be valuable as marbles. The lower beds become more or less silicious and show embedded nodules of chert.

These cherty beds afford transition to the Knox limestones, which are very cherty in the upper portions. The lower portions contain much shale with silicious limestones, and near the base is a curious limestone, somewhat silicious, which is veined with white spar and contains great blotches of the same material. This is a notable bed, which is recognized in many places where it promptly affords a key to the puzzles. Its presence on New river and at several other localities in Pulaski county shows the relations of the rocks on both sides of the Walker and Pulaski faults, and proves the presence of Knox beds in that part of Pulaski county lying between the Altoona railroad and New river. A good section of this group should be obtained along the Valley pike in Wythe county beyond Reed creek, beginning near Kent's Mills, where the series is well exposed almost to the fault of Draper mountain.

Along the southern side of Wythe and Pulaski counties, the Knox beds, more or less dolomitic, carry important deposits of zinc and lead ores, some of which have been utilized. The mine of the Wythe Lead and Zinc Company will be described in its own place. There the lead ore has been worked for more than a century, but the zinc ore had been neglected until the near approach of the Cripple Creek extension of the Norfolk and Western railroad led to its development and preservation. The zinc ores at the Bertha mine, also in Wythe county, yield a spelter of the finest quality. This strip of zinc and lead ores extends from Smyth county across Wythe and Pulaski, but developments thus far have been confined to Wythe county.

The brown hematites of the Knox limestones in Pulaski and Wythe counties, along the New river and its tributary, Cripple creek, have been well described by Mr. A. S. McCreath,* who examined most of the openings and analyzed the ores, using samples collected by himself. The ore lies not far from the lead and zinc, and appears to be present in great quantity. Much of it is of excellent quality.

Manganese oxide and barytes are reported as occurring at several localities, but no information was received respecting the quantity.

The Cambrian.

Here are placed the Lower Knox shales and the Potsdam. The former are probably equivalent to the Hydromica schists of Pennsylvania and the lower part of the Calciferous of New York; the latter is the Potsdam of New York, vastly increased in thickness.

The Knox shales are shown in Draper valley, within Wythe and Pulaski; they surround Lick mountain in Wythe and continue for some distance eastward along the anticlinal; they are continuously exposed within a mile of the southern border of Wythe and Pulaski counties, and are brought up for a little way under an anticlinal lying south from the Wytheville synclinal.

For the most part these shales are reddish, sometimes streaked with white, usually more or less greasy, often talcose-looking on the slipped surfaces. The rock is hard and is used for repairs of the Valley pike. An admirable exposure occurs on that pike for some distance east from the Cripple Creek railroad crossing, and one almost equally good is on the road crossing Lick mountain on the way from Wytheville to Brown Hill furnace. Streaks of limestone occur in the upper part, but they are wanting below. In the upper part are also some beds of yellow and blue shales,

* The Mineral Wealth of Virginia tributary to the lines of the Norfolk and Western and Shenandoah Valley Railroad Companies. 1884.

but they are thin. These shales are hard enough to form bluffs; where they have been long exposed to the weather, their surface becomes very dark and the dismal effect is increased by the abundant growth of ashen lichens, which are never absent from the older outcrops. The thickness of the group cannot be determined without careful study, as at all localities crossed the beds are badly folded; but it cannot be less than six hundred feet.

The Potsdam forms the great mass of Lick mountain; is the sandstone of Draper mountain; and is found along the southern border of Wythe, Pulaski and Montgomery counties. The upper beds are alternations of sandstones and shales. The sandstones are mostly white, vary from slightly conglomerate to exceedingly fine grain, almost like quartzite; many layers are hard and on long exposure become beautifully polished. The lower beds shown in the deeply eroded gorges of Lick mountain and on the northerly side of Draper mountain, are sandy shales, mostly grayish and often so thickly bedded as to be shaly sandstones. The bottom of the group is found not far from the line of Grayson and Carroll counties, but that line was not reached by the writer. No measurement to determine the thickness of the group was attempted, as the bottom is not exposed in either Draper or Lick mountain, but in Draper the thickness is not less than 2000 feet, the calculation being based on the dip and a rough estimate of the horizontal distance through the mountain from the fault to the bottom of the Knox shales. The amount of rock exposed along the road traveled over Lick mountain is not so great, but the deeper ravines of that mountain should show an equally extensive section.

No fossils were observed in the Knox or Potsdam shales, but the search for them was not diligent. Some layers of sandstone near the bottom of the Potsdam sandstone yield *Scolithus linearis* abundantly on Lick mountain; but neither that nor any other fossil was seen in the Potsdam of Draper mountain.

Ores of manganese and iron are reported as occurring near the bottom of the Knox shales, but no effort has been made to develop these except in a small way on Lick mountain.

III. THE REGION NORTH FROM BIG WALKER'S MOUNTAIN, BLAND AND GILES COUNTIES.

In descending Walker's mountain by the Wythe and Tazewell pike, one leaves the Medina at the summit and comes to a fossiliferous bed at barely one hundred feet vertically below the mountain crest. This is from six to eight feet thick and contains many typical Hudson fossils in great numbers; *Rhynchonella increbescens, Orthis occidentalis* (?), *Avicula emacerata, Ambonychia radiata, Modiolopsis* with fragments of *Orthoceras* were collected within a few moments. Other fossiliferous beds were seen lower down the slope, but no specimens were taken. These reddish shales with streaks of sandstone pass gradually into the yellowish shales of the Hudson, which in turn pass into the dull reddish calcareous shales or shaly limestones of the Trenton. The cherts at the base of the Trenton or top of the Calciferous are reached at the first house. Thence exposures are rare until at the Sharon Springs some sandstones with indefinite dip are shown in the stream. These springs, which are the sources of the North Fork of Holston river, are very large and issue from very near the Saltville fault. The place was a popular summer resort in former times, but the construction of the railroad through the Great valley made it practically inaccessible and the hotel has few visitors.

The Saltville fault passes very near the yard at Sharon Springs, the ridge behind the hotel being sandy. The dip where the pike passes through this ridge is southward at fifty-eight degrees, and the silicious limestone of the Vespertine is shown at the northerly foot of the hill. The lower beds of the Vespertine have been eroded near the pike, but at a fourth of a mile eastward they form a low hill, in which a coal bed was mined at one time to supply local needs. The pits have fallen shut and most of them appear to have been little more than extensive strippings along the outcrop. The thickness varies greatly; it is reported as eleven feet at one place. The coal is badly twisted, but the crushing and polishing are much less than at many other localities. Notwithstanding this crushing, the volatile matter is considerable and the coal cokes on the fire. The rocks enclosing the coal are regular and not much distorted except at one place, where the distortion may be due to a surface creep.

The Tazewell pike continues northward, crossing Garden mountain, and, within a direct distance of four miles, entering Burk's garden, to which reference was made in the notes on Russell and Tazewell counties. This road was not followed beyond the abandoned coal-pits.

The Rich Valley road is near the top of the Calciferous until six or seven miles beyond Seddon, where it crosses the Saltville fault; but within a little way it returns to the Calciferous and remains in it. The Calciferous limestones and shales are apparently non-fossiliferous; certainly fossils are rare, none having been seen, though the exposures were examined for several miles. The dips vary from twenty to forty degrees, the more common rate being not far from thirty. Waddell's lead mine, abandoned long ago, is a group of rude excavations in Calciferous at five or six miles east from Sharon Springs. The road leading to Hunting Camp creek leaves Rich valley at nearly seven miles from the springs. The dips quickly steepen on that road, so that limestones exposed in the little stream-bottom near the first house are dipping southward at from fifty to sixty degrees. The Saltville fault is reached at barely half a mile, at top of an abrupt grade beyond the first house.

The blossom of a thin coal bed, indicating a thickness of not more than ten inches, was seen at the top of the first hill, which may be the same with a thin bed digged in the bed of a run not far west from the road. The silicious limestone is exposed at R. Waddell's house and a coal bed is worked in a small way by Mr. Harmon, very near the summit of the road, which is far from being the summit of Brushy mountain. The pit was not examined and the thickness of the bed, which is said to be between three and four feet, was not ascertained.

The road descends rapidly on the northern side to a large branch of Hunting Camp creek, which follows a long gorge through Brushy mountain. The *upper conglomerate* of the Chemung is shown soon after the stream has been reached and forms a ridge on each side of the road; the exposed thickness is not far from forty feet. The layers of conglomerate are distinct and one of them is ferruginous, with pebbles as large as a walnut. The gorge below this is exceedingly rugged, the shaly beds of the Chemung being held in cliffs by thick flags which are shown nicely in the stream so often crossed by the road. A second gray sandstone, with layers of conglomerate and closely resembling the former, is shown just above the mouth of the gorge. The more shaly beds at the base of the Chemung are shown as one approaches Hunting Camp creek, at Mr. Soutter's. There one sees, in looking back, that the tributary streams have cut Brushy mountain into parallel ridges, each with one of the harder Chemung sandstones for its crest.

The lower shales of the Chemung with their hard flags form a low but very distinct ridge, which follows the foot of Brushy mountain and curves round the easterly end of the Garden anticlinal to form a similar ridge for a little distance between Round and Rich or Wolf Creek mountains. The Hamilton shales, which can be hardly separated from the Chemung during a hasty examination, continue to the northerly side of Hunting Camp, where the road first reaches it, though at a little way further down the stream cuts almost to their base. The Oriskany sandstone is exposed just north from the creek at barely a mile below Mr. Soutter's and thence its fragments are very numerous. The rock crosses the end of Round mountain as the Burk's Garden anticlinal dies away, and it is shown in the road at a short distance above the mouth of Hunting Camp creek. The most notable fossil is the stem of a *crinoid* of which individual joints are extremely common. *Spirifera arrecta* appears to be more abundant than any other of the ordinary forms. Evidently associated with the sandstone, but not seen in place, is a white chert, which contains a delicate *Stromatopora*. Whether this represents the Lower Helderberg or not could not be determined.

The road to Seddon leaves Hunting Camp creek at about two miles from its mouth and crosses Brushy mountain to Rich valley, at Seddon. The shales northward from the creek on this road are without doubt largely Hamilton, but beyond the creek southward the road quickly enters the low ridge of olive shales and flags, which has been referred to already as persistent along the foot of Brushy mountain for fully twelve miles. As the road ascends the mountain, it passes over olive flags with olive, gray, ashen, blue and yellow shales, continuing to the summit of the road; the southward dip being somewhat irregular, but rarely falling below twenty, or rising above forty degrees. These shales show no fossils aside from occasional impressions of crinoid joints and rude traces of fucoids on the surfaces of the flags. Similar shales and flags continue for a little distance down the southerly side of the mountain, but the upper beds are soon reached and some of them are very fossiliferous. On one slab *Rhynchonella orbicularis*, (?) *Grammysia subarcuata*, *Modiomorpha*, *Mytilarca* and *Edmondia* were seen and the specimens were remarkably well preserved. The gray sandstones of the group are not exposed along the road, but their fragments are very abundant and the rocks themselves form the summits of the subordinate ridges. The Kimberling anticlinal is crossed at less than half way down the mountain and brings up again at least one of the sandstones. The passage to Vespertine is not easily made out. A mass of red sandstone occurs in a narrow gorge, say half a mile from Seddon, which probably marks the bottom of the Vespertine. Coal belonging to that group has been mined in a small way at half a mile west from Seddon and at about the same distance north-east from that village. A mine has been opened for domestic use at about three miles further east; but none of these pits was visited. The topography is reversed on the road crossing Brushy mountain, the long gorge being on the southerly side.

The road in Rich valley lies in Calciferous for somewhat more than six miles from Seddon or to a little beyond Point Pleasant. The chert ridge is south from the road and attains to considerable height in its eastern extension. The road lies south from the Saltville fault to Point Pleasant, but almost directly beyond that place it turns northward and thence to the road crossing the mountain to Kimberling creek it lies north from the fault. The dips in the limestone seldom exceed thirty degrees, except near the fault, where they become fifty-five and sometimes even more. Exposures are very indefinite along the road to Kimberling creek, as it ascends the slope of Brushy mountain. No coal blossom was seen and no coal is digged anywhere near the road. Fragments of the Chemung *upper conglomerate* are very numerous at the first summit of the road and the rock forms the crest of the first main ridge. Between this and the second or main summit of the road, fossils may be obtained in considerable quantity, *Rhynchonella*, *Chonetes*, *Grammysia* and *Goniophora* all well preserved, having been obtained from a single block. *Ambocoelia* occurs in vast numbers, its casts forming the mass of several thin beds. From this summit to Kimberling creek, the road is in the shales and flags which are exposed almost constantly thence to the mouth of No-Business creek. The dip is steadily southward, but becomes comparatively gentle along the creek, being barely ten degrees at the mouth of No-Business. There Kimberling changes its course to south-east and evidently flows through Devonian to where it crosses the Saltville fault at two or three miles east from Mechanicsburg. The stream was followed only to within about four miles of the fault so that the limits of groups as given on the map are only approximate. Dismal and No-Business creeks, tributaries of Kimberling, take their rise respectively in Sugar Run and Pearis mountains, double outcrops of Medina with Clinton between the outcrops: but the streams enter Kimberling in Devonian, which is the surface group in nearly all of the broad space between Brushy mountain at the south and Wolf Creek mountain at the north, the distribution being due to the disappearance of the Burk's Garden anticlinal and to the growth of the Kimberling anticlinal. The portion of the area lying north from Kimberling is almost uninhabited and is known as the "Wilderness."

Exposures are very indefinite along the Wilderness road for some distance from Kimberling creek on the way to Rocky gap; but near Mr. Benton's house, at, say, two miles from the creek, the rocks are dipping northward at nearly fifty degrees, and the rate increases at a little distance further, as is well shown by exposures in the stream.

The dip again becomes southward at somewhat more than a mile from Benton's house and the Chemung rocks are soon shown with almost vertical dip forming an irregular broken ridge. No exposures aside from those of a few dark shales occur in the interval to the next ridge, a space which should be occupied by Hamilton. A sandstone ridge, evidently Oriskany, is cut by the road at somewhat more than a mile and a half from the Rocky gap by which Wolf creek passes through Wolf Creek mountain, the same with that known in Tazewell county as Rich mountain. This ridge is cut by the creek at, say, three-fourths of a mile from the forks of road at head of the gap. No fossils were observed in the sandstone. Some white chert which may represent the Lower Helderberg was observed here.

The Clinton is quickly reached with its dark red sandstone; it makes a well-marked ridge and terrace along the southerly foot of Wolf Creek mountain. Fossil ore occurs very abundantly, but the fragments seen along the foot of the mountain are very silicious. Medina is shown in the stream-bed at the very head of the gap, whence it rises rapidly to crest of the mountain with a dip of twenty-five to twenty-seven degrees. The immediately underlying red beds are more silicious than at most of the localities visited, and they are exposed to a thickness of about 250 feet. Exposures are very indefinite beyond this until the Trenton is reached midway in the gap. The Calciferous beds next come up and at the mouth of the gap they are dipping southward at thirty-five degrees. These beds prevail to the cross-roads at J. D. Honaker's store.

Wolf creek bends northward immediately below Honaker's store and soon crosses the Wenonah fault, which brings Calciferous against Clinton, the dip of the latter being eighty degrees. The Medina caught in this double fault forms the Valley ridge, which is persistent thence to the New river. The creek passes through this ridge at say a mile and a half below Honaker's and affords a fine exposure of Medina on the easterly wall of the gap. The Calciferous limestones are reached immediately behind the ridge and within one-fourth of a mile are faulted against the Medina of Buckhorn mountain, a low ridge following the southerly foot of East River mountain. The road crosses this fault to the Medina, but returns to the limestone on the hill opposite Mr. Carpenter's house about three miles from J. D. Honaker's store. Thence to New river the road is in the limestone between the two faults. The creek approaches the Buckhorn fault very closely near the line of Giles county, but the Wenonah fault, whose course is marked by the Valley ridge, is touched nowhere by Wolf creek below the gap near Honaker's. The dips in limestones between the two faults vary greatly, being from fifteen to forty degrees along the creek; but the rate diminishes toward New river, where it rarely exceeds twenty degrees. Though underlaid by limestones and calcareous sandstones, much of this Wolf Creek valley is very poor. Great fragments of Medina are numerous and the disintegrated sandstone has contributed most largely toward formation of the detrital covering.

The valley between Buckhorn and East River mountains is reported to be "freestone." No examination of its structure was made, but there appears to be a synclinal here, in which case the surface rocks would be Silurian shales.

The valley is contracted near the mouth of Wolf creek and the locality is known as the "Narrows." The crest of Wolf Creek mountain is carried northward in a bold knob which overlaps the Valley ridge. Thence it recedes southward, limiting the broad deep valley of Mill creek, to return northward and form the bold knob of Pearis mountain. The point of this mountain is at about two miles from Pearisburg and there the Medina outcrop curves southward under the influence of the Kimberling anticlinal. The Valley ridge becomes indistinct where the fault is crossed by the pike near Wenonah station. Thence to Pearisburg the road lies in Calciferous and Trenton limestones. The synclinal north from the Kimberling anticlinal is crossed by the Dublin pike at the southerly end of Pearisburg and in this is the "Angel's Rest" or terminal peak of Pearis mountain. The outcrop of Medina climbs the anticlinal as the fold declines, crosses it at the head of Sugar run and then moves eastward along the southerly side of the anticlinal. It soon recedes toward the west as it ascends the weakening anticlinal of Sinking creek and finally disappears against the Saltville fault.* That fault is crossed by the Dublin and Pearisburg pike at a very little way north from Poplar hill, where the Trenton and Calciferous are in contact and the road passes into the Rich valley between Big Walker's mountain and the Saltville fault.

A road, leaving the pike north from Poplar hill and leading to New river at Scott's ferry, crosses the Saltville fault at four miles from the pike or at a little more than one mile by Walker's creek above Staffordsville. Erosion here, as on the pike, has cut away all rocks higher than Trenton limestone from the north side of the fault, but, within a short distance, the Medina appears again and forms Buckeye ridge, the northern boundary of Rich valley to and beyond New river. The dying away of the Walker's Creek anticlinal permits the Walker's Mountain outcrop of Medina to advance northward so that the valley is narrow near New river.

*This outcrop was not followed to the Saltville fault and the statement given in the text is based on the topography.

The many railroad cuts along New river from this gap northward to Big Stony creek exhibit the structure very well. Only Calciferous is shown under the Kimberling and Sinking creek anticlinals until the Wenonah fault is reached near the mouth of Big Stony creek, where one sees Medina. Thence to the foot of Buckhorn or Little mountain the limestone is exposed in cuts and less frequently in natural outcrops.

The surface of the area between Pearis and Sugar Run mountains on the westerly side, and the Salt Pond mountains on the easterly side of New river shows traces of erosion planes. The underlying rocks belong to the Calciferous, Trenton and Hudson, but the detrital coat is very thick and for long distances completely conceals the bedded rocks.

The Buckhorn fault is continuous eastward from New river certainly for twelve miles and the limestones of the Calciferous are exposed frequently along Big Stony creek. The fault runs along the face of Buckhorn or Little mountain, but what becomes of it or of the limestone valley just south from it was not ascertained as the creek was followed only for three miles from the river, but the valley appears to be continuous to the county line. Big Stony creek approaches very closely to the Wenonah fault at barely a mile from the river, where the limestone is turned up suddenly at forty degrees northward and Medina is shown in the hill above.

A road leading to Little Stony creek leaves this stream at rather more than two miles and a half from the river. The Medina of the Valley ridge is reached before one comes to the first house, being shown in place at a little way from the road. The summit of the ridge is about 600 feet above New river at Snidow's lower ferry and there the Medina is reached a second time. The rock is not shown in place, but the surface is covered with fragments of the sandstone which could hardly have come down from Butte mountain. The limestones are reached again as the road descends to a little stream and they are still dipping southward.

The Trenton shales and shaly limestones are shown on the next ridge, but the Hudson beds are shown only further up the ridge eastward from the road. The summit of the road, at approximately 400 feet above the river at Snidow's lower ferry, is covered with debris of Medina and this ridge is merely the termination of Butte mountain. The Pearisburg synclinal passes at somewhat more than a mile from Little Stony creek, and the northward dip is well shown on the road as it descends to the creek. The Trenton limestones form a bold ridge on the southerly side of the creek, the southerly wall of a deep gorge which has Butte mountain for its northerly wall. Medina forms the double crest of Butte or Big mountain. The northerly outcrop encroaches on the narrow strip of Cambro-Silurian between the mountain and the Valley ridge so that the two lines of Medina appear to overlap. The area of the lower rocks is certainly so narrow that it cannot be represented on the map.

The road to the Mountain lake leaves the pike at Doe creek, which it follows to very near the lake. The cherts of the Calciferous are exposed at the pike and the axis of the Kimberling anticlinal must pass near the fork of the road. The Lake road winds up the mountain side and reaches the Hudson beds within two miles of the lake. The Pavilion Knob, just west from the lake, shows the red shales with *Rhynchonella* and *Ambonychia* half way up, while at the very top is a large Lingula in vast numbers associated with a *Modiolopsis*. Medina caps several knobs on the ridge between Doe and Little Stony creeks. The outcrops of that rock meet on the summit of the Kimberling fold at a considerable distance east from the lake and thence to the eastern edge of Giles county Big and Salt Pond mountains are covered by dense forest, through which no road passes.

The Mountain lake or Salt pond is at somewhat more than 4000 feet above tide and is three-fourths of a mile long by one-half mile wide, the measurements being extreme in each case. It occupies a great sinkhole, which, within fifty years contained only a small pond of water at the bottom of the depression, by which a farmer salted his cattle. In some way, the outlet of the pool became choked, and water from the adjacent springs accumulated until it overflowed the rim and discharged itself into Little Stony creek. The subterranean outlet may be opened again and the pond drained. The spot is very attractive, and at one time it was a popular resort.

The road to Newport winds along the side of Salt Pond mountain, descending rapidly after it passes the point of the mountain, which is in the synclinal between Kimberling and Sinking Creek anticlinals. The Trenton shales are reached at about three miles from the Lake hotel and are thrown into numerous and complex folds, many of which are broken and slightly faulted along the axial plane. These occupy the synclinal and exhibit conditions the same with those observed in these shales in the Pearisburg synclinal on the point of Butte mountain. The massive beds of the Trenton are reached quickly after the road begins direct descent to Sinking creek, but exposures soon become rare, as the surface is thickly covered by debris, derived largely from Medina, of which huge fragments are numerous. The Calciferous cherts are shown occasionally, but not in place.

The Sinking Creek anticlinal is crossed at not more than two-thirds of a mile north from that creek, and the massive limestones of the Trenton are shown at the stream with southward dip. The pike is reached at a little way beyond the creek, and there the Trenton shaly limestones are shown much distorted and describing many complicated folds; the dip on each side being often eighty degrees. The thicker limestones are brought up several times. The road crosses the Saltville fault at a little more than half a mile north from Newport, the Trenton shales being brought into contact with the lower cherts of the Calciferous. The fault passes along Buckeye mountain, which, where crossed by the pike, has suffered much from erosion; but at a little distance on each side the Medina is present and the mountain is conspicuous. The Sinking Creek anticlinal diminishes eastward and the Medina outcrops unite before reaching the county line.

Rich valley widens between New river and Newport. The dips in its limestones are from fifty to sixty degrees. The massive beds of the Trenton are shown on Gap or Big Walker's mountain with this dip, and Medina at the summit shows a dip of sixty degrees. Exposures are very good on the northerly side of this mountain.

IV. THE COUNTRY SOUTH FROM WALKER'S MOUNTAIN EMBRACING PORTIONS OF WYTHE, PULASKI AND MONTGOMERY COUNTIES.

By far the greater part of Wythe county south from the Norfolk and Western railroad shows only rocks belonging to the Knox group, but the Potsdam is brought up along the southern border of the county, as well as at a little way from the railroad, in a bold east and west ridge, known as Lick mountain. In going southward from Wytheville, one finds the Knox limestones so much twisted as to suggest that the Draper mountain fault has not wholly disappeared. The Knox shales are shown within two miles from the railroad, where the road enters Lick mountain and the Potsdam beds at not many rods further. The sandstones of this great group form the hog-back ridges, of which the mountain is made up, while the shales are exposed in the deep ravines. The sandstones are passed at about eight miles from New river, where one comes again to the Knox shales, which are badly distorted.

On the road leading to the Wythe lead and zinc mine, which is reached at about two miles from Cripple creek, the rocks are concealed for long distances by the thick cover of terrace debris; but the Knox limestones are well shown in the river bluffs, at the Wythe lead and zinc mine, both above and below Thorn's ferry, where the New river cuts a fine anticlinal.

The Wythe lead and zinc company have their mine at Austinville, in Wythe county, nearly seventeen miles from Wytheville, or twelve miles from Max Meadows station. The ore was discovered and first utilized not far from 130 years ago, but systematic mining has been prosecuted for barely fifty years. The reduction works have a capacity of between 600 and 700 tons per annum, and are of interest, as they were practically the only lead works within the limits of the confederacy and yielded nearly all of the lead employed in the manufacture of bullets for use of the Confederate soldiers.

The lead and zinc ores occur in an enormous impregnation deposit and are extracted both by open cut and by deep mining. The conditions in the surface workings are approximately as follows:

1. Gray limestone.......................................25′

   The upper part shows a network of galena; some excellent blende almost free from galena is found midway; while lower down both galena and blende occur abundantly. The lower half of the rock, which had been digged extensively, is said to contain a large amount of both blende and galena; but it was concealed by a slide at the time of examination.

2. Gray sandy limestone................................10′

This appears to be barren.

3. Ore........ ....8′

This consists of carbonate and silicate of zinc associated with much galena. The calcareous matter has been leached out and the ore is in irregular honeycomb masses.

4. Limestone, evidently barren........................9′

5. Ore...8′

The conditions are the same as those in No. 3.

6. Limestone, gray........... ....25′

This contains a very large amount of blende and galena, but the ore is not sufficiently concentrated to make working profitable.

7. Ore.......................................2 to 10′

The conditions in this are the same as in Nos. 3 and 5. The deposit shows more irregularity than was observed in the others.

8. Limestone, apparently barren..................10′ to 12′

9. Ore................................. ....6′ to 10′

Here too the calcareous matter has been removed and the ore, which consists of zinc silicate and carbonate, with only a trace of galena, is cavernous.

10. Limestone, barren, seen............................5′

No further exposures occur. The upper edges of the limestone in this extensive stripping are rounded as though they had been exposed to long erosion, and the whole was covered with a tough reddish clay, fifteen to thirty feet thick, overlaid by slidden material, ten to twenty feet thick. For the most part the clay is barren, but sometimes it yields fragments of galena and altered zinc ores; and at a cutting just beyond No. 10 it has yielded a very considerable quantity of earthy carbonate of lead. These silico-carbonate ores are merely superficial, for at less than 100 feet from the surface in No. 9 blende occurs to the almost complete exclusion of calamine and smithsonite.

Though commonly spoken of as "leads," these deposits have no features entitling them to that name. The characteristics are well shown in surface workings made on this property by J. S. Noble in 1866, when he mined the zinc ore for shipment to New Jersey. These pits, at say half a mile from the tipple of the present surface workings, are on Bald hill, where erosion has removed the superficial material so as to expose the limestone over many acres. As the lease under which the work was done was short and as lump ore alone was to be removed, the deposit was worked only where richest and most distinctly marked; when it became indefinite the pit was abandoned and a new opening was made elsewhere. The whole area is pitted and the openings vary greatly in shape. Clearly no systematic mining is possible in deposits such as this, and the only available method is follow ore, wherever found, until it ends.

The separation of the lead and zinc ores is effected by jigging. The ore, after crushing and grinding, passes to the jigs, which are in sets of four. The galena is almost wholly removed in the first, while the ores of zinc are separated by the remaining three. The separation is almost complete and the amount of escaped ore passing off in the tailings is insignificant. Much of the lead produced here is manufactured into shot of decidedly excellent quality, and an air-shaft, 262 feet deep, is utilized as the shot tower.

Along the road leading from Thorn's ferry to the Valley pike, exposures are few until Mr. Raper's house has been reached, but thence to the pike exposures are good. The Knox limestone is shown in the road near Mr. Raper's house and at a little way further the shales are at the surface. But a slight fault exists here, for the limestone re-appears within a few rods and continues until a short distance beyond the road leading to Walton's furnace. Thence to the pike the road lies in the shales and the Potsdam of Lick mountain nowhere reaches it. The beds seem to be thrown into two anticlinals, of which the more northerly is crossed near the last fork in the road, less than two miles from the pike, which is reached at barely seven miles from Wytheville.

Knox limestones, dipping west of north at sixty-five to sixty-seven degrees, are well exposed in Wytheville along the street leading from the railroad station to the court-house ; but exposures are very poor for some distance northward from the borough on the Wythe and Tazewell pike. The dip is soon changed on that side and the first good exposures show the south of east dip practically the same as the opposite dip on the other side of this Wytheville trough. The ridge on which the borough of Wytheville stands marks the course of the synclinal, which is cut off by the Max Meadows fault at a little way further east. The anticlinal north from this, in which the Max Meadows fault may originate, has been crossed before one comes to the blacksmith's shop two miles and a half from the court-house in Wytheville, for there the dip is northward at from twenty-five to thirty degrees ; but the place of the axis cannot be determined easily as the surface is covered with a thick coat of sands and clays.

The dip is changed again at somewhat more than two miles and a half from Stony Fork of Reed creek, the southerly direction being very marked at the S-curve in the road, while at Mr. Brown's house it is fifty-five degrees almost east of south. This direction of dip continues to the little valley in front of Stony Fork M. E. Church, where the Walker Mountain fault is crossed and one comes to the Umbral shales. The Knox limestone is well shown in the low hill, while shales are seen at its northerly foot dipping toward the fault at from thirty to thirty-five degrees. The shales are exposed occasionally at the roadside, and one comes to the silicious limestone at the Vespertine ridge, which forms the foothill of Little Walker mountain. The coal-bearing group begins below this limestone and its red or brownish-red sandstones are shown for some distance southward from the ford.

Col. J. T. Boyd of Wytheville has opened several of the coal beds alongside of the stream as well as in a hollow coming down by Mr. Davidson's house. The numerous openings on the south side of the creek show fairly well the relations of the lower beds, the following section having been obtained:

1. Coal bed, V, said to be....................1′ 6″ to 2′
2. Interval, said to contain Coal bed, IV, 2′..........67′
3. Coal bed III, said to be............................1′ 7″
4. Sandstone and shale..............................13′
5. Coal bed II, said to be...............6′ or more to 2′ 6″
6. Sandstone...17′
7. Coal bed I.......................................0′ 10″
8. Sandstone, seen about.............................20′

Mr. C. R. Boyd, who has reported on this property, says that the interval, No. 6, becomes thirty feet at only a few rods from the locality visited. Coal beds II and III have been opened in a hollow above Mr. Davidson's house, where both are badly crushed, the lower much more than the upper. The roof shales have been crushed as badly as the coal at most of the pits, but at one under the road and alongside of the creek a fragment of *Lepidodendron* was seen, altogether without distortion; at all other points, however, the crushing and consequent distortion have practically destroyed all details of structure. The underclays are full ot leaves or appendages belonging either to *Lepidodendron* or to *Stigmaria*.

The coal bed, II, has been opened at several places along its outcrop east from the creek, where it shows material variations in thickness and structure, due evidently to the pressure which the bed has undergone. The thickness at one opening appears to be more than four feet, but the structure could not be made out. A new cut showed

1. Black shale and coal streaks ....1′ 6″
2. Clay...1′ 0″
3. Coal ....2′ 6″

Here there is apparently no distortion, but the crushing is no less severe than at an older pit where the bed has been twisted beyond recognition. The coal occurs in thin laminæ, easily separable and beautifully polished.

The "Quarry rock," the lowest bed of the Vespertine, which comes to the creek at the coal pits, is a gray, sometimes slightly conglomerate sandstone. The Chemung is not well shown in the gap through Little Walker mountain. The relation of Devonian to Upper Silurian is not altogether clear, as the Oriskany was not recognized in the "Poor Valley." Black shales, dipping northwardly, were seen nearly opposite Mr. Hedrick's house, which seem to be continuous thence to the final crossing of the stream, where they are associated with drab and yellow shales which contain fossil ore and are of Clinton age. From that place, the road winds for three or four miles up the side of Big Walker mountain and for certainly half the distance is on Clinton which is thrown into many narrow folds. Where the Medina is first reached, the dips vary from fifteen to twenty-five degrees, but the rate increases, until at the summit the lower beds with *Arthrophycus harlani* dip south-eastwardly at forty degrees. Another form, like a *Scolithus*, penetrating a layer about ten inches thick, is seen at the summit. It is single at each surface of the layer, but forms a loop in the body of the rock.

The Vespertine beds form a foothill to Little Walker mountain and are faulted against the Lower Silurian rocks in Crockett's Cove of Wythe county as they are on Stony Fork of Reed Creek. But the Max Meadows fault crosses the strike and the eastern side of Wythe county shows a much longer continuous section than is found in the western part. On the southerly side of Crockett's cove the Trenton and Hudson beds pass upward into the short but bold Medina ridge known as Cove mountain, which is a notable feature of the scenery. Clinton forms the southerly flank of the mountain as well as the northerly side of the valley between Cove mountain and Max Meadows or Tract mountain, which lies north from the railroad between Max Meadows and Pulaski. The southerly side of the valley is occupied by Devonian shales passing upward into hard sandstones of the Chemung, which make the body of the mountain.

In following the Norfolk and Western railroad from Wytheville station eastward, one finds the north-westward dip continuous until the Knox shales are reached at about three and a half miles from Wytheville. Beyond that, exposures become few, but the road follows closely the line between the limestone and the shales until the Max Meadows fault has been reached beyond Max Meadows. Exposures are good and almost continuous between Max Meadows and Pulaski.

Some dark shales and impure limestones are exposed immediately beyond the former station and red shales are shown at and beyond the first small bridge. These are succeeded in the first cut by the dark limestone with veins and pockets of white spar, which lies at the base or nearly so of the Knox limestone. Owing to the direction of the railroad, this limestone is exposed until nearly two miles from Max Meadows. In a deep cut beginning there, the limestone has been replaced by a conglomerate, which may be of recent origin. It is not less than forty feet thick, has no definite bedding and is variable in composition, some parts breaking down readily on exposure, while others retain their shape and disintegrate very slowly. This may mark the course of an extinct stream.

The next cut, beginning at two and a half miles from Max Meadows, shows first a gray sandstone, quartzite-like in fineness of grain, which is succeeded by irregularly bedded reddish shales with thin streaks of sandstone, the dip being south eastward at about fifteen degrees. The shales in the next cut are very red and somewhat fissile. These continue to Clark's Summit cut, which begins at somewhat more than four and a half miles from Max Meadows, where they are succeeded by reddish sandstone and shales containing a thin coal bed. These have been thrown into petty folds and the coal bed has been the chief sufferer. It has been squeezed beyond recognition as a bed and the coal is laminated; but the lamination, unlike slaty cleavage, is rudely parallel to the plane of bedding.

The rock exposure ends abruptly midway in this cut and thence to the end, fully one-eighth of a mile, the material is a loose incoherent mass of clay and sand, loaded with fragments of sandstone, chert and a little limestone, all of the fragments being angular. This accumulation bears much resemblance to those containing "wash ores" in Bedford county of Pennsylvania. The limestone at the top of the Vespertine is shown in this cut very near the beginning of the rubbish.

The next cut shows the Vespertine rocks with a thin coal bed and with gentle dip. Some prospecting pits were sunk on the Clark property in search of coal, and, according to the report made to the writer, coal of fairly good quality was found in quantity to repay working; but no attempt to utilize the deposit has been made. The coal in the cut is too thin to be of any value, but the Hon. J. S. Draper states that beds of workable thickness occur on his property at a little way south.

It is sufficiently clear that the Max Meadows fault is crossed at not far from three and a half miles from Max Meadows, and that the red shales in the cut west from Clark's summit belong to the Lower Carboniferous.

Vespertine sandstones remain in sight to the Bertha Zinc Works, just west from Pulaski. Near the 86th milepost, or somewhat more than six miles east from Max Meadows, the blue sandstone is reached. This handsome stone has been quarried for building purposes; it has been used largely in railway masonry, and is the stone of which the Maple Shade Inn at Pulaski has been built. The rock is blue, fine-grained, cross-bedded and breaks with a conchoidal fracture. Where first seen it is exposed to a thickness of about twenty-five feet and contains many rounded balls of red clay or red shale scattered throughout the mass of the rock. The lower layer is less coarse but contains small pebbles of quartz and sandstone. No fossils were observed at any of the exposures.

This rock is shown along the railroad and Peak creek, forming bluffs alongside of the creek, and being quarried at several places on the railway. The thickness is not less than forty feet. Underlying it are shales and sandstones, the shales drab, gray to red, while the sandstone very closely resembles the more massive beds above. Some fucoids were seen in the red shales, but no other forms were observed.

The synclinal between Peak hills and Draper's mountain is crossed by the railroad at the tunnel near the second bridge over Peak creek, where the north-westward dip is twelve degrees. The sandstones of the group form a line of hills south from the railroad which are distinct from near Clark's summit to certainly two miles beyond Pulaski. The railroad runs on the easterly side of the synclinal to the Zinc Works. Between those works and the station passes the Pulaski fault, which brings the Vespertine into contact with almost the lowest bed of the Knox limestones.

Returning to Wytheville and taking the macadamized road leading thence to Newbern, one rides on the lower limestones of the Knox group until he crosses Reed creek, where the Knox shales are shown, still dipping sharply toward the west-north-west. The first good exposure beyond the creek is at the roadside near Kent's mill, where the limestones are shown with vertical dip, so that the axis of the anticlinal must pass at but a little way from the creek. The dip gradually decreases and within half a mile the massive limestones are dipping at from twenty to twenty-five degrees almost south-east. These limestones belong to the upper part of the Knox.

Half a mile further east, there being no exposures in the interval, Knox red shales were seen with almost vertical eastward dip. An exposure of sandy limestone, also with nearly vertical dip, was seen on the northerly side of the road at a little way further east, but thence the exposures are poor for several miles. The dip is reversed again near the Max Meadows road.

Where the road leaves Reed creek, at nine or ten miles from Wytheville, there is a close anticlinal whose formation was connected with severe disturbance, for the rocks are much crushed and there seem to be some petty faultings. The road turning southward soon rises to near the summit of the Lick Mountain anticlinal and follows it for a number of miles. The rock exposed for a long distance is the same limestone with veins and pockets of white spar, which is so well shown in the railroad cuts east from Max Meadows. It is associated with yellowish shales which are especially well shown in the cuts beyond the Pulaski road.

The chert ridge is double in the synclinal between the Lick Mountain anticlinal and Draper's mountain, and it forms an imposing knob near Reed creek, while one side of it forms a low persistent ridge between the pike and Draper's valley, terminating in a double knob at the eastern end of the mountain. This ridge is notched by many little streams which rise in the valley and unite to form larger streams only after passing through the ridge.

The Pulaski road leaves the pike at about twenty miles from Wytheville and crosses Draper's mountain. As it passes through the ridge of Draper's valley it shows the Knox limestones with easterly dip. The limestones end at a little way east from Mr. J. S. Draper's house, which is on the Knox shales. There the road begins to ascend the mountain and within a short distance sandy shales or shaly sandstone of the Potsdam is imperfectly exposed at the roadside. The next exposure, beginning at somewhat more than half a mile from Mr. Draper's house, is continuous to beyond the summit. This shows Potsdam sandstone dipping south-eastward at from thirty-five to fifty-five degrees, the average being not far from forty-five degrees. No fossils were observed in this sandstone, but the rock bears close resemblance to the Potsdam of Lick mountain as much in the intercalated brown or reddish-brown shaly beds as in the sandstone itself. There is nothing on either side of the mountain to answer to Hudson or Clinton, but on the northerly side is a mass of shale like that forming the lower part of the Potsdam on Lick mountain.

These underlying shales are well shown on the northerly side of Draper's mountain, where, for a few feet directly under the sandstone they are almost black; but for the most part they are grayish, sandy, and in rather thick layers, so that they might almost be termed shaly sandstones. Their south-easterly dip is as abrupt as that of the sandstone on the other side of the summit.

The Draper Mountain fault passes about one-third of a mile west northwest from the crest of the mountain, and on this road brings the lower beds of the Potsdam into contact with the lower Chemung shales. The Chemung sandstones form a bold ridge beyond the old Pepper road, in which the brownish beds contain many fossils. The Chemung conglomerate was not seen in place as the foliage was very dense, but its fragments are numerous. Vespertine beds form the next, a low ridge in which traces of coal have been observed and the bluish sandstones have been quarried. Thence for a little way there are no exposures, but in the bank behind the Maple Shade Inn the veined limestone of the Knox group is quarried, while just beyond Peak creek, immediately north from the railroad station in Pulaski, limestone belonging to the same group is exposed. These limestones are shown on the country road to the Robinson tract, a distance of about six miles, and that beautiful tract must also be underlaid by the Lower Silurian limestone; but no examination to ascertain this was made.

The limit between the shales and shaly sandstones of Devonian and Carboniferous at the west and Lower Silurian at the east was not followed out in detail, but it passes almost midway between the Altoona coal road and the county road in Pulaski; it is a little way west from the Poplar Hill church, four or five miles from Pulaski. Beyond that northward, it evidently lies east from the Altoona railroad.

The Altoona coal mines are in Pulaski county, at eleven miles by rail from Pulaski, though the actual distance is much less. The bed now mined is the second of the Vespertine beds, which varies in thickness from four to twenty-two feet, in the latter case including not a little shale. The pressure has crushed the coal to such an extent as to destroy in great measure its marketable value, but a large quantity is mined each year for use at the Salt works in Smyth county. At one time the third bed, said to be four feet thick, was mined here, but work on it has been discontinued, only a small quantity being taken out to run the locomotives on the coal road. The coal from this bed is far superior to that from the other.

A road follows the bottom of Peak creek for nearly two miles below Pulaski, and then leaves the creek to cross the easterly point of Draper's mountain to the Valley pike, which it reaches at somewhat more than a mile and a half southward from Peak creek. The Vespertine ridge is cut off by the Pulaski fault before this road reaches the line, but the Devonian ridge continues beyond the road. The Draper Mountain fault is greatly diminished in strength and the Potsdam sandstone makes little showing along this road. That rock evidently extends to near Peak creek and the limestone on the north side of the Pulaski fault must be in contact with it near the creek.

Where the road reaches the pike, Knox shales are shown at the roadside with almost vertical dip. For the most part they are red, weathering dark brown and covered with lichens. With these are some yellow and blue shales, and streaks of impure limestone. The shales continue along the pike to beyond Peak creek, where one crosses the Draper mountain fault and comes again to the Knox limestones. An anticlinal was observed in Newbern, the county seat of Pulaski county. Thence to half a mile north from Dublin the limestones are dipping northwardly.

But a little more than half a mile north from Dublin, exposures practically cease and thence almost to Back creek very little is shown. The whole space is an old erosion plane and the bedded rocks are concealed under a deep cover of debris. The few imperfect exposures show only shales, which are dipping southwardly. These belong to the lower part of the Knox limestone and are the same with those exposed on the valley pike, east from the Pulaski road. Limestones are reached near Back creek and continue to perhaps half a mile or more north from that stream. The beds appear to be wholly without fossils, but their relations are clear enough and they belong to the lower part of the Knox limestone. The lowest bed is the dark limestone carrying veins and geodes of white spar, which is exposed for a long distance on the Valley pike, east from Reed creek.

After crossing Back creek, the road begins to ascend Cloyd's or Little Walker mountain and exposures are good. A great thickness of red shales comes immediately behind the geodal limestone and some of the upper beds are very like those of the Knox shale; but shales of very different character are soon reached, which belong to the Lower Carboniferous, to the Umbral period. The Vespertine or coal-bearing division is reached at a short distance below the Jennell place, where one of the beds has been mined to some extent. The blossoms of four beds are shown in the roadside, above the Jennell house, within a vertical distance of about 115 feet. The upper beds are not more than three or four inches thick, but the second is almost nine feet from rock to rock. It is said to contain one foot of good coal at the bottom, while the rest of the interval is occupied by alternating thin layers of coal and shale. The lowest bed is from two feet to two feet six inches thick, and is said to yield very good coal. This is said to be the bed worked by Mr. J. H. Tyler, two miles east from this road. That mine was not visited. The interval between the two beds at the roadside is about fifteen feet and is filled mostly with sandstone.

The lowest bed of the Vespertine is a gray sandstone, well-shown at the roadside. The passage to the Chemung is imperceptible through concretionary sandstone and shale, undoubted Chemung being reached in a fossiliferous sandstone containing *Chonetes* and other forms which are not recognizable on the weathered surface. Concretionary sandstones continue below this and, at say 300 feet lower in the series, the upper conglomerate of the Chemung is shown, with not a few of its layers containing flattened pebbles. The concretionary structure gradually disappears below the conglomerate and many of the beds on the northerly side of Cloyd's mountain are fossiliferous. The conglomerate forms the crest of the mountain for nearly the whole length. The variegated flags and shale in the lower part of the Chemung are reached quickly on the northerly side of the mountain as the road descends to the valley of Little Walker creek. Exposures are fairly good in the valley and in the gap through Big Walker mountain, but Oriskany was not recognized, so that, if present, it must be very thin. Medina forms the great part of Big Walker mountain and is fairly well exposed in the gap made by Little Walker creek.

The Medina is well shown in the gap made through Big Walker mountain by New river, where it appears to be in all not far from 375 feet thick. Good exposures occur here between the mountains, but, if present, the Oriskany and Lower Helderberg are so thin that they escaped observation. The Chemung beds are sufficiently well shown to make the construction of a complete section by no means difficult to one doing systematic work ; but no section was attempted by the writer, who began his examination near the top of the group.

The "point" of Cloyd's mountain in New River gap is at a little more than eight miles from New River station on the main line. There the Chemung conglomerate, which forms the backbone of the mountain, comes down to the river and is exposed in a railroad cut. Behind it for about 130 yards—beyond which no examination was made—fragments of the bluish-red sandstones of the Chemung are plentiful in the debris which covers the mountain side. Many of these fragments are fossiliferous and the locality will prove to be a good one for the collector. The sandstones are very hard and the fragments are used in ballasting the track from this place almost to New River station.

The upper conglomerate of the Chemung, as shown in this New River gap through Cloyd's mountain, is not far from thirty feet thick. Its upper part is well exposed, is about fifteen feet thick, very hard and coarse, with pebbles often as large as a hen's egg, mostly of quartz and frequently flat. In some of the layers the longer axis of the pebbles is vertical to the plane of bedding. The lower part is less hard, is conglomerate only in some layers and has a rusty color on the weathered surface. The dip is almost south-east at fifty-five degrees.

Ten feet of brownish sandstone are exposed at fifteen feet above this conglomerate, but no further exposure occurs in a horizontal space of about 1175 feet. Fragments with Chemung fossils are abundant in the first 500 feet of this interval, but beyond that they become less plenty and soon disappear, so that proof of Chemung is not likely to abound in the upper half of this interval.

The bottom of the undoubted Vespertine, the "Quarry rock" of Lesley is exposed at the end of this interval. The exposure shows only five feet, but the fragments indicate a thickness of fully thirty feet. The rock is light gray, some parts are very hard and in thick layers, but others are in thin layers ; the dip is nearly fifty degrees.

This rock is succeeded by shales ill-exposed and extending nearly 400 feet to the eighth mile post. The exposure is so poor that the dip could not be ascertained, but it may be taken as averaging not far from thirty-five degrees. Here belong the coal beds, to which reference has been made, and one of them is mined on the opposite side of the river.

From the eighth mile post for 1175 feet, everything is practically concealed. Clearly enough the interval is occupied by gray to bluish sandstones and shales, but there is no exhibition good enough to tell the rate of dip. An uncertain measurement almost midway in the interval made the rate not far from twenty-five degrees. As the next exposure shows a dip of only fifteen degrees, the dip in this concealed interval may be averaged at twenty degrees.

This is succeeded by a reddish or bluish sandstone, forty feet thick, which is well shown in a cliff on the hillside but does not appear in any of the railroad cuts. The dip is fifteen degrees.

No further exposure occurs for 200 feet, beyond which comes a sandstone with dip of ten degrees. This is shown as a cliff, but it was not seen in the cuts ; it continues for a horizontal distance of 600 feet. The color varies from gray to rusty brown and the rock is fine-grained but irregular in bedding.

This is succeeded by a concealed interval of 375 feet, in which the dip is twelve degrees ; beyond it one comes to red sandy shale extending 300 feet with dip of twelve degrees. Upon this rests a red to gray, irregularly bedded sandstone continuing for 200 feet, also with dip of twelve degrees. After a concealed space of ninety feet, sandstone, gray to red, is reached, which, with dip of fourteen degrees, extends for 300 feet along the track. It contains many thin beds of red shale and some insignificant beds, or rather streaks, of impure limestone or possibly only calcareous sandstone. Above this are alternations of red sandstone and red shale, with dip of fifteen degrees and continuing for 2200 feet to Back creek just beyond Tyler's coal switch. Next comes the geodal limestone, to which reference has been made so frequently and which belongs at the base of the Knox limestone. Evidently the fault of Walker mountain has been crossed ; so the succession may be summarized. It is as follows :

Lower Silurian.

Limestone in bank of Back creek......................25′

The Walker Mountain fault.

Lower Carboniferous.

1. Red sandstones and shales.........................570′
2. Sandstone, red to gray with some shale.............. 73′
3. Concealed...................................... .... 23′

4. Sandstone, red to gray............................ 42′
5. Red shales.. 63′
6. Concealed... 78′
7. Sandstone...105′
8. Concealed... 42′
9. Sandstone, reddish brown to bluish................ 40′
10. Shales and sandstones............................400′
11. Shales with coal beds............................230′
12. "Quarry" sandstone............................... 30′

Devonian.

1. Concealed...900′
2. Sandstone... 10′
3. Concealed... 15′
4. Conglomerate...................................... 30′
5. Sandstones, flaggy, not well shown................160′

The Walker Mountain fault passes very near the mouth of Back creek and is crossed by that stream at a little way west from the railroad. The exposure of the shales is practically continuous to the creek, but there were seen none of the yellow shales observed on the Dublin and Pearisburg pike. The line of fault is therefore drawn directly under the limestone of the Knox group.

Southward from Back creek for nearly a mile, the whole region near the railway is covered with a thick deposit of terrace debris, and the only exposure is in a cut at about 1000 feet from the end of the Back creek trestle, where a veined, somewhat brecciated limestone is shown associated with light drab shales, all belonging to the lower part of the Knox limestone. The next exposure is in a stream at, say, 600 feet south from Belspring station, where limestones and shales are shown. Similar beds are exposed on the railroad at about 300 feet further, where the shales, or rather shaly limestones, weather light yellow or grayish white. The limestone is drab to blue, is somewhat silicious, is veined with white spar and is more or less brecciated. The dip is south-eastward at about eighteen degrees. But the dip quickly becomes flexuous and these shales and limestones remain in sight to the fifth mile post. The irregular dip continues for half a mile further, but thence for a mile or two, to within three miles and a half of New River station, the more prevalent dip is south-eastward, so that the massive limestones with large nodules of chert are brought down. These thicker beds are separated by impure shaly limestones which weather into clays, usually yellowish red.

The dip becomes north-westward at three miles and a half from New River station, and this direction is kept for probably a mile along the road, which follows the strike for much of the distance. In the deep cuts about two miles and a half from New River station, the beds are in great disorder and consist of the shaly limestones which the reversed dip has brought to the surface again. Thence no exposure was found until the first mile post was reached, where somewhat higher beds are shown in very confused stratification. From this place to the main line of the Norfork and Western railroad at New River bridge, the thick bedded limestones of the Knox group are bent and folded to a degree, which one would think hardly possible in rock of that character, yet so far as could be ascertained no fractures exist.

Returning to the New River gap through Walker mountain and crossing the river so as to take the road leading across Price mountain to Christiansburg, one comes to the Vespertine as the road rises to the river hill. But exposures quickly become indefinite and little is shown until beyond Price's fork in the road, about five miles west from Blacksburg. The only exposures in this interval of four or five miles are of drab shales such as were seen in the cut south from Belspring station on the New River branch of the Norfolk and Western railroad. The whole area for several miles from the river is covered with the terrace deposit, which is very deep. The Knox limestones are shown on the Blacksburg road, as well as to a short distance south from it, dipping southwardly; but a synclinal is crossed between that road and the northerly fault of Price's mountain, so that the limestones, where last seen, dip away from the fault.

Red shales of the Lower Carboniferous, such as those seen on New river, are shown on the flank of Price mountain, and are underlaid by the coal-bearing Vespertine. The coal beds are mined along a fork of Strouble's creek on the northerly side of the Price Mountain anticlinal. Several abandoned openings were seen on the Bruce property, one of which showed

1.	Sandstone	not measured.
2.	Clay	0′ 5″
3.	Coal	0′ 10″
4.	Slaty coal	1′ to 0′ 10″
5.	Coal seen	2′ 6″

The dip is northward at thirty degrees; the coal has been crushed badly but not so badly as in the mines of Little Walker or Brush mountain. The bed is mined by Linkous and Kipp at somewhat more than half a mile further west, where, according to Mr. Linkous, the lower part of the bed is

5.	Coal	2′ 6″ to 2′ 10″
6.	Coal	1′ 3″
7.	Coal	1′ 6″

No. 6 is soft and is used as the "bearing-in," but the others are very hard. The coal has been crushed to but a very slight extent in comparison with that on the other mountains. It bears much resemblance to cannel. It is mined extensively and is wagoned to Bang's station, whence it is shipped to neighboring stations.

The rocks alongside of the road dip at fifty-five degrees as the crest of the anticlinal is approached; but on the other side near Mr. Church's mine, the dip in the southerly direction is barely twenty degrees. Thence nothing was seen aside from the shales and sandstones until the Blacksburg and Christiansburg road was reached, on which the southerly fault of Price's mountain was crossed at a little way north from Mr. Stevens's house, where Umbral shales and Knox limestones are in contact.

Directly north from Mr. Stevens's house, the road from the coal mines unites with that leading northward to Blacksburg and Newport. Exposures are very indefinite on this road as it crosses Price's mountain, though the Lower Carboniferous shales are shown in several shallow cuts. No coal blossoms were seen along the road and no coal is mined near it.

The Knox limestones are reached at somewhat more than two miles south from Blacksburg, but exposures on this old erosion plane are few and widely separated, so that nothing can be told respecting the character of the rocks.

The place of the Walker Mountain fault is about half a mile south from Tom's creek, where Umbral shales are thrown over to almost vertical dip, while the Knox limestones are shown within a few rods with much gentler dip. Coal is mined at several places on Tom's creek both above and below this road. The dip at a pit immediately south from the creek is twenty-five degrees toward the south-east. The bed is thin, being reported as follows:

Coal	1′
Clay	0′ 6″
Coal	1′ 6″

but the bed is thicker at other pits and, at some, it has three feet of workable coal. The crush has been severe and the coal of the Tom's creek mines is so loosely laminated that the laminæ are easily separated by the fingers.

The dip becomes gentler as the road ascends Brush or Little Walker mountain. Sandstones with dip of ten to twelve degrees make the road-bed for a long distance and form spurs extending southward from the mountain. The passage to the Chemung is through these yellowish sandstones, which appear to be thicker than on New river. The upper beds of the Chemung are not shown near the road; fragments of the upper conglomerate are numerous, but the rock was not seen in place. It however forms the crest of Brush mountain and Chemung fossils are numerous at several exposures on the northerly slope as the road descends to "Poverty flats," the "Poor valley" between the Walker mountains. The conditions in this valley, digged out of Chemung, Hamilton and Clinton shales, differ in no way from those in the "Poor valleys" already described. Exposures show nothing but shales.

The Clinton ore was mined here many years ago for the furnace at Newport, in Giles county, but nothing can be learned now respecting either its quantity or quality. Medina forms the southerly slope of Gap or Big Walker mountain and on the summit is dipping south-eastwardly at sixty degrees.

The Triassic Mammals, Dromatherium and Microconodon.

By Henry F. Osborn, Sc. D.

(Read before the American Philosophical Society, April 15, 1887.)

The mammalian jaws discovered by Professor Emmons in the Upper Triassic beds of North Carolina, and ascribed to a single genus, *Dromatherium,* were recently examined by the writer and found to belong to separate genera. The type mandible of *Dromatherium* is preserved in the Williams College Museum, and differ widely from the mandible preserved in the Museum of the Philadelphia Academy. These differences have already been pointed out,* but require to be more fully stated, as both Professors Marsh and Cope have expressed doubts as to the distinct separation of these genera. The accompanying lithographic figures also bring out the characteristic features of these mandibles much more fully than in the pen drawings which accompanied the earlier description.

In many respects these genera agree with each other, and stand separate from the Jurassic mammals of both England and America. There is, first, a considerable diastema behind the canine, a very rare feature in the division of Mesozoic mammals to which these genera belong, although always present in the division to which *Plagiaulax* and its allies belong, viz., the sub-order *Multituberculata* Cope.

Dromatherium has three premolars and seven molars, but the number in *Microconodon* is quite uncertain, as only four of the series are preserved. The molars agree in one particular, which separates them widely from other Mesozoic genera, viz., in the imperfect division of the fangs. This division is indicated merely by a depression at the base of the crown, as in the genus *Dimetrodon,* among the Theromorph reptiles.

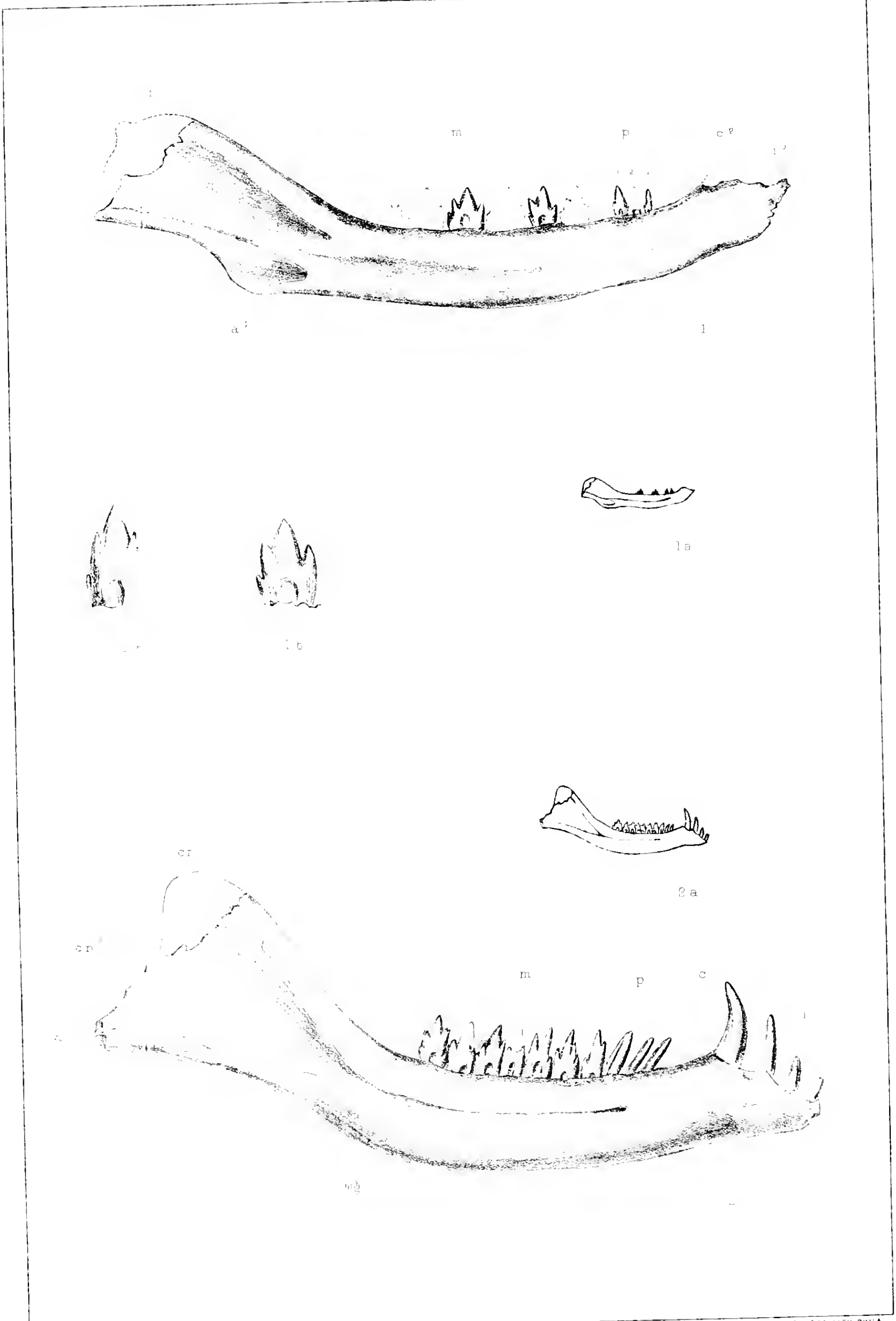
In all other respects these mandibular ramî differ widely. The *Microconodon* ramus is two-thirds the length of that of *Dromatherium*; it is flattened and slender, with a nearly straight lower border beneath the molar alveoli, and a characteristic depression of the border which possibly represents the angle of the jaw as in Prof. Owen's genus *Peramus.* The coronoid process is low and the vertical diameter of the jaw at this point is very narrow. This ramus offers a great contrast to that of *Dromatherium,* which is very stout and convex with a thick lower border, projecting widely from the matrix, an elevated coronoid process and has the curvature of the lower border unbroken by any downward projection. If these differences may be given merely a specific value, and attributed in part to the fact that the *Microconodon* jaw is seen upon the outer surface, and that of *Dromatherium* upon the inner surface, let us compare closely the teeth in the two genera. Unfortunately the canine and incisors of the

* Proceedings of the Academy of Natural Sciences of Philadelphia, 1886. p. 359. I find upon a second examination of Prof. Emmons' original figure, that I did unintentionally criticise it too severely in the former article, p. 359. While far from accurate the figure is not so misleading as I at first supposed.

Microconodon ramus are wanting. We first observe that the premolars of *Dromatherium* are styloid and procumbent; if erect they would rise above the level of the molars; they have no trace of a cingulum. In the other genus the premolars are subconical and, although erect, they do not reach the level of the molar tips; they show a faint posterior cingulum, and the third premolar has the same evidence of a division of the fang which is seen in the molars, while in *Dromatherium* there is no trace of such a depression, but a distinct groove on the postero-internal face of the tooth reaching nearly to the summit. The molars of *Dromatherium* are narrow and lofty; the general pattern of the crown consists of a single main cone with a high anterior and lower posterior accessory cusp upon its slopes; but these cusps are very irregular in disposition. For example, in the second molar there are two anterior cusps; in the third molar the posterior cusp is nearly as large as the main cusp; in the fifth molar there is a trace of a postero-external cusp; in the last molar both the anterior and posterior cusps are distinctly bifid at the tip. In *Microconodon*, on the other hand, the molars are comparatively low and broad, with a low anterior and higher posterior accessory cusp; these cusps are regular and very prominent; there is also a well-marked posterior cingulum, which cannot be distinguished in the corresponding molars of the other genus.

Although the two posterior molars are wanting in *Microconodon*, the rise of the coronoid probably marks the position of the last molar; taking this estimate of the posterior point of the molar-premolar series and comparing it with the length of the series in *Dromatherium*, we find that while the ramus of one genus is only two-thirds the length of the other, the total space occupied by the molar-premolar series is very nearly the same. Estimated in another way, the molar-premolar series of *Microconodon* is a little less than one-half the entire length of the jaw ($\frac{6}{13}$), while that of the other genus is exactly one-third the length of the jaw. This discrepancy is due to the difference in the proportions of the molars; in one genus they are low and broad at the base, in the other they are unusually high and compressed.

It is difficult at present to assign any systematic position to either of these genera. *Dromatherium* is entirely unlike any known mammal, fossil or recent. The form of the molars is extremely primitive both in respect to the incomplete separation of the fangs and the remarkable variations in the number and size of the accessory molar cusps. In fact the molars appear to be in what may be called an experimental stage of structure. The accessory cusps are sometimes large and distinct, as in the third true molar; sometimes minute like needle points, as in the second molar. The incomplete separation of the fangs is a reptilian character, which correlated with the styloid premolars and recurved canine-incisor series, place *Dromatherium* very remote from any of the known Mesozoic mammals. *Microconodon*, on the other hand, is a somewhat more "recent" type, the premolars have the trace of a low posterior heel, and the molars


m
p
1
1 a
1 b
2 a
cr
m
p
c

have that regular tricuspid division of the crown which is first observed in the genus *Amphilestes* of the English Lower Jurassic and characterizes a large number of the Jurassic mammals.

EXPLANATION OF PLATE.

Figure 1. *Microconodon tenuirostris.* The outer surface of the right mandibular ramus, enlarged. The two premolars preserved are the first and third, with the fang of the second between. The space behind the third was occupied either by a fourth premolar and the first molar, or by the first and second molars. The molars preserved are, therefore, either the second and fourth, or the third and fifth. The dotted outlines are purely conjectural.

1*a*. The same, natural size.

1*b*. The fourth or fifth molar, much enlarged.

Figure 2. *Dromatherium sylvestre.* The inner surface of the left mandibular ramus, enlarged.

2*a*. The same, natural size.

2*b*. The second molar, much enlarged.

ABBREVIATIONS.

a. Angle; *c*. canine; *cn*. condyle; *cr*. coronoid; *i*. incisors; *mg*. mylohyoid groove; *m*. molars; *p*. premolars.

The Relation of Aerolites to Shooting Stars.

By Professor Daniel Kirkwood.

(*Read before the American Philosophical Society, April 15, 1887.*)

The writer more than twenty years since gave reasons for believing that shooting stars, fire balls and meteoric stones move together in the same orbits.* The facts then collected were deemed sufficient to sustain the theory advanced, or at least to give it a high degree of probability. This view has been rejected, however, by several eminent astronomers, and especially by the present Astronomer Royal for Ireland, the distinguished author of "The Story of the Heavens." He remarks: "It is a noticeable circumstance that the great meteoric showers seem never yet to have succeeded in projecting a missile which has reached the earth's surface.

* Meteoric Astr., Chap. v.

Out of the myriads of Leonids, of Perseids, or of Andromedes, not one particle has ever been seized and identified. Those bodies which do fall from the sky to the earth, and which we call meteorites, never come from the great showers, so far as we know. They seem indeed to be phenomena of quite a different character to the periodic meteors" (Story of the Heavens, p. 349).

In pointing out the coincidence in the epochs of shooting stars and meteoric stones,* the present writer neglected to assign an obvious reason for the fact that star showers are so seldom observed at the same time with the fall of aerolites: a majority of the latter have been seen in the day time, when ordinary shooting stars would be invisible. At night, however, the phenomena have more than once occurred at exactly the same time. The writer called special attention to one of these epochs as long since as 1881.† In describing the shower of April meteors as it occurred in the year 1094, the historian says: "At this period so many stars fell from heaven that they could not be counted. In France the inhabitants were amazed to see one of them of great size, fall to the earth, and they poured water on the spot, when to their exceeding astonishment, smoke issued from the ground with a hissing noise."‡ A few other examples are given below:

(1.) During the meteoric display which continued through three consecutive nights in the latter part of October, A. D. 585, a globe of fire, sparkling, and producing a great noise, fell upon the earth.§

(2.) A simultaneous fall of aerolites and shooting stars is indicated by the phenomena of 1029, as described in the catalogues of Herrick and Quetelet.

(3.) But without quoting other records which imply the existence of aerolites and ordinary meteoric matter in the same streams or clusters, it is sufficient to refer to the recent and very decisive phenomena of November 27, 1885.‖ During the periodic star shower from the fragments of Biela's comet a mass of meteoric iron weighing about ten pounds was seen to fall near Mazapil, Mexico, in lat. 24° 35′ N., long. 101° 56′ 45″ W. from Greenwich. The evidence afforded by the phenomena of 1094 and 1885, apart from the other cases cited, renders the coëxistence of large and small masses in the same meteor streams almost infinitely probable.

* Metr. Astr., pp. 58–64.

† Science, Feb. 5, 1881, p. 59.

‡ Am. Journ. of Sci., Jan., 1841, p. 356.

§ Quetelet's Physique du Globe, p. 291.

‖ Am. Journ. Sci., March, 1887, p. 221.

Organic Variation Indefinite not Definite in Direction—an Outcome of Environment.

By Prof. E. W. Claypole, B. A., B. Sc. (Lond.), F. G. S., &c. Akron, O.

(Read before the American Philosophical Society, April 1, 1887.)

I.

Introduction.

Two remarkable utterances have recently appeared from the pens of two of the most distinguished biologists of the day in defense of a theory of evolution radically unsound and differing, as the writer thinks, from that which is held by the majority of evolutionists. The eminence of the names of these authors is sufficient reason to justify a consideration of the view they have advocated. It cannot be supposed that Prof. Asa Gray, of Cambridge, Mass., and Dr. W. B. Carpenter,* of London, would put forward statements all the aspects of which they had not fully considered, and all the legitimate conclusions from which they were not prepared to maintain. Yet both these distinguished writers have enunciated a view of evolution fraught with momentous consequences to biology. So momentous indeed are they that they exclude (if the views in question are well founded) a very large part of the field of investigation now before the biologist from the lawful domain of natural science and relegate it to another department of enquiry.

The nature and direction of organic variation are subjects which have become prominent during the intellectual ferment excited by the publication of the "Origin of Species." As a fact variation is admitted by all evolutionists. It is indeed the cardinal fact on which all theories of evolution do and must depend. And both the writers above mentioned alike admit its reality and its importance. Both allow or tacitly assume that there runs through all organic nature a capability of varying from generation to generation—that under the superficial and obvious resemblance existing between parent and offspring there lie deeper and less easily discerned distinctions which differentiate the one from the other and accumulate in certain directions from age to age. This capacity, manifesting itself in the fact of variation, when encouraged or repressed by the action of natural or other selection has—so Darwin maintained—resulted in the extinction of old and the production of new species.

But while agreeing thus far with most evolutionists the two writers in question express views on variation that are remarkable in the following respect. Instead of proceeding on the ground that variation occurs, or

* These pages were written before science had been deprived of the services of this veteran laborer and leader in biological research by the deplorable accident which caused his death.

may occur, indiscriminately in any direction as lines radiate from a centre, both Prof. Gray and Dr. Carpenter assume or maintain that it takes place only along certain definite lines. Yet further, in their view the changes thus produced in an organism are uniformly of a beneficial kind.

That I may not be subject to the charge of misrepresentation I quote the following extracts from the writers referred to.

In a paper entitled "On an Abyssal Type of the genus *Orbitolites*; a Study in the Theory of Descent," published in the Philosophical Transactions, for 1883, Dr. Carpenter remarks, after detailing the variation exhibited by the forms of *Orbitolites*, "that no exercise of natural selection could produce the successive changes presented in the evolutionary history of the group." "And," he adds, "as all these earlier forms still flourish under conditions which, so far as can be ascertained, are precisely the same, there is no ground to believe that any one of them is better fitted to survive than another." "To me therefore it appears that the doctrine of natural selection can give no account of either the origin or the perpetuation of those several types of foraminiferal structure which form the ascending series that culminates in *Orbitolites complanatus*." "On the other hand there seems traceable through the series a plan so obvious and definite as to exclude the notion of "casual or aimless variation." "Everything in their history shows a well-marked progressive tendency along a definite line towards a highly specialized type of structure in the calcareous fabric."

The significance of these remarks is unmistakable. The writer is evidently maintaining that alongside of the capacity for variation there acts some power guiding the ensuing variation along a definite course to a definite end.

One expression in the above passage calls for a passing remark. In saying that the doctrine of natural selection can give no account of the *origin* of these types Dr. Carpenter appears to have overlooked the fact that no evolutionist attributes the *origin* of varietal or specific forms to this source. Their origin must be sought in variation. Natural selection is only the means of preserving and perpetuating or of destroying and eliminating them. This remark would perhaps be impertinent were it not that other expressions in the same essay also apparently ignore the part played by variation in every accepted theory of evolution. For example, we read, "Those who find in natural selection or the survival of the fittest an all-sufficient explanation of the origin of species seem to have forgotten that before natural selection can operate there must be a range of varietal forms to select from." "No exercise of natural selection could *produce* the successive changes presented in the evolutionary history of the typical *Orbitolites* from *Cornospira* to *Spiroloculina* thence to *Peneroplis*, to *Orbiculina*, to the simple and then to the complex forms of *Orbitolites*."

There is in this passage a singular omission of all reference to the fact and function of variation, the existence of which no naturalist can doubt, be his explanation what it may.

The second utterance of opinion to which I have alluded is contained in a letter from Prof. Asa Gray, printed in "Nature" (Jan. 25, 1883). The letter itself is written in reply to some remarks made by Mr. G. J. Romanes in an article in the "Contemporary Review" for October, 1882. It is difficult to quote any particular passages in exemplification of the views of Prof. Gray, which are rather implied than expressed. The main point of difference between the two writers is however the denial by Mr. Romanes that "the facts of organic nature furnish evidence of design other and better than any of the facts of inorganic nature," and the maintainance by Prof. Gray that this denial rests on no good foundation. In some passages indeed the latter writer goes apparently even farther than this merely negative position and implies, if no more, that in his opinion variation has been beneficently guided by intelligence. It is difficult to extract any other meaning from the following passage: "The evidence of design may be irresistible in cases where we cannot indicate its limits. We can only infer with greater or less probability according to circumstances and especially according to relation to ends. Better evidence than that of exquisite adaptation of means to ends is seldom if ever attainable of human intention and in the nature of the case it is the only kind of evidence which is scientifically available in regard to superhuman intention. With what propriety then can it be affirmed that organic nature furnishes no other and no better evidence of underlying intelligence than inorganic nature? The evidence is certainly *other* and to our thinking *better*."

It seems impossible to attribute to the author of this passage any intention other than that already expressed; viz.: that alongside of the capacity for variation there acts some power guiding the ensuing actual variation along a definite course to a definite end.

If any doubt yet exists concerning Dr. Gray's meaning, such doubt must be altogether removed by the following extract. In a notice of Dr. Carpenter's paper in the "American Journal of Science," for April, 1884, Prof. Gray says:

"Variation has been led along certain beneficial lines like a stream along certain definite and useful lines of irrigation."

The expression "has been led" is rather indefinite, but can scarcely mean less and may mean much more than I have above attributed to its author. To assert that variation has been led along definite lines implies the coaction of some guiding power. To assert that these lines are always beneficial to the variant organism implies a postulate of vast magnitude and one whose admission is infinitely difficult in face of the phenomena of organic nature.

II.

Definition of Terms.

The purpose of this paper is in the first place to examine so much of the evidence of nature on this point as shall be sufficient to show that the theory of evolution favored by the writers above quoted is not in harmony with the facts, and in the second place to prove that, taken as a whole, the phenomena of nature in the organic world are much more easily explained by the principle of indefinite variation.*

To prevent ambiguity and perhaps misunderstanding it will be well to define at the outset the principal terms that will be employed in this paper.

"Variation" will be here taken to mean all deviations of every kind and degree from perfect resemblance to the immediate parents of the organism whether animal or vegetable. This is the widest signification which it is possible to give and with no other can any useful conclusion be reached. Any limitation can only result in invalidating the argument because it would confine the discussion to a special part of the subject indicated by such limitation. The universal signification to be here employed is also the only fair interpretation that can be accepted by all Evolutionists.

The organism in which such Variation is supposed possible will be called a "Variable." The term is borrowed from mathematics and will be understood to mean an animal or plant possessing the capability of varying whether that capability be latent or active. At any one given instant this power may be always considered latent, time being a necessary element in actual variation.

When from any cause this possible variation has become actual and the organism shows progressive resulting changes, this organism may be called a "Variant." And again when a series of changes is complete or when any particular phase is intended the organism in that stage may be called a "Variate." Thus the term "Variable" will indicate that change is possible; "Variant," that such change is in process, and "Variate," that it is complete, at least for the time, in any given organism.

The term "beneficial" will be employed to characterize any change that conduces to the longer life of the variant organism; this being, for the most part, and other things being equal, the greatest benefit that can accrue to it. I do not deny that there are exceptional cases in which other inherited or acquired advantages may outweigh even this usually supreme one. But almost always a long life may be considered the most conducive to the continuance of the species as it indicates vigor in the individual and increases the chances of multiplication.

The expression "Tendency to Variation," sometimes employed by writers on this subject, either commits an author to the views here opposed (for such tendency must have a cause) or it is meaningless. When variation occurs it must have been antecedently possible. But its occurrence is our only proof of this possibility. Of any "tendency to variation" inherent in the organism we have no proof whatever. For all that we

*The possible assertion that variation is always beneficial in consequence of some cause underlying the constitution of the organic and inorganic worlds and their relation to one another will not be here considered. No writer has, so far as I am aware, ever distinctly enounced it and moreover it will be excluded if, as I hope, I shall succeed in showing that as a fact variation is not always beneficial.

know to the contrary an organism is capable ot existing unvaried for any length of time, through generation after generation, without showing the least tendency toward any other form. As well might the mechanician or the astronomer speak of a "tendency to motion" in the heavenly bodies because he sees them all in a state of active movement. For anything that he knows to the contrary all the matter in the Universe may be capable of lying at rest for countless ages. Matter itself has no tendency to motion or to rest. It is absolutely a creature of conditions and of circumstances. So we have reason to believe that organisms have no tendency to variation or to invariance. Changes if they occur, or their absence if they do not, are simply accidents of the environment. The astronomer sees all matter in motion and comes almost instinctively to the belief that the two are inseparable. The biologist sees every organism varying and grows unconsciously into the opinion that variation is a necessary concomitant of life. Both are equally unphilosophical. Absolute rest may be almost inconceivable to the physicist and absolute invariance to the naturalist. Yet both so far as we can know, are thinkable and possible, and both may form a part of the actual scheme of Nature. We see no ground for the expression "tendency to variation."

III.

Variation not Always Beneficial.

In the consideration of this part of the subject it will be manifestly impossible within due limits to even notice any large portion of the facts that bear more or less directly on the question. No attempt will therefore be made to take a wide range. Nor is this necessary for the argument. If sufficient proofs can be adduced to show that in some cases the actual variation is prejudicial to the variant the purpose will be served. Yea, more, in logical strictness if a single such case can be established the advocacy of definite variation in a uniformly beneficial direction becomes futile. For unless such beneficial variation be absolutely constant and unfailing no object can be attained by maintaining its occurrence in any single instance.

I propose therefore to limit myself to the presentation of a few of the more conspicuous instances of prejudicial variation, of which some one or more must during a lifetime fall within the cognizance of all who take any interest in the study of Nature.

I may here remark in passing that of the two authors quoted at the outset, Prof. Gray does not give a single instance in support of the proposition which he is maintaining and that the only one under discussion by Dr. Carpenter is drawn from the lowest class and one of the most obscure in the animal kingdom—the Rhizopods—among the Protozoa.

1. *Variation in color.*—Among the many variations in color constantly occurring among animals is the production of a white descendant from colored ancestors.

Every naturalist knows that among wild land animals, with some few exceptions, this color is exceedingly rare. The cause of this rarity is obvious. In a green world a white individual is very conspicuous. Such an animal has much less chance of escaping from its enemies if pursued, or of capturing its prey if a pursuer, than one whose color is more in harmony with its surroundings. Hence its prospects of living and of leaving offspring are proportionally reduced. And in places where green is not the prevailing color, we find the wild animals dressed in harmony with their surroundings. In the Polar regions and in winter the fur-bearing inhabitants are clad in white. No other livery would give them so good a chance of life. In dry and sandy deserts the prevailing color of the fur of the residents is nearly the same as that of the sand. Nevertheless in the parts of the world that are clad in green, white individuals are frequently produced. And we can hardly doubt that similar exceptions to the prevalent color occur elsewhere. Thus we find white deer, white mice, white blackbirds and white wild horses. But their extreme rarity shows that there is some check to their multiplication. And in asserting that this check is nothing more than early destruction in consequence of their conspicuousness I am not going beyond what has often been observed in cases falling within our notice. "On some parts of the continent," says Darwin, "persons are warned not to keep white pigeons" on account of their liability to destruction by hawks. (Origin of Species, 1860, p. 84.)

And when to these disadvantages we add those of deafness, of epilepsy and of other diseases which often accompany the white color in animals, cats for example, we find an accumulating variation which cannot fail of being deeply prejudicial to the variant.* Darwin says, "Cats with blue eyes are almost invariably deaf." He has collected a great number ot cases showing the disadvantages to which animals are liable whose hair is partially or altogether white.†

Another instance is afforded by some pet rats kept by a relative of the author's, which were with one exception wholly white. They all recently became troubled with bronchitis or some similar complaint, and the sound of their breathing was so unpleasant that they were destroyed except one. The sole survivor was the rat that was not entirely white. This one, though sharing in the disease, was much less severely affected.

The case of albinoes may fairly be cited here. In this form of variates not only is the increased color-risk a source of danger, but the imperfect sight so frequently accompanying the whiteness is almost equally prejudicial.

In regard to the vegetable kingdom similar facts may be given. Every gardener is aware that the white seedlings that so frequently come up, in a field of maize for instance, usually die down and yield no seed. Here, as in the case of albinoes among animals, the radical cause of prejudicial

* See examples of this published in various numbers of Nature, 1884.

† See "Animals and Plants under Domestication," Vol. i, p. 330.

results seems to be the want of the usual vigor, probably in consequence of arrested development or of imperfect ante-natal nutrition—two of the most fruitful sources of variation.

2. *Variation in strength.*—It comes within the observation of all that among animals great difference of bodily strength exists. This is easily noticed in those that are reared for draught. Though less conspicuous the fact is equally true of the savage species. Now this deficiency of power is prejudicial to the variate. The load which one horse can draw with ease is a severe tax on another. A battle between two wild beasts is decided, other things being equal, to the injury and often the death of the weaker. Indeed the prejudicial effect ensuing upon bodily weakness is so evident that long proof is superfluous.

Nor is the deficiency of mental power any less prejudicial. Every one accustomed to observe animals must have noted great difference in their intelligence. Among domesticated species one individual shows mental power fully entitled to the name of reason, while another, perhaps of the same brood, manifests so little that education is impossible. A well-known horse-trainer once told me that though he never failed to train a horse when he took him in hand, yet there were but few that he could train at all, and that he could, in a very short time, pick out and reject the many with which success would be impossible. Some rats are so cunning that to catch them requires all the craft and skill of the householder. Others are so silly that they walk into the trap the first time it is set, and are killed to their great prejudice. The sagacity of bears in avoiding the snare is sometimes wonderful, compelling the belief that they have mastered its construction and found out how to take the bait and yet avoid the danger. Others show no subtlety of this kind, and are caught and killed with ease. Such tales may be found in any work on the habits of animals, and need not be repeated here. But enough has been said to show that the range of variation of the mental faculties of animals is great, and that while the higher degrees confer much advantage on their possessors, the lower are so far inferior as to be seriously prejudicial.

Though pertinent to the argument, it is scarcely worth the time to point out the frequent occurrence of similar prejudicial variation in the human species where the range of the mental faculties is from idiocy upward. In our present state of civilization this disadvantage is partially and temporarily neutralized by the humane sentiment prevailing in society which counteracts the laws of natural selection as they operate among other animals. Yet all such deficiency of power is seriously and often fatally prejudicial

3. *Variation in the senses.*—Whatever prejudicial effect ensues from deficiency of bodily or mental strength is aggravated when this deficiency takes the form of the absence of one or more of the senses. Yet animals are not infrequently born blind or deaf, and the probable reason why such cases are seldom seen is that the absence is so prejudicial as to be soon fatal.

In the consideration of this subject we must bear in mind that to obtain evidence from wild animals is difficult, because they are not under our supervision. Hence it is necessary in most instances to quote facts from animals kept in domestication. But abundance of cases have been recorded to show that similar prejudicial variation occurs among animals in the wild state.

4. *Variation in form.*—Under this head I may quote the well-known case of the Ancon or otter sheep of Mass., "which originated in 1791 with a single specimen having short crooked legs and a long back like a turnspit dog." This change in a natural state would have been extremely prejudicial to so active an animal. But under human control the very defect was, for a time, a convenience to the farmer, who found that these sheep could not leap over his fences. Hence he preserved and bred them. But the Merino superseded the Ancon, and without the preserving care of man the latter soon disappeared, as it would have done much earlier in a state of nature.

The once well-known turnspit dog supplies another case in point.

A friend of the writer once had a kitten which was born without any hind legs— a defect which had occurred in several litters dropped by the same cat. It lived for some years to my knowledge, and may be living still. When I last saw it it was nearly or quite full grown. Its difficulty of motion was great. Yet I have seen it get up on a chair, and when it walked it threw up its hind quarters and moved with a series of jumps, much as a boy moves when walking on his hands with his feet in the air. Without the care of man so defective an animal must soon have starved for want of locomotive power.

From the above instances the transition is slight to that of monsters. Indeed the line between these and malformation so great as that last mentioned is not easily drawn. Nor do I care to insist on the distinction. The only obvious difference between them lies in the transmission or arrest of the defect. In most cases malformation so serious necessarily ends with the individual.

Some may feel unwilling to admit the pertinence of monsters to the present argument. But they cannot logically be excluded. They are only the extreme cases in which the variation is so prejudicial that life is usually short and transmission impossible. No department of either the animal or the vegetable kingdom is free from the occasional appearance of these usually inexplicable forms. Five-legged calves, sheep with two tails, two-headed fowls and other such cases of malformation are often announced. And after making all due allowance for mere external abnormality there remain enough instances certified by anatomical demonstration to show that the birth of such monsters is by no means rare.*

"The Museum of Michigan University contains a double-headed milk

*Abundant evidence that the human species is not less liable than others to this kind of variation may be seen on the shelves of almost any medical museum and especially on those of the Royal College of Surgeons of London.

snake (*Ophibolus triangulus*) of which the remainder of the body appears to be perfectly normal. Another case is recorded by Prof. Wyman * of a water snake (*Tropidonotus sipedon*) with two heads and two tails, and a similar case as well as one of a five-legged frog is reported by Mr. Kingsley,† Mr. Ryder also calls attention‡ to a specimen of the pickerel frog (*Rana palustris*) with five limbs or rather an additional pair of hind limbs fused together. This leg had six toes and its digital formula might be written—5, 4, 3, 3, 4, 5.

Among insects such monstrous forms have been observed. "Numerous instances of supernumerary legs and antennæ are recorded. The antennæ are sometimes double but more commonly the legs." Asmuss has collected eight examples and in six of these the parts on one side are treble. "Newport relates that from a single coxa of *Scarites pyrachmon* on the left side two trochanters originated. The anterior supported the true prothoracic leg, while the posterior carried two legs each as well formed as the first."§

"Other deformities occur in the wings. Cases of hermaphroditism are on record in which one wing bears the colors of the male insect and the other those of the female. Sometimes the wings are aborted or deformed."

Most persons who have had much experience in the breeding of animals can recall similar instances.

At a recent meeting of the American Entomological Society a monstrosity was noted in a longicorn beetle of the genus Acmæops in which the left front leg has three tarsi. A specimen in the collection of Prof. Riley (*Isosoma tritici*) was also described in which the fore wings are represented by rudimentary pads while the hind wings are fully developed (Science, Dec. 5, 1884, p. v).

Mr. J. A. Ryder has recently recorded similar malformation among lobsters under his observation such as the absence of eyes, partial fusion of two bodies, fusion of the eyes on the median line. These changes were coincident with the stage of gastrulation.‖

In lecturing on the denizens of the aqueous kingdom, on Friday last, at the Royal Aquarium, Mr. A. Carter referred to deformities that exist among fish. In 1885 and 1886 he had examined thousands of salmon and trout fry at South Kensington, on their emerging from the ova, and found one case of deformity in every thousand, and one case of monstrosity such as twin and dual-headed fish in every four thousand.¶

Though as said above these forms are usually inexplicable, yet their dependence on the chances of outside conditions in some instances at least is indicated in the following passage taken from Darwin's Animal and Plants under Domestication (p. 279).

* Proc. of Bost. Nat. Hist. Soc., Vol. ix, p. 183.
† American Naturalist, Vol. xii, pp. 594, 751.
‡ Zoölogy of Ohio, p. 690.
§ Packard's Guide to the Study of Insects, p. 84.
‖ See American Naturalist, for 1886.
¶ Nature, Jan. 6th, 1887, page 231.

"It is known from the labors of G. St. Hilaire, and recently from those of Dareste and others, that eggs of the fowl if shaken, placed upright, perforated, covered in part with varnish produce monstrous chickens. Now these monstrosities may be said to be directly caused by such unnatural conditions, but the modification thus induced is not of a definite nature."

It is not by any means unlikely that the indefiniteness to which the great naturalist here alludes is a mere consequence of our want of knowledge of this obscure subject and not inherent in nature. The recent experiments of Warynski & Fol, as quoted in the Journal of the Royal Microscopical Society (June, 1866, p. 401), tend strongly to confirm this opinion. These zoölogists have succeeded in producing double hearts in chickens by artificial means. The mode of procedure is as follows: "The blunt edge of a scalpel is carefully and lightly drawn backwards along an embryo between twenty-four and thirty-six hours old from just behind the head without injuring any tissues. If all goes well the embryo will continue to develop normally with the exception of possessing two hearts." The authors quoted were also able to produce other abnormalities in a similar manner.

In the absence of any evidence to the contrary it is more logical to infer that all such cases owe their origin to similar causes, antenatal accidents, not yet discoverable.*

Turning now to the vegetable kingdom we find monstrous forms by no means rare. Not seldom among wild plants the botanist finds flowers in which one portion in hypertrophied to the injury or the atrophy of another or of others. When this atrophy includes the essential organs, such as the anthers or stigmas, it results in sterility and the extinction of the species along that line. Human selection has enormously increased this form of variation. Most of the double flowers of the gardener are monsters to the anatomist. The showy double corolla is obtained at the cost of more important though less conspicuous organs. To quote special cases is here needless. Abundance of them will occur to every naturalist or may be found in works on the subject.

5. *Moral variation.*—Another phase of the subject should not be passed over though any adequate discussion of it is not practicable here. Most naturalists will agree that the moral development of an organism may be prejudicial. Animals born in domestication are not seldom so ill-tempered or obstinate that little or nothing can be made of them. Horses, subject to vice, as it is termed, are sold from hand to hand, lower and lower in the labor scale, until they end by being employed as drudges in the hardest and most menial tasks which exhaust their strength and kill them off before their time Dogs, too, are often met with which show a disposition so ferocious or uncertain that their owners are compelled to kill them from a regard to their own safety or to that of others. And the testimony of

* For some curious illustrations of another but kindred topic in this connection see a paper on the "Disadvantages of the upright position in man," by Dr. E. Clevenger, in the American Naturalist for 1884.

the tamers of wild animals proves that the same is true among them. The temper of tamed elephants, of tamed lions (so-called), and of other wild beasts indicates a difference of moral qualities quite equal to what we see in the domesticated species. The difference is often very conspicuous in members of the same litter.

The tendency to vice born in many individuals among mankind and growing with age—the inheritance from vicious ancestors—impels its possessor to acts which shorten his days and are in other ways extremely prejudicial to him. The evolutionist may assert that this result is only Nature's way of killing off those unfit to live. The philanthropist may pity them and spend time and labor and money in trying to reform them, and occasionally with success. But both evolutionist and philanthropist thereby proclaim their belief that the moral tendencies developed in these individuals are highly prejudicial and often fatal. They are, however, the outcome of environment of themselves and their ancestors. They are effects of the variability of the organism moulded by circumstances. They are variates whose variation is hostile to their civilized surroundings and leads to extinction. In other countries and among other circumstances they might yet be fairly in harmony with their conditions of life and might live. "The most inhuman monster of crime that ever was condemned by a court and executed by an officer of the law would among such tribes as those of Australia surely pass for the embodiment of all excellences and rise to an uncontested chieftainship" (Bergen: "The Development Theory," p. 178).

It is not relevant to reply that most of the cases here cited are accidents and should not be quoted in proof of the proposition. All such actual occurrences can be logically employed. Accident merely means happening out of the expected course. If accidents happen often they partially lose that character; if they prevail they lose it altogether. If such accidents as those above mentioned were advantageous to the organism they would soon be perpetuated and become the rule. All variations are accidents and their continuance and repetition are dependent on their advantage to the variant. If prejudicial they are soon eliminated and cease.

> "Treason doth never prosper; what's the reason?
> Why, if it prosper none dare call it treason."

Variation is treason to the original organism. If it can sustain itself it becomes the new organism and supersedes the old one. If not it soon goes down and is forgotten.

These cases therefore are not only relevant but they are the only cases that can be cited. So quickly do all prejudicial variations die out that in the wild state only now and then can they be noted and recorded. Hence the exceptional are the only relevant and valid examples, and to reject them on this account would be to put out of court the only witnesses whose testimony is pertinent and by which the proposition can be established.

So far, therefore, is variation from being uniformly beneficial in its results to the variable or to the variant organism, that in not a few cases that come under our observation it is positively hurtful or even fatal. And these must be only a few out of all that actually occur, inasmuch as they are necessarily taken for the most part, indeed almost entirely, from animals and plants in a condition of domestication.

In domestication also a new and almost omnipotent factor enters the problem—human selection. Now if this beneficial tendency in variation had any existence, it might be expected to show some sign of its action in species under human control. Yet here no trace of it can be detected. When a cattle-breeder attempts to develop certain features it would be evidently beneficial that the stock should vary in the required direction, for failure to do so is quickly fatal. Yet immense care and pains, and the constant elimination of faulty individuals are requisite to obtain success in the endeavor. So with plants. In the attempt to establish a new variety of cabbage or lettuce, years of work are essential and thousands of "rogues" must be pulled from the seed-bed and destroyed before the strain desired attains persistence and perpetuity.

IV.

Beneficial Variation and Natural Selection inconsistent.

It is further worthy of remark that supporters of the theory of evolution alluded to in the extracts given above can find no use in their system for the subsidiary doctrine of natural selection. Maintaining a beneficial tendency in all variation guiding it in a channel favorable to the variant, they cannot logically admit the directive influence of selection. All variation being favorable, there can be no forms to be rejected. Yet one at least of the writers quoted is evidently an adherent to the doctrine and admits that its action has much influence in determining the surviving individuals. Were directive beneficial variation a fact, all variates must be equally well adapted to their environment though different from each other. So evident is this that proof is needless. Yet Prof. Gray himself appeals to the action of natural selection in his "Darwiniana," where with a beautiful metaphor he writes:

"Natural selection is not the wind which propels the vessel, but the rudder which by friction—now on this side and now on that—shapes the course. The rudder acts while the vessel is in motion, effects nothing when it is at rest. Variation answers to the wind."

Directive beneficial variation and natural selection are logical contradictories, and cannot both exist. The former if real must be universal. But I have shown that it is not so. Hence every evolutionist who adopts the theory of natural selection must abandon that of beneficial variation, and *vice versa* every adherent to the theory of beneficial variation is unable to admit the agency of natural selection in any of its forms.

V.

Indefinite Variation.

The instances already given have sufficiently illustrated the fact of prejudicial variation. Of beneficial variation no evolutionist entertains any doubt. To dwell on it will therefore be needless. But there is a third aspect of the change which must not be omitted. As we have seen, the gain or loss of an organism by varying may be of any degree from that which gives the variate a surpassing advantage and predominance over his fellows to that which leads straight to extinction. In mathematical language the range of variation is from positive infinity ($+\infty$) through zero to negative infinity ($-\infty$). We must consequently admit the existence of variation which confers no advantage and inflicts no disadvantage on the variant—neutral variation it may be called. This neutral variation is an important factor in the problem, though hitherto it has received very little attention. It is capable of explaining some difficulties, of removing some anomalies. Darwin has alluded to it in a single passage: "I am inclined to suspect that we see in polymorphic genera variations in points of structure which are of no service or disservice to the species" (Origin of Species, p. 46).

Variation of the kind now under consideration may be often seen among the domestic animals where the struggle for existence is less severe and controlled by other laws than among the wild species. For example, six-toed cats (see "Nature" for 1886 and 1887) are a not uncommon though usually a local variety. The peculiarity is freely transmitted. Yet no ill effect seems to attend the irregularity. Indeed if, as asserted, they are good mousers, it may confer a slight benefit though it detracts much from a light and graceful appearance. The same variation is not uncommon among mankind, is there also freely transmitted and is also equally inert in result. The tailless Manx cats may also be quoted in the same connection,* the great range of color in the domestic animals and the manifold shapes of the leaf in many of our garden vegetables which are reproduced with certainty and seem to work neither good nor evil to the plant.

Among wild species the same fact may be noted. Great difference may be seen among the leaves of any species of our forest trees attended with no perceptible advantage or disadvantage. In these cases we need not be surprised to see the variates living side by side with their unvaried ancestors. The red maple of North America is a striking instance. This tree, whose remains are found fossil in the Miocene strata, yet lives in company with its more highly developed and later variates which do not occur in the fossil state.

On this principle I would explain the fact brought forward by Dr. Carpenter of the existence of ancestral forms of *Orbitolites* alongside of later

* In a case that recently occurred under my own observation a single kitten of a litter was born without a tail. It is now nearly full grown and appears to suffer no inconvenience from the curtailment. In a similar way the Manx cats may have originated.

variates. We have but to admit that the changes which occurred to the earlier variable organism were attended with little or no advantage, and that consequently the variable shows no diminution or tendency to extinction by the side of its more specialized variate offspring and the difficulty entirely disappears.

We are compelled to admit variation of all degrees ranging from that which rapidly kills off through that which is absolutely neutral to that which puts its variates at so great an advantage above their fellows that they soon leave them behind and become the "Winners in Life's Race."

VI.

The Cause of Variation.

For a variation so wide in its range as that above described a cause equally wide must be sought. No narrow or arbitrary limits can be set to the cause of a universal consequence. And what more natural or more obvious cause can be suggested than the changes constantly occurring in the environment of the organism? This is of course not a new suggestion, but some writers on evolution seem afraid to carry it out to its full extent. They seem unwilling to abandon the organism to the uncontrolled, confused and seething waves of the sea of physical nature. Yet only in the ceaseless, never repeated tossing of this unresting sea can be found a cause at once sufficiently changeful and far reaching to correspond with the observed changes of the organisms that are borne upon its surface or that live among its waters. Elsewhere in vain do we look for any means of explaining them. All other known natural causes are insufficient and to resort in a difficulty to the unknown and the supernatural is to place the enquiry beyond the pale of science.

In the changes of the physical world therefore and in these alone do we find a cause even presumably sufficient to account for the continual and contemporaneous changes in organic beings. It would be idle to assert that we know the precise mode of action in which the former produces the latter. So new and unexplored is this field that such knowledge is at present impossible. But with every advance we see more and more probability that in the one we have the real and efficient cause of the other. Experiments on the influence of food, temperature, light and other physical agents upon the modification of organisms especially during the formative part of their existence are gradually giving us a mass of information which has already greatly modified former opinions. Some forms once ranked as distinct varieties or even species are now known to be mere accidents resulting from the conditions in which part of their previous existence was spent. Especially is this true with regard to the lower forms.

Time and space will not allow many quotations. One or two must suffice.

"The Mexican axolotl is a tadpole-like animal of considerable size which lives in the water, breathes by gills and is reproduced from eggs.

In its native country this animal is not known to change its form but hatches from the egg into a minute object much like a young tadpole and gradually grows to the form and proportions of the axolotl.

"Now in 1867 the astonishing fact was observed at the Jardin des Plantes that some of these animals cast their skins after crawling out of the water and began a new existence in the shape of a common salamander (Amblystoma).

"This change from axolotl to salamander is accomplished in from fourteen to sixteen days and may, it seems, be always brought about in healthy specimens by placing them in shallow water and gradually diminishing the supply.

"Since these axolotl-descended salamanders are of precisely the same species as other salamanders in the western part of the United States it seems certain that these wild individuals are descended from axolotls and it has been suggested that a dry season or a succession of such seasons first caused the change to take place. If so we have here a striking instance where change of climate has produced not merely another species but another genus.*

The following case given by Schmidt in his work "Descent and Darwinism" I borrow from the author last quoted.

"At Steinheim, in Wurtemberg, was once a small lake and in its waters grew countless little shellfish many of them water snails like those of lakes and rivers at the present day. By the appropriation of the limestone dissolved in the water of the lake generation after generation of these snails built up their shells only to let them fall to the bottom on the death of the little inhabitant. By this slow process a layer of shell-mud was formed which has, since the deposit was made, hardened into chalk. About forty distinct layers of this chalk differing from one another slightly in appearance may be distinguished and throughout these layers are the perfectly preserved remains of many shells. The shells of each layer remain much the same throughout its thickness but toward the upper limit of each they are observed to vary, so as to approach the form which will be found in the next layer. And not only are the shells of the lowest layer so different that if the intermediate forms had not been discovered they would certainly have been called different species but there are also many among the intermediate forms themselves which if they had been found separated from the others would have been counted distinct."

A figure accompanies this account which exhibits the progressive change from a flat, discoid, planorbiform shell at the base of the deposit to one with a much elevated spire at the summit. A more striking instance of invariance in monotonous conditions followed by variation on the ensual of physical change can hardly be imagined. †

* Bergen, "The Development Theory." See also Buckley's "Winners in Life's Race."

† Mr. W. H. Edwards, of West Virginia, has recently demonstrated similar facts in regard to several species of the Butterflies. He has shown that several forms hitherto considered distinct are in reality only seasonal or other variates. See his "Butterflies of N. America" and his numerous papers on the subject in the "Canadian Entomologist."

Facts of this kind fully and fairly considered (and geology is yearly bringing them in great numbers before us) urge us strongly to the belief that great results are constantly wrought in an organism by physical changes in its environment, and failing evidence of any other agent competent to effect them it is not irrational to ascribe to the same cause all the variational changes. We may then view the organism as plastic material in the hands of its environment, shaped by it entirely and absolutely, and owing its form to its external conditions. Resuming the mathematical illustration the organism is a variable quantity; the physical conditions around it are the causes of its variation ; in response to these it varies and after an uncertain period of variancy it becomes another—a Variate.

In thus attributing all changes in an organism to changes in its environment we are under no obligation to admit that such changes are or must be favorable. The physical world exists in total independence of the organic. It was before organization and may be after it. So far from serving or aiding it, phenomena lead us to the conclusion that animate nature is, as it were, permitted by and during certain states of inanimate nature. Within certain limits of temperature, light, etc., organic beings can exist. Beyond those limits their existence is impossible. The organism is, so to speak, an accident among its physical surroundings. If these are compatible with life it lives, if not it dies. It exists on sufferance and its existence is lengthened by its power of adaptation—by its variability. If physical changes ensue the organism must adapt itself to them if it can, and continue in being. If it cannot do so it becomes extinct.

Summing up results thus far obtained we reach the conclusion that the doctrine of evolution by variation in a definite beneficial course is not in consonance with the facts of Nature. On the contrary we find that this variation both of animals and plants appears to take place in every direction indifferently and quite without regard to the welfare of the variant. We find further that no cause is known to which these changes can be referred except the accompanying changes in the physical world. To these accordingly we refer them, conscious at the same time that the exact method of their action is as yet largely unknown.

Further we find that the changes thus produced may be either beneficial, neutral or injurious to the variant organism, following, as they do, certain physical laws which are, if the expression may be allowed, totally indifferent to its welfare. In a word, adopting again the language of mathematics, we may say that the Variate is a function of the original Variable dependent on its constitution and the conditions of its environment—that the changes between the Variable and its function, the Variate may be beneficial in a high or low degree ; and may lead to its extension and increase ; they may be neutral and leave the organism where they found it ; or they may be prejudicial and lead to its diminution or extinction. In every case, however, they are necessary consequences of the interaction of the laws of organic nature within and of physical nature without the organism, inevitable, inexorable, fatal.

VII.

A Possible Objection Considered.

It will not improbably be objected that in thus attributing organic variation *entirely* to outward agency I am going considerably beyond what can be proved. In the strict sense of the term this is true. We cannot yet demonstrate all the effects of physical change on a variable organism. But we are constantly seeing more and more clearly the immense effects of physical nature on organic beings. And experiments, purposed and accidental, are gradually enabling us to trace special organic changes to their causes in inorganic nature, and thus, as it were, to correlate the kingdoms. A vast field of experiment lies here before us in the attempt not merely to correlate but to commeasure these two, not only to determine what physical changes produce certain organic effects, but to measure both, to estimate and weigh them and at length to predict the organic effect of any given physical cause.

And in this direction modern biological research is tending. The results already obtained warrant the hope that some day the present chaos will be reduced to order, and the changes of organic nature will appear as only the outcome of contemporaneous or antecedent changes in the physical world. A correlative and commensurate scale will be established. Rest in inorganic nature, if possible, will be accompanied with invariance of organic nature, for as said above, no "tendency to vary" exists. On the other hand change in the former, if uncompensated, must as certainly induce change in the latter. The induction is not complete, as no induction ever can be, but the number of instances is already so great and so rapidly increasing that the conclusion cannot be called premature, and while every day increases its probability.

It is true that we cannot as yet show many examples of invariance through very long periods of time. Species die out and others come in. Change is the rule, and we have so far found few exceptions. But the biologist does not stand alone in thus advancing a step beyond the cover of "bald facts." Other students in other departments are accustomed to do the same, and boldly to accept the logical outcome of their observations even in cases where for want of opportunity the crucial experiment cannot be performed. A mechanical illustration will make the meaning clear. The first law of motion is thus expressed by mechanicians: "A body continues in a state of rest or of uniform rectilinear motion unless acted on by some outside force." Yet the mechanician has never seen "a body in a state of rest or of uniform rectilinear motion." His faith is nevertheless unshaken. He argues that as every approximation to the necessary conditions is followed by a nearer approach to such motion if he could obtain perfect conditions, perfectly uniform rectilinear motion would result. The force and justice of his argument are admitted. And on proof like this he builds his science of mechanics, and on this science the works of the engineer confidently rest.

Now conceive an organism as the moving body, the motion of the latter being represented by the specific life of the former. As the moving body travels through space, so the organism travels through time. If unaffected by outside disturbing force the former continues in a straight line. So if unaffected by changes in its environment, the latter remains unvaried from generation to generation, merely changing its position in time as the former in space. Thus each would continue indefinitely, the same in all respects except position, after many thousand years had passed away.

But on its way the flying body approaches some other mass of matter, and immediately feels an influence by which its own motion is modified. So on its way through time the organism comes into a different environment to the influence of which it responds by modification of structure or habits or both. These modifications are the necessary consequences of the changes in its surroundings. In the former case we call them physical, in the latter natural. But in neither do we know anything of the mode of working. Of the "why" and the "wherefore" of both we are equally ignorant. The mechanician sometimes imagines that by attributing the one to "universal gravitation" he has explained it. But he has not. He knows nothing of the nature or of the cause of this universal gravitation. The biologist is not yet sufficiently advanced to generalize variation and give a definite name to its cause. But with this unimportant difference the two are in the same predicament.

The parallel may be followed a step farther. The body moving through space and the organism through time are alike in another respect. The former may be drawn forward and its motion accelerated by an outside force. So the latter may vary and improve under the influence of environment. The former may be retarded and its motion may be diminished or destroyed. So by unfavorable environment the latter may vary in a prejudicial manner until extinction ensues. Yet again the former may, under the influence of the disturbing forces, change its direction without either acceleration or retardation. So the latter may vary in directions which shall be perfectly neutral in their effect upon its welfare, and the new form may be as capable of survival as the old. In both cases the variable is perfectly passive and plastic in the hands of its environment, and the environment is perfectly indifferent to the welfare of the variable. The ensuing variate is an outcome of the conditions of the world around it and must take its chance among them, living if in harmony, or dying if in discord.

In both the above cases the crucial experiment is beyond our reach. To obtain absolutely uniform rectilinear motion there must be only one body in the universe, and no resisting medium. To obtain an absolutely unchanging variable organism there must be no alteration of the conditions of existence. Both are alike unattainable. Yet, as with the mechanician so with the biologist, every approximation brings him nearer to the desired result. The vertebrates are least capable of enduring changes of environment, and land surfaces afford the most variable conditions of life.

Among the vertebrates, therefore, of a terrestrial fauna occurs the most rapid evolution of animal forms. The depths of the sea are the places where conditions vary most slowly. The lowest forms of animal life are least affected by changes of environment. Accordingly among low forms of life, and at the sea-bottom, we find most persistence of type. Illustrations might readily be quoted, but they are needless. The facts are familiar to every naturalist. And reasoning from these facts in the same manner as does the mechanician the biologist argues that could he obtain the requisite unchanging conditions his species would continue unvarying for an indefinite time. Though still variable they would be perfectly invariant.

VIII.

Nature's Waste of Variates.

Nature's variates thus produced take their place among their physical and organic surroundings. With these they are more or less in harmony and in discord. If they can, they live; if not, they die. Nature has no care for her nurselings. She casts them adrift on the world to shift for themselves; to swim if they can; to sink if they cannot. She neither aids nor hinders them. She "cares for nothing." It is a game of "hit or miss;" a method of "trial and error."*

If a somewhat homely simile may be here allowed I will liken the process of Nature in producing variates that are in harmony with their environment to the plans adopted by large commercial houses in making their goods known. Not knowing where their customers can be found they scatter advertisements wholesale over the country. Here we find the name of the firm in a newspaper, there at a railway station, here in a magazine, there on a blank wall, here on the fly-leaf of a book, there on the back of a railway ticket, in one place on the pavement underfoot, in another on the ceiling overhead, now on a handbill forced on us in the street, then around the pages of a railroad guidebook, and sometimes even on the fences and the rocks in little frequented spots. Everywhere crops out evidence of a systematic effort to catch the eye of the public by dint of irrepressible advertising without definite method. Of all these attempts the greater part are doomed to failure. Overlooked by the eager readers of the news-sheet and of the railway guide, trampled under foot by the hasty passenger in the street, read and immediately forgotten by the preoccupied and the thoughtless, they live out their little lives as variates among uncongenial conditions, as seed in stony ground, and pass

* It is to this neglect of her variates that the slowness of Nature's results are due compared with the rapidity with which varieties are obtained by man. A valuable seedling grows up in some out of the way place; man secures it, propagates from it and so perpetuates the variate. But if left to Nature it is probably destroyed and the opportunity lost. Every variety and, still more, every species of Nature's making may fairly be looked on as the result of many experiments undertaken and brought to the verge of success only to be abandoned and fail.

away without remembrance or result. But here and there one out of the great number catches the eye of some one in want of the thing advertised. It brings him in as a purchaser and a sale is made. One success out of a myriad of failures. Yet the purpose is served and the business maintained.

So with nature. She launches into the world her countless hosts of variates—in form, in color, in size, in strength, in bodily and mental qualities. Of these, myriads—perhaps the great majority—die and leave no trace. But here and there an individual possessing characters more in harmony with its environment than those of its ancestors or relations takes advantage of the fact, increases rapidly and finally in the struggle vanquishes them and takes their place. The old organism yields and the variate is called the new species. Such is the method of trial and error employed in Nature if we judge impartially from the facts that meet our eye in every field of the organic world.

Strictly speaking every individual is a variate, for never does the offspring in all minute points resemble its parents. But when out of these hosts of variates all the unfit have been eliminated how few remain. How few even among the human family live to manhood, and how much smaller is the number among the wild species. Nature appears to keep in her workshop moulds of almost every conceivable form, and in these moulds she casts her variates, issuing them broadcast on the world in order to see which can survive. The greater number perish. Only here and there does one prove to be in harmony with its environment and live. But those that perish are quickly destroyed and forgotten—melted down and recast —while the survivors apparently testify by their fitness in favor of special adaptation.

IX.

Creation by Beneficial Variation and by Special Design.

In this prodigal waste of her variates therefore rather than in their economical production by beneficent variation, we find the clue to Nature's method of creation. She does not make a new variate in perfect harmony with its surroundings and then carefully watch and nurse it into growth and supremacy. She does not study the surroundings in order to make the variate. Still less does she fashion the surroundings to fit the variate. On the contrary her plan is to produce her organisms in vast numbers, and of varied forms and leave them to be assorted by the sifting process of natural selection. The unfit many soon perish. The fit few alone survive and multiply. The result is that nearly all living species thus sifted out are in a harmony so nearly complete with their environment that it seems at first view intentional. And this is the fallacy underlying the argument of the teleologist, whether he belong to the school of "beneficial variation," represented by the writers quoted at the outset of this paper, or to that older school that formerly pressed and whose adherents still press, though with somewhat diminished confidence, the famous arguments for "creation by special design."

These writers maintain that the adaptation of an organism to its surroundings is a proof of a specially designing intelligence. They say that the countless instances of accommodation discoverable in existing nature and those which may be inferred in past ages could not have come to pass except by intent. It is needless to quote examples. They are familiar to everybody. They have been enlarged on from the days of Paley's watch picked up on a common down to the present day. And even now books issue from the press reasserting and attempting to reinforce this old argument. Yet from the point of view here taken this "argument from design" is entirely illusory and obtains all its apparent importance and its seeming strength from being based on a mere partial view of the subject. The teleologist picks out instances of organisms that are in harmony with their surroundings, sees and studies the many and minute adaptations of the one to the other, and then somewhat hastily infers a special intention in the arrangement. From the examination of a few instances he infers a general rule and asserts that every organism is specially adapted to its environment by intelligence. The inference is natural, obvious and pardonable on a superficial view, but wider and closer observation refutes it. Every organism is in approximate harmony with its surroundings because, as said above, it lives only on that condition. If not it dies. This fact the teleologist fails to see or to appreciate. By him the constant struggle for existence is unseen, the cries of the vanquished are unheard, the thousands that are born only to die of unfitness are unnoticed. Were all these elements taken into account his problem would be less simple and his results less easily reached and less confidently announced. Special intention or design in creation could hardly be affirmed of a world where the greater part of the experiments fail of success.

Returning for a moment to the illustration employed above, the teleologist is in the position of one who seeing an advertisement fall into the hands of a man in need of the article advertised should straightway infer a special design in the advertiser to bring these two together. Not seeing or not heeding the thousands that went to waste he comes to a hasty and incorrect conclusion by imperfect induction. A wider view would give a juster sense of the relation between the failures and the successes and enable him to see the design, for such it may fairly be called in its true light.

For, be it understood that evolution as here defined by no means disproves design. To assert or to imply this would be as illogical as the fault just condemned, but in the opposite direction. That it disproves "special design" is, it appears to me, evident. But design of another kind and of a wider scope, working in quite another fashion—"the method of trial and error"—may yet exist behind all. On this question evolution thus far speaks doubtfully and the biologist holds no positive opinion.

Of one fact, however, he is confident—that all the changes of organic life are results of unswerving "natural law," the details and modes of whose working he cannot yet trace. Chance at present seems supreme among the tranformations which evolution has revealed. But chance is only a name under which we disguise our ignorance. In a world under the action of universal natural law, Chance, that is, causeless effect, cannot exist. Chance in this sense is to the careful student of Nature unthinkable, inconceivable. Every event is a consequent of antecedents and an antecedent of consequents. Order, such as it is, prevails everywhere. The sequence is unbroken. Every existing species is a single link of a chain, one end of which is lost in the distant past and the other end has not yet emerged from the distant future. Every link depends from that preceding it and serves as a point of attachment for that which follows. What the one is the other will be, barring the effect of outside influences, and could the exact nature of the organism be known and the exact effect of environment be determined, it would be possible to foretell the exact nature of the ensuing variate.

But firm as is the faith of the biologist in the existence and ceaseless action of universal law he admits his utter ignorance of that deeper force or of those deeper forces that keep the law in action. This must be determined from the working of the law itself. He must reason back from the law to the underlying principle and determine the nature of the latter from the mode of the former. And if in this profound investigation he finds himself coming to results which clash with prevalent or preconceived opinion, if the law of the universe seems other and harder than poets have feigned, yet sentiment and prejudice should not be allowed to lie as stumbling-blocks in the path of advancing knowledge, nor should the faint voices and dim lights which come to us out of the darkness ahead be disregarded, though they would lead us in different direction from that in which we were wont and wishing to go.

Conclusion.

A possibility looms up before the biologist on this view of his science which no other theory can encourage. If all organic changes come about as consequences of changes of environment, why should it be beyond reasonable hope that he may some day be able to grasp the effects of the latter so completely as to foretell the former? Astronomy was once in the state of confusion and ignorance in which biology now lies. The movements of the planets were an unsolved enigma, their paths a tangled maze, their mutual influences a seemingly hopeless chaos. But Copernicus, Kepler, Galileo, Newton, Laplace and Leibnitz arose. The key of the enigma was found, the clue to the maze, the order in the chaos. And now of all the physical sciences, astronomy is the most exact, the most thoroughly under control of mathematical laws. The astronomer, rising above the task of merely recording the past, predicts the future. The movements of the planets are understood ; universal gravitation enables him to grasp them, and the subtle mathematical analysis gives him the means of seizing any one of them, of tracking it through space, of marking its course, of including the varying effects of other globes, and finally, from his complicated formula, he educes a prediction of its place at any moment in the future.

Is it too much to hope that some day the biologist too will rise to the same position; that some other and greater Darwin will be born to give us a generalized law of variation; that some biological Newton will arise and enable us to compute the complicated problem which organic beings present in passing through their different stages of variation? If even now the pigeon-fancier will undertake to produce in a given time a bird with any desired plumage (within possible limits); if the cattle-breeder can call into being a variety retaining desirable and excluding undesirable qualities; if a gardener can develop a new and valuable variety of plant, and fix its characters so that it comes true from seed for many years, why should we not hope that some day the special will become the general, and that what can now be done in a few cases will then be done in all at will? When the effects of changes in the environment are definitely known and traced back to their special causes, their direction and amount determined and their condition so fully understood that they can be reproduced at pleasure, then will the material be in our hands for the final generalization. Is it too sanguine to hope that a biological analysis will then be invented and perfected as mathematical analysis has been perfected, and that the biologist, armed with this new engine of investigation, will be able to trace the past evolution of organisms to its causes in the organic world? And, bolder still, may he not venture into the future, seize in the grasp of his Calculus any variable organism, and involving in his formula the successive conditions of its environment, trace it through its complicated changes during its period of variance until his equation yields up the function—the variate—at the end of any desired interval, exhibiting new characters and forming a new species?

Is such a prospect, though distant, altogether visionary? May we not hope some day to solve the great evolutionary problem? Given, a variable organism and the conditions of its environment during a certain time, to determine the consequent changes.

THE MEDICAL MYTHOLOGY OF IRELAND.

By James Mooney, Washington, D. C.

(Read before the American Philosophical Society, April 15, 1887.)

NOTE.—The information contained in the following paper has been obtained by the writer's personal investigation among the people who believe and practice the things described, and has not been obtained from books, although numerous works bearing on the subject have been consulted. Every belief and custom described is still in vogue in some part of Ireland, especially in the west. They have even been transplanted to this country, and some of the charms mentioned have been used by Irish men and women for the relief of children at the request of fairly intelligent American parents, while the accidental death of a young man at Holyoke, Mass., some years ago, is attributed by his friends to the evil eye of a Mearnan who was near him at the time. Where inquiry among people of different sections has shown a custom to be general, the fact has been stated, and most of the charms described as local would probably prove to be generally known on further investigation.—THE AUTHOR.

For several reasons the mythologic theory of disease has probably reached its highest development and retained most of its original strength among the people of Ireland. Her national life was crushed into the ground by an alien tyrant while still the gloom of the Dark Ages hovered over Europe, and when the Irish nation itself had hardly emerged from the tribal condition. The island which had been the home and the refuge of scholars during the troubled centuries which followed the fall of the Roman empire was given over to desolation, and the fire kindled upon the altar of learning went out in blood and tears. Laws were enacted against the dress, the language, the very names of the people, and it was held no crime to kill an Irishman. Schools and monasteries were despoiled and their inmates hunted down like wild beasts or banished from the country—the same price was offered for the head of a priest and for the head of a wolf—and for nearly seven hundred years teaching was a treason and education a crime. When at last, within the present century, the laws became at least human, and schools were established throughout the country, the same landlord system against which the Irish people are now fighting fastened them down with a weight of poverty which their utmost exertions were not sufficient to throw off. The people had no time or money to go to school, and therefore remained in a great measure uneducated. In addition to all this must be considered the peculiarly spiritual temper of the Kelt, and especially of the Gael, which inclines him to a strong faith in the things of the invisible world, and renders the Irish nation an eminently religious people. The same qualities, when not properly directed by education, lead naturally to superstition, the religion of ignorance.

If a line three hundred miles long be drawn through the greatest extent of the island, from Inishowen in the north to Cape Clear in the south, it will divide the country into two parts, of nearly equal size. The eastern section is a fertile plain, shut in by low mountains along the coast, and being naturally easy of access and more exposed to foreign influence and colonization, its inhabitants have lost much of their original character and nearly all of their language. The western section is chiefly a region of rugged mountains, and limestone cliffs covered with a thin layer of soil, where no one but an Irishman would attempt to raise a crop. Its inhabitants, who are fishermen on the coast and shepherds in the mountains, are still in the primitive condition of their ancestors, retaining in a great degree their simple habits and their Gaelic language. The typical districts of this region are Donegal in the north, Kerry in the south, and Connamara in the extreme west. Here the practices and beliefs which were once general throughout the country still have full sway, the enchanted horse dwells in the lough, and the fairies dance under the hawthorn.

The Practitioners.

In describing these customs and beliefs they will be treated, not as half-forgotten superstitions raked up out of the past, but as living realities, for such they are in fact. The medical professors of this region are generally old women, whose stock in trade consists of a few herbs and simple decoctions, a number of prayers and secret formulas to be recited while applying the remedy, and a great deal of mystery. Such a woman is commonly called a *cailleac· luib·e** "herb hag" or *bean feasac·*† "knowing woman." When her art is of that doubtful kind which tends rather more to the injury than to the good of her neighbors, she is called a *piseog*‡ and the same name is also applied to her nostrums. In some few cases the doctor is a man. There are also a number of persons who have cures for particular diseases, these cures being innate in the individual, owing to some accident of birth, or hereditary and transmitted from parent to child from a remote generation. When hereditary, the secret is jealously guarded—even by the mother from her child—and only revealed upon the deathbed, to some one of the family who, at the same time, is pledged to silence. For this reason it is almost impossible to get the formulas used with any of these cures, but there are a number of charms in use which are common property, and from a knowledge of these the character of the others may be guessed. In rare instances the possessor of a cure bestows it upon another in return for some favor, the charm losing none of its efficacy by the transfer. It is generally considered essential that the charm should have been inherited from a woman by a man, or from a man by a woman. Persons who possess these single cures give their services

* Pronounced *cawl-yakh liva*. The Connamara pronunciation is given, unless otherwise noted. In the Gaelic text the aspirated consonants are indicated by a dot placed after them near the top. When the Irish characters are used the dot is placed above the aspirated consonant, and when the Roman characters are used, as in Scotland, the consonant is followed by an *h*. The *h* is not here used, as it does not properly belong to the Gaelic alphabet, and gives a false appearance of harshness.

† Pronounced *ban fàsakh*.

‡ Pronounced *pishoeg*.

freely, as their powers are looked upon as sacred gifts which would depart from them were a fee demanded, although they may accept a small present. The other class, on the contrary, who are considered as akin to dealers in the black art, act upon the principle of "nothing for nothing." In Connamara it is customary to cross their hand with a two-shilling piece, a silver coin having a cross upon one side, the sacred emblem being supposed to compel them to speak the truth. The herbs are gathered fasting, generally by moonlight, and whisky enters largely into the decoctions.

These practitioners have their specialties, and one who deals with the evil eye will have nothing to do with a fairy sickness, neither will the "fairy woman" meddle with an illness which is due to the influence of the evil eye. It must not be supposed, however, that the people depend entirely upon the skill of these doctors. On the contrary, every housekeeper is well acquainted with the virtues of all the common herbs, to which she never fails to resort in case of need—always accompanying the application with a prayer—and it is only when she has exhausted her resources or is convinced that the sickness is of supernatural origin, that she applies to the *cailleac· luib·e.* When an ailment does not yield readily to simple treatment, it is generally ascribed to one of three causes, viz., the fairies, the evil eye, or witchcraft. The last of these is not often held responsible, as Irish witches usually confine their operations to stealing the butter, and seldom harm the owners. We will speak first of the fairies.

The Sig·efreog and Fairy Influence.

The person, of either sex, who treats illness of fairy origin is called a *sig·efreog,** the name being probably a diminutive of *sig·efear,*† a "fairy man." In the south they are called *sheefers* or *sheefros*, while in the east they are known as fairy men or women, as the case may be. They have generally obtained their knowledge by a residence of some years with the fairies, who frequently carry off both grown persons and infants, and detain them for three, five or seven years, unless forced to return them sooner. Young mothers and their infants are especially liable to be abducted, and to prevent such a calamity numerous precautions are adopted, which need not be described here. The health—at least of grown persons—is in no way affected by their sojourn among the fairies, while they learn all the secrets of their captors and afterward use this knowledge to defeat their purposes. Although, after returning to their friends, their services are in constant demand to counteract the fairy influence, they are never able to shake it off from themselves, but are frequently called away, even in the dead of night or from the midst of a company, to perform some office for the "good people"—generally to wait upon a fairy mother or her child. The fairies naturally resent the interference of

* Pronounced *sheefroeg.*

† Pronounced *shee-fär.*

the *sig'efreog*, and while gathering her medicinal herbs she is frequently stricken with convulsions and falls to the ground, foaming at the mouth, owing to the violence of her struggles with the invisible beings, who strive to tear the plants from her grasp. In one instance, in the County Clare, they seized a man at night in a lonely place, and beat him so terribly that he was confined to his bed for a week afterward.

In addition to her medical knowledge, the *sig'efreog* can read the thoughts of others, and tell the whereabouts of missing articles, and her powers are often inherited by any of her children who may be born after her return from fairy land. She also warns the people occasionally against doing anything which would incur the ill will of the fairies, such as throwing out dirty water after nightfall, when the elves are engaged at their sports; forgetting to leave clean water on the dresser for them to drink; or saying grace over the potatoes without first setting aside a portion for the fairies, who cannot touch consecrated food. Such is the dread of offending these spirits that they are seldom mentioned under their true name of *sig'e*,* or "fairy," but are generally called *daoine mat'a*,† or "good people," frequently accompanied by the invocation, *Fogramuid deag'-c'om'arsanac't oraib'*,‡ "we beg good neighborship of you."

The supernatural power of the *sig'efreog* is sometimes due to some remarkable cause other than a residence with the fairies. In the County Clare is a wild mountain lake known as Lough Doon, where St. Patrick confined the last of the serpents, which still at rare intervals comes out upon the bank. On one of these occasions the serpent was seen by a man who ever afterward "had a cure." There formerly lived near Tuam, in the County Galway, a cripple known as *Dom'nal Crom*,§ or "Crooked Daniel," who, on account of his infirmity, was generally appointed to watch his neighbors' cattle upon the mountain side. While thus engaged one day he saw a bull descend from the heavens and associate with one of the cows. By drinking the first milk drawn from the cow after the birth of the calf he was endowed with a knowledge of fairy doings and the gift of prophecy.‖

A single instance, from east Galway, will serve to illustrate the manner of fairy seizure and rescue. A woman was carried off while her husband was out of the house for a short time, and on his return, instead of the blooming young wife he had loved, he found a shriveled whimpering creature, who would take no care of the child. He was in great trouble over the matter for some time, until one night, as he was coming across

* Pronounced *she*.

† Pronounced *dheence mōha*.

‡ Pronounced *Foegramūj jaw-khoersanakhth ŭriv*.

§ Pronounced *Dhonawl Crum*.

‖ This man is referred to on page 83 of Sir Wm. Wilde's valuable and interesting work on Lough Corrib, published in 1867. The account here given was obtained from a native of that vicinity.

the field, he saw his wife standing in the *haggart*.* Going up to her, he asked her, in the name of the Trinity, who had her in their power, and what he must do to rescue her. She told him that she was with the fairies and that there was one way by which he could recover her, if he had sufficient courage to try it. On a certain night and at a certain hour, a company of mounted fairies, with her in their midst, would enter a fairy fort† near his house. He must be ready with some urine and some chicken dung, which he must throw upon her and then seize her. He promised to do as directed, and at the appointed time he was in waiting near the fort. Soon he heard the fairies approaching, and when the noise came in front of him he threw the dung and urine in the direction of the sound, and saw his wife fall from her horse. He seized her, and although the fairies crowded around and strove to tear her away from him, he defied them and held on to her until they gave up the attempt and retired into the fort, when he brought her home with him. At the instant he seized her there came such a blast that "you'd think the wind would sweep the roof from the house," and in the midst of it all the withered hag disappeared and was not seen afterward. The woman lived to a good age and had several children after her return.

The method adopted in this case to break the power of the enchantment is especially to be noted, as it is a cardinal principle in Irish mythology that fairies, being pure spirits, cannot endure defilement. Even a handful of dust thrown into their midst will sometimes cause them to release their hold on a prisoner. The same ingredients enter into most of the charms and amulets used as a protection against the fairies. The chicken, also, is regarded as peculiarly sacred, and some wonderful virtue is connected with everything belonging to it. According to popular belief, the fairies can take anything but a chicken or an egg.

Unusually promising young children—especially infants not yet baptized—are frequently carried off by the fairies, who leave instead what are known to be changelings by their pinched and withered features, their hollow voice, their constant crying and inordinate appetite, and their unnaturally shrewd remarks and actions. In other words, the uninformed observer might think them precocious children in delicate health. In such cases, when there is no longer any doubt in the matter—for mothers are always slow to be convinced of the real truth—the fairy woman is called in to bring back the stolen child. Her usual method is to heat the shovel in the fire, place the changeling upon it and put it out upon the dunghill. She then returns to the house and recites certain words, after which the family go out to the dunghill and find there the real child, in place of the other, which has been taken away again by the fairies. The child seldom

* An outdoor inclosure for storing grain and hay.

† Prehistoric circular earthworks, with underground passages, very numerous throughout the south and west, and popularly believed to be the abode of the fairies. Antiquarians generally regard them as ancient communal village inclosures.

lives long after its return, owing to the rough treatment it receives while in the hands of the fairies.

In this operation we have a combination of fire, iron and dung, the three great safeguards against the influence of fairies and the infernal spirits. Three is also the sacred number in Ireland, as well as throughout Europe. The changeling sometimes leaps through the window at sight of the preparations, and disappears in some unaccountable manner, when the real child is found asleep in the cradle. This method is known throughout the country, but there are also other ways to accomplish the same purpose. In the County Cork the mother, while still fasting, takes the changeling before sunrise to a point where three running streams meet, and after stripping it, dips it into the water three times in the name of the Trinity. This is done on three successive mornings, and on returning home the third morning her real child is restored to her arms as she enters the doorway, the substitution being effected instantaneously by the fairies.

In another instance a young man was suddenly stricken with a rheumatic illness, which confined him to his bed nearly three years. At last one day while his parents were gone to the market he got up and joined the younger children playing outside the house, and was as active as any of them. When it was about time for the parents to return he went back to bed again. The children told the old folks all about it and an elder brother agreed to watch the next day. In the morning the parents started off again, but were hardly out of sight when the sick man was out of bed once more and in the field with the children. The watcher ran toward the house to see if the bed was empty, but with all his swiftness, the rheumatic got there first and was in bed when he entered the door. The brother took up an ax, and approaching the sick man, swore that he would kill him if he did not tell who he was. "Oh, brother," cried the sick man, "don't strike me, for I have only a few more days to serve, and then I will be with you again." The brother desisted and soon after the young man was restored as well and strong as he was three years before. He explained that a servant girl of the family, who had apparently died about a year before the beginning of his illness, was with the fairies, and had warned him not to accept food or drink at their hands. He followed her advice, and at the end of three years, the shortest period of fairy detention, they were consequently obliged to release him, while the girl who had made the fatal mistake of eating with them was never restored. The young man was the son of a respectable farmer named Halpine, in the County Limerick.

This belief in the presence of a fairy changeling in place of the sick person is very general, especially in the case of infants which pine away without apparent cause, strong young men suddenly stricken down, and old persons whose illness is of a fitful and lingering nature. It probably has its origin in the change in disposition and features under such circumstances, and the unwillingness of the people to believe that this can be the result of natural causes. The supposed fairy is sometimes threatened to force him to reveal his identity, and when the case is evidently hopeless, although the patient still lingers, a piece of *Lus-Mor,** or foxglove, is put under his bed. If he be a changeling, the fairies will be compelled to restore, at once and in good health, the person taken away. If the invalid be really present in his proper person, he will not recover, but die. The reason of this is, that when the soul, after death, is brought up for judgment, it is sometimes condemned to return and re-animate the body, and endure with it all the miseries of sickness until its sins have been expiated, when it is finally separated from the flesh and enters into eternal happiness. The fairies take advantage of this temporary absence of the soul before the judgment bar to put one of their number into the body so that when the soul returns it finds its place occupied and is obliged to go with them. The presence of the *lus-mor* compels the fairies to take away their spirit from the body and release the soul, which then enters at once into glory. This, of course, is no part of the Catholic belief, but a survival of the old paganism.

Lameness is frequently the result of having intruded upon the precincts of the fairies or interfered with them in some other way. For this reason the people are especially careful not to disturb the fairy forts or venture near them after nightfall. A girl near Feakle, in the County Clare, fell asleep in a fort on a harvest day, and on awaking in the morning found herself unable to walk on account of a painful ulcer on her limb. The fairies had struck her for coming upon their ground. After a long illness something like a thread of flax came out of the wound and she recovered. Ulcers, scrofula and running sores are commonly called "fairy strokes," and attributed to fairy influence. The particles of hardened pus which sometimes come out of the sore are the fairy darts which have caused the wound. A man near Dunmore, in Galway, rented a small farm upon which was a fairy fort, which was overgrown with bushes. As these were never disturbed they at last began to encroach upon the cultivated ground. In spite of the remonstrances of his wife he determined to root out some of them, but had hardly begun the work when he was struck with such a sharp pain in his leg that he fell to the ground and had to be carried into the house and put to bed. His wife went out and replanted the bushes just as they were before, when he at once got relief. This was told by the man himself and confirmed by his wife, who was present and added: "If there is one thing certain, it is that there are fairies in Ireland." He holds a responsible position at a salary of $1300 per year. Near Bandon, in the County Cork, lived a man who in his youth was a noted jumper, and on one occasion leaped across a ditch twenty-two feet in width and alighted in such a manner as to severely injure his foot. A running sore appeared on his ankle and pieces of bone came out. His mother procured from a fairy woman a "bottle of herbs," which was rubbed upon the foot and

* Pronounced *lus-more;* literally the "great herb."

resulted in a cure. The bottle was paid for with a basket of eggs, each one of which was marked with a black cross made with the burned end of a stick, probably of furze. The woman explained that he had been kicked by the fairies, who were passing that way when he jumped into their midst. This woman went every night with the fairies, who summoned her with a peculiar whistle, which was heard by other persons as well as herself. She was once called away from a wake in this manner, but no one had the courage to follow her. The story is given as told by the man who made the leap, an old soldier who has spent the last thirty years fighting Indians and border outlaws on the frontier, and is now laid up for repairs at the soldiers' home near Washington. When a boy he often watched all day at the entrance to a fairy fort to catch a glimpse of the fairy shoemaker, but he says he no longer believes in such things.

Another of these women kept a bottle of water, and by holding it up to the light could tell whether or not a sick person would recover. A man once came to her to inquire about his brother, who was sick. She looked at the bottle of water and said, "You have come three minutes too late." The man went home and his brother died.

When any one sneezes, it is in consequence of a blast from the fairies, who are then endeavoring to carry him off. At the third sneeze they will accomplish their object, and leave a corpse or an invalid changeling in his place, unless some one present exclaims, "God bless us!" On hearing the name of God the fairies take flight, and it is hardly too much to say that this ejaculation is never omitted on such occasions. A similar custom prevails throughout Europe and has been traced back as far at least as the time of Homer.

The prehistoric stone arrow head, or *saige·ad** occasionally found in the country, is a fairy dart which has been shot at some man or animal, and thus lost. The fortunate finder can counteract the designs of the fairies, and the old woman who possesses one is regarded with much veneration, and in the expressive language of the people, "she will get good nursing." When an illness is supposed to be due to the influence of the fairies, the *saig·ead* is put into a tumbler and covered with water, which the patient then drinks, and if the fairies are responsible for his sickness he at once recovers. The *saig·ead* is preserved in some iron receptacle to prevent the fairies stealing it.

As so many physical evils are due to the fairies, it is natural that some means should be used to ward off their influence. For this purpose a horse shoe is nailed over the door, while garlic is planted in the thatch above it. As newly made brides and young mothers are in most danger from this source, a great many measures—which come more properly under the head of marriage customs—are taken to prevent the abduction of either the wife or the child. It may be in order here to state that no fire must be taken out of a house while a woman is sick within it, and

* Pronounced *siedh*, equivalent to the Latin *sagitta*.

there is a general reluctance to lending anything whatever out of the house at such times. The ancient religion of Ireland was fire worship, and numerous vestiges of the old belief still exist among the popular customs.

Scraps of iron are frequently carried as a protection against the fairies, and in Connamara it is still a common practice to wear about the person what is exactly equivalent to the medicine-bag of the Indian. The contents of this bag, which is about the size of a hickory nut, are known only to the owner, who conceals also the fact of its possession even from his most intimate friend, but among them are usually found tobacco, garlic, salt, chicken dung, *lus-crea,* and some dust from the roadside. This is worn also as a protection against the evil eye, and something of the same nature is sewed into the clothing of the bride when her friends are preparing her for the marriage ceremony.

Convulsions in a child are sometimes due to the influence of the fairies, being probably the result of its struggles to escape from their grasp. The theory and practice are best illustrated by relating an instance, which is given just as it was told by the narrator, who knew the mother and believed the story. A woman had a child which was subject to dangerous convulsions, and after one unusually violent attack she consulted a fairy woman, who told her what she must do. On her way home the mother picked up from the roadside ten small white pebbles known as fairy stones. On reaching home she put nine of these into a vessel of urine and threw the tenth into the fire. She also put into the vessel some chicken dung and three sprigs of a plant (probably garlic or ivy) which grew on the roof above the door. She then stripped the child and threw into the fire its shirt and the other garments which were worn next the skin. The child was then washed from head to foot in the liquid, wrapped in a blanket and put to bed. There were nine hens and a rooster on the rafters over the door. In a short time the child had a violent fit and the nine hens dropped dead upon the floor. The rooster jumped down from his perch, crew three times, and then flew up again to the rafters. If the woman had put the tenth stone with the others, he would have dropped dead with the hens. The child was cured.

Vicarious Cures.

This single instance combines in itself a number of important features in connection with the popular mythology—the dung, the urine, the plant over the door, the chicken, the fire and the garment worn next the skin—and introduces also a new element in the popular theory of disease, viz.: the idea of vicarious cure, or rather, of vicarious sacrifice. This belief, which is general, is that no one can be cured of a dangerous illness unless, as the people express it, "something is left in his place," to suffer the sickness and death. A few illustrations from the County Clare will exemplify this belief.

A father, whose son was nearly at the point of death, applied to a man noted for his healing powers, who told him that the boy could be saved but that something must go in his place. "Well," said the father, "take anything that I have but a Christian." The other said it would not do for him to accept anything, but that he would put his own horse in the place of the boy. He then told the father to watch the horse, which was just coming up from the sea with a load of sand. The moment the cart reached the spot where the sand was to be put, the horse dropped dead. When the man arrived at home his son was well.

In another instance a woman was sick, and her husband called in a man who told him to take every living thing out of the house before he proceeded to cure her. The husband put his children out of the house, but forgot "a sow with a litter of *bonnivs*"* in one corner. The other man then recited certain prayers and restored the woman to health, but when the family came back again into the house they found the sow and the *bonnivs* dead.

At another time a man's wife was sick and the operator was sent for. He recited some words and the woman began to recover, but the next morning a fine cow belonging to her husband was found lying in the field, groaning and unable to rise. The cow grew worse as the woman grew better, and when the cow died the woman was well.

In the same connection may be mentioned a custom which prevails among the fishermen of Mayo and Connamara. Every master of a fishing boat carries a dog with him when out at sea, and should a storm arise, the dog's legs are tied together and it is thrown overboard, in the belief that the sea will at once become calm. This practice exists in Ireland to-day, in the nineteenth century, and is exactly what formerly existed among the Indians on the great lakes, as we learn from the trader, Alexander Henry. In 1766, while crossing Lake Huron in a canoe with a party of Ojibwas, a storm came up, which was attributed by the Indians to the anger of the snake god, whom he had offended the day before by attempting to kill a rattlesnake. After calling on the snake god for help, "One of the chiefs took a dog, and after tying its four legs together threw it overboard, at the same time calling on the snake to preserve us from being drowned, and desiring him to satisfy his hunger with the carcass of the dog."† We read in the Bible how, nearly three thousand years ago, the prophet Jonah, fleeing from the will of God, was on board a ship in the Mediterranean when they were overtaken by a storm. After calling upon their several gods, and using every effort to right the vessel, the sailors cast lots to discover who was responsible for the storm, and the lot fell upon the prophet. "Then said they unto him, What shall we do unto thee, that the sea may be calm unto us? for the sea wrought and was tempestuous. And he said unto them, Take me up and cast me forth into the sea; so

* Gaelic, *banab*, a sucking pig.

† Henry, Travels, 178, 1809.

shall the sea be calm unto you, for I know that for my sake this great tempest is upon you. * * * So they took up Jonah and cast him forth into the sea, and the sea ceased from her raging" (Jonah, i: 11, 12, 15).

Another belief, which exists alike in Ireland and among the Indians, is that certain localities are the abode of invisible malignant spirits, which visit sickness and death upon those who come within their reach. These evil spirits are overhead in the air, and are quite a different order of beings from the fairies, who live upon or under the ground, and on the whole are rather regarded as benevolent. If sickness or death occurs in a new house, it is frequently ascribed to this cause, and the house will be removed, or torn down and rebuilt in another place.

There is also a way by which the pains of maternity can be transferred from the woman to her husband. This secret is so jealously guarded that a correspondent in the west of Ireland, who had been asked to investigate the matter, was at last obliged to report: "In regard to putting the sickness on the father of a child, that is a well-known thing in this country, but after making every inquiry I could not make out how it is done. It is strictly private." It came out, however, in a chance conversation with a woman who, when a child, had once been selected to wait upon a nurse on such an occasion. At a critical moment the nurse "hunted her out of the room," and then, taking the husband's vest, she put it upon the sick woman. The child had hid behind the door in the next room and saw the whole operation, but was too far off to hear the words which were probably repeated at the same time. It is asserted by some that the husband's consent must first be obtained, but the general opinion is that he feels all the pain, and even cries out with the agony, without being aware of the cause.

The Evil Eye.

The belief in the existence of the *evil eye* is general throughout Ireland as well as throughout the greater portion of Europe and Asia. It was held also by the ancients, among whom there were whole nations whose glances were supposed to be fatal, and it was even thought that there was death in the sound of their voices. The eastern nations, both Christian and Mohammedan, ascribe almost every unaccountable illness to this cause; and among the Turks sentences from the Koran are written upon the walls of the houses to counteract it, while glass balls are hung from the ceiling, and gaudy trappings put upon the horses, to divert from the owner the attention of the evil-minded beholder. So general is this belief that a writer upon the subject says: "It is not improbable that if the matter were still more profoundly investigated, it would be found that every nation that exists, or has existed, with anything like a developed system of superstition, believes or has believed in the reality of fascination in some form or other."* There seems to be nothing exactly similar among the Indians, at least among the Siouan tribes of the plains,

* Am. Cy., iv, 177, 1880.

although the belief is said to exist among some Californian tribes. It may be that the idea is too subtle and intangible for the mind of a savage.

The general prevalence of this belief would seem to indicate that there must be some good reason for its existence, and this reason is doubtless to be found in the wonderful properties of the eye itself. We all know how much of attraction, repulsion, love or hate, may be expressed by a glance, and how intensified is this power of expression in certain individuals. There is unquestionably some innate, inexplicable power in the human eye, although more apparent in some persons than in others, and we can readily understand how the people of Ireland believe that every individual possesses this faculty at some period in his existence, and that it is sometimes hereditary, like other physical and mental characteristics. The influence of the human eye over the inferior animals is well known, and much has been written concerning the fascinating powers of the serpent, although in the latter case modern biology has shown that the result is due not so much to the eye of the serpent as to the paralyzing effect of fear upon his victim.

Droc'-s'uil, the "bad eye,"* is the name given to the evil eye in the Gaelic-speaking districts of Ireland, while it is known as the *bad eye* in the east, and the *ill eye* in the north. The act of fascination is called *deanad' droc'-s'uil*†, "making a bad eye," or *overlooking*. Those who possess this blighting power are generally unaware of its presence in themselves, and the evil consequences of its influence are not usually the result of any malevolent desire upon their part. The evil eye, either in man or woman, is generally due to some omission or irregularity in the ceremony of baptism. Should any word of the prescribed formula be forgotten, or should the sponsor fail to give the surname of the child as well as the name about to be conferred upon it, the infant will, in spite of itself, come into possession of this dreaded power. The idea underlying this belief may be that, as the child is born in a state of original sin, it is under the influence of the evil spirit until sanctified by baptism, and that if the ceremony be improperly performed, a part of this influence still remains and manifests itself in the evil eye. In some instances the *droc'-s'uil* is hereditary, and there are even cases where it exists among all the relatives of the same surname. A notable example of this occurs in the western part of the County Clare, where all the members of a family named Mearnan are known to possess an evil eye, even to the remote degrees of kinship. Notwithstanding this, they are much esteemed for their upright character, as it is well understood that this mysterious power is not subject to their own control. This family is referred to, but not named, in Hall's Ireland (III, page 250), a book published about forty years ago. The stories given further on concerning the Mearnans were obtained, with others, from natives of the County Clare, who were well

* Pronounced, *dhrŭkh-uil*.

† Pronounced, *jeenoo dhrŭkh-uil*.

acquainted with the family. While the evil eye belongs to some persons in a special manner, every man, woman and child possesses this faculty unawares once in every twenty-four hours, and a single glance at such a time is followed by all the ordinary disastrous consequences. This explains many mysterious cases of sickness otherwise unaccountable.

As has been shown, sickness and death sometimes result from the unconscious glance of one possessed of the evil eye, without any desire upon his part to injure the victim. Should a person, however, known to possess an evil eye, speak admiringly of another, praising his good looks, his healthful color, or his robust physique, or speak in a similar manner of his child, his cow, his crops, or anything belonging to him, it is inferred that he intends evil toward the person or thing thus spoken of, and measures are at once taken to prevent it. In many cases the evil-minded person is compelled by the injured man, on pain of bodily damage, to spit upon the object of his pretended admiration, and at the same time to invoke a blessing upon it. In Connamara a bowl is sometimes sent around the neighborhood, and each person to whom it is presented is expected to spit into it. The bowl is then taken home, and the person or animal overlooked is anointed with the spittle. The object of this is to obtain the spittle of the person responsible for the injury without giving him offense or awaking his suspicion, as a direct appeal to him would be certain to do. When the spittle cannot be procured, the same result is accomplished by burning near the afflicted person a piece taken from the clothing of the one who has overlooked him.

Should any one accidentally meet a person suspected of an evil eye, its influence may be averted by doubling the thumbs under the fingers. This gesture, and the measures just mentioned, are used throughout a great part of Europe for the same purpose. It has been asserted that the closed hand is used from its fancied resemblance in shape to the initial letter of the Hebrew name for God; but while the name of the Hebrew letter also signifies a *hand*, the equivalent Phœnician and Egyptian hieroglyph is an open, instead of a closed hand. It seems also to be of different origin from the ancient Italian gesture still used to avert the evil eye, which is made by extending the first and fourth fingers, and is supposed to have had reference originally to a pair of horns. The true reason for using the closed hand probably lies in the fact that in this position the thumb and finger form a cross. In all Catholic countries it is a common practice to make the sign of the cross as a protection against dangers, especially those which are due to the influence of evil spirits. This sign is usually made upon the forehead, while occasionally the second finger is simply crossed over the first, but the method of the closed hand would naturally be adopted in this case to avoid attracting attention, just as an entire neighborhood is sometimes laid under contribution for spittle in order to avoid giving offense to the suspected party.

When an illness is thought to be due to the influence of the evil eye, the *bean feasac'* who makes a specialty of such cases is called in to determine the matter, and to point out the author of the trouble, but her office seems to go no further, as the mode of cure is generally understood.

Anything which renders an individual conspicuous is liable to attract the attention of the evil eye—a belief also held by the Turks—and this explains some Irish blessings which are intended and regarded as curses. A common one of this kind is, *Go mbeid· ba b·ána do c·uid ba, go mbeid· teac· air an airde do t·eac·, agus go mbeid· bean b·reag· do b·ean.** "May your portion of cows be white cows, may your house be a house upon the height, and may your wife be a fine woman." Here the real wish of the speaker is that the conspicuous color of the cattle, the prominent position of the house upon a hill, and the pleasing qualities of the wife, may attract the attention of the evil eye to the possessor.

A few of the stories related of the Mearnans will illustrate the various phases of this belief. They are given substantially as told by the narrators. Two parties of men were one day at work in the field putting up the hay into reeks, and one party was getting ahead of the other. A man of the slower party called the attention of a comrade named Mearnan to this fact. "Never mind," said Mearnan, "just wait." The others had their reek finished first and were just putting the top on it, when the whole pile fell over, burying the men under it, and Mearnan's party came out ahead.

Another one of the same family stopped one day to admire a fine mare. As he started to go, a neighbor suggested to the owner that Mearnan ought to bless the mare. Much against his will he was compelled to come back, bless the animal and spit upon it. Soon after the mare had two foals, which were both dead, and if he had not blessed the mother she would have died likewise. The same man was one day passing along the road when he stopped to admire a horse in an adjoining field. The next day the animal, in attempting to jump across a ditch, fell into it and could not rise again. The owner and several of the neighbors tried for some time to get the animal upon its feet, without success, until at last one of the men remarked to the owner, "Micky, didn't Mearnan say yesterday that was a fine horse?" "He did," says Micky. "Well, then, you send for him and make him spit on it." So Mearnan was sent for, and whether he liked it or not he had to come. As soon as he laid his hand upon the horse the animal neighed. He said, "God bless you," and spit upon it, and the horse at once climbed up out of the ditch. The owner's wife, who was looking on, said to her husband, "Faith, Micky, if spitting ever got a horse out of the ditch, and it did yours to-day."

A woman of this name caused an accident to her little boy, just learning to walk, on three several occasions, by calling attention to his agility in climbing up on the table or the dresser. Each time he fell down from his elevated position and broke his leg. When this happened the third

* Pronounced, *Gŭ mó bawh wawna dhŏ khuj bawh, gŭ mŏ chókh er an awrja dhó hŏkh, ŏgus gŭ mŏ ban vraw dhŏ van.*

time her brother, who well knew the reason of it, told her that it was her fault, in not having blessed the child when she spoke of it. The mother would not believe it, and insisted as strongly that the brother was responsible for the accident. When the boy grew up he was obliged to wear trousers instead of knee breeches to conceal the deformity caused in this manner. This woman one day met a young man going to church, and carrying his shoes in his hand, as the road was muddy. She made some complimentary remark about his feet, and when the young man got home from church they were turned inward, and he was unable to stand upon them. The woman was sent for and compelled, very unwillingly, to bless his feet and spit upon them, but as she was going out of the door she turned round and said, "May it never thrive with you." The young man recovered the use of his feet, but there was always a twist in them afterward. In this climate a tramp of several miles barefoot over a muddy road, together with kneeling or standing for two hours in a cramped position on the cold floor of a church, might have resulted in rheumatism.

One of the Mearnans was so well aware of this blighting influence in himself, that on entering a house to pay a visit he would always spit upon and bless each member of the family before sitting down.

A number of men, including two carters with their horses, were one day at work in the County Cavan, when one of the party happened to say something in praise of the animals. On quitting work for the day the horses were found to be sick, and soon lay down and were unable to rise. Several remedies were tried without avail, until some one told the owner of one of the horses that the man who had praised them in the morning had an evil eye, and advised him to get him to spit upon them. He said he could not do that, as that man had a grudge against him. His friend then told him to get a piece of the man's clothing and burn it near the horses. That night the carter secretly cut a piece from the coat of the man who was responsible for the trouble, and going out to the horses he set fire to the rag and held it first near the head of his own animal and then near the other. In the morning his horse was well and the one belonging to the other carter was dead. The virtue was gone from the cloth before it reached the second horse. As the one who related the incident said, it was, "Man, save yourself." In this instance the knife used belonged also to the owner of the coat, but this had no effect upon the result.

The Blessed Wells.

In addition to the practitioners of various kinds, the people have great recourse to the numerous "blessed wells" throughout the country. The religious veneration for healing wells is older than history, and is found, not only in Ireland, but throughout Europe and Southern Asia. It is frequently referred to in the Bible, the most notable instance being that of the pool of Bethesda. There seems to be nothing of the kind among our Indians, who, although they regard certain localities with peculiar reverence as the abodes of invisible manitos, to whom they never fail to make some offering in passing, yet apparently do not attach any healing powers to such places.

There are hundreds of these wells in Ireland, at least twenty being in the County Galway alone. They are generally dedicated to some saint, and there is always a legend to account for their origin. Thus Colum-Cille's well, at Kells, in the County Meath, sprang up from the floor of the saint's house while his mother was lying on a sick bed, thirsting for a drink. In many, and perhaps in most cases, ancient Druidic remains or round towers are found near them, showing that these have been places of religious resort even before the dawn of Christianity. Should one of these wells be defiled, it would at once cease to flow, and the perpetrator of the sacrilege would wither away under the curse of the patron saint of the spring. The water must not be used for ordinary purposes. Incidents are related of women, who, being in haste to prepare a meal, have taken water from a blessed well close at hand rather than go to another spring at a distance, but found, after exhausting their patience in fruitless efforts, that it was impossible to bring the water to a boil. This is perfectly true, as the strong mineral impregnations which give the water its medicinal virtues, render it extremely difficult to boil under ordinary circumstances. There is usually a fish, a worm, or a peculiar stone at the bottom of the well, and the circumstances attending its appearance are regarded as omens of success or failure in obtaining relief. On departing from the well, pilgrims leave behind some small token of their visit, generally a shred torn from the clothing, which is twisted into the ivy that clambers up the rock, or hung from the limb of a tree overshadowing the water. These trees may be distinguished afar off by the number of rags suspended from their branches and fluttering in the breeze. This is an ancient custom, and is still practiced in Southern Asia as far east as Ceylon, and throughout Northern Africa, and along the east coast as far south as Zanzibar. Cripples who have recovered the use of their limbs leave also the crutches and litters used in coming. Besides the wells, there are many small lakes and waterfalls which are visited for the same purpose. Many of these wells have been deserted since the great famine of 1847-8.

While religious exercises are a prominent feature at all these resorts, there are some which are visited principally from motives of devotion. Chief among these is the celebrated Lough Dearg, in Donegal, which was resorted to by pilgrims from all parts of Europe during the Middle Ages, and where the rigid discipline imposed upon the penitents in its subterranean caves is said to have served as the model for Dante's Purgatorio. The wells are resorted to for almost every variety of ailment, but there are some which are especially noted for the cure of particular diseases, such as ulcers, sore eyes, or rheumatic affections. The pilgrims frequently come from long distances, sometimes even walking a hundred miles. The exercise, which is known as "making the stations" or "going a round," is sometimes performed by proxy, or by the invalid after recovery in accordance with a vow made during his illness. In the latter case, he is generally accompanied by a friend, who goes through the same exercises. The sanitary part consists of immersion, shower baths—where the water falls over a rock—rubbing and drinking the water. The operation is generally repeated on three, sometimes on seven or nine consecutive mornings, while the patient is still fasting. The religious part consists of the repetition of a number of prayers, usually the Our Father and Hail Mary, or the two combined in the rosary. While reciting these prayers the patient walks or is led around the well a certain number of times, always following the course of the sun. The circuit is frequently made upon the knees, and in every case the pilgrimage is undertaken and carried out in a spirit of deep religious fervor.

The wells are visited at all seasons of the year, but the favorite time is the day consecrated to the patron saint of the well. In some cases a remarkable phenomenon takes place at a certain hour, and is awaited by the people as the signal for entering the water. Thus St. John's well, a noted well at Kilcarty, in the County Meath, is visited on St. John's eve—June 23, or midsummer eve, the great fire festival of ancient and modern Ireland. Just at midnight a mist rises from the surface of the water, on seeing which those in waiting begin the circuit around the well. A similar phenomenon is related of Lough Ee-Cinlaan, a small "blessed lough" near Kenmare, in the County Kerry, which is also visited on St. John's eve and the following day. At a certain hour three "tussocks" of floating grass in the middle of the lough begin to move around in a circle, upon which the people waiting on the bank go down into the water. Compare this with the Bible account of the pool of Bethesda, which was surrounded by five porches. "In these lay a great multitude of impotent folk, of blind, halt, withered, waiting for the moving of the water. For an angel went down at a certain season into the pool and troubled the water. Whosoever then first after the troubling of the water stepped in, was made whole of whatsoever disease he had."* In each case the remarkable appearance is doubtless owing to the same causes which govern the periodic movements of geysers and other intermittent springs.

In the lough just mentioned, one of the three tussocks always moves around in the rear of the other two, which, like everything else in Ireland, is accounted for by a legend. They formerly moved along abreast, until one day a sacrilegious wretch attempted to mow the grass for his own use The moment he struck his scythe into the first tussock, blood followed, as from a living thing, and dyed the waters of the lake. Terrified at the sight, he desisted from his purpose, but ever since the wounded tussock has limped behind its fellows.

A brief extract from a recent Irish letter, written in reply to some questions concerning the blessed wells of the County Galway, will give a

John v: 3, 4.

better idea of the present beliefs and practices in this connection than many pages o description. The writer is one of the people, and has been familiar all his life with the customs which he describes so accurately. The extract is given in his own words, with the exception of a few slight grammatic changes. The letter is written from Curnamona, near Clonbur, about twenty miles north-west from the town of Galway:

"Thubber Muira and Feheen, in Ballintubber. Noted to cure any kind of sickness that may occur in a family. Station days are the eve of any of the Lady Days—eighth of September, fifteenth of August and second of February. The stations are performed thus:

"The person will kneel before the wells barefooted, will say so many prayers, and will take in his right hand seven pebbles, of stones which are for the purpose at the mouths of the wells. After walking around the well he will drop a pebble at each round, will kneel again and say more prayers, and so on until finished. There is one remarkable thing about these wells. After promising a station at these wells, if a person goes and prays there, he will see a small worm; and if the worm lives (*i. e.*, is alive) the patient will recover, and if seen dead the patient will die. After performing a station here, if it be a male person he will drop a button in the well, sometimes a piece of coin, etc.; and if it be a female, she will pull some threads out of her shawl or some part of her clothes, which she ties on the bush that covers these wells. Persons abroad promise stations at these wells and get some of their friends on this side to perform them, which must be done by two persons together."

In this instance there are two wells at the same locality. The name of the principal one, Thubber Muira,* or "Mary's well," shows that it is dedicated to the Blessed Virgin, and consequently the favorite times for visiting it are the "Lady Days," or days specially devoted to her honor. These are named in the order of their importance, which is the reverse of the chronologic order. Feheen† is the name of a saint of local celebrity, and is sometimes rendered by Festus. It is to be noted that the name of the place, Ballintubber,‡ signifies the "town of the well," showing that the village owes its name, and perhaps also its origin in the remote past, to the presence of the spring in its vicinity. The water is probably used as previously stated, according to the nature of the complaint.

A second extract from the same letter furnishes an excellent illustration of some of the beliefs connected with these wells, aside from their healing powers. After describing Thubber Enue, or Eneas' well, which springs out of a rock in the hill of Doon, in the same region, and is especially noted for the cure of sore eyes, the writer goes on to say, "There was another remarkable affair about this well—a kind of a round stone, called

* Gaelic, *Tobar Muire.* The three wells and the *lear* described in this letter are also noticed in Wilde's Lough Corrib, already referred to, pages 267–9.

† Gaelic, *Fec'in.*

‡ Gaelic, *Baile'n-Tobair.*

*Lyoc Enue.** Prayers were offered and this *lyoc* turned over. For instance, if one person belied another, or gave scandal by any means, then the person would go and offer those prayers and turn the *lyoc*, and whosoever of them would be in the fault, he was sure to die ; but whatever time of the year this would occur, it was sure to be followed by bad weather, thunder and rain. So the farming class was almost ruined by this work, and the people practicing it more and more, until at last the clergy got the *lyoc* taken away and thrown into the deepest spot of Lough Corrib—and more was the pity, for the people were not so often at that time going to petty sessions as they do now ; they were leaving it all to God and *Lyoc Enue*."

In another letter, dated January 20, 1887, the same writer thus mentions a noted waterfall in the same neighborhood : "There is a waterfall convenient to this place that cures pains of the back. The patient goes in his or her nakedness, for about ten minutes, under this waterfall, and the third time is sure of being all right. The only thing given down for this is, that a priest in the time of *Shawn-na-Soggarth*† was concealed for twenty-four hours under this waterfall." Whatever may be thought of the theory in this instance, it is plain that the treatment is exactly that adopted by the best surgeons in dealing with sprains and similar ailments, including "pains of the back," viz., subjecting the affected part to the action of a stream of cold water falling from a considerable elevation.

The pool of Bethesda at Jerusalem has already been noticed in this connection, and a comparison of the present Irish beliefs and customs in this regard with the Bible story of Naaman will show that they are substantially those which existed among the Jews nearly three thousand years ago. Naaman was a Syrian general, living at Damascus. He was afflicted with leprosy, and at last, by the advice of his friends, undertook a long journey to Samaria to procure the help of the prophet Elisha. When he had reached the latter city, "Elisha sent a messenger unto him, saying, Go and wash in Jordan seven times, and thy flesh shall come again to thee and thou shalt be clean. * * * Then went he down and dipped himself seven times in Jordan, according to the saying of the man of God ; and his flesh came again, like unto the flesh of a little child, and he was clean."‡ In this case the Syrian practice seems to have been different from that of the Jews, as Naaman had expected that the prophet would cure him by simply touching the diseased part and invoking the name of his God.

There can be no doubt that these "blessed wells" of Ireland are mineral springs of great medicinal virtues, as the whole country is a mineral region, containing coal and iron in abundance, with limestone cliffs along

* Gaelic, *Leac Aong'us* "Eneas rock, or slab."

† Gaelic, *Seag'an na Sagart*, "John of the Priests ;" the name given by the people to a "priest hunter" during the time of the penal laws.

‡ 2d Kings v : 10, 14.

the western coast, while the alluvial soil is deposited upon a stratum of turf or peat, which crops out at intervals in the numerous bogs. We should thus expect to find in these wells the same constituents that give a reputation to the mineral springs of the mountain region of Virginia and Pennsylvania. According to Dr. John Rutty, the author of two valuable works* on the mineral springs of Ireland and of Europe in general, some of the Irish wells commonly resorted to by the people are equal to any of the celebrated continental spas, while those noted for the cure of particular diseases contain just the constituents most beneficial in such cases. The ordinary impregnations are combinations of iron, lime, soda, magnesia and sulphur. In addition to these, many wells and streams are impregnated with petroleum and bituminous compounds, owing to their vicinity to the bogs, which contain large quantities of half-fossilized pines and other resinous conifers. It is a well-known fact that bog water has preservative qualities, and bodies of persons drowned in these bogs have been recovered long afterward still undecayed. There are also some streams and lakes, notably Lough Neagh, whose waters have petrifying properties. Were Ireland free to develop her own resources, not only would her neglected mines and marble quarries be made available, but her healing springs, now visited only by barefooted peasants, would speedily acquire a reputation, which, together with the natural beauties of the country, would attract thousands of those who yearly seek health or pleasure on the continent. There is nothing but simple truth in the proud boast of the people of Ireland that in their native country the grass is always green, the soil harbors no venomous reptile, and the waters are blessed.

Miscellaneous Charms.

Besides the blessed wells and the *sig'efreog*, the people have a number of charms for various diseases—in fact, it is probably safe to say that they have a charm for every malady, real or imaginary, that ever existed. Many of these charms are accompanied by verses or other formulas, which have been handed down for generations, and there is generally a legend to explain the formula. A few of these charms are here given. It must be stated at the outset that the application is always made in the name of the Father, Son and Holy Ghost. Should any one become sick in church while wearing a garment sewn on Sunday, it will be impossible to cure him.

Epilepsy is called *tinneas mor*,† the "great sickness," and is regarded with such dread that it is seldom mentioned except under some figurative name. The patient is cured by drinking milk boiled in a human skull. An "essence" prepared from a human skull was formerly used in Italy to cure the same disease, according to a medical work published in that

* A Methodical Synopsis of Mineral Waters, &c., and Essay Towards a Natural, Experimental and Medicinal History of the Mineral Waters of Ireland.

† Pronounced *chinyas moer*.

country in 1726, and the skull of one who had died a violent death was preferred, being considered to retain more of the vital principle.

Toothache is cured by rubbing the gum with the finger of a corpse, or washing it with some of the water used in washing the corpse when preparing it for burial. The cure is permanent. The pain is commonly supposed to be caused by a small worm eating the tooth, and this worm is sometimes killed by applying to the tooth a piece of tobacco, guano, or some other pungent substance. The Omaha Indians, who hold the same theory, kill the worm by blistering the skin on the outer surface of the jaw. The dead hand holds an important place in Irish mythology.

Headache is called *fiab'ras beag,** or "little fever," and is caused by the joints of the skull springing apart until "the head is open"—just as we sometimes hear a man under such circumstances say that his head is splitting. The woman who has the cure takes a woolen string, with which she measures the head of the sufferer in three different directions, in order to see how far it is open. First the string is put under the chin, and the ends are brought up over the top of the head. Next it is measured in the same way from under the nose to the back of the head, bringing the ends of the string across just above the ears, and finally the string is drawn around the forehead and over the temples to the back of the head. Having learned how much the head has opened, she presses it firmly between her hands to bring the sutures together, says certain words, and the cure is effected. In one instance the patient was told that his head had opened something more than an inch. There may be more virtue in this method than is at first apparent.

Earache is cured by putting into the ear a piece of wool from a black sheep, saturated with oil, at the same time reciting the appropriate words. The last remark holds good also of this cure.

Sore throat is cured by putting the head of a live gander into the mouth of the patient and making it scream down his throat. The *thrush* in children is cured in a similar way, by getting a posthumous child to blow into the mouth of the sufferer. The blowing must be done by the operator while still fasting, and is generally repeated for three successive mornings.

Some persons can "set a charm" to *staunch a wound* so that not a drop of blood shall flow from it. The charm is said to consist solely in the repetition of certain words, without any application whatever. A hemorrhage can be stopped instantly by the application of a garment, which has been washed or ironed on Sunday.

There are several cures for a *sprain.* The most common method is to tie around the joint a *fogee,* or worn-out thread from a loom. Sometimes a string is used which has been held in the mouth while a certain charm is recited. The most remarkable method is used in Kerry, both for men

* Pronounced *fevearas b'yug.*

and animals, and is here given without comment, as described by a man who saw the operation performed at his own house for the cure of a lame horse, which recovered before morning. There is a thorny shrub, known in that county as *sgeac'-m'adera,** or "dog briar," whose white flowers are fixed close to the stem, while its thorns point downward. As our Savior, when a child, was one day walking with His mother, they met this briar and admired its flowers. The Mother tried to pluck one of them, but could not reach it until the briar bent down to her grasp. Since then its thorns always bend downward. To perform the cure a rod about three feet long is cut from the *sgeac'-m'adera* and split down the middle. Two men then stand close together, facing each other, each one holding against his body, at the right and left side, one end of the two pieces thus made, while his companion holds the other two ends in the same manner. In a short time the two rods begin to bend in toward the centre and gradually approach each other until they are firmly united for about six inches of their length in the middle. The man who sets the charm—a third party—then cuts off this portion and lays it upon the sprained joint, repeating certain words at the same time. The rest of the stick is thrown away. This charm never fails, excepting when there is a stain upon the birth of one of those holding the rods.

Scrofula, or the *evil*, is sometimes cured by applying a little powder from a deer's horn, which is kept in houses for this purpose. Another common method is to apply the blood of nine or twelve young wrens. The number must be decided by the ornithologist, as they take the whole brood, which, according to some persons, always consists of twelve birds, while others say there are only nine. This blood is called *fuil rig'e*† or "king's blood," for the wren is the king of birds in Ireland as in Germany. There may be some connection between king's blood and king's evil. The water of St. John's well, already referred to, is also noted for curing this disease.

The cure for *sore eyes* due to the presence of some foreign body, is best described by an incident, given as related by the man who was cured by the operation. While gathering seaweed on the strand he got something in his eye, and sent instructions to a *bean feasac'* living six miles away to take it out. She put some clean water in a glass, took it in her mouth, repeated a charm known as *aroid a b'raoinin,*‡ the "charm of the little drop," and then squirted the water back into the glass. The obstruction was seen floating on top of the water, and the woman took it out and threw it away. At the same instant the man working on the seashore experienced relief. This reminds one forcibly of the orthodox Indian medicine man.

A man who found a cataract growing over his eye walked on three suc-

* Pronounced in Kerry *shg'yŏkh-wŏdhera.*

† Pronounced *fuil ree.*

‡ Pronounced, *ŏroej a wreeneen.*

cessive mornings before breakfast to the house of the woman who cured it, which she did by making the sign of the cross upon his eye with her finger three times on each occasion, repeating a charm at the same time. If a bramble, or the finger, should accidentally strike the eye, the pain is at once relieved by making the sign of the cross in the same way three times with the object which caused the injury.

There are several cures for *rheumatism.* One, which has its parallel in this country, is to carry a potato in the pocket, and as the potato dries up the patient will recover. Another way is for the patient to lie upon his breast, and let a man who came into the world feet foremost walk along his body from the feet to the head. In one instance, where a man was completely crippled by rheumatism in his knee, he was advised by a woman to make a poultice of raw potatoes sliced very thin, and bind it upon his knee, and keep it there without change until the potatoes became offensive from decay. He did as directed, and after wearing the poultice for several weeks until he could endure the smell no longer, he found himself recovering. The potato is believed to have great medicinal virtue, as is also the water in which potatoes have been boiled.

A man who suffered from *colic* applied to another who had a cure for it, and was given a small piece of unsalted butter, with instructions to take a little of it for three consecutive mornings, while still fasting, reciting certain prayers at the same time. He could not say positively what those prayers were, "for fear of telling a lie." The doctor was not allowed to take pay for his cure, but might accept a free gift. The man did as directed, and was permanently cured, nor did the butter ever melt or become less, although he kept it until he was coming to America. Another man on the vessel was troubled in the same way. He lent him the butter, and it cured him, but on looking for it the next morning it had disappeared. Unsalted butter is used in a great many charms, and may not be such a bad thing after all.

The following charm for *tumors* and similar swellings comes from Meath. The patient, a child who was afflicted with an unnatural swelling just above the upper lip, on three consecutive Friday afternoons walked several miles into Navan, so as to arrive at the house of the *bean feasac** just as the sun was setting in the west. Turning the child's face toward the setting sun, the woman bathed the swelling with a liquid from a glass which she held in her hand, repeating certain words at the same time. After the third Friday the swelling disappeared. This idea in connection with the setting sun is part of an old belief common to all Europe, which prompts farmers to plant crops with a growing moon, and leads fishermen to expect the end of a dying man when the tide is going out. It is impossible to learn the composition of the liquid.

Warts are cured in the same county by impaling a snail upon a hedge thorn. As the body of the snail shrivels up, the wart disappears. The idea here is similar to that just mentioned. In Connamara for the same trouble ten joints (the knots only) are cut from an oat stalk, nine of which are tied up in a small parcel, while the tenth is thrown away. The parcel is left at the cross-roads, and the warts will go to the one who picks it up. The idea here is also common in European folk-lore, and almost the same method is used in Switzerland. The selection of ten similar objects, one of which is afterward thrown away, appears also in the account already given of the child cured of convulsions. It is also proper to mention here that oats are the sacred grain in Irish mythology.

Another method is, on rising in the morning, to spit upon the hearth while still fasting, and then rub the spittle upon the wart with the second finger. The first finger is never used for rubbing spittle or ointment upon sores of any kind, as it is supposed to have a poisonous effect. The operation is repeated every morning until the wart disappears.

Another method, used in Galway, is to bathe the wart with water found lying in a depression in the surface of a rock, saying at the same time :

"*Uisge cloc'a gan iarraid',*
Ni'g t'iarraid' tá me."*

"Water of a stone without seeking,
It's not seeking for you I am."

As the words of the formula imply, the water must be found accidentally, no benefit resulting from its application when a deliberate search is made for it.

In a case resembling *asthma*, where the patient, a boy about seven years old, felt a constant choking sensation and was rapidly losing flesh, he was taken by the old man who had the cure, and placed standing with his back against a tree growing in a field—the tree, in this instance, being an apple tree. A hole was then bored in the tree just above the child's head, a lock of his hair cut off and placed in it, and the opening closed up again. Although not mentioned by the informant, some words were undoubtedly repeated at the same time. As the boy grew above the hole in the tree, he grew away from the disease.

A well-known charm used in cases of *decline*, or incipient consumption, may be described by giving an instance, without comment, as related by an eye-witness. A young girl of lively disposition suddenly lost health and spirits, and appeared to be rapidly sinking into the grave, when her friends persuaded her to visit an old woman who offered to cure her. On arriving there the woman filled a tumbler with oatmeal, even with the top, and wrapped a thin cloth around it. Then loosening the girl's dress she applied the mouth of the tumbler first to her back, then to her side, and lastly to her bosom. On removing the cloth from the tumbler it was found that half the meal had disappeared. The glass was refilled and the

* Pronounced, *Ishga clŭkha gun eerree,*
Nee gă cheerree thaw mae.

operation repeated, and on removing the cloth a part of the meal was gone, but not so much as the first time. Once more the tumbler was filled and applied as before, and this time, on removing the cloth, there was hardly a depression in the surface of the meal, and the woman pronounced the cure complete. The girl's friend, who had looked on with wonder, now asked what had become of the meal. The woman replied, "I gave that to the worms that were eating her heart." In some cases the three operations are repeated on as many consecutive days.

For *worms* an amulet is worn, which consists of a small piece of paper on which is written a charm. The *bean feasac*, holding this paper in her hand, kneels down and recites a prayer, and the paper is then sewn into a covering of red woolen (flannel) cloth, of three-cornered shape, and worn about the neck.

Cramp is caused by worms, which twist themselves into a knot about the intestines. For this trouble, in men or animals, a string is tied with a peculiar triple knot, known as *snaid·m na peiste*,* or "the worm's knot," in such a manner that on pulling the ends of the string the knot is undone. The sufferer is struck on the stomach or back several times with the string, before and after knotting it, the name of the Trinity being invoked at each blow. In Kerry it is merely placed upon the stomach of the patient, and the ends pulled so as to undo the knot. Any one subject to cramps will be cured by making the sign of the cross three times on his stomach on seeing a rainbow.

For *convulsions* in children it is sometimes customary in the County Galway to use a preparation of charcoal made by burning and pulverizing the bones of an infant which has died before baptism.

Boils, however swollen and painful, may be cured by a blacksmith who is the seventh son of a blacksmith. It is only necessary that he shall open and shut his tongs three times in front of the boil, without touching it. The seventh son has generally great power over disease.

The *ringworm* is called *teine-d·iad·a*,† or the "divine fire," and is cured in a number of ways. Perhaps the most common method is to rub the inflamed spot three times with a ring or other article of gold, or with a live coal of fire, saying at the same time, *C·ugat* || *a teine*, || *a t·eine-d·iad·a.*‡ "Beware of the fire, *teine-d·iad·a*," the gold or coal of fire being applied as each of the principal words is being pronounced. The operation is repeated three times, making nine applications in all. Another method is to apply the blood of a black cat, and in some houses there are cats whose ears have been cut away by piecemeal for this purpose. Black and red (the color of fire) are the principal colors of Irish mythology. Another method is to write around the ringworm the full name of the sufferer,

* Pronounced *sneem na paeshcha*.

† Pronounced *chinnee-yea*.

‡ Pronounced *hŭgath a chinnee, a hinnee-yea*.

while still another is to rub the spot with spittle upon the second finger for three successive mornings.

The *black tongue* in cattle is called *bolg-t'eanga*,* or "swelled tongue," and is sometimes cured by bleeding the animal in the tail, but more often by reciting the following charm, by means of which the Blessed Virgin, while one day walking with her Son, cured the cow of a poor widow, who was unable to give them a drink of milk on account of the illness of the animal:

"'*N aroid a c'uir Muire go b'o C'ual-an-daire,*
O feid' a druime go feid' a siorra;
Air b'uinn, air c'enn, air b'o-g'éimneac', air g'alra truad',
Agus air leig'eas na bolg-t'eanga." †

Cual-an-daire, which is evidently a compound word, is explained as the name of the village where the widow lived, while *buinn* and *cenn* appear to be the names of two cattle diseases. The Gaelic may be thus rendered:

"The charm which Mary put on the cow of Cual-an-dherra,
From the sinew of her back to the sinew of her pastern,
For *bùinn*, for *cenn*, for the groaning cow, for the wasting sickness,
And for a cure of the swelled tongue."

There is another contagious cattle disease, which generally attacks young animals of the best breeds, and is known in the Gaelic districts as *ceat'ram'a-d'ub'*,‡ the "black quarter," and elsewhere as black-leg or quarter-ail. It begins with a slight lameness in one of the quarters, which soon swells and becomes discolored, and in a very short time the animal dies, the instances of recovery being extremely rare. In Kerry, as soon as the animal is dead, the affected quarter is cut off and hung up in the chimney, in the belief that this will prevent the spread of the contagion. As the infection may be communicated to the other cattle by smelling the diseased part, and as there is always danger that the buried carcass may be rooted up by hogs or dogs, there seems to be something in this method to recommend it.

Any one who licks a lizard three times along the under side from the tail to the head can cure a *burn* by applying his tongue to the injured part three or nine times. This may have some connection with the old salamander theory. In Galway, on receiving an accidental burn, it is customary to ejaculate: *Lab'ras easbal agus Dia d'a f'reastail*,§ "Lawrence, the apostle (*sic*) and God to care for it." In Meath they exclaim, *Morra*

* Pronounced *bŭlag-honga*.

† Pronounced:

'Nŏroqj a khùir Mŭira gŏ woc Khual-an-dherra,
O fae a dhrŭma gŏ fae a sherra,
Er win, er khen, er woc-yaumnakh, er ghawlra thrua,
Ôgus er l'yire na bŭlag-honga.

‡ Pronounced in Kerry *carhoo-ghoov*.

§ Pronounced *Lowaras asbal ógus jea ghaw rasthal*.

sneef, which is probably a corruption of *Maire 's naom·t·a,** "Most Holy Mary!"

When the *palate falls* it is raised by lifting the skin at a certain point at the back of the head. A similar method is used by the negroes.

Hooping cough is called *troc·*† by the Gaelic speakers, and *chin-cough* in the eastern districts, and there are a number of charms for it. One used in the south is to pass the sufferer three times over and under the body of a donkey, in the name of the Trinity. The same thing is done in Scotland. Sometimes a piece of bread or something of that kind is given to the donkey to eat, and the crumbs which he lets fall to the ground are put into broth for the patient. The most remarkable method is adopted in Galway, where the mother of the child goes to the owner of a white horse and asks:

> "*G·ioll' an eac· g·eal,*
> *Cé rud a leig·eas air a troc·?* ‡
>
> "Fellow of the white horse,
> What thing is the cure for the whooping cough?"

He generally replies, "A cup of tea and a piece of bread," or something of the kind, and whatever he advises is given to the child in the confident hope of relieving it. The words used in asking this question are important, as showing the antiquity of the charm. The ordinary form for "white horse" is *capal bán,*§ while *eac·* is an obsolete word, and such an expression as *eac· geal* is found only in the ancient manuscripts and in poems and stories and similar compositions which have been handed down from a remote period.

The donkey is also in great repute for curing almost any contagious fever, as typhoid fever, etc. If the patient be a child, the donkey—a young one being preferred—is lifted three times over his head from front to back, after which the sick person drinks some of the milk of the dam. If the invalid be an adult, and sufficiently strong, he takes the animal by the fore and hind feet and lifts it over himself in the same manner. The donkey, or ass, is regarded as sacred, on account of being the animal upon which the Saviour once rode. The black cross upon his back, formed by the intersection of two lines of dark hair near the shoulders, is supposed to commemorate this event, and a young animal is preferred in these charms on account of the greater distinctness of the mark in the foal. It is considered lucky to have a donkey about the house, and many farmers who own horses, and have no need of donkeys, keep one in the field for this reason. A similar belief in regard to the sacredness of the donkey,

* Pronounced *Morra 'sneeva;* in the vocative the sound becomes *Worra.*

† Pronounced *thrŭkh.*

ronounced, *Yil' an yŏkh yal,*
Caer'dh a l'yice er a thrŭkh!

§ Pronounced *cŏpal bawn; capal* is the Latin *caballus,* while *eac·* is equivalant to *equus.*

and its usefulness in the cure of certain diseases, especially whooping cough, prevails also in England and Scotland.

There is a disease, called *cleid·in** in Gaelic, which is difficult to characterize, but is described as a general break down or loss of strength, resulting from some sudden and violent over-exertion. In lifting heavy weights it sometimes happens that what is known in the eastern districts as the "spool of the heart"—probably the diaphragm from the description—is torn loose and drops down, so as to press upon the intestines. When this occurs the spool of the heart must be raised again, which is done in the following manner: A coin is stuck upon the lower end of a short piece of candle, which is then lighted and placed upright upon the bare breast of the patient, who, of course, is lying down. A tumbler is then inverted over the lighted candle, and in a few moments the skin over the inclosed surface is raised up into a blister and the sufferer finds relief. It is hardly necessary to state that this is simply a crude cupping process. This method is known throughout the country, but it is a disputed point whether the coin should be a copper ha'penny or a silver sixpence. The disease bears a different name in the south.

Erysipelas is called *ruaid·*,† which signifies something red, by the Gaelic speakers, while in the east it is known as *rose*, or *St. Anthony's fire*. It is generally cured by means of a charm used in connection with the *dearg-liac·*.‡ This is a grassy plant growing in the bogs, and having the lower part of its stems of a bright red color, by reason of the bog water with which they are always covered. The fact that it is sometimes used by laborers as a substitute for soap, shows that it possesses some peculiar properties. The operator—who should be a woman if the patient be a man, or a man if the contrary be the case—gathers a considerable quantity of this grass, holds it up in front of the mouth and breathes upon it, at the same time reciting a certain charm, after which it is bound tightly around the inflamed part. This must be done on the next Monday after the disease first appears, and is repeated "*d·a Luain agus Dia-d·ardaoin eadorra*,"§ that is, "two Mondays and Thursday between them," making three applications in all. The sufferer must endure the pain until Monday comes round, and it is also essential that the three applications be made under the same moon in which the illness is first noted, otherwise the trouble will be liable to recur every month afterward. Unsalted butter is sometimes used instead of the *dearg-liac·*, but is not considered so good, although the charm is recited in the same way. If a sick person should overhear his friends say that he has the *ruaid·*, he would at once be obliged to undergo the operation, no matter what might be the nature of

* Pronounced *clá-een.*

† Pronounced, *rua*, or *ruee.*

‡ Pronounced *jărag-leeakh;* perhaps from *dearg*, "scarlet," and *liac·*, "gray," the *dearg* referring to the discoloration of the stems.

§ Pronounced *ghaw Luan ógus Jaerdheen ádharra.*

his illness, under the certain penalty of taking the disease if he neglected the precaution. For this reason his relatives are careful not to "accuse" him of this disease unless the fact is beyond question. Stripped of all mythologic embellishments, there seems no reason to doubt the existence of some curative property in the *dearg-liac·*, as numerous instances are related of its efficacy.

A stitch in the side is cured by applying the blood of a rooster which has been sacrificed to St. Martin. On the eve of St. Martin it is customary to sacrifice an animal to the saint, or, as the people express it, they "draw blood for St. Martin." The animal most commonly selected is a rooster, which has been consecrated to this purpose some time in advance. The blood is soaked up with tow or cotton, and preserved as a remedy for the stitch. At the moment of applying it to the side of the sufferer the following words are recited :

> "*Fear caoin aig a mnaoi b·oirb·,*
> *A c·uir Iosa Críosd na luig·e anns a g-colg ;*
> *C·uig m·euraib· Iosa Críosd fuascailt do g·reime,*
> *Dearna M·uire agus a Mic leat.*" *

Which may be thus rendered :

> A mild man with the haughty wife,
> Who put Jesus Christ lying on the hulls (of the tow) ;
> The five fingers of Jesus Christ to relieve your stitch ;
> The palm (of the hand) of Mary and of her Son with you.

In Galway the form is somewhat different, and the characters of the man and his wife are reversed. In the same county the blood is sometimes sprinkled upon the different members of the family when the animal is killed, and the words alone are used to cure the stitch, as well as a stomach ache. The words are founded on the legend that Christ once asked permission to stop over night at a house, where the husband, a kind-hearted man, was disposed to accommodate him, but his wife, who was of the opposite disposition, compelled the Savior to sleep on the hulls stripped from the flax. For this reason tow is preferred to cotton. The practice is known throughout the country.

One more instance and we have done. In this case the informant was ignorant of the words which were undoubtedly used, and we have left the simple statement of the medical treatment and its result. The son of well-to do parents in the County Kerry was so crippled by a painful swelling of the leg that he had to be taken to Tralee for treatment. The doctors held a consultation and decided that the limb must be amputated. At this juncture a "traveling woman" from the north—where the people are supposed to have most knowledge in such matters—called on the

* Pronounced, in Kerry : *Fawr eeen ig a mnee wŭrav,*
A khŭir Esa Creesdh na lee ans a gŭlag ;
Khuig vaeriv Esa Creesdh fuascalth dhŏ ghrēma.
Jawrna Wirra ŏgus a Mic lath.

father of the young man and asked permission to try her skill. The doctors objected, but the father said that as they had done their best to no purpose, she could do no worse. Having obtained permission, she went out and gathered a quantity of the herb known as *uarac·-a-loc·*,* which she put into water and boiled to a poultice. This was in the middle of the afternoon. She then put the poultice upon the swollen limb, and had the young man tied down to the bed so that he could move neither hand nor foot. In a few hours the poultice began to cause him such terrible agony that, if he had not been so securely fastened down to the bed, the efforts of several men would be required to hold him. This continued for some time, after which the sufferer fell into a sound sleep, which lasted all night. When he woke up in the morning he called out to his father that the poultice had come off. On going to his bedside it was found that the limb had resumed its natural size, which was the cause of the poultice falling off. The young man was able to start home in a short time, and was so overjoyed at his recovery that he walked the entire distance, twelve miles. The cure created a sensation in the vicinity at the time. The herb used is common in pastures and is eaten by cattle with great relish. Its leaves are about an inch across at the base, and from six to ten inches long, and are distinguished by having a semi-circle taken out from one side, which is popularly known as *greim a diab·ail,*† "the devil's bit."

Corresponding Belief in Scotland.

It is an established fact that the ancient connection of cognate nations may be traced in their mythology, even though the people themselves have been separated for ages. This is strikingly true of the Gaelic race of Ireland and the Scottish Highlands. They are still one people, speaking the same language, with but slight dialectic differences, although their fortunes have been widely separated for nearly fifteen centuries, while their customs and beliefs are in a great measure identical. Compare the following cures given by Rev. W. Gregor in an article on "The Healing Art in the North of Scotland in the Olden Time," (in the Journal of the Anthropological Institute of Great Britain and Ireland, Vol. iii, 1874.) The coincidence is the more striking as the article had not come to the notice of the writer until the rest of the paper was in type, and consequently no questions could be asked to draw out parallel customs :

Hooping Cough : "Let the first man seen riding on a white horse be asked what is the cure. Whatever he says, is the cure.

"Let the patient be passed three times below the belly of a piebald horse. .

"The milk of an ass was an effectual remedy. * * *

"The patient was held below the animal's head, so as to inhale its

* Pronounced, in Kerry, *oorakh-a lŭkh ;* the word appears to be a compound.

† Pronounced, in Kerry, *greem a jecal.*

breath. When this inhalation of breath had been carried on for a considerable time the patient was passed three times under the belly and over the back of the brute."

Ringworm: "The common cure for this disease was rubbing with silver. The modes of rubbing were various."

Warts: "Wrap up in a parcel as many grains of barley as there are warts, and lay it on the public road. Whoever finds and opens it inherits the warts.

"Rub the warts with a piece of raw meat, bury it, and as it decays the warts disappear.

"Wash the warts with water that has collected in the hollow parts of a *layer-stone.*"

Eye Disease: "Catch a live frog and lick the frog's eyes with the tongue. The person who does so has only to lick with the tongue any diseased eye, and a cure is effected." Compare this with the cure for burns.

Rheumatism: "Those who were born with their feet first possessed great power to heal all kinds of sprains, lumbago and rheumatism, either by rubbing the affected part or by trampling on it. The greater virtue lay in the feet."

On the Henry Draper Memorial Photographs of Stellar Spectra. By George F. Barker.

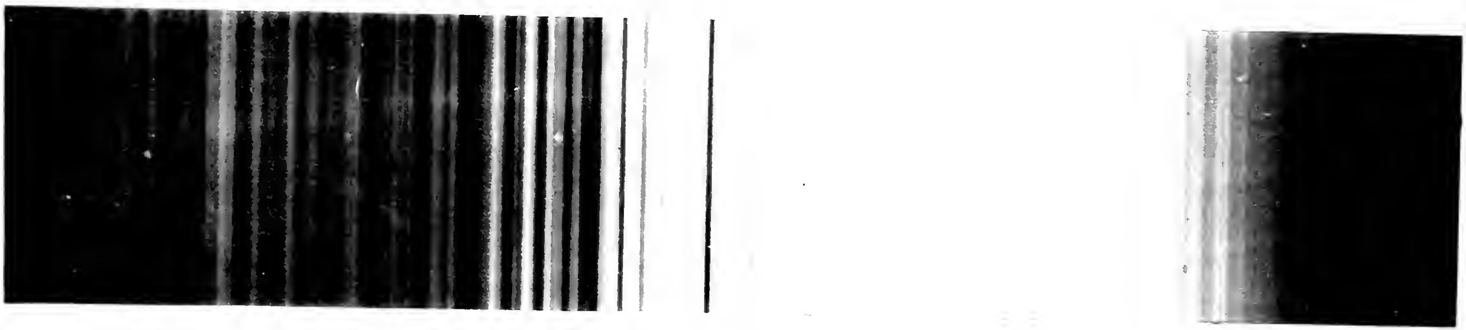
(*Read before the American Philosophical Society, April 1, 1887.*)

By the courtesy of Prof. Edward C. Pickering, Director of the Harvard College Observatory, I have the pleasure of exhibiting to the members of the American Philosophical Society some of the remarkable photographs of stellar spectra which have been recently taken under his direction, and which form part of an original research to be called the Henry Draper Memorial.

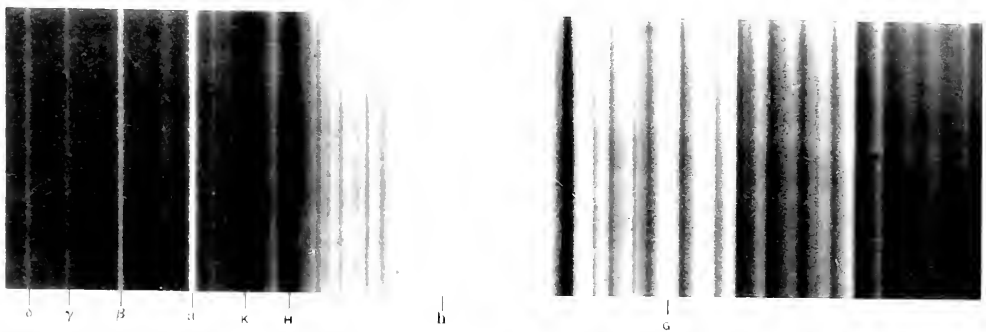
The first photograph of a stellar spectrum ever taken was that of the star Sirius (α Canis majoris), obtained by Dr. Huggins in 1863. But, as he says, it was scarcely more than a stain on the plate, and showed no indications of fixed lines.* The first spectrum photograph showing distinct lines, was obtained by Dr. Henry Draper in 1872. The star photographed was Vega (α Lyræ), and the spectrum showed four strong lines toward the more refrangible end. It was taken with the twenty-eight inch reflecting telescope which Dr. Draper had himself constructed. Subsequently he used for this purpose the twelve inch refractor which he had obtained from A. Clark & Sons in 1875. Up to the year 1877, he had taken, beside α Lyræ, the spectra of α Aquilæ, Arcturus, Capella, the moon, Venus, Mars and Jupiter.† In 1880 this refractor was exchanged for another, also

* Phil. Trans., 1864, 428.

† Am. J. Sci., III, xviii, 419, 1879.



α TAURI. 2 PRISMS.



o CETI. 1 PRISM.

made by the Clarks, but which, although of slightly less aperture—half an inch—was provided with a photographic correcting lens. The large amount of work done with these instruments appears from the fact that at the time of his death in 1882, he had taken more than a hundred stellar spectrum photographs, the later ones having a comparison spectrum upon the same plate. The methods employed both by Dr. Huggins and by Dr. Draper in all their later work were in general the same. The light of the star was concentrated by the object glass of a large telescope upon the slit of a spectroscope placed at its focus. In consequence, a narrow slit was necessary in order to obtain good definition, and very perfect adjustment of the driving clock was required to keep the image of the star upon the slit. The spectra thus obtained were of course quite minute; being about half an inch only in length, and only one sixteenth or thereabouts in width. Dr. Huggins made use of a cylindrical lens placed in front of the slit to obtain the necessary width to the spectrum. But Dr. Draper secured this end by throwing the image of the star slightly out of focus.

The first attempts to obtain photographs of stellar spectra which were made at the Harvard College Observatory were undertaken in May, 1885, by the aid of an appropriation from the Rumford fund of the American Academy of Arts and Sciences. In these experiments an entirely new photographic method was adopted. The prism was placed in front of the object glass of the telescope; a plan originally suggested for eye observations by Fraunhofer in 1823* and employed subsequently, practically, by Secchi and Respighi. The advantages, for photographic purposes, of this method are two fold: First, the loss of light is extremely small; and second, the stars over the entire field of the telescope will impress their spectra upon the plate. Hence while previous observers could photograph but one star at a time, and this satisfactorily only with stars of the first or second magnitude, more than one hundred spectra have now been simultaneously obtained on a single plate, many of them of stars no brighter than the seventh or eighth magnitude. The earliest photographs obtained at the Observatory were taken by placing a prism whose refracting angle was 30° in front of a Voigtländer photographic lens of two inches aperture and about seven inches focal length. No clock-work was used, the spectra being formed of the trails of the stars. In the spectrum of the Pole-star thus taken, over a dozen lines could be counted; and in the spectra of *α* Lyræ and *α* Aquilæ, the characteristic lines were shown, even when the time of exposure was only two or three minutes.

In the autumn of 1885, an appropriation was made from the Bache fund of the National Academy of Sciences for the purpose of continuing these investigations. A prism of 15° refracting angle and eight inches in clear aperture was employed, placed in front of a Voigtländer photographic lens having an aperture of eight inches and a focal length of about forty-five inches. The details of the method are thus described in the report of Prof. Pickering:†

*See Schellen's Spectrum Analysis, English ed., 1872, p. 462, et seq.

†Memoirs Am. Acad. Arts and Sci., xi, 209, 1886.

"The prism was always placed with its edges horizontal when the telescope was in the meridian. The spectrum then extended north and south. If clock-work was attached, a line of light would be formed, too narrow to show the lines of the spectrum satisfactorily. The usual method of removing this difficulty is the employment of a cylindrical lens to widen the spectrum; but if the clock-work is disconnected, the motion of the star will produce the same effect. Unless the star is very bright, the motion will, however, be so great that the spectrum will be too faint. It is only necessary to vary the rate of the clock in order to give any desired width to the spectrum. A width of about one millimeter is needed to show the fainter lines. This distance would be traversed by an equatorial star in about twelve seconds. The longest time that it is ordinarily convenient to expose a plate is about an hour. If then the clock is made to gain or lose twelve seconds an hour, it will have the rate best suited for the spectra of the faintest stars. A mean time clock loses about ten seconds an hour. It is only necessary to substitute a mean time clock for the sidereal clock to produce the required rate. It was found more convenient, however, to have an auxiliary clock whose rate could be altered at will by inserting stops of various lengths under the bob of the pendulum. One of these made it gain twelve seconds in about five minutes, the other produced the same gain in an hour. The velocity of the image upon the plate when the clock is detached could thus be reduced thirty or three hundred and sixty times. This corresponds to a difference of 3.7 and 6.1 magnitudes respectively. Since the spectrum of a star of the second magnitude could be taken without clock-work, stars of the sixth and eighth magnitudes respectively could be photographed equally well with the arrangement described above."

The work already undertaken in this direction developed so rapidly that the Bache appropriation soon proved entirely inadequate to carry it further. Whereupon early in 1886, Mrs. Henry Draper, who from the first had taken a great interest in this work as a continuation of that so auspiciously begun by Dr. Draper himself, generously came forward and agreed to place at Prof. Pickering's disposal, not only the excellent eleven inch photographic telescope which Dr. Draper had so successfully used in his spectrum researches, but also a sufficient sum of money to enable the experiments already suggested to be fairly tried. In consequence, Prof. Pickering decided to continue the investigation along three more or less independent lines: First, he purposed to make a general survey of stellar spectra, each spectra being photographed with an exposure of not less than five minutes. These photographs exhibit in general the spectra of all stars brighter than the sixth magnitude, with sufficient distinctness for measurement. Second, he desired to undertake a determination of the spectra of the fainter stars, each photograph of this set receiving an exposure of an hour. All stars not fainter than the ninth magnitude, and included in a region ten degrees square, are represented upon a single plate. The work in both these directions has been done thus far with the Bache photographic telescopes, 15,729 spectra having been already photographed and measured. Third, he decided to carry on a more careful study of the spectra of the brighter stars. For this work, the Draper eleven inch corrected refractor was specially used, a suitable observatory having been erected for it in Cambridge. Four prisms, each having a refracting angle of 15°, were constructed, of which three had a clear aperture of nearly eleven inches, the fourth being somewhat smaller. These four prisms with their mounting weighed more than a hundred pounds and occupied a cubic foot of space.

The original negatives have been enlarged by a novel process which gives most excellent results. A cylindrical lens is placed close to the enlarging lens with its axis parallel to the length of the spectrum. In the apparatus actually employed the length of the spectrum and with it the dispersion, is increased five times, while the breadth is increased nearly one hundred. This arrangement has the great advantage that it greatly reduces the difficulty arising from the feeble light of the star. Until recently, the spectra in the original negatives were made very narrow, since otherwise the intensity of the starlight would have been insufficient to produce the proper decomposition of the silver particles. The enlargement being made by daylight, the vast amount of energy then available is controlled by the original negative, the action of which may be compared to that of a telegraphic relay. The copies therefore represent many hundred times the original energy received from the stars.

It was with the apparatus above described and under these conditions, that the photographs were taken that I have the honor of exhibiting to the Society. Although the earliest satisfactory results were obtained in October, 1886, yet it is evident that the full meaning of these photographs can be discovered only after they have been carefully measured, and after these measurements have been reduced and thoroughly discussed. Some points of interest, however, appear on simple inspection of them. This photograph of α Cygni for example, which was taken November 26, 1886, shows the H line to be double,* its two components having a difference of wave-length of about one ten-millionth of a millimeter. This photograph of o Ceti shows the lines G and h as bright lines, as well as the four ultra violet lines which are the characteristic of spectra of the first type; to which Dr. Huggins gave the letters α, β, γ and δ. In this spectrum, however, the H and K lines are seen to be dark; showing that they do not belong to that series of lines. The spectrum of α Tauri shows a multitude of lines and bands, massed in the more refrangible region; thus accounting for the ruddy color of the star. The spectrum of Sirius shows, besides the well-known broad lines characteristic of this brilliant star, a large number of fainter ones. The spectrum of α Canis minoris, taken with four prisms, shows the solar dark lines G, h, H and K.

This entire research is entitled "The Henry Draper Memorial." The

* According to Young, the line H in the solar chromosphere, which is bright, is double also.

first annual report has just been issued by Prof. Pickering and contains an account of the investigations thus far made, together with the results obtained. It is illustrated with a plate (which I have the pleasure of placing before you) illustrating the rapid progress which has been made within the past few years in photographing stellar spectra. The first figure, which is a direct copy of the spectra obtained in 1885, was taken with the Voigtländer lens of two inches aperture having a 30° prism in front of it and shows the spectra of α Lyræ, α Aquilæ, α Bootis and β and γ Ursæ Majoris; the instrument having been directed successively to these stars and the plate exposed five minutes on each. The longest of these spectra is not over four millimeters in length. The second figure is the spectrum ζ Ursæ Majoris accompanied by that of an adjacent fifth magnitude star. It was taken with the larger Voigtländer lens, with an exposure of five minutes. It is about nine millimeters long and one wide, and illustrates the size of spectra used in preparing the catalogue of spectra of the brighter stars, one or two hundred of these being sometimes photographed on a single plate. The third figure represents the spectrum of α Lyræ, and was taken with the Draper eleven-inch telescope with two prisms, on November 5, 1886, with an exposure of fifty-nine minutes. This spectrum is a little more than fifty millimeters long and about two and a half millimeters wide. The fourth spectrum, taken on January 21, 1887, represents β Geminorum. The exposure was fifty minutes, four prisms being used with the eleven-inch Draper telescope. This spectrum is nearly eighty millimeters long. All these now described are original negatives printed by contact. The fifth figure in this plate represents a little more than half of the spectrum of β Geminorum (as given in figure four) enlarged by Prof. Pickering's special process above described. This spectrum is 220 millimeters long and seventy-five wide, and shows a mass of dense lines irregularly distributed. Below this is a narrow strip, fifteen millimeters wide, of the spectrum of the same star taken on January 12th. It is given for comparison and shows that practically all of the lines shown belong really to the star itself and are not produced in the photographic processes.

It is gratifying to know that Mrs. Draper has been so well satisfied with these splendid results that she has decided greatly to extend the original plan of the work and to have it conducted in the future on a scale suited to its importance. The attempt will be made to include all portions of the subject so that the final results shall form a complete discussion of the constitution and conditions of the stars as revealed by their spectra, so far as scientific methods at present permit. It is expected that a station will be established in the southern hemisphere, so as to permit the work to be so extended that a similar method of study may be applied to stars in all parts of the sky. The investigations already undertaken include (1) a catalogue of the spectra of all stars north of 24°, of the sixth magnitude or brighter, (2) a more extensive catalogue of spectra of stars brighter than the eighth magnitude, and (3) a detailed study of the spectra of the bright stars. This last will include a classification of the spectra, a determination of the wave-lengths of the lines, a comparison with terrestrial spectra and an application of the results to the measurement of the approach and recession of the stars. A special photographic investigation will also be undertaken of the spectra of the banded stars and of the ends of the spectra of the bright stars. Beside the instruments already mentioned, there will be used the twenty-eight-inch and fifteen-inch reflectors constructed by Dr. Draper, which Mrs. Draper has decided to send to Cambridge for this purpose, and also the fifteen-inch refractor belonging to the Observatory.

From these statements it will appear that photographic apparatus has here been provided on a scale quite unequaled elsewhere. "But," says Prof. Pickering, "Mrs. Draper has not only provided the means for keeping these instruments actively employed, several of them during the whole of every clear night, but also of reducing the results by a considerable force of computors and of publishing them in a suitable form. A field of work of great extent and promise is open, and there seems to be an opportunity to erect to the name of Dr. Henry Draper a memorial such as heretofore no astronomer has received. One cannot but hope that such an example may be imitated in other departments of astronomy, and that hereafter other names may be commemorated not by a needless duplication of unsupported observatories but by the more lasting monuments of useful work accomplished."

Note added May 1, 1887.

The excellent phototype plate which accompanies and illustrates this paper, shows the enlarged positives of the spectra of α Tauri taken with two prisms and that of o Ceti taken with one. The negatives from which the phototype plate was prepared were kindly furnished me by Prof. Pickering especially for this purpose. My obligations are due to him, therefore, for this courtesy. I am also indebted to Mr. Gutekunst for the faithfulness of their reproduction.

It is a gratifying evidence of appreciation of Prof. Pickering's photographic work, that the National Academy of Sciences, at its meeting in Washington, in April, awarded to him the Henry Draper gold medal, for having in their opinion made the most important progress in Astronomical Physics during the two years which have elapsed since the preceding award.

Dr. Frazer made the following remarks:

A question suggests itself in relation to the very important results of Prof. Pickering, which Prof. Barker has so lucidly and interestingly described.

As the extremely minute point of light which is received on the first prism represents the radiation from every part of the star under examination, of course the line of light produced by the prism will represent at any infinitesimal fraction of time, the whole radiation of light from the half of the star turned towards us during that time ; and during an indefinitely short exposure might be said to represent the condition of the surface visible to us as it was during a certain minute time interval when the waves set out from that surface. [Neglecting for the moment the modification of this statement which the curvature of the star's surface would render necessary owing to the fact that the light which proceeded from the extreme outer edge would have a longer distance to travel than that in the centre by a little more than the radius of the star, and therefore its arrival at the instrument might be later than that from the central portion.]

But the broadening of this line into a surface by making a slight difference between the rate of the clock-work and the angular motion of the earth, would represent this same elongated surface of the star at different times. In other words the one axis would represent different parts of the star at the same instant of time, and the other axis would represent the same region (the hemisphere visible to us) at different periods of time.

If the movements of the atmosphere of the star observed were as rapid and extensive as those of our own sun, the consequence would be that we would have a succession of different conditions of the star's atmosphere placed in close juxtaposition, the whole series representing all the changes that had occurred in the star's photosphere during the interval of exposure. On this account it would seem that this method was not adapted to do more than give the resulting average of these changes on a sensitive plate of measurable breadth and would not permit the condition of the photosphere at any one instant of time to be studied.

It would be interesting to know what effect a similar procedure on the disc of the sun would show, by juxtaposing a large number of instantaneous photographs of the disc as different parts of the latter were successively brought over the slit of the spectroscope.

Notes on the Surface Geology of South-west Virginia. By John J. Stevenson.

(Read before the American Philosophical Society, May 20, 1887.)

New river, rising in North Carolina, flows across the Archæan area of Virginia, and enters the "Great Valley" of that State in Wythe county. It flows through Wythe and Pulaski counties, separates the latter from Montgomery, and flows through Giles county into West Virginia on its way to the Ohio river at Point Pleasant. It drains the counties named, with the addition of Bland. The most important forks of the Holston river flow through Smyth and Washington counties of Virginia into Tennessee ; while the Clinch river rising in Tazewell county of Virginia flows through Russell and Scott counties and drains much of Wise. It is joined in Tennessee by Powell river, which drains Lee county and part of Wise.

The Clinch and Holston unite to form the Tennessee, through which their waters reach the Ohio at Paducah.

The effects of erosion in Bland county are seen in the removal of limestone and shales so as to throw the harder rocks into relief as mountains; to form narrow valleys in limestones near the present lines of faulting, and to scoop out a basin in Devonian and Upper Silurian shales. Within Giles county, New river flows on Knox (Calciferous) limestone, and the later rocks have been eroded from a considerable space on both sides of the stream. The conditions became approximately the same throughout this area after the removal of the Devonian and Upper Silurian, and good illustrations of certain types of erosion are afforded here as well as further southward along New river.

Remnants of two planes of erosion, one 225 (1810 feet above tide) feet and the other 115 (about 1670 feet above tide) feet above New river at Snidow's ferry, were seen in Giles county on the road from the county-seat to that ferry, which is opposite the mouth of Big Stony creek, where the altitude of the water surface is about 1555 feet above tide. The upper plane originally extended far into the recess between Pearis and Sugar run mountains;* and even now it can be recognized easily in the many hills, whose leveled tops have almost the same altitude. The second plane is more distinct, being better preserved than the other, and having a larger area. Still lower benches river terraces, were seen, but they do not exist on the road followed by the writer, and no measurements of their height could be obtained.

The deposit on the higher planes is sand and clay, carrying vast numbers of transported polished fragments, most of which are barely three inches in diameter, though some were seen upwards of ten inches. For the most part, these pebbles are of local origin, or, at least, they came from the confines of the "Great Valley," for the sandstones predominate; but there are not wanting pebbles of glassy and milky quartz, seldom more than four inches in diameter, which must have come from the Blue Ridge, not less than seventy miles away by the nearest waterline. And these are found on the highest bench at nearly three miles from the river's present channel way.

A fine plane of erosion is well preserved on both sides of New river south from Little Walker mountain in Pulaski and Montgomery counties. Its summit is shown on the west side of the river near Belspring station, with an altitude of not far from 1775 feet above tide, the station being 1766 feet A. T., while a higher plane is reached along the New River R. R. on this side of the river at the summit cut, two and a half miles from New River station, and about 1925 feet above tide, the track in the cut being

* For explanation of the relations of the mountains and of most of the localities referred to in this paper, the reader is referred to memoirs on Southwestern Virginia, published by the writer in Proc. Amer. Phil. Soc., as follows: Vol. XIX, pp. 88, 219, 498; XXII, p. 114, and XXIV, p. 61. The faults are described summarily in a paper in the Amer. Journ. of Science for April, 1887.

1914 feet. This bench extends eastward from New river for more than eight miles between Little Walker and Price mountains, and it is probably the same with the fine terrace shown above the railroad bridge over New river. It is distinct on the west side at four miles from the river on the railroad; and it appears to be the same with the plain seen nearly six miles further west on the road leading across Pulaski county from Dublin to Pearisburg; but the barometric readings on that road are not wholly satisfactory.

The deposit on these benches is of clay and sand, containing pebbles of varying size, most of them, as before, of local origin, but not a few of them have come from the Blue Ridge. The upper bench is deeply trenched here and there by narrow valleys in which rock exposures occur; elsewhere such exposures are rare, as the detrital cover is from five to thirty feet thick. River terraces, apparently unbroken and almost as perfect as those shown in theoretical diagrams were seen in the "Horseshoe bend" bottom, but they could not be reached for measurement.

Erosion planes are equally well marked along New river within Wythe county for some distance above and below the Wythe lead and zinc mines. The lead company has sunk a shaft at about half a mile south from New river, beginning at the topmost part of the bench, which, according to the barometer, is 310 feet above the river at Thorn's ferry opposite the company's offices, or 2260 feet above tide. The surface is covered with loose boulders, mostly three inches or less, though some are fully eight inches. The deposit, as found in the shaft, is nearly fifty feet thick, and the bench is of great extent on this southerly side of the river. Crossing to the other side and taking the road over Lick mountain to Wytheville, one soon comes to a bench, 120 feet by barometer above the river or 2070 feet above tide. This was not recognized at the lead mines on the southerly side of the river, but on this side it is distinct almost from Jackson's ferry to the Wytheville road, on which it is reached at three miles from New river. The higher bench is reached by the Wytheville road at six miles from the river, and, according to the barometer, is 320 feet above low water at Thorn's ferry or 2270 feet above tide. It carries a thick coat of debris loaded with pebbles.

The tributary streams of New river are terraced. A fine bench was seen on Wolf creek in Giles county at a mile or so from the river. It is sixty-five feet above the stream and carries a thick deposit, which is rich in rolled stones. The upper terrace of Reed creek below Wytheville was not measured, but it is fully 150 feet above the stream. It shows huge boulders of Potsdam sandstone resting on the Knox limestone, though a broad and deep ravine separates their resting place from Lick mountain, whence they came. An erosion plane, similar to that seen in Pulaski county, was observed north from Wytheville within the New river area. Its superficial deposit of sand, often carrying many pebbles, is so thick as to conceal the bedded rocks for long distances.

Great planes of erosion are shown in all parts of the "Valley" from the Tennessee line to the eastern side of Montgomery county; no doubt they are continuous thence into Pennsylvania, where such planes are sufficiently distinct. At all localities they illustrate effects of erosion during a long period in which the channel-ways of the main streams are not deepening materially.

By some means the erosive or channel-deepening power of the New river has been greatly increased since the erosion of the upper planes was completed; for the river has excavated a gorge 255 to 300 feet deep with the hills abrupt on one or both sides for considerable distances; while erosion extends at best to but a little way from the river. The tributary streams flow for the most part in comparatively narrow valleys, even where the conditions appear to be such as to favor extended erosion. Meanwhile the destruction of the elevated planes has gone on irregularly; the upper bench south from Walker mountain has suffered little in Montgomery county except near the river. But that in Giles county has been eaten away and another, widely extended, has been formed at a lower horizon; and there appears to be nothing south from Walker mountain to compare in extent with the lower plain north from that mountain.

While the erosion of the "Great Valley" and of the region drained by New river appears easily referable to a simple plan, the conditions in the limestone area of Tazewell, Russell and Scott counties, drained by Clinch river, are not so clear. Benches exist, but they are not so obvious as are those in the valley, they do not always carry a deposit loaded with pebbles and they seem rarely to have great extent. One gravel deposit was found on the line between Russell and Scott within a mile of Clinch river and at 640 feet above that river at Osborn's ford, making its height above tide not far from 1920 feet. The pebbles are rarely larger than a hen's egg, and are mostly quartz; comparatively few could have been derived from the region now drained by the Clinch, and most of them must have come from the Blue Ridge or further at the south.

The Clinch and North Holston are as handsomely terraced as the New river and its tributaries. The "bottom" of Clinch river appears to maintain a uniform height of about fifteen feet above low water; a fine terrace is shown near Osborn's ford at ninety-five feet above the river or 1375 feet above tide, and it is present on both sides of the river at a little way above the ford. A higher bench is shown on the southerly side, but its height could not be ascertained. Near Nash's ford in Russell county, three terraces are crossed as one descends to Clinch from the south. These are about 155, 40 and 15 feet above low water at the ford. The highest reaches far back from the river and its height above tide is not far from 1700 feet. A fine terrace was seen on the north fork of Holston below the mouth of Laurel creek in Smyth county, where the top of the deposit is between eighty-five and ninety feet above the river or at not far from 1625 feet above tide. The deposit on these river terraces consists of sand and clay carrying abundance of boulder, all apparently of local origin.

In some portions of South-west Virginia, notably in the region embracing much of North-west Tazewell county, Virginia, and of Mercer and Summers counties of West Virginia, which is known as "Flat Top," there are high benches or fragmentary plains which are of considerable extent, but do not appear to carry many water-worn stones in their thin cover. They are very like the higher benches observed by the writer* in South-west Pennsylvania, and very possibly they are due to the same causes.

But what these causes were is still an open question. The most natural explanation is that which regards them as erosion planes, such as were termed "base levels of erosion" by Major Powell. But in discussing these benches as they occur in Pennsylvania and adjacent States, the writer showed that as they line valleys and form irregular rings about isolated hills, they are merely incidental modifications of a topography due to prior and long continued erosion ; and that they are too well preserved to be regarded as fragments of great erosion planes. More than this. The deposit on these benches is marked by the absence of water-worn and rounded fragments ; the absence of such fragments cannot be accounted for by the supposition that they have been broken up by exposure, for the greater part of the deposit has been protected from atmospheric agencies until exposed by the plough or in excavations for roads. The Coal Measures of Western Pennsylvania contain sandstones, whose fragments should resist disintegration equally with the Medina and Potsdam pebbles of South-west Virginia ; while in Bedford county of the former State, where high benches are as conspicuous as in the Coal Measures counties further west, the Chemung conglomerates and the Medina sandstones are present and the stream beds are loaded with their fragments ; yet no rounded pebbles were seen on the benches.

The absence of these boulders militates against any application of the base level process, as generally understood, and equally against the supposition suggested by the writer, that the benches were produced by shore erosion between tides. The problem of their origin is not simplified by denying their existence, for, unfortunately, the benches are "here to stay." A ride along the National road in Pennsylvania, from Uniontown in Fayette county to Washington in Washington county, enables one to secure a key to the whole succession.

Returning to Virginia. That the great erosion has occurred since the faulting took place is sufficiently shown by the contrast between the upthrow and downthrow sides of the faults ; for on one side is seen the highest portion of the Lower Carboniferous while on the other are the lowest beds of the Knox limestones. It may be that the main streams antedated the faults and possibly the folds. The course of New river, which rises far beyond the axis of the Blue Ridge crosses at least six great faults as well as all the folds, great and small, from the Blue Ridge to the Ohio river, suggests that it may be following in a general way the original direction.

* Proc. Amer. Phil. Soc., Vol. XVIII, Aug. 15th, 1879.

But there have been great changes in the water-ways. The fragmentary deposit on the line between Russell and Scott counties, carrying quartz pebbles at 640 feet above Clinch river, tells the story of one great change, for nothing along the upper Clinch could furnish the material for this deposit, of which so little remains. The deep erosion near the North fork of Holston river, from Saltville in Smyth county eastward for sixteen miles, cannot be referred to any present drainage system ; its bottom is more than 600 feet below the present bed of the river and the excavation has been filled with a deposit of gypsum and rock salt. This was digged out after the faulting, for the excavation crosses and re-crosses the Saltville fault.*

It is sufficiently clear that the courses of many of the present streams are due in no small degree to the geological structure. The fans formed by the Clinch and Holston with their tributaries show a co-incidence with the general course of the rocks and faults which cannot be merely fortuitous. Tributaries to New river in Bland and Giles counties flow irregularly with the strike of the beds ; between outcrops of sandstone they follow the more readily yielding rocks, so that they are often brought near to the fault lines ; and many streams belonging to the other systems do the same. But in the broad limestone areas, some other cause has determined the direction, for not a few streams exist there whose courses appear to bear no relation to the geological structure. No especial weakness now exists in the immediate vicinity of the faults, for the streams flow with utter indifference to them. New river crosses all of the faults. Big Walker creek and the North fork of Holston flow back and forth over the Saltville fault, and the latter at times wanders to a distance of two or three miles, apparently without reference to the character of the rocks. Clinch river coquettes in the same way with the Clinch faults and eventually deserts them to cross the limestone area in Scott county and to cut the Copper creek fault at ten miles toward the south-east. The North fork of Clinch crosses two faults and many of the smaller streams flow directly across one or more.

It is altogether probable that the present lines of the faults are very far, in some cases at least, from the original lines. The lateral thrust in more than one case must have been enough to push the upthrown rocks to a considerable distance over upon the downthrown series ; so that the areas of weak or crushed or much distorted rocks lay north or north-west from the lines as now observed. The crushed portions have been removed by erosion and the streams have changed their channel-ways as the erosion advanced. It is difficult, therefore, to determine much respecting the former drainage ways.

The thickness of rock removed by erosion in this region, though not equal to that removed from Western Colorado and adjacent parts of Utah, is still sufficient to challenge respect. There is no room for doubting that the Coal Measures reached at one time beyond the "Valley" to the Blue

*See Proc. Amer. Phil. Soc., Vol. XXII, p. 154 *et seq.*

Ridge, for those rocks are just missed on the northerly side of the Draper Mountain fault, at twelve miles from the Blue Ridge. Even now the Coal Measures must be caught on some of the Washington county hills beyond the Saltville fault. The Lower Potsdam is brought up under the Lick Mountain anticlinal at not more than four miles from the line of the Lower Carboniferous in the Draper Mountain area. The whole of the Palæozoic column, then, or not less than 22,000 feet, has been removed from the westerly side of the Blue Ridge in South-western Virginia; while in the "Valley" and on the upthrow side of the faults the thickness of removed rocks is from say 18,000 feet in Lick mountain to 12,000 feet or more along the faults. Additional proofs of this enormous erosion are found in the occurrence of Lower Silurian valleys separated by ridges carrying small areas of the Coal Measures.

This enormous erosion occurs only on the upthrow side of the faults; so that on the downthrow side one may find even the Coal Measures, while the lower beds of the Calciferous may be on the other. So, 15,000 feet or more may have been removed from one side, while on the other, the whole loss may not exceed 3000 or 4000 feet. This great contrast between the two sides seems to suggest that the lateral thrust was enough in every case to *push the upthrown beds far over on the downthrown*, so that there could be no erosion of the latter until after removal of the former.

Of course, there are perplexing problems here; they usually abound. One is suggested by the successive increase in height of the erosion planes as one ascends New river. Thus the highest south from East River mountain is at 1810 feet above tide; that south from Big Walker mountain is at about 1925 feet; while that south from Draper and Lick mountains is at about 2270 feet. These benches were all made during a long period when the river in each area had practically ceased to deepen its channel-way. It may be that the Medina sandstone of Draper mountain, the Chemung conglomerate and Medina sandstone of the Walker mountains and the Medina sandstone of the East River mountains may have proved sufficiently hard to resist erosion for a long time. However that may be, corrasion advanced regularly after it began, for the first bench below is reached at 140 feet south from East River mountain, at 150 feet south from the Walker mountains, and at nearly 200 feet in the space between Lick mountain and the Blue Ridge.*

A long halt in corrasion occurred during the formation of the second bench; but thenceforward no important obstacle seems to have been encountered and the interruptions were only long enough to admit of forming narrow river terraces, which usually are found on but one side of the river.

University of the City of New York.

* For the elevations along New river, I am indebted to Mr. W. W. Coe, Chief Engineer of Norfolk and Western R. R.; and for those on the Clinch and Holston rivers to Mr. Oramel Barrett, Jr., of Abingdon, Virginia.

The Signal Service Bureau. Its Methods and Results. By William Blasius.

(Read before the American Philosophical Society, May 6, 1887.)

In 1872 the Leipzig Conference propounded this question, with others, to the principal meteorologists of the world: "Are you of the opinion that the present state of our knowledge of the weather justifies giving definite prophecies or predictions instead of the telegraphic communication of facts, or shall we limit ourselves to intimations upon the state of the atmosphere in the surrounding countries, from which the receivers of the communications may deduce their own rules?"

The replies were almost uniformly in the negative, and among them that of the very distinguished meteorologist, Prof. Buys-Ballot, of Utrecht, who said: "No prophecies, if we do not want to bring this matter into discredit. It is impossible for the director to say on which part of the coast the wind will blow first, and be the strongest, if he does not await the beginning of the storm at a place at some distance, and then it is too late. The state of the weather may be given. Every one may have the fixed rules by which, from this state, he may deduce his own results." And then, in a humorous way, he adds: "He who shall predict the weather, if he does it conscientiously and with inclination, will have no quiet life any more, and runs great risk of becoming crazy from nervousness."

The United States Signal Service Bureau has from the beginning—owing to the nature of its organization perhaps—taken a different course; it has devoted its chief efforts to *prediction* and *signaling*, while the study of nature and its laws has received but scant attention. And what is the result? Can it now give the "fixed rules," of which Buys-Ballot speaks, by which every one may be enabled to form some judgment of the weather? What additions to meteorological science has it ever made? Is there even one valuable result in all its voluminous literature that cannot be found in the prior works of others? If so, where and what is it? Nay, more. It has published during the last twenty years a vast conglomeration of facts and observations, at great expense of labor, intelligence and money, but from all this great material have any meteorologists the world over been able to make generalizations that have been accepted as sound and valuable?

I think, upon reflection, we must all see that the answer cannot be affirmative, and that when the results of the Signal Service Bureau's work are summed up, it is found to be utterly disproportionate to the means at its disposal, even in the matter of prediction. Its methods must therefore be at fault. Let us examine.

At the close of our civil war, upon the suggestion of the late Prof. Henry, the Telegraph Corps, whose services in the field as an active part of the army were no longer needed, was reorganized as the Signal Service Bureau, and its officers and soldiers became at one stroke, full-fledged meteorologists, but remained under strict army discipline, and worked under rigid rules. The duties assigned to them individually were, however, and still are of a very simple nature. The "observers" at the various stations, at certain hours of the day, record in tabular columns the readings of their meteorological instruments, and telegraph these to Washington; and since my work on "Storms"* was published in 1875, in which I called especial attention to the Bureau's neglect of cloud forms, some simple observations upon the clouds are added to the telegraphic reports. Upon receipt of these reports at Washington, they are written down upon blank maps, on which the respective stations are marked. The points of lowest equal barometric pressure are then united by a line called the Isobar which usually form an ellipse. In the same way the stations of five or ten points of higher pressure are joined by a line. The field enclosed by these somewhat concentric Isobars is the "area of low pressure," or the "cyclonic storm" so called. From the results of the next reading the next position of the area of low pressure is ascertained in the same way, and by comparing the distance traveled with the time occupied, the probable position for some hours ahead is calculated, and predictions are issued. The labor is thus of a routine character

"Areas of high barometer" are likewise noted, but these are thought to bring fair weather. The barometer therefore is still the chief reliance in the prediction of storms, and those storms which are distinguished as "areas of low pressure" are practically all that the Signal Service is able to predict.

Now, in the report of the Chief Signal Officer for 1884, there are noted as having occurred during the year 152 of these areas of low pressure, 172 tornadoes, 947 hailstorms, and 1745 thunder-storms, so that if every one of the 152 "cyclonic storms"—the "areas of low pressure"—are correctly predicted, we have some 2864 storms, of which the Bureau knew nothing until after they had occurred. Relying on the barometer and on machine methods, it could not be otherwise.

Lieut. J. P. Finley, Chief of the Tornado Division of the Bureau, in "Signal Service Notes, No. XII," says: "Probably if a barometer were placed in the immediate track of a tornado cloud, it would not with any certainty indicate the presence of the storm until the crushing winds had fallen on the instrument." Indeed, although the Bureau appears to proceed on the old rule that has obtained predominance since the days of Otto von Guericke, that a falling barometer denotes an approaching storm, it has long been well known that the most destructive storms often arrive with a rising barometer, and this for reasons that I explained as long ago as 1852. One of these storms took place at Colon, or Aspinwall, Panama, December 2, 1885. The New York *Herald* of December 18 says: "This storm was not preceded by any distinct precursory signs. The barometer on the Isthmus apparently remained stationary or slowly rose during the progress of the tempest. Much property, many vessels and lives were lost."

*STORMS: Their Nature, Classification and Laws. Porter & Coates, Philadelphia, 1875.

One of the most destructive storms this country has ever witnessed, occurred on the coasts of Nova Scotia and Newfoundland, August 23, 24 and 25, 1873, by which about 500 lives were lost and 1032 vessels destroyed, including 435 small fishing schooners. The Signal Service Bureau was entirely taken aback by this storm, because an "area of high pressure" or an "anti-cyclone" had been moving from Manitoba to the coast, and therefore, fair weather was to be expected. But in the weather maps for several days previous could be traced the gradual advance of a wave of cold air from the North—the "area of high pressure"—which banking up the warmer air in its front as shown by the gradually rising gradient, finally culminated in a terrific south-east storm with its centre of destruction on the coast. We thus have a storm of the most violent character traced on the maps of the Signal Service Bureau for several days as a fair weather indicator.

The Chief Signal Officer reports 80 "areas of high barometer" during 1884. Those occurring in the cold season mean fair weather, as they displace the warm current which has previously discharged its moisture. In the summer, however, this cool air from the North, which being heavy can be identified as an "area of high pressure," causes—in its displacement of the then prevailing warm and moist air—the south-east storm, with its tornadoes, hail-storms, cloud-bursts and thunder-storms, none of which the Signal Service Bureau predicts, and which cause vastly more destruction than the north-east storms—the "areas of low pressure"—both from their greater violence, and because they mostly occur at a season of the year when the work of the agriculturist is going on and his crops—on which the nation depends for its prosperity—are subject to injury.

It is true that quite lately the Bureau has turned its attention to this branch of the subject, after so many years of practical neglect, and that claims of considerable magnitude have been advanced as to what has been accomplished and what will be accomplished, both in the way of prediction and scientific discovery. Let us therefore examine into this a little.

The most eminent of American meteorologists—Redfield, Espy and others—agree in thinking the tornado the most instructive of all storms. It is in some respects the type of our American storms, since here the opposition of air-currents of different temperature and density, which is the general cause of storms, is most strikingly manifested and within the narrowest limits.

Mr. Wm. A. Eddy, an attaché of the Bureau, in *The Popular Science Monthly* for January, 1886, says: "During the first part of 1884, the United States Signal Service began to pay special attention to the question of tornado prediction. The development of the science was rapid under the active supervision of Lieutenant John P. Finley, having charge of that department of the service. It was found that the public interest in the question was widespread, and that with the aid of voluntary reporters of tornado phenomena, the possibility of saving life and property had begun to crystallize into a practical scheme." He further says: "During the summer of 1886, it is hoped that, by means of signals, hundreds of lives and much valuable property will be saved."

The summer of 1886 has passed; can it be said that this hope is realized? Has the Signal Service saved a single life or any property by its tornado predictions?

Mr. Eddy tells us that the "invariable location south-east of the storm-centre is one of the main peculiarities of tornado development upon which the predictions depend." And yet to this same peculiarity, with its explanation, I called attention as early as 1852, and again in 1875, in the publication of my work on storms already referred to, and I urged it on the Signal Service Bureau during a personal visit to Washington at that time.

Mr. Eddy also says: "When the conditions are unfavorable for the development of tornadoes, there are no unusual contrasts of temperature, the areas of warm and cold air neither great nor well defined northward and southward, the winds are variable and not very strong, and the distribution of pressure is about normal." All this can be found in my work on "Storms," published in 1875—why is it put forward as a new discovery in 1886?

Indeed, it was only after the publication of that work that the Signal Service Bureau began to note the difference of temperature in air-currents—to which I had called attention—and made various and important changes in its method of prediction. But when Lieutenant Finley puts forth as a discovery of his own, the fact that tornadoes are caused by "two opposing air-currents of different temperatures and moisture," it seems a little singular, in view of my communication of the same fact to the Academy of Science in Boston, in 1851, its publication in 1852, and again, in 1875.

As to the prediction of tornadoes by the Signal Service, it can never be done with any certainty, except in so general a way as to be valueless. If any one has mastered the principles of atmospheric disturbance—and they are not so difficult—he will be able to judge for himself as to the probability of tornadoes being imminent in his locality ten times as well as the Signal Service can ever tell him. Just where the tornado will strike, and its path is a narrow one, no man can tell until within a few minutes of its passage.

Mr. Eddy says: "That during 1884, 3228 predictions *un*favorable to tornadoes were made, and of these 3201 were verified." But what a simple matter it is with the most ordinary knowledge and circumspection to say that tornadoes will *not* take place, when the dark clouds of the south-east storm give ample notice when there is a possibility of their happening? If we have a south-east storm we may or may not have tornadoes; but if we have *not* a south-east storm, then we have no tornadoes.

As to the prediction of a tornado itself, Mr. Eddy cites that which passed over Camden and Philadelphia, August 3, 1885, as "one of the best illustrations of the advance made in definiteness in predictions;" and he further says: "The chart used by Lieutenant Finley shows that tornadoes were predicted and their location marked upon the map for the State of Delaware, South-eastern Pennsylvania and for New Jersey. The tornadoes actually occurred in these States, about eight hours from the time of prediction."

Now if we ask how valuable to the owners of the houses damaged by that tornado in Philadelphia was the Signal Service's prediction eight hours before, that tornadoes would occur somewhere in "Delaware, South-eastern Pennsylvania or New Jersey," we cannot fail to see, I think, the entire impracticability of the whole scheme.

The Signal Service is perhaps obliged by circumstances to devote most attention to those things which will show most apparent results to the general public and to Congressmen who vote for the annual appropriation. It is hampered too by its routine methods and its army rigidity of discipline. It cannot however but be a cause of disappointment that whether owing to these causes or others, it has added so little of scientific value to the knowledge of meteorology during the twenty years of its existence. It has been following the old methods in reference to which Sir William Herschel says : "In endeavoring to interpret the weather, we are in the position of a man who hears, at intervals, a few fragments of a long history, related in a prosy, unmethodical manner; a host of circumstances omitted or forgotten, and the want of connection between the parts prevents the hearer from obtaining possession of the entire story." And the great Biot, after enumerating the efforts to advance this science, says: "What has come of it? Nothing, and nothing will ever come of it. No single branch of science has ever been fruitfully explored in this way."

No, the methods followed have been wrong. Would astronomy be in its present position if the great astronomers had been dependent on the data furnished by observations made according to arbitrary rules, and for a minimum of time at one or two hours of the night, and for the most part, too, by observers of meagre training and intelligence? And how much would the great naturalists have learned, had they been content to send out into the fields three times a day for five minutes, and sit in their closets to generalize upon the data thus obtained?

Thirty five years ago, I urged that only by *continuous* observations could we hope for anything beyond mere empirical knowledge; that we must gather up the "host of circumstances" now "omitted or forgotten," and supply "the connection between the parts." I am not unmindful of the practical difficulties that are in the way of a method of observation that alone can give a continuous knowledge of a storm as it passes; but it seems to me that this may be obtained with the means now available, if the meteorological organization would devote more attention to the discovery of general laws than to the more sensational part of their duties—the weather predictions, which the newspapers now make a matter of business enterprise. If we know the laws, there will be little trouble about the prediction. Each of us can do this for himself sufficiently well for all practical purposes.

Stated Meeting, December 17, 1886.

Present, 39 members.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows:

Letters of envoy from the Musée Teyler, Leyden, and Meteorological Office, London.

Letters of acknowledgment from Serge Nikitin, St. Petersburg (123); Dr. Paul Albrecht, Hamburg (121, 122, 123); R. Accademia dei Lincei, Rome (122); Mr. William John Potts, Camden (123).

The College of Physicians requested, by letter, the oil portraits of Dr. Franklin Bache, Dr. Elisha Kent Kane and Dr. Joseph Priestley, for use at its approaching Centennial.

On motion, the paintings were ordered to be loaned, the Curators taking proper guarantees for their safe keeping and return.

Accessions to the Library were announced from the following:

Geological Survey of India, Calcutta; Naturforscher-Verein, Riga; Fondation de P. Teyler, Harlem: Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; Messrs. R. Friedlander & Sohn, Berlin; Académie Royale de Belgique, Bruxelles; Biblioteca Nazionale Centrale V. E. di Firenze; Société d'Emulation, d'Abbeville; Société Historique Littéraire; Artistique et Scientifique du Cher, Bourges; Société des Sciences Naturelles et Archeologiques de la Creuse, Guéret; Institut de France, Sociétés de Geographie, Geologique, Zoologique, Musée Guimet, Ministéres de la Marine et de l'Instruction Publique, Paris; Meteorological Council, Nature, London; American Journal of Science, New Haven; Museum of Comparative Zoölogy, Prof. Benjamin A. Gould, Cambridge; Messrs. Walter Baker & Co., Dorchester; American Chemical Society, New York; Mr. George A. Bacon, Publisher, Syracuse; College of Pharmacy, Publishers of the American

Naturalist, Messrs. Chas. A. Lagen, Henry Phillips, Jr.. Philadelphia; Johns Hopkins University, Baltimore; Department of State, Public Opinion Co., Washington; Academy of Sciences, St. Louis; Geological and Natural History Survey of Minnesota, St. Paul; University of California, Sacramento.

On motion the following were ordered on the Society's exchange list to receive Proceedings from No. 119:

La Ministère de la Marine Imperiale, Administration générale de la Hydrographie, St. Petersburg; Société Historique, Littéraire, Artistique et Scientifique du Cher, Bourges, France; Société des Sciences Naturelles et Archéologiques de la Creuse, Gueret, France; R. Societa Italiana d' Iginie, Milan.

A photograph was received for the Society's album from Prof. Serge Nikitin, St. Petersburg, Russia.

The death of Hon. Isaac Lea, LL.D., was announced by the President in some appropriate remarks, as having taken place at Philadelphia, on December 8th, in the ninety-fifth year of his age, and on motion, the President was authorized to appoint a suitable person to prepare the usual obituary notice.

The Committee on Finance made its report and, on motion, the appropriations for the ensuing year were passed to the same amounts and for the same purposes as those of the last year.

On motion of Dr. Allen, the Society extended an invitation to the American Society of Naturalists to visit its hall during the forthcoming meeting.

On motion of Mr. Ames, the Society ordered that new electrotype plates should be prepared for a table for the interconversion of English and metric units by Dr. Frazer, he stating that the old ones were worn out.

This being the stated meeting for balloting for candidates, an election was held and the following were declared to have been chosen members of this Society:

2105. Prof. Morton W. Easton, Philadelphia.

2106. Prof. William F. Norris, M.D., Philadelphia.

2107. Prof. James MacAlister, Philadelphia.

2108. Charles S. Dolley, M.D., Philadelphia.

2109. Prof. John A. Ryder, Philadelphia.

2110. Prof. Hermann V. Hilprecht, Ph.D., Philadelphia.

2111. George W. Childs, Philadelphia.

2112. Prof. W. B. Scott, Princeton, N. J.

2113. Sir Henry Sumner Maine, F. R. S., London.

2114. Sir Monier Monier-Williams, F. R. S., Oxford.

2115. Prof. Dr. Hugo Von Meltzel, Koloszvar.

2116. Prof. Dr. Paul Hunfalvy, Buda-Pesth.

2117. Prof. Dr. G. Weil, Berlin.

2118. Prof. Dr. Henri Kiepert, Berlin.

2119. Prof. Dr. Adolph Bastian, Berlin.

2120. Prof. Dr. Friederich Mueller, Vienna.

2121. Prof. Dr. Matthæus Much, Vienna.

2122. Prof. Dr. A. Reville, Paris.

2123. Prof. Dr. Paul Topinard, Paris.

2124. Prof. Dr. Remi Simeon, Paris.

2125. Prof. Dr. Conrad Lemanns, Leyden.

2126. Prof. Dr. George Curtius, Leipsic.

2127. Julius Platzmann, Leipsic.

2128. Prof. Lucien Adam, Rennes.

2129. Prof. Guido Cora, Milan.

2130. Bishop Crescencio Carrillo, Merida, Yucatan.

2131. Prof. Juan de Dios de la Rada y Delgada, Madrid.

2132. Vicomte Hyacinthe de Charency, St. Maurice-les-Charency, France.

2133. G. A. Hirn, C.E., Colmar, Alsace.

And the Society was adjourned by the President.

Stated Meeting, January 7, 1887.

Present, 24 members.

President, Mr. FRALEY, in the Chair.

Dr. Marshall, a lately-elected member, was presented to the Chair, and took his seat.

Correspondence was read as follows:

Acknowledgments were received from: Société Historic Littéraire, Artistique et Scientifique du Cher, Bourges (96–123): Royal Institution, Society of Antiquaries, Royal Horticultural Society, South Kensington Museum, Mr. R. W. Rawson, London; University Library, Cambridge; Prof. I. Geikie, Edinburgh; Free Public Library, New Bedford (123).

Acceptance of Membership.—Prof. Charles S. Dolley, Prof. Morton W. Easton, Dr. Hermann V. Hilprecht, Prof. James MacAlister, Dr. Wm. F. Norris, Prof. John A. Ryder, Philadelphia: Prof. Wm. B. Scott, Princeton, N. J.

Photographs were received for the Society's Album from Messrs. Wm. Blades and H. Carvill Lewis.

Accessions to the Library were reported from the Asiatic Society of Japan, Yokohama; Royal Asiatic Society (North China Branch), Shanghai; Messrs. R. Friedlander & Sohn, Berlin; Gartenbauverein, Darmstadt: Dr. A. Weisbach, Freiberg; Astronomische Nachrichten, Kiel: Der Naturforscher, Tübingen: Société Batave de Philosophie Experimentale de Rotterdam; Sociétés Malacologique, Entomologique de Belgique, Académie de Belgique, Bruxelles: Biblioteca Nazionale Centrale di Firenze; R. Società Italiana d'Igiene, Milan; R. Accademia dei Lincei, Rome; Société de Geographie, Ecole Libre des Sciences Politiques, Revue Internationale de l'Enseignement, Paris; Sociedade de Geographia de Lisboa, R. Academia de la Historia, Madrid; Revista Euskara, Pamplona, Spain; Royal Society, Royal Astronomical and Geographical Societies, Greenwich Observatory, Royal Horticultural Society, Liverpool; Natural History Society, Montreal; Mr. George L. Vose, Boston: Yale College, American Journal of Science, New Haven; Meteorological Observatory, American Chemical Society, New York; Franklin Institute, American Journal of Medical Sciences, Publishers of the American Naturalist and the Naturalist's Leisure Hour; Prof. Angelo Heilprin, Henry Phillips, Jr., Mrs. Zelia Nuttall, Baltimore, Md.; United States Naval Institute, Annapolis; Johns Hopkins University, Baltimore, Md.; United States Commission of Fish and Fisheries, Navy Department, Public Opinion Co., Washington; Washburn College, Topeka; Imperial Observatorio, Rio de Janeiro.

An obituary notice of the late Judge James R. Ludlow, prepared (by request) by Hon. Richard Vaux, was read by the Secretary.

The President announced the death of Pliny Earle Chase, LL.D., Vice-President of the Society, December 17, 1886, æt. 65, and, on motion, was authorized to appoint a suitable person to prepare the usual obituary notice, pursuant to which the selection of Hon. Philip C. Garrett was made.

The President announced the death of Mrs. Emma Seiler December 21, 1886, æt. 65.

The President reported that, pursuant to the resolution of the last meeting, he had appointed Prof. Joseph Leidy to prepare the obituary notice of the late Isaac Lea, LL.D., and that said appointment had been accepted.

The stated business of the meeting was then taken up, and the report of the tellers of the annual election being received, the following officers and councilors were declared duly chosen for the year 1887:

President.

Frederick Fraley.

Vice-Presidents.

E. Otis Kendall, W. S. W. Ruschenberger, J. P. Lesley.

Secretaries.

G. F. Barker, D. G. Brinton, Henry Phillips, Jr., George H. Horn.

Curators.

Charles G. Ames, John R. Baker, Philip H. Law.

Councilors for three years.

Daniel R. Goodwin, Henry Winsor, William A. Ingham, Thomas H. Dudley.

Councilor for two years in place of Oswald Seidensticker, resigned,

Richard Vaux.

Treasurer.

J. Sergeant Price.

This being the evening for the nomination of a member to serve as Librarian for the ensuing year, Dr. D. G. Brinton renominated Mr. Henry Phillips, Jr., Dr. Persifor Frazer nominated Admiral E. Y. McCauley, and the nominations were closed.

Dr. D. G. Brinton read "Some Critical Remarks on the Writings of Diego de Landa."

Pending nomination No. 1151 and new nomination No. 1152 were read.

A report was presented by the Committee on Library, accompanied by the following resolution, which was adopted by the Society:

"*Resolved,* That the Society request that the Library be kept open during the year 1887 from 10 A.M. to 3 P.M. from January 1st to May 31st and from October 1st to December 31st."

A communication was read from Mr. E. Muybridge, requesting a subscription to his proposed work on "Animal Locomotion."

On motion the Library Committee was directed to report at the next stated meeting of the Society on the expediency of subscribing to it.

And the Society was adjourned by the President.

Stated Meeting, January 21, 1887.

Present, 87 members.

Mr. RICHARD VAUX in the Chair.

Prof. James A. MacAlister, a newly-elected member, was presented to the Chair and took his seat.

Correspondence was submitted as follows:

A letter of envoy from the Real Academia del la Historia, of Madrid, Spain, accompanying certain numbers of its publications, for which a request had been made.

A letter from Prof. Horsford, in relation to Heckewelder's MS. vocabulary of the Lenni-Lennape, etc., was referred to the Secretaries with power to act.

Letters of acknowledgment from the Statistical Society, London (121, 123); Portland Society of Natural History; New Hampshire Historical Society, Concord; State Library of Massachusetts, Boston; Museum of Comparative Zoölogy, Mr. Robert N. Toppan, Cambridge; Essex Institute, Salem; American Antiquarian Society, Worcester; Rhode Island Historical Society, Providence; Connecticut Historical Society, Hartford; Prof. James Hall, Albany; Prof. C. H. F. Peters, Clinton; Dr. J. J. Stevenson, University of the City of New York, Astor Library, New York; Oneida Historical Society, Utica; U. S. Military Academy, West Point; New Jersey Historical Society, Newark; Dr. George H. Cook, New Brunswick; Rev. James A. Murray, Carlisle; Prof. M. H. Boyé, Coopersburg; Prof. J. W. Moore, Easton; Numismatic and Antiquarian Society, Drs. S. W. Gross, C. A. Oliver, Messrs. T. U. Walter, Thomas M. Cleeman, Henry Phillips, Jr., Philadelphia; Maryland Institute, Baltimore; Surgeon-General's Office, Washington, D. C.; Leander McCormick Observatory, Prof. J. W. Mallet, University of Virginia; Elliott Society, Charleston; Georgia Historical Society, Savannah; Cincinnati Observatory; Chicago Historical Society; Rantoul Literary Society; State Historical Society of Wisconsin; University of California; Prof. John L. LeConte, Berkeley, Cal. (124); Prof. James MacAlister, Philadelphia, (121, 122, 123 and 124, etc.).

Accessions to the Library were received from the Administration Générale de la Hydrographie, St. Petersburg: Bataviaasche Genootschap van Kunsten en Wetenschappen: Anthropologische Gesellschaft, Vienna; Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte; Astronomische Nachrichten, Kiel; R. Società Italiana D'Igiene, Milan: Société de Geographie, Paris; Société de Borda, Dax; R. Academia de la Historia, Madrid; R. Geographical Society, London; Geological Society of Glasgow; Prof. Daniel Wilson, Toronto; Brooklyn Entomological Society; Mr. William J. Potts, Camden; College of Pharmacy, Prof. E. D. Cope, Dr. D. G. Brinton, Messrs. Henry Phillips, Jr., and William S. Baker, Philadelphia; Johns Hopkins University, Baltimore; Census Office and U. S. Coast and Geodetic Survey, Bureau of Education, Washington; Rev. Stephen D. Peet, Chicago; Observatorio Astronómico Nacional de Tacubaya, Mexico.

This being the evening for the selection of the Standing Committees to serve for the ensuing year, on motion, the President was authorized to appoint the same and to report his action at the next stated meeting of the Society.

This being the evening for the election of a member to serve as Librarian for the ensuing year, a ballot was gone into and on the votes given being counted by the Tellers, it was announced that Mr. Henry Phillips, Jr., had received 61 votes, and Admiral E. Y. McCauley 25, and one vote blank, and Mr. Henry Phillips, Jr., was declared duly elected Librarian for the ensuing year.

Nominations Nos. 1151 and 1152, and new nomination No. 1153, were read.

At this point Vice-Pres. Dr. Ruschenberger took the Chair.

The Committee on the Library presented a report, accompanied with the following resolution, which was adopted:

Resolved, That this Society do appropriate the sum of $100 as a subscription for one series of plates of E. Muybridge's work on *Animal Locomotion;*

the said plates to be selected by him, and the selection to be approved by a Committee to be appointed by the President of this Society.

The Committee on the Michaux legacy presented a report, accompanied by the following resolution, which was adopted:

Resolved, That the sum of $280 be expended under the supervision of the Michaux Committee to enable Dr. J. T. Rothrock to secure a collection of photographic plates of the unique flora of Florida, which may be used as lantern slides to illustrate the course of lectures to be delivered this year in the Park under the auspices of the Society.

And the meeting was adjourned by the presiding member.

Stated Meeting, February 4, 1887.

Present, 12 members.

Vice-President, Dr. RUSCHENBERGER, in the Chair.

Correspondence was read as follows:

Letters of envoy from the Mining Department, Melbourne, Australia; La Société de Borda, Dax, France; The U. S. Geological Survey, Washington, D. C.

La Société Liégeoise de Littérature Wallone, Liege, and La Société des Antiquaries de la Morinie, St. Omer, France, were placed on the exchange list to receive Proceedings from No. 119; K. Meteorologisches Institut, Berlin, Preussen; Physikalische-Medicinische Societät zu Erlangen.

Letters of acknowledgment were read for No. 123 from J. Steenstrup (Copenhagen); Het Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte, Rotterdam; La Société Royale de Zoologie de Amsterdam; Musée Teyler, Harlem; Victoria Institute, London; Cambridge Philosophical Society; for No. 124 from Museum Comp. Zoölogy, Cambridge, Mass.; Mr. L. A. Scott, Philadelphia; Prof. J. H. C. Coffin, the U. S. Geological Survey, and the Smithsonian Institution, Washington, D. C.; Prof. Serge Nikitin, St. Petersburg, 121.

A letter was read from the College of Physicians thanking the Society for the loan of portraits at the late Centennial Celebration of the College.

A letter was read from G. Eichler, in Berlin, in reference to his reproductions from the antique.

Also one from the Buffalo Library inviting the Society to the opening of its new Building, on February 7th, 1887.

Accessions to the Library were received from the Department of Mines, Melbourne; K. K. Geologische Reichsanstalt, Wien; Gartenbauverein zu Darmstadt; Naturwissenschaftliche Gesellschaft "Isis," Dresden; Verein für Thüringische Geschichte, Jena; Astronomische Nachrichten, Kiel; K. Sächsische Gesellschaft der Wissenschaften, Zoologischer Anzeiger, Leipzig; Deutsche Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, München; Prof. E. Renevier, Lausanne; Nordisk Oldkyndeghed og Historie, Copenhagen; Biblioteca N. Centrale, Vittorio Emanuelle, di Roma; Biblioteca N. Centrale di Firenze; Académie des Sciences, Arts and Belles-Lettres de Caen; Société de Borda, Dax; Sociétés de Geographie, de L'Enseignement, D'Anthropologie, D'Ethnographie, and Société Americain de France, Paris; Société des Antiquaires de la Morinie, St. Omer; Royal Society, Society of Arts, Meteorological Office, "Nature," London; Cambridge (Eng.) Philosophical Society; Boston Society of Natural History; Essex Institute, Salem; American Oriental Society, Cambridge; Publishers of "The Travelers' Record," Hartford; American Journal of Science, New Haven; New York Meteorological Observatory; Mr. Wm. John Potts, Camden; Prof. George H. Cook, New Brunswick; Franklin Institute, Pharmaceutical Association, Mercantile and Philadelphia Libraries, Dr. D. Jayne & Son, Henry Phillips, Jr., Philadelphia; Wyoming Historical and Geological Society, Wilkes-Barre; Johns Hopkins University, Prof. Ira Remsen, Baltimore; the Philosophical Society, the U. S. Geological Survey, and John H. Hickcox, Washington, D. C.; Mr. Charles C. Jones, Jr., Augusta, Ga.; the State Historical Society, Iowa City, Iowa; the Imperial Observatory of Rio de Janeiro.

A communication entitled "An Egyptian Ecclesiastes," by Dr. George Selikovitch, was read by the Secretaries; also one by Dr. Earl Flint, of Rivas, Nicaragua, "On the fossil human foot-prints lately discovered in the *tufa* of Nicaragua." Also one by S. N. Clevenger, of Chicago, entitled "Suggestions concerning the nature of comets."

Dr. Persifor Frazer mentioned the occurrence of a crystallized garnet in a garnet schist in a specimen brought from the Stikine river and presented to him, stating that the matrix was similar to that in which garnet was found near this city.

Pending nominations Nos. 1151, 1152, 1153, and new nominations Nos. 1154, 1155, 1156 were read.

The President reported that according to the request of the Society at its last meeting he had appointed the following to serve as the Standing Committees of the Society for the year 1887:

Finance,

Henry Winsor, J. Price Wetherill, William B. Rogers.

Publication,

Daniel G. Brinton, George H. Horn, Persifor Frazer,
J. Blodgett Britton, J. Cheston Morris.

Hall,

J. Sergeant Price, William A. Ingham, Harrison Allen.

Library,

Edwin J. Houston, William V. McKean, Thomas H. Dudley,
Francis Jordan, Jr., Edwin A. Barber.

The President reported that he had received and paid over to the Treasurer the sum of $132.12, being the amount of interest on the Michaux Legacy, due January, 1887.

On motion the Library Committee was requested to examine into the desirability of a subscription by the Society to the International Geological Map of Europe; and the Society was adjourned by the presiding officer.

Stated Meeting, February 18, 1887.

Present, 14 members.

Vice-President, Dr. RUSCHENBERGER, in the Chair.

Dr. Charles S. Dolley, a newly-elected member, was presented to the Chair and took his seat.

Correspondence was submitted as follows:

Letters acknowledging election to membership from Dr. A. Réville, Paris; Lucien Adam, Rennes; Vicomte Hyacinthe de Charency, St. Maurice-les-Charency, France; Dr. Conrad Lemanns, Leyden; Sir Henry Sumner Maine, London: Dr. Friederich Mueller, Wien: Dr. Julius Platzmann, Leipzig; Dr. Gustav Weil, Heidelberg; Dr. Henri Kiepert, Berlin; Bishop Crescencio Carrillo, Merida, Yucatan; Dr. A. Bastian, Berlin; Dr. Paul Hunfalvy, Buda-Pesth; Dr. M. Much, Vienna.

Letters of acknowledgment were read as follows:

Kong. Danske Videnskabernes Selskab, Copenhagen (122, 123 and list of members); Dr. E. Suess, Vienna (121, 122, 123, &c.); Oneida Historical Society, Utica, N. Y. (124); Kansas State Historical Society (124); Boston Public Library (124); Maryland Historical Society (124); Lackawanna Institute of Science (124); Royal Society of Tasmania (120); Physikalische Gesellschaft, Berlin (123); K. Meteorologisches Institut, Berlin (123).

Letters of envoy were read as follows: United States Geological Survey, Washington, D. C.

A circular was received from the Trustees of the Elizabeth Thompson Fund stating that the income was again available for appropriations in aid of scientific work; that applications for the same should be made to Dr. C. S. Minot, Boston, Mass.

Accessions to the Library were announced from the following:

Astronomische Nachrichten, Kiel: Zoologischer Anzeiger, Leipzig; Der Naturforscher, Tübingen: K. Statistika Central Byrån, Stockholm; Musée R. d'Histoire Naturelle de Belgique, Bruxelles; R. Società Italiana D'Igiene, Milan;

Société de Géographie, Paris; Royal Society, "Nature," Benjamin Ward Richardson, M. D., London; Geological and Natural History Survey of Canada, Montreal; Rev. Edward E. Hale, Boston; Harvard University, Edward C. Pickering, Cambridge; Prof. James D. Dana, New Haven; Astor Library, New York; College of Pharmacy, Historical Society of Pennsylvania, Messrs. A. E. Foote, Philip H. Law, Henry Phillips, Jr., Philadelphia; War Department, Department of State, U. S. National Museum, Hydrographic Office, U. S. Geological Survey, Washington; Cincinnati Society of Natural History; State Historical Society of Wisconsin, Madison; Minnesota Historical Society, St. Paul.

This being the Stated Meeting for the balloting for candidates for membership, an election was held and the following declared duly elected members of the Society:

No. 2134. John S. Billings, M.D., LL.D., Washington, D. C.

No. 2135. Henry F. Osborn, Professor of Geology, Princeton, New Jersey.

Pending nominations Nos. 1154, 1155 and 1156 and new nominations Nos. 1157 and 1158 were read.

Dr. Harrison Allen made a verbal communication on "Muscular Anomalies in the Subject of an Idiot."

The Minutes of the Board of Officers and Council were submitted.

The Board recommended that the Society should abandon the quarterly issue of its Proceedings and return to the original half-yearly publication.

The Board recommended that the principal of the Michaux legacy should be invested in American securities.

And on motion the meeting was adjourned.

Stated Meeting, March 4, 1887.

Present, 26 members.

President, Mr. FRALEY, in the Chair.

Prof. John F. Ryder, a newly-elected member, was presented to the Chair and took his seat.

Letters were read, accepting membership, as follows: Dr. John S. Billings, Washington, D. C.; Prof. Henry F. Osborn, Princeton, N. J.; Sir Monier Monier-Williams, London; Remi Simeon, Paris; Prof. Paul Topinard, Paris.

Accessions to the Library were announced from Gesellschaft für Erdkunde, R. Friedlander & Sohn, Berlin; Gartenbauverein, Darmstadt; Verein für Erdkunde. Halle a S.; Deutsche Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, München; Académie R. de Copenhagne; Société R. des Sciences de Liege; Musée R. d'Histoire Naturelle de Belgique, Bruxelles; R. Accademia dei Lincei, Rome; Sociétés de L'Enseignement et de Geographie, Ecole des Mines, Paris; R. Academia de la Historia, Madrid; Royal Society, R. Astronomical and Geographical Societies, Meteorological Council, London; Philological Society, Cambridge, England; American Antiquarian Society, Worcester; American Journal of Science, New Haven; Brooklyn Entomological Society; Warner Observatory, Rochester; Mr. Thomas H. Dudley, Camden; Numismatic and Antiquarian Society, Dr. William F. Norris, Dr. F. A. Genth, and Henry Phillips, Jr., Philadelphia; Department of State, U. S. Geological Survey, U. S. National Museum, U. S. Fish Commission, Smithsonian Institution, Washington, D. C.; University of California, Sacramento.

The President presented a communication for the Magellanic Premium, "On the correct determination of the Moon's mass," signed "*Baboika*," which was read and referred to Council.

Pending nominations Nos. 1154, 1155, 1156, 1157 and 1158 were read. The recommendations of Council, submitted at the last meeting, were taken up and considered.

On motion it was resolved to discontinue the quarterly publication of the Proceedings of the Society and to return to the former method of semi-annual issue.

On motion it was resolved to sell the principal of the Michaux legacy, now invested in French *Rentes*, and to cause the proceeds of such sale to be remitted to this country, and that the Finance Committee and the Treasurer be directed to take all the steps necessary to sell the same whenever such sale shall be deemed expedient and advisable by them; and further that they shall invest the same in good American securities and that the Officers of the Society be empowered to execute all necessary documents and to comply with all requisite formalities.

And the meeting was adjourned by the President.

Stated Meeting, March 18, 1887.

Present, 14 members.

President, Mr. FRALEY, in the Chair.

A letter was read from Columbia College, New York city, New York, inviting the Society to be present by delegate at its approaching Centennial anniversary, April 13, 1887, and the President was empowered to appoint a suitable person to represent the Society.

Letters of envoy were received from the K. P. Meteorologisches Institut, Berlin; Physikalisch-Medizinische Societät, Erlangen; Meteorological Office, Statistical Society, London; Bureau of the Mint, Washington.

Accessions to the Library were reported from the Royal Society of New South Wales, Sydney; K. Akademie der Wissenschaften, Verein zur Beförderung des Gartenbaues in den K. Preussischen Staaten, Physikalische Gesellschaft, K. P. Meteorologisches Institut, Berlin; Physikalisch-Medizinische Societät, Erlangen; K. Nordiske Oldskrift, Selskab, Copenhagen; Institut Royal Grand-Ducal de Luxembourg; Academie Royale de Belgique, Bruxelles; R. Accademia dei Lincei, Rome; Biblioteca N. C. di Firenze; Société de Geographie, Paris; R. Geographical Society, Statistical Society, Meteorological Council, "Nature," London; Philosophical Society of Glasgow; Manitoba Historical and Scientific Society, Winnipeg Board of Trade, Mr. Charles N. Bell, Winnipeg; Museum of Comparative Zoölogy, Cambridge; Meriden Scientific Association; Wesleyan

University, Middletown; Connecticut Academy of Arts and Sciences, New Haven; Editor of "The Critic," New York; Natural History Society, Trenton; Academy of Natural Sciences, College of Pharmacy, Editors of "The American Naturalist," Messrs. H. H. Furness, H. Carvill Lewis, Henry Phillips, Jr., Philadelphia; Gov. James A. Beaver, Harrisburg; Johns Hopkins University, American Journal of Archæology, American Journal of Philology, Baltimore; Light-House Board, Census Office, United States Coast and Geodetic Survey, Bureau of the Mint, Washington; Mr. Jed. Hotchkiss, Staunton; Minnesota Historical Society, St. Paul.

The following papers were presented for the Proceedings:

By Dr. F. A. Genth. "Contributions from the Chemical Laboratory of the University of Pennsylvania. No. XXIX. Contributions to Mineralogy."

Through the Secretaries:

From Prof. John J. Stevenson—"A Geological Reconnaissance of Bland, Giles, Wythe, and portions of Pulaski and Montgomery counties of Virginia."

From Prof. E. D. Cope, on "The Reptilian Fauna of the Mato Grosso, Central Brazil."

Pending nominations Nos. 1154–58 and new nomination No. 1159 were read, and the meeting was adjourned by the President.

Stated Meeting, April 1, 1887.

Present, 16 members.

President, Mr. Fraley, in the Chair.

A letter of envoy was read from the Meteorological Office, London.

Letters of acknowledgment were read from the K. Zoolog. Genootschap, Amsterdam (124); the Royal Society, Edinburgh (122).

A letter was read from "*Baboika*," requesting the return of a communication under that name for the Magellanic premium, which was on motion ordered to be returned to the writer. A letter was read from M. J. Thore, of Dax, France, accompanying his pamphlet, entitled "*Une Nouvelle Force?*"

A photograph for the Society's Album was received from Prof. J. W. Moore, of Easton, Pa.

Accessions to the Library were announced from Geological Survey of India, Calcutta; Gartenbauverein, Darmstadt; Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; "Der Naturforscher," Tübingen; Sociéte Hollandaise des Sciences à Harlem; Biblioteca N. C. di Firenze Societé Toscana di Scienze Naturali, Pisa; R. Accademia dè Lincei, Rome; Société de Borda and Mr. J. Thore, Dax; Sociétés de Geographie, de L'Enseignement and publisher of the Revue de L'Enseignement Secondaire et Supérieur, Paris; Sociedade de Geographia, Academia R. das Sciencias, Lisbon; Royal Society, Geological Society, Royal Astronomical Society, Meteorological Council, "Nature," and "The Earth," London; Cambridge Philological Society; Bath and West of England Society; Natural History Transactions of Northumberland, Durham and New Castle on Tyne; publisher of the "Travelers' Record," Hartford; Brooklyn Entomological Society; Franklin Institute, Engineers' Club, Journal of Medical Sciences, Mercantile Library Co., publisher of the "American Naturalist," and Mr. Henry Phillips, Jr., Philadelphia; Germantown Dispensary and Hospital; Johns Hopkins University, Prof. Ira Remsen, Baltimore; Bureau of Education, Department of State, Washington, D. C.: Rev. Stephen D. Peet, and the publisher of "The Open Court," Chicago; Observatorio Meteorologico Magnetico Central, Mexico.

The Secretaries presented a communication from Prof. E. W. Claypole, Akron, Ohio, entitled "On Organic Variation, indefinite not definite in direction, an outcome of environment."

Prof. Barker made a communication on the methods and discoveries of Prof. Pickering in Astronomical Physics, based upon his researches with the Bache and Draper funds, and exhibited spectra of the stars *a Cygni* and *a Tauri*, on which some remarks were made by Dr. Frazer.

Pending nominations Nos. 1154–59, and new nominations Nos. 1160–66, were read.

Dr. D. G. Brinton offered the following resolution: "That after action on the candidates now proposed for membership, the resident members shall be limited to 150 persons."

Dr. Frazer offered as an amendment: "That a Committee of scrutineers be elected as a permanent committee of the Society, of which the duty shall be to examine the qualifications of all candidates for membership and report upon the same to the Society, and no vote shall be taken on candidates by the Society, until the presentation of a report on their qualifications by the scrutineers."

At the suggestion of the President, the motions were withdrawn, and Dr. Brinton offered the following substitute, which was unanimously adopted: "Resolved that the President be authorized to appoint at his leisure a committee of five members to consider these resolutions and the whole subject of the restriction of membership in the Society, and to report its action to the Society.*

Prof. Barker stated that he had received from Prof. G. A. Hirn, of Colmar, a letter accepting membership in the Society, and thanking it for the honor conferred.

And the Society was adjourned by the President.

Stated Meeting, April 15, 1887.

Present, 15 members.

Mr. Thomas H. Dudley in the Chair.

Correspondence was submitted as follows: A circular from the Académie des Sciences, Arts et Belles-Lettres, Dijon, announcing the awarding of prizes.

Envoys from the Physikalische Central Observatorium, St. Petersburg; K. Preuss. Geologische Landesanstalt u. Berga-

* On April 1, the President appointed Dr. D. G. Brinton, Chairman; Dr. Frazer, Dr. Wm. Thomson, Dr. Goodwin and Mr. Ingham as the committee.

cademie (Berlin), and requesting exchanges;* R. Geographical Society, London; Col. Garrick Mallery, Washington, D. C.

Acknowledgments from the Comité Géologique, St. Petersburg (122); Anthropologische Gesellschaft, Berlin (96–124); Verein für Thüringische Geschichte und Alterthumskunde, Jena (96–110, 112–124); Fondation de P. Teyler Harlem (124); Bataafsch Genootschap van Proefondervindelijke Wijsbegeerte, Rotterdam (124); Société R. des Sciences, Liège (124), and asks for (100);† Société D' Emulation d'Abbeville (124); Société Historique Artistique et Scientifique, du Cher (119); Cambridge Philosophical Society and University Library, Cambridge, England (124); Royal Institution, Society of Antiquaries and Sir Richard Owen, Royal Horticultural Society, London (124).

Accessions to the Library were received from the Geological Survey of India, Calcutta; Société Impériale des Naturalistes, Moscow; Natural History Society, Odessa; Comité Géologique, Physikalische Central Observatorium, St. Petersburg; R. Friedlander and Sohn, Berlin; Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; Dr. F. v. Sandberger, Würtzburg; Académie R. de Belgique, Bruxelles; R. Società Italiana D'Igiene, Milan; Biblioteca, N. C. V. E., Rome; R. Academia de la Historia, Madrid; Royal Society, R. Geographical Society, R. Meteorological Society, Meteorological Council, "Nature," London; Rousdon Observatory, Devon; Philosophical Society, Cambridge (England); Massachusetts Historical Society, Boston; Museum of Comparative Zoölogy, Cambridge; Free Public Library, New Bedford; Providence Public Library; publishers of the "Travelers' Record," Hartford; American Journal of Science, New Haven; Brooklyn Entomological Society, American Chemical Society, Meteorological Observatory, New York; Historical Society of Pennsylvania, College of Pharmacy, publishers of "The American Naturalist" and "Naturalists' Leisure Hour," Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Baltimore; Hydrographic Office, Garrick Mallery, Washington, D. C.

* Ordered to receive from 96.

† Ordered to be sent.

Elliott Society and Art, Charleston; Wm. Harden, Savannah: Cincinnati Society of Natural History.

A paper for the Transactions by Joseph L. Hancock, of Chicago, on the Datames Magna, was presented and referred to a committee to be appointed by the President.

The following communications were offered (through the Secretaries) for the Proceedings: "On the medical mythology of Ireland," by Mr. James Mooney, Bureau of Ethnology, Washington, D.C.; "On the relation of Aerolites to Shooting Stars," by Prof. Daniel Kirkwood, Bloomington, Indiana; "On the Triassic mammals Dromatherium and Microconodon," by Prof. H. Osborn, Princeton, N. J.

Prof. Cope made a communication "On the Vertebrata of the Trias of New Mexico," which he illustrated by specimens.

Pending nominations Nos. 1154–1166, and new nominations Nos. 1167, 1168, were read.

The Trustees of Building Fund presented their annual report.

A communication was presented from Dr. Brinton, Chairman of the Special Committee, appointed at the last meeting, reporting progress, and on motion the committee was continued.

And the Society was adjourned by the presiding member.

Stated Meeting, May 6th, 1887.

Present, 13 members.

President, Mr. Fraley, in the Chair.

Correspondence was submitted as follows: Letters of envoy from Department of Mines, Wellington, New Zealand; Hong Kong Observatory; Institut Météorologique de Roumanie, Bucharest; Maatschappij der Nederlandsche Letterkunde te Leiden; Bureau des Longitudes, Paris; Meteorological Office, London; Literary and Philosophical Society of Liverpool.

Letters of acknowledgment from The Royal Society of New South Wales (122); Comité Géologique de la Russie, St. Petersburg (124); Prof. Serge Nikitin, St. Petersburg (124);

Société des Antiquaires de la Morinie, Saint Omer (121, 122, 123), and Register, etc.

A letter was read from Dr. Genth in reference to an addition to his paper on Pseudo-maple Mimetites.

Accessions to the library were reported from the Department of Mines, Wellington, New Zealand; Hong Kong Observatory; K. Akademie der Wissenschaften; Comité Géologique, St. Petersburg; Institut Météorologique de Roumanie, Bucharest; K. K. Zoologisch-Botanische and Geographische Gesellschaften, K. K. Geologische Reichsanstalt, Vienna; Hungarian Academy, Budapest; K. Preussischen Akademie der Wissenschaften, Deutsche Geologische Gesellschaft, and R. Friedlander & Sohn, Berlin; Prof. G. vom Rath, Bonn; Gartenbauverein zu Darmstadt; Naturwissenschaftliche Gesellschaft "Isis," Dresden; Oberlausitzer Gesellschaft der Wissenschaften, Görlitz; Deutsche Gesellschaft für Anthropologie, Ethnologie, etc., München; Voigtländ. Verein für Naturkunde, Reichenbach; Maatschappij der Nederlandsche Letterkunde, Flora Batava, Leiden; Musée R. d'Histoire Naturelle de Belgique, Bruxelles; Naturwissenschaftliche Gesellschaft, St. Gallen; R. Accademie dei Lincei, Rome; Société Linnéenne de Bordeaux; Musée Guimet, Institution Ethnographique, Bureau des Longitudes, Sociétés de l'Enseignement superieur, Zoologique, Marquis de Nadaillac, Paris; Société des Antiquaires de la Morinie, Saint Omer; Literary and Philosophical Society, Liverpool; R. Astronomical Society, Meteorological Council, Diplomatic Review Office, Rev. E. W. Syle, London; Yorkshire Geological and Polytechnic Society, Halifax (England); Natural History Society, Montreal; The Canadian Institute, Toronto; Astronomical Observatory of Harvard College, Prof. Eben Norton Horsford, Cambridge; Massachusetts Historical Society, Boston; American Journal of Science, New Haven; Academy of Sciences, Historical Society, "The Forum" Publishing Co., Prof. John J. Stevenson, New York; Secretary of Internal Affairs, Harrisburg; Johns Hopkins University, Baltimore; United States National Museum, Hydrographic Office, Washington (D. C.); University of Virginia; Scientific Association of Peoria; State Historical Society, Iowa City; Impereal Observatorio do Rio de Janeiro.

Dr. Horn, from the Committee on the *Datames Magna*, reported progress, and on motion the Committee was continued.

A paper by William Blasius on "The Signal Service Bureau, its methods and results," was presented.

Prof. Cope presented MS. of his communication on the "Vertebrata of the Trias of New Mexico," with a plate.

A communication was presented for the Magellanic premium, signed "Magellan," which was referred to Council.

Pending nominations 1154 to 1168 and new nomination 1169 were read.

Dr. Brinton, chairman of the Committee appointed April 1, 1887, presented a report, and the Committee was on motion discharged.

The President reported receipt and payment to the Treasurer of $132.43, interest on the Michaux legacy.

Notice having been given to the members that the Society would consider the subject of the sale of the French *Rentes*, constituting the corpus of the Michaux legacy, the subject was taken up and the President informed the Society that he had handed to Drexel, Harjes & Co., of Paris, an attested copy of the resolution adopted on March 14, 1887, for the sale of the said Rentes, and one of the forms of sale and transfer used here for selling and transferring stocks and loans and inquired whether the sale could be made in that way, and that he had also sent to them a copy of the laws of this Society. In reply they had sent a letter indicating what they by inquiry had found to be deemed necessary, which letter was then read to the Society.

The President then stated that he had prepared the following resolutions in order to meet the views suggested in said letter, and submitted them for the action of the Society thereon, as follows:

"*Resolved*, That the Society authorizes the sale of certificates of 2778 Rentes, French 3 per cent, which the American Philosophical Society possesses in its name upon the books of the French Public Debt No. 279,732 of Seriè 7, coming from the Michaux legacy.

"*Resolved*, That Frederick Fraley, President, and J. Sergeant Price, Treasurer, of the American Philosophical Society, be and they are hereby authorized and empowered to make, execute and deliver under the corporate seal of the Society a power of attorney in legal form constituting John H. Harjes, of the firm of Drexel, Harjes & Co., Paris, France, the attorney of said Society to sell, assign and transfer to any purchaser thereof, the 2778 francs French three per cent *Rentes* described in the foregoing resolution, and to do all matters and things legally necessary for the sale, transfer and assignment of the said *Rentes* that may be required by the French Treasury."

The resolutions were seconded by Dr. Ruschenberger, and after due consideration were unanimously agreed to and further action thereon was ordered to be made part of the stated business of the meeting of the Society to be held on May 20th, 1887, of which due notice shall be given to the members.

And the Society was adjourned by the President.

Stated Meeting, May 20, 1887.

Present, 38 members.

President, Mr. FRALEY, in the Chair.

Dr. W. H. Wahl was presented to the Chair and took his seat.

Correspondence was submitted as follows: Envoys, from the Hong Kong Observatory; Geological Survey of India; Naturforschende Verein in Brünn; K. Sachsischer Alterthums-Verein, Dresden; Meteorological Office, London; Department of the Interior, Washington, D. C.

Letters of acknowledgment from the South African Philosophical Society, Cape Town (96–123 and Register, etc.); Prof. J. J. Steenstrup, Copenhagen (124); Observatorio Astronomico Nacional Mexicano (123).

Accessions to the Library were received from the Hong Kong Observatory; China Branch of the R. Asiatic Society, Shanghai; The Great Trigonometrical Survey of India, Dehra Dun; K. Russische Geographische Gesellschaft, St. Petersburg; Anthropologische Gesellschaft, Wien; Gesellschaft für Anthropologie, Ethnologie, &c., K. Preussische Geologische Landesanstalt und Bergakademie, Gesellschaft für Erdkunde, Berlin; Naturforschende Verein in Brünn; Gartenbauverein zu Darmstadt; Sachsische Geschichte und Alterthumskunde Verein, Dresden; Prof. Dr. Paul Albrecht, Hamburg; K. Sachsische Gesellschaft der Wissenschaften, L. Fernan (publisher), Leipzig: Verein für Erdkunde, Stettin; Société Hollandaise des Sciences à Harlem; Académie R. de Belgique, Bruxelles; Biblioteca N. C. di Firenze; R. Società Italiana D'Igiene, Milan; R. Accademia dei Lincei, Rome: Société Americaine de France, Société de Geographie, Paris; R. Accademia de la Historia, Madrid; Meteorological Council, Nature, London; Nova Scotia Institute of Natural Sciences, Halifax; Harvard University, Cambridge; Rhode Island Historical Society, Providence; Buffalo Library: American Chemical Society, publisher of "The Public Service Review," Prof. Samuel Lockwood, New York; College of Pharmacy, Zoölogical Society, Philadelphia: Prof. Ira Remsen, Baltimore; U. S. Naval Institute, Annapolis: U. S. Geological Survey, Department of Agriculture, Washington, D. C.

Dr. Horn, from the Committee on the "Datames Magna," reported progress, and on motion the committee was continued.

The following deaths were announced: Prof. Bernard Studer, Berne, May 2, 1887, in his 93d year; John T. Napier, Rothesay, Scotland, May, 1887, in his 29th.

On motion the President was authorized to appoint a suitable person to prepare the usual obituary notice of Mr. Napier.

The minutes of the Board of Officers and Council were submitted.

On motion the President was authorized to appoint at his leisure a committee of five (5) members to examine the communication signed "Magellan," submitted for the Magellanic premium, and to report to Council as to its merits.

Notice having been given to the members that the Society would take a final action upon the question of the sale of the French *Rentes*, constituting the Michaux legacy, the same was taken up as the stated business of the meeting and considered, and the resolution passed at the last stated meeting of the Society was again put to the vote and unanimously adopted.

This being the stated meeting for balloting for members an election was gone into, and after scrutiny, by the tellers, of the votes given, the following were declared to have been duly elected members of the Society:

No. 2136. Mr. Joseph S. Harris, Philadelphia.
No. 2137. Dr. William Powell Wilson, Philadelphia.
No. 2138. Dr. James Tyson, Philadelphia.
No. 2139. Mr. William Henry Rawle, Philadelphia.
No. 2140. Mr. Henry D. Wireman, Philadelphia.
No. 2141. Prof. Albert H. Smyth, Philadelphia.
No. 2142. Miss Helen C. de S. Abbott, Philadelphia.
No. 2143. Mr. Henry H. Houston, Philadelphia.
No. 2144. Prof. William T. Barnard, Baltimore.

Pending nominations Nos. 1156, 1159 and 1164 were on motion deferred until the next regular meeting for the balloting for candidates.

Pending nomination No. 1169 and new nomination No. 1170 were read.

A paper was presented, through the Secretaries, by Prof. John J. Stevenson, "Notes on the Surface Geology of Southwest Virginia."

A letter was read from Dr. Frazer in reference to the discharge, at the last meeting, of the committee appointed April 1st, asking that "the action of the Society be recalled."

Dr. J. Cheston Morris moved "that the resolution of the Society adopted at the last meeting discharging the said committee be reconsidered."

The motion was seconded and after discussion being put to a vote, the yeas were 15 and nays 20, and the Society refused to reconsider the said motion.

And the Society was adjourned by the President.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXIV. JULY TO DECEMBER, 1887. No. 126.

A Contribution to the History of the Vertebrata of the Trias of North America. By E. D. Cope.

(*Read before the American Philosophical Society, April 15, 1887.*)

The vertebrata of the Trias of North America are not as yet well known, and scarcely twenty species have been described. Those known to the writer in 1870 are enumerated in the Transactions of this Society, Vol. xiv; and the species discovered in Pennsylvania are catalogued in the Proceedings of this Society for 1886, p. 403. Some species from New Mexico are described in the American Naturalist, 1881, p. 922,* and April, 1887. Descriptions of several forms from this formation, from the Rocky Mountain region, with plates, were given in the Report of the U. S. Geol. Geogr. Survey W. of the 100th Meridian, 1877.

I am now able to add descriptions of some new species from New Mexico; and furnish additional characters of species already described.

1. EUPELOR DURUS Cope. Transac. Amer. Philos. Soc., 1869, p. 25, V. xiv.

A good many fragments of this species or one nearly allied to it were obtained by Mr. C. M. Wheatley, in York county, Pennsylvania. These pieces are not all as yet identifiable, but one of them consists of a large part of the ramus of the lower jaw which supports the bases of the posterior teeth, but from which the cotyles and angles have been broken off. The bases of the teeth are cylindric, and show delicate grooves, being similar to those of Eryops, and proving that my original reference of teeth to this genus was probably correct. All the bones show the coarse honeycomb pattern of sculpture of the external surfaces characteristic of the species. Towards the margins of the bones the pits become confluent into radiating grooves. A subtriangular plate measures:

	M.
Length	.345
Greatest width	.140

* *Belodon buceros* and *B. scolopax* Cope.

The fragment of jaw measures :	M.
Depth at last tooth	.040
Length, including three teeth	.027

Nothing can yet be determined as to the characters of the vertebræ of this form.

2. Typothorax coccinarum Cope. U. S. G. G. Survey W. of 100th Meridian, Capt. G. M. Wheeler, 1877, iv, Pt. ii, p. 30. Pl. xxii, figs. 4, 5 and 9. American Naturalist, 1887, p. 468.

The genus Typothorax was distinguished by me, l. c., from Belodon, on account of the regularly pitted surface of the dermal bones. With such dermal bones others of a different character were found, which it was thought best to refer to the same genus, and a fragment of maxillary bone found near by was included in the description. I now suspect that the dermal bones which do not possess the pitted character belong to some other reptile, and the fragment of jaw is not to be referred, certainly, to the *Typothorax coccinarum,* but is more likely a part of a Belodont Saurian.

The additional material belonging to this genus and species which I possess consists of two ribs with corresponding dermal bones attached to their superior surfaces, and two femora, one of which adheres to one of the ribs. Also several other more or less incomplete dermal bones. There are numerous other bones accompanying, but their reference is not certain.

Char. Gen. The peculiarities of this genus as displayed by these specimens are as follows : Ribs greatly expanded but with free margins, each overlaid by a band-like dermal bone for its entire length. The dermal bones with pitted sculpture and straight, simple margins, the one acute and the other obtuse. The margins of the ribs are similar to each other. It results that a gaping groove is formed between the parallel acute edge of the dermal plate and the rib into which the appressed edges of the adjacent rib and plate enter and fit. Thus is formed a complete cuirass covering the body. Femur sigmoid, without distinct head or trochanters, excepting a prominent, ridge-like third trochanter on the posterior face. Condyles with a posterior lobe separated from the external lobe by a fossa.

It is possible that one of the ribs described is abdominal in position, as it does not appear to have had a head. There is no head preserved on the other. The dermal bands described may be therefore abdominal. The ribs are, however, strongly curved in the longitudinal direction, and it is to be supposed on this account that they are dorsal, and perhaps in the position of flying ribs. The adhesion of a femur to one of them indicates posterior position. The character of the femur is different from that of the Belodontidæ in its trilobate condyles, approaching thus the Goniopod Dinosauria. The third trochanter is much better developed than in any known Belodont.*

* Von Meyer Palæontographica, vii, 1861.

Future comparison must be had with the genus Aëtosaurus Fraas,* which accompanies Belodon in the Upper Keuper of Wurtemberg. That genus is encased in parallelogrammic scuta arranged in contiguous cross-bands, on both surfaces of the body. But the scuta are not co-extensive with the ribs as in Typothorax; at least the latter are represented by Fraas as much narrower than the osseous dermal bands. The latter are also transversely subdivided in Aëtosaurus.

It is highly probable, however, that Typothorax represent Aëtosaurus in the Upper Trias of North America, and may belong to the same family of the order Rhynchocephalia.

The relations of the dermal bones and ribs are highly interesting. The great expansion of the latter needs but the development of sutural surfaces on their borders to produce an osseous continuum. The same modification of the dermal bones above it would form a second external roof. A subsequent fusion of the superior and inferior roofs would give us the testudinate carapace. And this history would be what embryology teaches us is the origin of that remarkable modification of the dermal and true skeleton exhibited by that order of reptiles. It is probable that Typothorax is nearly allied to the type from which the order of tortoises has been derived. It is unfortunate that we know nothing of its skull and vertebræ, but there is nothing in the characters of the femora to preclude the above hypothesis. They belong to a type which progressed in a prone position, and which probably differed much from both Belodonts and other Dinosauria.

Char. Specif. Ribs strongly convex in the longitudinal direction; in the transverse direction flat above, and with a longitudinal convexity below. This convexity occupies about one-third of the inferior surface, and extends obliquely to one of the lateral borders at the extremity. At the other extremity the surface is flat, the rib-convexity disappearing. In both ribs one edge is subacute and the other obtuse. The rib-thickening runs out to the thin edge. The dermal scuta have the same width as the ribs. They have thicker and thinner edges corresponding with those of the ribs. Where the rib-thickening of the latter is prominent, the dermal bone has a median convexity below; and this disappears at the other end as the thickening does from the rib. The superior face of the dermal bones is perfectly flat. It is sculptured with coarse shallow pits, separated by obtuse ridges, which have a reticulate pattern, since the pits are not in rows.

These osseous bands are probably in contact, thus forming an impenetrable buckler, as in Aëtosaurus. One edge of the osseous combination of rib and dermal plate gapes, the thin edges of the two elements diverging so as to receive the margin of the adjacent band. The matrix along this border is clearly impressed so as to prove the former presence of the succeeding portion of the carapace.

* *Aëtosaurus ferratus* Fraas; Festschrift zur Feier d. vierhundertjährigen Jubiläums Univ. Tübingen, 1877.

Measurements.	M.
Length of rib on curve on inner side	.276
" " chord of rib	.250
Width of rib near proximal end	.090
" " " distal end	.074
Thickness of rib at proximal end	.005
" " " middle	.014
" " scuta at proximal end	.005
" " " " middle	.011
" " " " distal end	.008
Average diameter of fossæ of do.	.007

The *femur* is quite characteristic. The long axes of the extremities form an angle of about 45° to each other. The shaft is incurved from the third trochanter proximad, and is expanded more externally than internally at the distal extremity. The proximal extremity is rhomboid in outline ; the internal border convex, the anterior concave, the posterior less concave, and the postero-exterior nearly straight, and joining the anterior by an acumination with obtuse apex, which represents the great trochanter. Surface of head, flat-convex. The junction of the internal and external posterior faces is marked by a convexity ; and the shaft below the external posterior face is longitudinally concave. The third trochanter marks about two-fifths the length of the shaft, and is quite prominent. It is convex externally, and concave internally. Below it the section of the shaft is a transverse oval, wider exteriorly. The condyles of the femur are considerably expanded transversely, the external being the most produced. The rotular groove is shallow but distinct. The external condyle, as already remarked, has a distinct posterior lobe, which is separated from it externally by a large ? ligamentous fossa within the bonndary of the articular surface. This posterior lobe is well within the exterior border, and bounds the intercondylar groove on the external side. It presents posteriorly, and is narrowed and obtuse. A corresponding part of the internal condyle presents posteriorly also.

Measurements of femur.			M.
Total length (axial)			.230
Diameters of head	anteroposterior (greatest)		.060
	transverse (axial)		.035
Anteroposterior diameter at great trochanter			.031
Diameters of shaft	anteroposterior		.022
	transverse		.030
Diameters of condyles	transverse		.081
	anteroposterior	internally	.040
		at groove	.032
		at posterior lobe	.051

The parts of this individual preserved indicate an animal of the average size of the Mississippi alligator. More perfect specimens will be awaited with much interest.

3. EPISCOPOSAURUS HORRIDUS. Gen. et sp. nov.

This species is indicated by a number of bones which were excavated at the same place. They are: Two caudal vertebræ, a proximal and a distal; a humerus; two ulnæ; a femur lacking the condyles; a proximal part of a tibia; the distal part of a fibula; a calcaneum, and a number of dermal bones. The only part of the skull possibly belonging to this animal is a splenial bone.

Char. Gen. The generic characters, so far as ascertainable from the materials, resemble those of Belodon with certain exceptions. Chief among the latter is the disproportion, in dimensions, between the anterior and posterior extremities, which is as great as that existing in many Dinosauria proper. Appropriately to this relation, the femur differs from that of Belodon in the absence of curvature of the shaft, having the straight form of that of most Dinosauria proper. There are no trochanters of any kind on this femur, and its head has the wedge-shaped Belodon outline. The head and condyles of the humerus are transversely expanded; the shaft is contracted; condyles not specialized. No epicondylar foramina of either side, but a strong ectepicondylar groove, which cuts off a narrow ectepicondylar ridge, which terminates freely. The caudal vertebræ are elongate, indicating a powerful tail. But one species is yet known.

Char. Specif. The body of the anterior caudal vertebra has a wedge-shaped section, the apex inferior, representing the section of an obtuse median keel. The articular faces are subcircular, widening upwards. Both are concave, the posterior more so than the anterior, which is nearly plane. No lateral ridges on the body. Arch lost. The posterior caudal is long and slender, and has a long compressed neural arch. The section of the body is heptagonal, as there are two low lateral angles on each side, and an obtuse median inferior keel. The inferior lateral angle is stronger than the superior. There is not so much difference in the concavity of the articular extremities, as in the case of the larger vertebra.

Dimensions of caudal vertebræ.		M.
Length of centrum of anterior vertebra		.070
Diameters of anterior face	transverse	.050
	vertical	.048
Length of centrum posterior vertebra		.069
Diameters anterior face	transverse	.033
	vertical	.031

The *humerus* is remarkable for the small diameter of its shaft as compared with the expanse of its extremities. The long axes of these extremities make an angle of about 45° with each other. The articular surface, which is co-extensive with the head, is long and narrow, widening gradually to the inner rounded extremity. Viewed in profile it is strongly convex, the convexity being a little nearer the internal than the external extremity. The articular surface descends on the inner edge of the bone towards but not to the bicipital crest. Viewed proximally, the convexity of the head is as wide as the inner extremity, and is distinguished from it by a concavity of the inner side. The bicipital crest is the incurved external border. It commences opposite the prominence of the inner extremity of the head, and extends but a short distance down the shaft. It is quite prominent. The face of the bone below the head displays a very shallow concavity. The posterior face is recurved towards the two margins, as we approach them. The shaft is very much contracted. Its section at the middle is a wide oval; the external edge subacute, the internal broadly rounded. The distal extremity is much expanded, though not so widely as the proximal end. The expansion is greater internally than externally. Neither epicondylar prominence, however, extends much beyond the articular surface. The latter is rather narrow, and is curved, the concavity anterior. The two extremities are wider than the middle region, the external part being the widest. There is a deep groove on the posterior face near the external edge, which runs out, leaving the external epicondylar process to terminate at about 20 mm. proximad of the condyle. The latter terminates outwards in an acute angle, which marks the internal edge of the ectepicondylar groove. The epitroclear fossa is well defined. Posterior face plane.

Measurements of humerus.

			M.
Total length			.220
Diameters of head	long (straight line)		.088
	transverse	internal	.025
		greatest (submedian)	.024
		least (external)	.015
Diameters at middle of shaft	anteroposterior		.021
	transverse		.027
Diameters of distal end	transverse	with ectepicondylar crest	.076
		below " "	.072
	anteroposterior	internal	.021
		median	.018
		external	.029

The *ulna* is characterized by its small size, and its great compression, especially of the distal half. The olecranon is deep, but it scarcely projects behind the cotylus, where it is more prominent than at the inferior border. On the external side a regular convex mark extends from the base of the coronoid process to the inferior posterior angle. Behind this arc-like border, the surface of the bone is dense and smooth, as though for a cartilaginous cap. What this structure indicates it is difficult to understand, as it is clearly not a muscular insertion. The coronoid process is quite prominent. The external face of the shaft is convex in the vertical section ; the internal flat. The vertical diameter increases a little at the distal extremity. The latter is in the plane of the shaft, and is gently convex in both directions. Its narrow proportions indicate a correspondingly feeble carpus.

Measurements of ulna.

		M.
Total length		.161
Depth of ulna	at olecranon	.037
	at coronoid process	.055
	at middle of shaft	.026
	at distal extremity	.035
Width of ulna	at cotylus	.022
	at middle of shaft	.010
	at distal extremity	.012

Parts of the *radius* resemble considerably that of a mammal. The head as a transverse oval, slightly concave, and the shaft is quite narrow, and with an oval section.

Measurements of radius.

		M.
Diameters of head	transverse	.035
	vertical	.020
Diameters of shaft	transverse	.015
	vertical	.012

The *femur* is the characteristic bone of the genus. The specimen preserved lacks only the condyles. The remainder of the bone is perfectly straight. The inner face of the shaft is rounded, becoming flat as it approaches the head. The external edge is an angle which vanishes above the middle of the shaft, to reappear again as a narrow ridge which terminates in the external extremity of the head, which is homologous with the great trochanter. A well-developed obtuse ridge, above the middle of the shaft on the posterior face, represents the third trochanter. The head occupies the entire proximal extremity. Viewed proximally, it is pyriform, with a concavity of the anterior, and a convexity of the posterior outline. The external extremity is narrowed ; the internal is broadly rounded. A wide groove occupies the center of the entire articular surface. Below the middle the shaft is uniformly convex in front; while posteriorly there is a shallow groove just within the external edge.

Measurements of femur.

		M.
Length of fragment preserved		.315
Diameters of head	internal	.057
	median	.052
	exterior	.030
Diameters of shaft below 3d trochanter	anteroposterior	.041
	transverse	.052

The *tibia* is represented by the proximal end only. It is much like that of Belodon, but, like the humerus, is characterized by a relatively small diameter of the shaft. The outline of the head is wide-reniform, the shallow concavity posterior. The articular surface descends on each side of this concavity, giving a convex outline to the superficial layer of the posterior face of the bone. Anteriorly the articular region projects further to one side than to the other, perhaps leaning to the external side.

Measurements of the tibia.

		M.
Diameters of head of tibia	anteroposterior (middle)...	.073
	transverse................	.107
Diameters of shaft	anteroposterior	.032
	transverse	.043

The distal end of the *fibula* is robust. One face of the shaft is concave; the opposite one is convex. On the concave side, one-half the bone projects distad abruptly beyond the other half. On the convex side, the edge of the articular extremity winds obliquely from the one level to the other. This indicates the fact that the articular face forms a segment, equaling three-fifths, of a spiral.

		M.
Diameters distal end of fibula	transverse (axial)......	.080
	anteroposterior	.048

The *calcaneum* has the form usual in crocodiles, and especially in Belodontidæ. It is wider and flatter than in any species known to me. The external rim extends from the anterior to the posterior extremities, and is quite expanded. The distal extremity is pyriform, and its recurved edges bound posteriorly a deep fossa on both the superior and the inferior aspects of the bone. These fossæ are continuous by the open concavity of the internal margin. This margin is flared inwards in front by its truncate anterior face, which bounds the astragaline fossa behind. The latter is wider than deep. The articular surface is divided into two planes; a narrow interior for the tibia, and a wider exterior for the fibula. Both are convex anteroposteriorly, and nearly plane transversely.

Measurements of calcaneum.

		M.
Anteroposterior diameters	longest....................	.90
	at astragaline fossa.........	.52
Transverse diameters	anteriorly......................	.50
	median (greatest)	.91
	posterior......................	.74

The *dermal bones* are of three types, of each of which I select an example. They are all, or nearly all, furnished with a prominence of the superior surface, which is more or less compressed, and which is abrupt at one face, and produced into a keel at the other extremity in the direction of the axis of the bone. All the bones preserved are unilateral in type. The simplest form is oval-parallelogrammic, with a low obtuse median keel, which rises at one extremity into a moderately compressed knob, which terminates abruptly. Shallow grooves separated by ridges radiate from this prominence in all directions. On its sides the sculpture becomes smaller and more irregular. In the second type of bone, the median keel is elevated into a crest which extends the entire length, and cannot be distinguished at any point as a knob. The section of such a bone is triradiate, and it is not always practicable to state which of the three laminæ is the free one. In any case the latter is not median on the fixed portion.

In the third type of dermal bone, the free keel is much developed and rises into a tuberosity so produced as to be a well-developed spine. The inferior surface of the bone is longitudinally concave. The section of the spine is triangular, the apex being the sharp edge which is the continuation of the keel. The sharpness of this edge is such as to render it probable that these spines constituted dangerous weapons of defense. One side of the spine is nearly vertically over the edge of the base, while the other is within the other edge. The surface of the bone is perfectly smooth. None of the dermal scuta of Belodon described by Von Meyer are developed into spines like those of this species.

Measurements of dermal bones.

		M.
No. 1.		
Diameters	anteroposterior	.100
	transverse	.070
Elevation of knob		.031
Distances of knob	from one end	.080
	from the other end	.020
No. 2.		
Length		.085
Elevation of laminæ	No. 1	.037
	No. 2	.016
No. 3.		
Diameters of base	anteroposterior	.096
	transverse	.034
Elevation of spine	from lateral border	.085
	from inferior groove (oblique)	.053
Diameters of spine at base	anteroposterior	.040
	transverse	.020

4. Belodon buceros Cope. American Naturalist, 1881, p. 922.

Some years ago* I identified certain fossils discovered in North Carolina by Emmons as Belodons; and later,† referred a species found by Wheatley in Pennsylvania to the same genus. I was subsequently able to prove that the genus ranged over the Rocky mountains, and that there, as in other parts of the world, it haunted the shores of the Triassic seas and lakes. There are two species of Belodon in my New Mexican collections,

* Proceedings of Academy of Natural Sciences, Philadelphia, 1866.
† Transactions Amer. Philos. Soc., xiv, 1869.

one as large as the gavial of India, the other smaller. In the former the muzzle is keeled above, and rises into a crest in front of the nares. In the other species the muzzle is subcylindric, and does not rise anterior to the septum of the nostrils. The larger species I call *Belodon buceros;* the smaller one *B. scolopax*, and define them below. Bones of the skeleton and of the dermal systems of this genus are common in the New Mexican beds, but I am yet unable to refer them positively to the species represented by the skulls.

Char. Specif. Size of the gavial. Muzzle slender, compressed, with a narrow median superior ridge, rising at the middle of the length into a compressed crest, whose summit is in the plane of the frontal region. Nostrils a little further anterior to the orbits than the diameter of the latter, longer than wide, and separated by a thin septum. Orbits round, looking a little upwards, the interorbital region a little narrower than each orbit. Preorbital region compressed; preorbital foramen large, inferior. The quadrate bones are directed forwards, and then downwards, and their articular faces are in the transverse line of the two rather narrow notches of the posterior outline of the pariëtal bone. The auricular meatus is bounded posteriorly by a descending hook-like process; and the squamosal bone is continued still further posteriorly into a short triangular acute horn. The superior surface of this bone, with the pariëtal and frontal, are roughened with tubercles. The palate has a strong ridge on each side, so as to be grooved. The posterior teeth have compressed denticulate crowns. Tip of muzzle lost. Total length preserved, M. .700; length of muzzle to posterior edge of nares, .420; do. from latter to lines of anterior edge of orbits, .060; do. from do. to posterior pariëtal notch, .160. Width at posterior border of quadrate condyles, .260; interorbital do., .048; do. at slender part of muzzle, .045. Depth of slender part of muzzle, .050; do. of elevated part, .120; do. at pariëtal region, .140.

This species is of the size of the *B. kapfi* Meyer, and is, in the form of the muzzle, intermediate between that species and the *B. plieningeri.*

Foramina. The alisphenoid bones embrace the olfactory lobes of the brain as far forwards as the middle of the orbits, when they contract to a foramen of moderate size. The under face of the median line of the frontal bones is openly grooved in continuation. The basioccipital has a horizontal axis, and is about as long as wide, including the condyle. Its anterior border has a median apex or projection on the sphenoid. The latter forms a transverse band of small anteroposterior diameter to a sharp transverse truncation or anterior border. Whether this is the boundary of this element or not is uncertain. It is probably merely a transverse crest, since in front of it the basicranial axis is continued. The latter is deeply concave in the middle, but sends downwards a process on each side, which fits into a notch of the posterior internal border of the pterygoids. Between these notches the pterygoids underroof the axis, and unite on the median line. This union has a less anteroposterior extent than is represented by

Von Meyer in the *B. kapfi*,* and the posterior nostrils, which commence in front of this union, have a much greater anteroposterior extent than in that species.

There is a fossa in the posterior part of the orbit which extends downwards and forwards. In the superior part of its fundus is the mouth of a canal which extends from the pineal fossa of the brain case. I call this the *orbito-pineal* canal. It will be again referred to in the description of the brain. Below the anterior part of this fossa, and at the base of the closed interorbital part of the brain-case, is the large optic foramen. It looks outwards and forwards, and it is not certain that it is separated from that of the other side by a septum. The lateral walls of the brain-case are imperforate. There is no foramen for the trigeminus in the usual position. A portion of the superior face of the sphenoid bone is split away, and it may be supposed that the trigeminal foramen was at the base of the brain on the line where the lost portion joined the lateral walls. It must have been of small size. A canal traverses the basioccipital bone on each side, commencing in conjunction with that of the opposite side, and extending outwards and backwards, and issuing on the suture joining the basi- and exoccipital bones.

Brain. The cast of the brain-case presents several peculiarities of importance. The size is a little greater than that of an *Alligator mississippiensis* whose skull slightly exceeds that of the *Belodon buceros.* Thus the dimensions of the former are, length 500 mm., width at quadrates 290 mm.; of the *B. buceros*, length 700 mm., width 240 mm. The distribution of parts is different. The prosencephalon is relatively and absolutely smaller in the Belodon, and the mesencephalon is larger. The epencephalon is not very different in the two, and the contraction on each side of it is apparent in the one as in the other. Posterior to it, the medulla is contracted to a still smaller diameter in a manner not seen in the alligator. This region is longer in the Belodon than in the latter. The brain proper is thus bunched up or shorter and more elevated in the Belodon than in the alligator. The contraction to the rhinencephalon is more abrupt in the Belodon. What gives the Belodon its especial character is the presence of an enormous epiphysis. This body is subquadrate in form, and occupies a large fossa in the cranial roof, which is, however, not perforate. On each side of the anterior portion a process extends outwards and forwards, occupying a corresponding anteroposterior fossa in the cranial walls. The process is continued, horn-like, on each side, and the cast forms a continuum through the orbitopineal canal to the orbit. Whether this represents a nervous or arterial canal can only be surmised, but from the size of the process of the epiphysis which enters it, I suspect that a nerve formed part of its contents. There is no median distinction between the halves of the prosencephalon and mesencephalon in the brain-case, thus resembling other crocodiles. The mesencephalic bodies were probably lateral, judging from the greater width of the cast below at the middle, as com-

* Palæontographica, Vol. viii.

pared with the contraction of the part behind the epiphysis. The hypophysis is distinct but not large, and occupies a fossa of the base of the cranial cavity, very much shorter than that possessed by the *Alligator mississippiensis.* The optic nerves issue immediately above and anterior to it.

Comparison with the brain of Diadectes. In these Proceedings for 1885, p. 234, I have described a cast of the brain-chamber of a species of the Diadectidæ from the Permian bed of Texas. As a successor of the Diadectes, and as descendent of probably one of the Clepsydropidæ, considerable interest attaches to a comparison of the brain of Belodon with it.

The first point which arrests the attention in making the comparison, is the similarly huge size of the epiphysis in the two types. A foramen on each side of the base of the epiphysis in the Diadectes gave exit to a process similar to that which enters the orbitopineal canal in the Belodon, and which I called the lateral process of the epiphysis in the latter. (Plate, figs. 1–3, l f). The processes are probably homologous in the two genera, but in the Diadectes they did not extend to the orbit, unless they were continued in membranous walls. There is little resemblance between the two brains in other respects, but they agree in the small size of the prosencephalon, and in the complete enclosure of the rhinencephalon by osseous walls. In the Diadectes there is no optic foramen, but a huge trigeminus; in Belodon, an optic foramen, and a very small trigeminus.

The presence of such a huge epiphysis in the Belodon as compared with its very small size in modern crocodiles, is a point of much interest, and points to its inheritance from the reptiles of the Permian. But if, as is probable, it contained the pineal eye, the latter could not receive light directly from above, since the pariëtal foramen is wanting. The presence of a communication with the orbit becomes interesting in this connection. A minute foramen passes from the base of the rhinencephalon into the orbit in the alligator, but the homology with the *canalis orbitopinealis* is by no means made out. The *nervus orbitopinealis* may have supplied the lack of light due to the closure of the pariëtal foramen, but in what way we are left to conjecture.

The equality of size of the brain of the Belodon to that of the existing alligator is a point of interest.

There is some reason to suspect that the Diadectes relied exclusively on the pineal eye for the sense of sight. The species of the family were probably subterranean in their habits, since their humeri indicate great fossorial power, resembling those of the existing monotremes, and even the mole. The vertebræ are locked together with the hyposphen beside the usual articulations, and the arches of the neural canal form an uninterrupted roof from the skull to the tail, of extraordinary thickness and strength. That the species were not aquatic is rendered probable by the fact that the orbits do not look upwards. Their superior borders are, on the contrary, prominent and straight. Add to this fact the apparent absence of optic foramina, and the probability that the Diadectidæ were blind and subterranean in their habits becomes great.

5. BELODON SCOLOPAX Cope. American Naturalist, 1881, p. 923.

This species is represented by a snout, which includes the anterior border of the nares; it is broken into five pieces, which should be connected with intermediate fragments, which are lost. This muzzle is a little shorter than that of *B. plieningeri*, but is a good deal more slender, the distal part having only half the diameter of the latter. Besides this character, it differs from that of *B. plieningeri* in three others. The extremity of the muzzle is not so much decurved. All the alveolæ have a more lateral exposure, and the lateral ridges of the palate are thus more distinctly seen from the side. The two teeth on the extremity of the muzzle are closely crowded together, and their large alveolæ are scarcely distinct.

The surface of the muzzle is distantly and weakly grooved and punctate. The anterior alveolæ are round, the posterior ones oval. Diameters an inch anterior to nares: transverse, .0230; vertical, .0235. Diameters three inches from extremity: transverse, .019; vertical, .0145.

6. TANYSTROPHÆUS LONGICOLLIS Cope. *Cœlurus longicollis* Cope. American Naturalist, April, 1887 (pub. May 4th), p. 368.

Numerous fragments of this genus are in my collection from the Triassic beds of New Mexico. The vertebræ resemble in various essential characters those which are preserved and described by Marsh as belonging to the species of his genus Cœlurus, and I therefore referred the present species to that genus, as above cited. It is now clear to me that the Triassic species must be distinguished from Cœlurus. Prof. Marsh states that the anterior cervical vertebræ of the latter have the anterior articular surfaces convex, while the posterior are concave. In the Triassic species the third cervical is concave at both extremities, thus resembling the posterior centra. In searching for a name for the Triassic genus, I find that the Tanystrophæus of Von Meyer will probably include the American species in question. This genus was established on caudal vertebræ which nearly resemble those of the New Mexican species. For the present then I will retain for them the generic name first given to the *Tanystrophæus conspicuus* of the Trias of Würtemberg.

The bones in my possession are from all parts of the skeleton, excepting jaws and teeth; fragments of skull, if present, are not yet determinable. These show that Tanystrophæus with Cœlurus,* must be referred to a family of the carnivorous suborder (Goniopoda) of the order Dinosauria. The acetabulum is widely perforate, its pubic and ischiadic processes being widely separated from each other. The pubis has a slender shaft directed downwards, as in Compsognathus, and in Creosaurus† as figured by Marsh, with an anteroposterior expansion proximally, but no symphysis distally. On the other hand the ischia have a symphysis. The

* Amer. Journal Sci. Arts, p. 339, Plate x.

† Amer. Journal Sci. Arts, 1884, Pl. xi, l. c., p. 340.

claws are compressed and strongly curved, and capable of very extensive flexion and extension. I cannot therefore agree with Prof. Marsh that Cœlurus cannot be referred to any known order.‡ It is in fact allied to Megadactylus (Hitchcock) from the Trias of Massachusetts, differing principally, so far as determinable, in the form of the condyles of the femur. They are simple in Cœlurus, but in Megadactylus, the external condyle has the double character seen in Megalosaurus.*

The vertebræ are all of slender proportions, especially those of the neck and tail. These, with most of the bones of the limbs, are hollow, having large central cavities surrounded by thin walls, as in Megadactylus. The parapophyses are confined to the anterior parts of the centrum. In the cervical and dorsal vertebræ there is a conical fossa at each base of the neurapophysis, which unite by their apices in the cervicals, forming a canal distinct from that for the vertebral artery. The zygapophyses are partly interlocking, having convexo-concave oblique articular surfaces. There are four vertebræ of the sacrum (in *T. bauri*), whose arches are coössified as well as the centra. The anterior caudal vertebræ only have chevron bones. Prof. Marsh says they are wanting in the genus Cœlurus; but he does not appear to have possessed the most anterior of the series. In neither species is there a distinct third trochanter of the femur; but there is not far below the great trochanter on the anterior face, a low longitudinal, ridge-like angle. The femoral condyles have but little antero-posterior extent, which implies but little flexure of the knee.

The form seems to have been that of a terrestrial reptile which walked readily on the hind legs, and was probably a great leaper. The extremely long neck is a striking peculiarity, having proportions to the body about like that of the swan. The habits were probably predaceous and carnivorous.

Three species are indicated by my collections.

Char. Specif. Cervical vertebræ one-third longer than those of *Cœlurus fragilis* Marsh, the sides of the centrum not sulcate, the anterior articular face of an anterior centrum not convex. The faces are oblique, showing that the head was carried above the level of the body.

		M.
Length of body of ? third cervical vertebra		.063
Diameters of posterior cup	vertical	.016
	transverse	.019

The *dorsal centrum* has subround articular faces, which are gently concave, and a much contracted shaft. The section of the latter is subround, a little flattened below. The inferior border of the neural arch is coössified and extends well down on the side, its inferior border being marked by an open longitudinal groove. On the superior border of the middle of this groove is an indistinct tuberosity. Above this line at the middle of the neural arch a thin longitudinal broken ridge probably repre-

* See Cope, Trans. Amer. Philosoph. Soc., xiv, 1870. Pl. xiii.

sents the base of the diapophysis. It is bifurcate for more than one-third of its length at each end, the bounding walls embracing a deep conical fossa. The walls of the centrum are thin, including a large central cavity.

		M.
Length of centrum of dorsal vertebra		.042
Diameters of posterior face	vertical	.020
	transverse	.021
Elevation of centrum to middle of diapophysis		.022
Transverse diameter of neural canal		.006

A caudal centrum is much elongate and has somewhat oblique articular surfaces, though they are not so strongly so as in the case of the cervical vertebra. The arch is lost from the specimen, so that nothing can be said of the diapophyses. The articular surfaces are distinctly concave, and the anterior is a little wider than deep, while the posterior is as wide as deep. The middle of the centrum is depressed, giving a well-defined inferior lateral longitudinal angle. There is also a low median inferior angle, which gives way posterior to the two ridges that terminate in the chevron facets, which are separated by a groove.

		M.
Length of caudal centrum		.051
Diameters posterior face	vertical	.023
	transverse	.021

Another caudal vertebra is much smaller, and has no chevron facets. It is more depressed than the larger one above described, and it has a wing-like lateral angle which connects the superior parts of the articular surfaces. Inferior surface flat, bounded on each side by a low angle. Neural arch distinct. It is a question whether this vertebra belongs to this species. It appears to me to be one of the terminal caudals.

		M.
Length of centrum		.035
Diameters of posterior extremity	transverse	.0105
	vertical	.0075

The *ilium* consists almost exclusively of a frame for the large acetabulum, and supports for the pubis and ischium. The anterior and posterior extensions are insignificant. The anterior process is somewhat depressed; the posterior is compressed. The external border of the acetabulum is produced, forming a roof, which is continued nearly to the articulation of the pubic process, and which ceases at a greater distance above the articulation with the ischium. The inner acetabular border is produced downwards, partially closing the acetabulum at its fundus. The pubic articular surface is rather larger than the ischiadic, and has a gently sigmoid longitudinal section, the middle being concave. The pubic surface is on the contrary gently convex in all directions, its outline being triangular. The apex of the triangle is continued into the posterior border of the acetabulum. The sacral or internal side of the ilium is flat.

Measurements of ilium.

	M. No. 1.	No. 2.
Anteroposterior extent at articulations below...	.065	.086
Depth at pubis	.036	
" " ischium	.042	
Anteroposterior diameter acetabulum	.035	.049
Width above acetabulum	.021	.034

The ilium No. 2 may belong to a species distinct from No. 1, as it possesses an anteroposterior crest continued upward from the interior or sacral face, and the external roof of the acetabulum is sloped downwards exteriorly. The question of distortion prevents me from deciding the meaning of these differences at present.

The *pubis* is a very elongate bone, with a proximal extremity widely dilated anteroposteriorly. The proximal end is fan-shaped, the expansion from the axis being posterior. The proximal extremity is narrow, but is widest anteriorly, and displays three surfaces. The anterior one is for the ilium, the middle one is part of the acetabular border, and the posterior and narrowest is for the ischium. The foramen for the internal femoral artery is below the acetabular portion. The anterior border of the pubis to the extremity is rib-like, while the posterior is laminiform. The internal lamina is continued from the antero-internal face, and forms a concavity with the postero-external. Its exact width is not determinable for a good part of the length, for owing to its tenuity its edge is broken off. The distal extremity does not appear to have been united to that of the other side; if it was it could only have been by the laminar edge. The extremity is something like the head of a crocodile's humerus, the laminar edge terminating in the usual position of a deltoid crest. The shaft of the pubis is nearly straight.

Measurements of pubis.

		M.
Length of shaft (a small part wanting)		.228
Diameters proximally	anteroposterior	.057
	transverse (widest)	.020
Diameters distally	anteroposterior	.023
	transverse	.012

The *ischium* is less perfectly preserved, the head and the distal parts only remaining. The ischia form a long symphysis distally, but are not suturally united or coössified. The distal end is moderately expanded anteroposteriorly, and resembles in section a half ellipse. The proximal end has the iliac face a little concave, and the acetabular surface oblique to it, and more concave. The pubic contact is broken off.

Measurements of ischium.

		M.
Diameters proximally	anteroposterior	?
	transverse	.024
Diameters distally	anteroposterior	.030
	transverse	.014

The confluent extremities of the ischium form a surface of contact with the earth on which the animal probably rested at times, as I have suspected to be the case with the genus Megadactylus.* The pubes are directed downwards, and being longer than the femora have projected below the knees. It is probable that the animal rested on the apices of these bones also, as suspected by Marsh in the case of the Goniopoda of the Jurassic.

The *femur* is remarkable for the incurvature of the proximal extremity, so that it might be said to have a neck, but that there is no great trochanter. This form is necessary to avoid contact with the large pubic region. The shaft is a slightly flattened cylinder at the middle, and is a little flatter below. Rotular groove slight. Internal condyle narrower than external, and produced a little farther posteriorly.

		M.
Length of femur		.215
Diameters of condyles	anteroposterior	.024
	transverse	.030
Diameters of shaft at middle	anteroposterior	.014
	transverse	.016

Neither bones of the lower leg nor of the tarsus are certainly preserved. A phalange is of considerable size, and indicates perhaps the first of the internal digit, which is especially large in Megadactylus. The trochlear surfaces are well marked and smooth, the proximal simple, the distal hour-glass-shaped, and with well-marked lateral ligamentous fossæ. The two ligamentous insertions of the proximal extremity are well developed and of unequal size.

		M.
Total length		.043
Diameters, proximal	vertical	.018
	transverse	.015
Diameters, distal	proximal	.013
	transverse	.013

An *ungual phalange* is remarkable for its abrupt but regular curvature, and its great compression. The superior edge is the arc of a circle whose center is on the inferior edge just in front of the ligamentous insertions. The latter form a ridge of each side, just in front of the articular face, and are separated by a deep fossa. The insertion of the extensor ligament is a concave triangular space above the articular surface. The apex is lost.

Vertical depth of unguis	.018
Width do. at base of articular face	.010

This unguis is so proportioned as to have fit the penultimate phalange

* Transac. Amer. Philos. Soc., 1869, Plate xiii.

of the digit to which belonged the phalange previously described above. It indicates powerful prehensile use of the feet.

The *Tanystrophæus longicollis* was about the size of a greyhound. Its neck was like that of a swan, and its tail was of considerable length.

7. Tanystrophæus bauri Cope. *Cœlurus bauri* Cope. American Naturalist, 1887, p. 368.

Almost as much of this species is preserved as of the last. There are no phalanges, but everything else is represented, including several cervical vertebræ, none of which are complete. There is a probable head of a tibia.

The differences are seen in the peculiarities of the cervical vertebræ and of the femur, and in the inferior size. The sides of the cervical centra are deeply and widely grooved on the posterior half, and the superior face of the neural arch is strongly grooved on each side on the anterior half. The femur is not so strongly grooved at the third trochanteric ridge on its exterior side, as in the *T. longicollis*.

		M.
Diameters of anterior face of third cervical	vertical	.010
	transverse	.0115
Width of do., including parapophyses		.017
Diameters of cervical centrum, behind	vertical	.0115
	transverse	.013
Length of dorsal vertebra		.030
Diameters do. posteriorly	transverse	.015
	vertical	.014
Length of sacrum		.073
Diameters of anterior sacral centrum, in front	vertical	.014
	transverse	.015
Diameters of head of pubis	anteroposterior	.032
	transverse	.010
Diameters head of ischium	anteroposterior	? .023
	transverse	.013
Diameters distal end ischium	anteroposterior	.020
	transverse	.013
Transverse diameter of femoral condyles		.022
Diameters head of tibia	anteroposterior	.024
	transverse	.018

The head of the *tibia* is trilobate posteriorly. The outline is anteroposteriorly sigmoid, the spine turning outwards and forming an acute angle. From this apex both borders are strongly sigmoid, the external commencing with concavity, the internal with convexity. The distal end of the ischium is oblique to the long axis of the bone, and its outline is triangular; the external convexity being stronger than in the *T. longicollis*.

The *sacrum* consists of four rather elongate centra, which have a subquadrate vertical section. A portion of an ilium adheres to it in the specimen, which is almost as large as that of the *T. longicollis*. If the ilium belongs to the same individual as the sacrum, the latter must belong to the *T. longicollis;* but I suspect that the association is accidental.

The diapophyses for the ilia are on the second, third and fourth sacral vertebræ. The second is directed forwards and upwards, the others backwards and upwards. There is a large deep fossa (or ? foramen) above the posterior halves of the second and third centra. The coössified bases of the diapophyses form a thin overhanging ledge.

8. Tanystrophæus willistoni sp. nov.

This, the smallest of the species, is represented by an ilium, from which the ischiadic process has been broken away, and probably by some vertebræ and other bones. The latter can only be associated with the ilium on account of their appropriate size, since they were found with those of the two other species mingled together in one locality.

The ilium is at once to be distinguished from those of the species already named, by the equal elevation of the internal and external superior borders of the acetabulum. The latter is as widely open internally as externally, which is not the case with the other species. The external superior border, though more produced than the internal, is not so roof-like as in the others. The anterior process above the pubic process is compressed. The pubic surface is sigmoid in vertical section, even more strongly than in the other species. The superior plate of the ilium is much compressed.

Width of roof of acetabulum	.015
" " pubic surface	.0095
Length of " "	.008

The dorsal centrum may be that of a young animal, since the neural canal is larger than in the larger species, and the neural arch is not coössified. The median portion is not so contracted as in the other species, and its section is rounded quadrate. Articular faces a little wider than deep.

Length of centrum		.019
Diameters of centrum	vertical	.008
	transverse	.010

Dedicated to Professor S. W. Williston, of Yale College, the author of numerous important works on vertebrate palæontology.

Remarks.—From the above determinations a close parallelism between the Upper Keuper of Würtemberg and New Mexico may be discovered. In both the genera Belodon and Tanystrophæus are abundant, and the Aëtosaurus of the former is represented by the Typothorax of the latter. This association of such very diverse forms is good evidence of general identity of fauna, and is a sufficient basis for asserting taxonomic identity of the formations in the two regions.

EXPLANATION OF PLATES.

Plate I.

Bones of *Typothorax coccinarum* Cope, two-fifths natural size.

Fig. 1. A rib, from below.

Fig. 1*a*. The same with dermal bone, edge view.

Fig. 1*b*. The same, view of fractured extremity.

Fig. 2. Another dermoösseous band, one end wanting, from above.

Fig. 3. Femur, right side, from behind.

Fig. 3*a*. Do., proximal view.

Fig. 3*b*. Do., distal view.

Plate II.

Casts of brain-cases of *Belodon buceros* and *Alligator mississippiensis*, natural size.

Figs. 1–3. *Belodon buceros.*

Figs. 4–5. *Alligator mississippiensis.*

Fig. 1. Left side.

Fig. 2. Superior surface.

Fig. 3. Front view.

Fig. 4. Left side.

Fig. 5. Front view.

RE. Rhinencephalon.

PE. Prosencephalon.

ME. Mesencephalon.

Ep.E. Epencephalon (Cerebellum).

MO. Medulla oblongata.

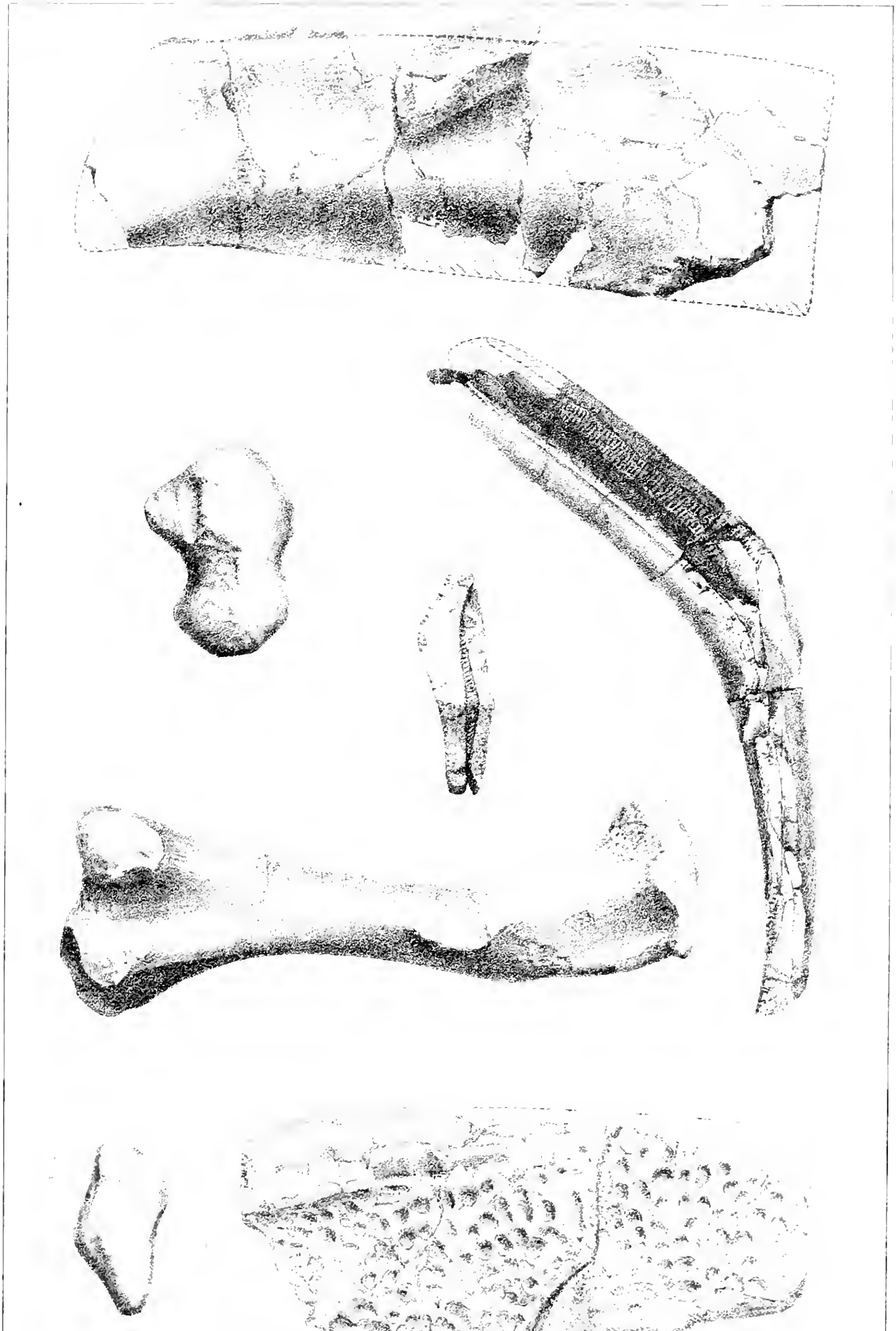
Ep. Epiphysis.

Hyp. Hypophysis.

ii. Optic nerve ; v. Trigeminus ; vi. Abducens ; viii. Facialis ; viii. Auditorius.

OP. Orbitopineal process or nerve.

PLATE I



Were the Toltecs an Historic Nationality?

By Daniel G. Brinton, M.D.

(Read before the American Philosophical Society, Sept. 2, 1887.)

In the first edition of my *Myths of the New World*,* published in 1868, I asserted that the story of the city of Tula and its inhabitants, the Toltecs, as currently related in ancient Mexican history, is a myth, and not history. This opinion I have since repeated in various publications,† but writers on pre-Columbian American civilization have been very unwilling to give up their Toltecs, and here lately M. Charnay has composed a laborious monograph to defend them.‡

Let me state the question squarely.

The orthodox opinion is that the Toltecs, coming from the north (-west or -east), founded the city of Tula (about forty miles north of the present city of Mexico) in the sixth century A.D.; that their State flourished for about five hundred years, until it numbered nearly four millions of inhabitants, and extended its sway from ocean to ocean over the whole of Central Mexico; § that it reached a remarkably high stage of culture in the arts; that in the tenth or eleventh century it was almost totally destroyed by war and famine; ‖ and that its fragments,

* *Myths of the New World.* By D. G. Brinton. Chap. vi, *passim.*

† Especially in *American Hero Myths, a Study in the Native Religions of the Western Continent*, pp. 35, 64, 82, etc. (Philadelphia, 1882).

‡ M. Charnay, in his essay, *La Civilisation Toltèque*, published in the *Revue d'Ethnographie*, Tome iv, p. 281, 1885, states his thesis as follows: "Je veux prouver l'existence du Toltèque que certains ont nié; je veux prouver que les civilisattons Americaines ne sont qu'une seule et même civilisation; enfin, je veux prouver que cette civilisation est toltèque." I consider each of these statements an utter error. In his *Anciennes Villes du Nouveau Monde*, M. Charnay has gone so far as to give a map showing the migrations of the ancient Toltecs. As a translation of this work, with this map, has recently been published in this country, it appears to me the more needful that the baseless character of the Toltec legend be distinctly stated.

§ Ixtlilxochitl, in his *Relaciones Historicas* (in Lord Kingsborough's *Antiquities of Mexico*, Vol. ix, p. 333), says that during the reign of Topiltzin, last king of Tula, the Toltec sovereignty extended a thousand leagues from north to south and eight hundred from east to west; and in the wars that attended its downfall five million six hundred thousand persons were slain!!

‖ Sahagun (*Hist. de la Nueva España*, Lib. viii, cap. 5) places the destruction of Tula in the year 319 B. C.; Ixtlilxochitl (*Historia Chichmeca*, iii, cap. 4) brings it down to 969 A. D.; the *Codex Ramirez* (p. 25) to 1168; and so on. There is an equal variation about the date of founding the city.

escaping in separate colonies, carried the civilization of Tula to the south, to Tabasco (Palenque), Yucatan, Guatemala and Nicaragua. Quetzalcoatl, the last ruler of Tula, himself went to the south-east, and reappears in Yucatan as the culture-hero Cukulkan, the traditional founder of the Maya civilization.

This, I say, is the current opinion about the Toltecs. It is found in the works of Ixtlilxochitl, Veitia, Clavigero, Prescott, Brasseur de Bourbourg, Orozco y Berra, and scores of other reputable writers. The dispersion of the Toltecs has been offered as the easy solution of the origin of the civilization not only of Central America, but of New Mexico and the Mississippi valley.*

The opinion that I oppose to this, and which I hope to establish in this article, is as follows:

Tula was merely one of the towns built and occupied by that tribe of the Nahuas known as *Azteca* or *Mexica*, whose tribal god was Huitzilopochtli, and who finally settled at Mexico-Tenochtitlan (the present city of Mexico); its inhabitants were called Toltecs, but there was never any such distinct tribe or nationality; they were merely the ancestors of this branch of the Azteca, and when Tula was destroyed by civil and foreign wars, these survivors removed to the valley of Mexico and became merged with their kindred; they enjoyed no supremacy, either in power or in the arts; and the Toltec "empire" is a baseless fable. What gave them their singular fame in later legend was partly the tendency of the human mind to glorify the "good old times" and to merge ancestors into divinities, and especially the significance of the name Tula, "the Place of the Sun," leading to the confounding and identification of a half-forgotten legend with the ever-living light-and-darkness myth of the gods Quetzalcoatl and Tezcatlipoca.

To support this view, let us inquire what we know about Tula as an historic site.

Its location is on one of the great ancient trails leading from

*Since writing the above I have received from the Comte de Charencey a reprint of his article on *Xibalba*, in which he sets forth the theory of the late M. L. Angrand, that all ancient American civilization was due to two "currents" of Toltecs, the western, straight-headed Toltecs, who entered Anahuac by land from the north-west, and the eastern, flat-headed Toltecs, who came by sea from Florida. It is to criticise such vague theorizing that I have written this paper.

the north into the Valley of Mexico.* The ruins of the old town are upon an elevation about 100 feet in height, whose summit presents a level surface in the shape of an irregular triangle some 800 yards long, with a central width of 300 yards, the apex to the south-east, where the face of the hill is fortified by a rough stone wall.† It is a natural hill, overlooking a small muddy creek, called the *Rio de Tula*.‡ Yet this unpretending mound is the celebrated *Coatepetl*, Serpent-Mount, or Snake-Hill, famous in Nahuatl legend, and the central figure in all the wonderful stories about the Toltecs.§ The remains of the artificial tumuli and walls, which are abundantly scattered over the summit, show that, like the pueblos of New Mexico, they were built of large sun-baked bricks mingled with stones, rough or trimmed, and both walls and floors were laid in a firm cement, which was usually painted of different colors. Hence probably the name *Palpan*, "amid the colors," which tradition says was applied to these structures on the Coatepetl.‖ The stone-work,

* Motolinia, in his *Historia de los Indios de Nueva España*, p. 5, calls the locality "el puerto llamado Tollan," the pass or gate called Tollan. Through it, he states, passed first the Colhua and later the Mexica, though he adds that some maintain these were the same people. In fact, Colhua is a form of a word which means "ancestors;" *colli*, forefather, *no-col-huan*, my forefathers, *Colhuacan*, "the place of the forefathers," where they lived. In Aztec picture-writing this is represented by a hill with a bent top, on the "ikonomatic" system, the verb *coloa*, meaning to bend, to stoop. Those Mexica who said the Colhua preceded them at Tula, simply meant that their own ancestors dwelt there. The *Anales de Cuauhtitlan* (pp. 29, 33) distinctly states that what Toltecs survived the wars which drove them southward became merged in the Colhuas. As these wars largely arose from civil dissensions, the account no doubt is correct which states that others settled in Acolhuacan, on the eastern shore of the principal lake in the Valley of Mexico. The name means "Colhuacan by the water," and was the State of which the capital was Tetzcoco.

† This description is taken from the map of the location in M. Charnay's *Anciennes Villes du Nouveau Monde*, p. 83. The measurements I have made from the map do not agree with those stated in the text of the book, but are, I take it, more accurate.

‡ Sometimes called the *Rio de Montezuma*, and also the *Tollanatl*, water of Tula. This stream plays a conspicuous part in the Quetzalcoatl myths. It appears to be the same as the river *Atoyac* (= flowing or spreading water, *atl*, *toyaua*), or *Xipacoyan* (= where precious stones are washed, from *xiuitl*, *paca*, *yan*), referred to by Sahagun, *Hist. de la Nueva España*, Lib. ix, cap. 29. In it were the celebrated "Baths of Quetzalcoatl," called *Atecpanamochco*, "the water in the tin palace," probably from being adorned with this metal (*Anales de Cuauhtitlan*).

§ See the *Codex Ramirez*, p. 24. Why called Snake-Hill the legend says not. I need not recall how prominent an object is the serpent in Aztec mythology. The name is a compound of *coatl*, snake, and *tepetl*, hill or mountain, but which may also mean town or city, as such were usually built on elevations. The form *Coatepec* is this word with the postposition *c*, and means "at the snake-hill," or, perhaps, "at Snake-town."

‖ Or to one of them. The name is preserved by Ixtlilxochitl, *Relaciones Historicas*, in Kingsborough, *Mexico*, Vol. ix, p. 326. Its derivation is from *palli*, a color (root *pa*), and the postposition *pan*. It is noteworthy that this legend states that Quetzalcoatl in his represented by a few broken fragments, appears equal, but not superior, to that of the Valley of Mexico. Both the free and the attached column occur, and figure-carving was known, as a few weather-beaten relics testify. The houses contained many rooms, on different levels, and the roofs were flat. They were no doubt mostly communal structures. At the foot of the Serpent-Hill is a level plain, but little above the river, on which is the modern village with its corn-fields.

These geographical particulars are necessary to understand the ancient legend, and with them in mind its real purport is evident.*

That legend is as follows: When the Azteca or Mexica—for these names were applied to the same tribe†—left their early home in Aztlan—which Ramirez locates in Lake Chalco in the Valley of Mexico, and Orozco y Berra in Lake Chapallan in Michoacan‡—they pursued their course for some generations in

avatar as *Ce Acatl* was born in the Palpan, "House of Colors;" while the usual story was that he came from Tla-pallan, the place of colors. This indicates that the two accounts are versions of the same myth.

* There are two ancient Codices extant, giving in picture-writing the migrations of the Mexi. They have been repeatedly published in part or in whole, with varying degrees of accuracy. Orozco y Berra gives their bibliography in his *Historia Antigua de Mexico*, Tom. iii, p. 61, note. These Codices differ widely, and seem contradictory, but Orozco y Berra has reconciled them by the happy suggestion that they refer to sequent and not synchronous events. There is, however, yet much to do before their full meaning is ascertained.

† The name Aztlan is that of a place and Mexitl that of a person, and from these are derived *Aztecatl*, plural, *Azteca*, and *Mexicatl*, pl. *Mexica*. The Azteca are said to have left Aztlan under the guidance of Mexitl (*Codex Ramirez*). The radicals of both words have now become somewhat obscured in the Nahuatl. My own opinion is that Father Duran (*Hist. de Nueva España*, Tom. i, p. 19) was right in translating Aztlan as "the place of whiteness," *el lugar de blancura*, from the radical *iztac*, white. This may refer to the East, as the place of the dawn; but there is also a temptation to look upon Aztlan as a syncope of *a-izta-tlan*, = "by the salt water."

Mexicatl is a *nomen gentile* derived from *Mexitl*, which was another name for the tribal god or early leader Huitzilopochtli, as is positively stated by Torquemada (*Monarquia Indiana*, Lib. viii, cap. xi). Sahagun explains Mexitl as a compound of *metl*, the maguey, and *citli*, which means hare and grandmother (*Historia de Nueva España*, Lib. x, cap. 29). It is noteworthy that one of the names of Quetzalcoatl is *Meconetzin*, son of the maguey (Ixtlilxochitl, *Rel. Hist.*, in Kingsborough, Vol. ix, p. 328). These two gods were originally brothers, though each had divers mythical ancestors.

‡ Orozco y Berra, *Historia Antigua de Mexico*, Tom. iii, cap. 4. But Albert Gallatin was the first to place Aztlan no further west than Michoacan (*Trans. American Ethnolog. Society*, Vol. ii, p. 202). Orozco thinks Aztlan was the small island called Mexcalla in Lake Chapallan, apparently because he thinks this name means "houses of the Mexi;" but it may also signify "where there is abundance of maguey leaves," this delicacy being called *mexcalli* in Nahuatl, and the terminal *a* signifying location or abundance. (See Sahagun, *Historia de Nueva España*, Lib. vii, cap. 9.) At present, one of the smaller species of maguey is called *mexcalli*.

harmony; but at a certain time, somewhere between the eighth and the eleventh century of our era, they fell out and separated. The legend refers to this as a dispute between the followers of the tribal god Huitzilopochtli and those of his sister Malinalxochitl. We may understand it to have been the separation of two "totems." The latter entered at once the Valley of Mexico, while the followers of Huitzilopochtli passed on to the plain of Tula and settled on the Coatepetl. Here, says the narrative, they constructed houses of stone and of rushes, built a temple for the worship of Huitzilopochtli, set up his image and those of the fifteen divinities (gentes?) who were subject to him, and erected a large altar of sculptured stone and a court for their ball play.* The level ground at the foot of the hill they partly flooded by damming the river, and used the remainder for planting their crops. After an indeterminate time they abandoned Tula and the Coatepetl, driven out by civil strife and warlike neighbors, and journeyed southward into the Valley of Mexico, there to found the famous city of that name.

This is the simple narrative of Tulan, stripped of its contradictions, metaphors and confusion, as handed down by those highest authorities, the Codex Ramirez, Tezozomoc and Father Duran.† It is a plain statement that Tula and its Snake-Hill were merely one of the stations of the Azteca in their migrations —an important station, indeed, with natural strength, and one that they fortified with care, where for some generations, probably, they maintained an independent existence, and which the story-tellers of the tribe recalled with pride and exaggeration.

How long they occupied the site is uncertain.‡ Ixtlilxochitl

* It is quite likely that the very stone image figured by Charnay, *Anciennes Villes du Nouveau Monde*, p. 72, and the stone ring used in the *tlachtli*, ball play, which he figures, p. 73, are those referred to in the historic legend.

† The *Codex Ramirez*, p. 21, a most excellent authority, is quite clear. The picture-writing—which is really phonetic, or, as I have termed it, *ikonomatic*—represents the Coatepetl by the sign of a hill (*tepetl*) inclosing a serpent (*coatl*). Tezozomoc, in his *Cronica Mexicana*, cap. 2, presents a more detailed but more confused account. Duran, *Historia de las Indias de Nueva España*, cap. 3, is worthy of comparison. The artificial inundation of the plain to which the accounts refer probably means that a ditch or moat was constructed to protect the foot of the hill. Herrera says: "Cercaron de agua el cerro llamado Coatepec." *Decadas de Indias*, Dec. iii, Lib. ii, cap. 11.

‡ The *Annals of Cuauhtitlan*, a chronicle written in the Nahuatl language, gives 309 years from the founding to the destruction of Tula, but names a dynasty of only four rulers. Veitia puts the founding of Tula in the year 713 A. D. (*Historia de Nueva España*, cap. 23). Let us suppose, with the laborious and critical Orozco y Berra (notes to the *Codex Ramirez*, p. 210) that the Mexi left Aztlan A. D. 648. These three dates would fit

gives a list of eight successive rulers of the "Toltecs," each of whom was computed to reign at least fifty-two years, or one cycle; but it is noteworthy that he states these rulers were not of "Toltec" blood, but imposed upon them by the "Chichimecs." This does not reflect creditably on the supposed singular cultivation of the Toltecs. Probably the warrior Aztecs subjected a number of neighboring tribes and imposed upon them rulers.*

If we accept the date given by the *Codex Ramirez* for the departure of the Aztecs from the Coatepetl—A. D. 1168—then it is quite possible that they might have occupied the site for a couple of centuries or longer, and that the number of successive chieftains named by Ixtlilxochitl should not be far wrong. The destructive battles of which he speaks as preceding their departure—battles resulting in the slaughter of more than five million souls—we may regard as the grossly overstated account of some really desperate conflicts.

That the warriors of the Azteca, on leaving Tula, scattered over Mexico, Yucatan and Central America, is directly contrary to the assertion of the high authorities I have quoted, and also to most of the mythical descriptions of the event, which declare they were all, or nearly all, massacred.†

The above I claim to be the real history of Tula and its Serpent-Hill, of the Toltecs and their dynasty. Now comes the question, if we accept this view, how did this ancient town and

into a rational chronology, remembering that there is an acknowledged hiatus of a number of years about the eleventh and twelfth centuries in the Aztec records (Orozco y Berra, notes to *Codex Ramirez*, p. 213). The *Anales de Cuauhtitlan* dates the founding of Tula *after* that of Tlaxcallan, Huexotzinco and Cuauhtitlan (p. 29).

* As usual, Ixtlilxochitl contradicts himself in his lists of rulers. Those given in his *Historia Chichimeca* are by no means the same as those enumerated in his *Relaciones Historicas* (Kingsborough, *Mexico*, Vol. ix, contains all of Ixtlilxochitl's writings). Entirely different from both is the list in the *Anales de Cuauhtitlan*. How completely euhemeristic Ixtlilxochitl is in his interpretations of Mexican mythology is shown by his speaking of the two leading Nahuatl divinities Tezcatlipoca and Huitzilopochtli as "certain bold warriors" ("ciertos caballeros muy valerosos." *Relaciones Historicas*, in Kingsborough, Vol. ix, p. 326).

† See the note to page 3. But it is not at all likely that Tula was absolutely deserted. On the contrary, Herrera asserts that *after* the foundation of Mexico and the adjacent cities (despues de la fundacion de Mexico i de toda la tierra) it reached its greatest celebrity for skilled workmen. *Decadas de Indias*, Dec. iii, Lib. ii, cap. 11. The general statement is that the sites on the Coatepetl and the adjacent meadows were unoccupied for a few years—the *Anales de Cuauhtitlan* says nine years—after the civil strife and massacre, and then were settled again. The *Historia de los Mexicanos por sus Pinturas*, cap. 11, says, "y ansi fueron muertos todos los de Tula, que no quedó ninguno."

its inhabitants come to have so wide a celebrity, not merely in the myths of the Nahuas of Mexico, but in the sacred stories of Yucatan and Guatemala as well—which was unquestionably the case?

To explain this, I must have recourse to some of those curious principles of language which have had such influence in building the fabric of mythology. In such inquiries we have more to do with words than with things, with names than with persons, with phrases than with facts.

First about these names, Tula, Tollan, Toltec—what do they mean? They are evidently from the same root. What idea did it convey?

We are first struck with the fact that the Tula I have been describing was not the only one in the Nahuatl district of Mexico. There are other Tulas and Tollans, one near Ococingo, another, now San Pedro Tula, in the State of Mexico, one in Guerrero, San Antonio Tula in Potosi,* etc. The name must have been one of some common import. Herrera, who spells it *Tulo*, by an error, is just as erroneous in his suggestion of a meaning. He says it means "place of the tuna," this being a term used for the prickly pear.† But *tuna* was not a Nahuatl word; it belongs to the dialect of Haiti, and was introduced into Mexico by the Spaniards. Therefore Herrera's derivation must be ruled out. Ixtlilxochitl pretends that the name Tollan was that of the first chieftain of the Toltecs, and that they were named after him;‡ but elsewhere himself contradicts this assertion. Most writers follow the *Codex Ramirez*, and maintain that Tollan—of which Tula is but an abbreviation—is from *tolin*, the Nahuatl word for rush, the kind of which they made mats, and means "the place of rushes," or, where they grow.

The respectable authority of Buschmann is in favor of this derivation; but according to the analogy of the Nahuatl language, the "place of rushes" should be *Toltitlan* or *Tolinan*, and there are localities with these names.§

Without doubt, I think, we must accept the derivation of

* See Buschmann, *Ueber die Aztekischen Ortsnamen*, ss. 682, 788. Orozco y Berra, *Geografia de las Lenguas de Mejico*, pp. 218, 255.

† *Historia de las Indias Occidentales*, Dec. iii, Lib. ii, cap. 11.

‡ *Relaciones Historicas*, in Kingsborough's *Mexico*, Vol. ix, p. 392. Compare his *Historia Chichimeca*.

§ Buschmann, *Ueber die Aztekischen Ortsnamen*, ss. 682, 797.

Tollan given by Tezozomoc, in his *Cronica Mexicana.* This writer, thoroughly familiar with his native tongue, conveys to us its ancient form and real sense. Speaking of the early Aztecs, he says: "They arrived at the spot called Coatepec, on the borders of *Tonalan, the place of the sun.*" *

This name, Tonallan, is still not unusual in Mexico. Buschmann enumerates four villages so called, besides a mining town, *Tonatlan.*† "Place of the sun" is a literal rendering, and it would be equally accurate to translate it "sunny-spot" or "warm place" or "summer-place." There is nothing very peculiar or distinctive about these meanings. The warm, sunny plain at the foot of the Snake-Hill was called, naturally enough, Tonallan, syncopated to Tollan and thus to Tula.‡

But the literal meaning of Tollan—"Place of the Sun"—brought it in later days into intimate connection with many a myth of light and of solar divinities, until this ancient Aztec pueblo became apotheosized, its inhabitants transformed into magicians and demigods, and the corn-fields of Tula stand forth as fruitful plains of Paradise.

In the historic fragments to which I have alluded there is scant reference to miraculous events, and the gods play no part in the sober chronicle. But in the mythical cyclus we are at once translated into the sphere of the supernal. The Snake-

* *Cronica Mexicana*, cap. 1. "Partieron de allí y vinieron á la parte que llaman Coatepec, términos de Tonalan, lugar del sol." In Nahuatl *tonallan* usually means summer, sun-time. It is syncopated from *tonalli* and *tlan;* the latter is the locative termination; *tonalli* means warmth, *sunniness*, akin to *tonatiuh*, sun; but it also means soul, spirit, especially when combined with the possessive pronouns, as *to-tonal*, our soul, our immaterial essence. By a further syncope *tonallan* was reduced to Tollan or Tullan, and by the elision of the terminal semi-vowel, this again became Tula. This name may therefore mean "the place of souls," an accessory signification which doubtless had its influence on the growth of the myths concerning the locality.

It may be of some importance to note that Tula or Tollan was not at first the name of the town, but of the locality—that is, of the warm and fertile meadow-lands at the foot of the Coatepetl. The town was at first called Xocotitlan, the place of fruit, from *xocotl*, fruit, *ti*, connective, and *tlan*, locative ending. (See Sahagun, *Historia de Nueva España*, Lib. x, cap. 29, secs. 1 and 12.) This name was also applied to one of the quarters of the city of Mexico when conquered by Cortes, as we learn from the same authority.

† Buschmann, *Ueber die Aztekischen Ortsnamen*, ss. 794, 797 (Berlin, 1852).

‡ The verbal radical is *tona*, to warm (hazer calor, Molina, *Vocabulario de la Lengua Mexicana*, s. v.); from this root come many words signifying warmth, fertility, abundance, the sun, the east, the summer, the day, and others expressing the soul, the vital principle, etc. (Siméon, *Dict. de la Langue Nahuatl*, s. v. *tonalli.*) As in the Algonkin dialects the words for cold, night and death are from the same root, so in Nahuatl are those for warmth, day and life. (Comp. Duponceau, *Mémoire sur les Langues de l'Amérique du Nord*, p. 327, Paris, 1836.)

Hill Coatepetl becomes the Aztec Olympus. On it dwells the great goddess "Our Mother amid the Serpents," *Coatlan Tonan*,* otherwise called "The Serpent-skirted," *Coatlicue*, with her children, The Myriad Sages, the *Centzon Huitznahua*.† It was her duty to sweep the Snake-Hill every day that it might be kept clean for her children. One day while thus engaged, a little bunch of feathers fell upon her, and she hid it under her robe. It was the descent of the spirit, the divine Annunciation. When the Myriad Sages saw that their mother was pregnant, they were enraged, and set about to kill her. But the unborn babe spake from her womb, and provided for her safety, until in due time he came forth armed with a blue javelin, his flesh painted blue, and with a blue shield. His left leg was thin and covered with the plumage of the humming-bird. Hence the name was given to him "On the left, a Humming-Bird," Huitzilopochtli.‡ Four times around the Serpent-Mountain did he drive the Myriad Sages, until nearly all had fallen dead before his dart, and the remainder fled far to the south. Then all the Mexica chose Huitzilopochtli for their god, and paid honors to the Serpent-Hill by Tula as his birthplace. §

* *Coatlan, to-nan*, from *coatl*, serpent; *tlan*, among; *to-nan*, our mother. She was the goddess of flowers, and the florists paid her especial devotion (Sahagun, *Historia*, Lib. ii, cap. 22). A precinct of the city of Mexico was named after her, and also one of the edifices in the great temple of the city. Here captives were sacrificed to her and to the Huitznahua. (Ibid., Lib. ii, Appendix. See also Torquemada, *Monarquia Indiana*, Lib. x, cap. 12.)

† *Centzon Huitznahua*, "the Four Hundred Diviners with Thorns." Four hundred, however, in Nahuatl means any indeterminate large number, and hence is properly translated myriad, legion. *Nahuatl* means wise, skillful, a diviner, but is also the proper name of the Nahuatl-speaking tribes; and as the Nahuas derived their word for south from *huitztli*, a thorn, the Huitznahua may mean "the southern Nahuas." Sahagun had this in his mind when he said the Huitznahua were goddesses who dwelt in the south (*Historia de Nueva España*, Lib. vii, cap. 5). The word is taken by Father Duran as the proper name of an individual, as we shall see in a later note.

‡ *Huitzilopochtli*, from *huitzilin*, humming-bird, *opochtli*, the left side or hand. This is the usual derivation; but I am quite sure that it is an error arising from the ikonomatic representation of the name. The name of his brother, Huitznahua, indicates strongly that the prefix of both names is identical. This, I doubt not, is from *huitz-tlan*, the south; *ilo* is from *iloa*, to turn; this gives us the meaning "the left hand turned toward the south." Orozco y Berra has pointed out that the Mexica regarded left-handed warriors as the more formidable (*Historia Antigua de Mexico*, Tom. i, p. 125). Along with this let it be remembered that the legend states that Huitzilopochtli was born in Tula and insisted on leading the Mexica toward the south, the opposition to which by his brother led to the massacre and to the destruction of the town.

§ This myth is recorded by Sahagun, *Historia de Nueva España*, Lib. iii, cap. 1, "On the Origin of the Gods." It is preserved with some curious variations in the *Historia de los Mexicanos por sus Pinturas*, cap. 11. When the gods created the sun they also formed

An equally ancient and authentic myth makes Huitzilopochtli one of four brothers, born at one time of the uncreated, bi-sexual divinity, the God of our Life, Tonacatecutli, who looms dimly at the head of the Aztec Pantheon. The brothers were the black and the white Tezcatlipoca and the fair-skinned, bearded Quetzalcoatl. Yet a third myth places the birthplace of Quetzalcoatl directly in Tula, and names his mother, Chimalman, a virgin, divinely impregnated, like Coatlicue, by the descending spirit of the Father of All.*

Tula was not only the birthplace, but the scene of the highest activity of all these greatest divinities of the ancient Nahuas. Around the Coatepetl and on the shores of the Tollanatl—"the Water of Tula"—as the stream is called which laves the base of the hill, the mighty struggles of the gods took place which form the themes of almost all Aztec mythology. Tulan itself is no longer the hamlet of rush houses at the foot of the Coatepec, surmounted by its pueblo of rough stone and baked brick. It is a glorious city, founded and governed by Quetzalcoatl himself, in his first avatar as Hueman, the strong-handed. "All its structures were stately and gracious, abounding in ornaments. The walls within were incrusted with precious stones or finished in beautiful stucco, presenting the appearance of a rich mosaic. Most wonderful of all was the temple of Quetzalcoatl. It had four chambers, one toward the east finished in pure gold, another toward the west lined with torquoise and emeralds, a third toward the south decorated with all manner of delicate sea-shells, and a fourth to the north resplendent with red jasper and

four-hundred men and five women for him to eat. At the death of the women their robes were preserved, and when the people carried these to the Coatepec, the five women came again into being. One of these was Coatlicue, an untouched virgin, who after four years of fasting placed a bunch of white feathers in her bosom, and forthwith became pregnant. She brought forth Huitzilopochtli completely armed, who at once destroyed the Huitznahua. Father Duran translates all of this into plain history. His account is that when the Aztecs had occupied Tollan for some time, and had fortified the hill and cultivated the plain, a dissension arose. One party, followers of Huitzilopochtli, desired to move on; the other, headed by a chieftain, Huitznahua, insisted on remaining. The former attacked the latter at night, massacred them, destroyed the water-dams and buildings, and marched away (*Historia de las Indias de Nueva España*, Tom. i, pp. 25, 26). According to several accounts, Huitznahua was the brother of Huitzilopochtli. See my *American Hero Myths*, p. 81.

* I have discussed both these accounts in my *American Hero Myths*, chap. iii, and need not repeat the authorities here.

shells."* The description of other buildings, equally wondrous, have been lovingly preserved by the ancient songs.† What a grief that our worthy friend, M. Charnay, digging away in 1880 on the Coatepec, at the head of a gang of forty-five men, as he tells us,‡ unearthed no sign of these ancient glories, in which, for one, he fully believes! But, alas! I fear that they are to be sought nowhere out of the golden realm of fancy and mythical dreaming.

Nor, in that happy age, was the land unworthy such a glorious city. Where now the neglected corn-patches surround the shabby huts of Tula, in the good old time "the crops of maize never failed, and each ear was as long as a man's arm; the cotton burst its pods, not white only, but spontaneously ready dyed to the hand in brilliant scarlet, green, blue and yellow; the gourds were so large that they could not be clasped in the arms; and birds of brilliant plumage nested on every tree!"

The subjects of Quetzalcoatl, the Toltecs, were not less marvelously qualified. They knew the virtues of plants and could read the forecasts of the stars; they could trace the veins of metals in the mountains, and discern the deposits of precious stones by the fine vapor which they emit; they were orators, poets and magicians; so swift were they that they could at once be in the place they wished to reach; as artisans their skill was unmatched, and they were not subject to the attacks of disease.

The failure and end of all this goodly time came about by a battle of the gods, by a contest between Tezcatlipoca and Huitzilopochtli on the one hand, and Quetzalcoatl on the other. Quetzalcoatl refused to make the sacrifices of human beings as required by Huitzilopochtli, and the latter, with Tezcatlipoca, set about the destruction of Tula and its people. This was the

* The most highly-colored descriptions of the mythical Tula are to be found in the third and tenth book of Sahagun's *Historia de Nueva España*, in the *Anales de Cuauhtitlan*, and in the various writings of Ixtlilxochitl. Later authors, such as Veytia, Torquemada, etc., have copied from these. Ixtlilxochitl speaks of the "legions of fables" about Tulan and Quetzalcoatl which even in his day were still current ("otras trescientas fabulas que aun todavia corren," *Relaciones Historicas*, in Kingsborough, *Mexico*, Vol. ix, p. 332).

† In the collection of *Ancient Nahuatl Poems*, which forms the seventh volume of my *Library of Aboriginal American Literature*, p. 101. I have printed the original text of one of the old songs recalling the glories of Tula, with its "house of beams," *huapalcalli*, and its "house of plumed serpents," *coatlaquetzalli*, attributed to Quetzalcoatl.

‡ *Les Anciennes Villes du Nouveau Monde*, p. 81 (Paris, 1885).

chosen theme of the later Aztec bards. What the siege of Troy was to the Grecian poets, the fall of Tula was to the singers and story-tellers of Anahuac—an inexhaustible field for imagination, for glorification, for lamentation. It was placed in the remote past—according to Sahagun, perhaps the best authority, about the year 319 before Christ.* All arts and sciences, all knowledge and culture, were ascribed to this wonderful mythical people, and wherever the natives were asked concerning the origin of ancient and unknown structures, they would reply, "The Toltecs built them." †

They fixedly believed that some day the immortal Quetzalcoatl would appear in another avatar, and would bring again to the fields of Mexico the exuberant fertility of Tula, the peace and happiness of his former reign, and that the departed glories of the past should surround anew the homes of his votaries.‡

I have elsewhere so fully represented this phase of the mythical cyclus that I need not emphasize it further; nor need I explain the significance of these myths as revealed to us by an application of the principles of comparative mythology; for that, too, would be repeating what I have already published in ample detail.

What I wish to point out in clear terms is the contrast between the dry and scanty historic narrative which shows Tula with its Snake-Hill to have been an early station of the Azteca, occupied in the eleventh and twelfth century by one of their clans, and the monstrous myth of the later priests and poets, which makes of it a birthplace and abode of the gods, and its inhabitants the semi-divine conquerors and civilizers of Mexico and Central America. For this latter fable there is not a vestige of solid foundation. The references to Tula and

* *Historia de Nueva España*, Lib. viii, cap. 5.

† Father Duran relates, "Even to this day, when I ask the Indians, 'Who created this pass in the mountains? Who opened this spring? Who discovered this cave? or, Who built this edifice?' they reply, 'The Toltecs, the disciples of Papa.'" *Historia de las Indias de Nueva España*, cap. 79. *Papa*, from *papachtic*, the bushy-haired, was one of the names of Quetzalcoatl. But the earlier missionary, Father Motilinia, distinctly states that the Mexica invented their own arts, and owed nothing to any imaginary teachers, Toltecs or others. "Hay entre todos los Indios muchos oficios, y de todos dicen *que fueron inventores los Mexicanos.*" *Historia de los Indios de la Nueva España*, Tratado iii, cap. viii.

‡ Quetzalcoatl announced that his return should take place 5012 years after his final departure, as is mentioned by Ixtlilxochitl (in Kingsborough, *Mexico*, Vol. ix, p. 332). This number has probably some mystic relation to the calendar.

the Toltecs in the *Chronicles of the Mayas* and the *Annals of the Kakchiquels* are loans from the later mythology of the Nahuas. It is high time for this talk about the Toltecs as a mighty people, precursors of the Azteca, and their instructors in the arts of civilization, to disappear from the pages of history. The residents of ancient Tula, the Toltecca, were nothing more than a sept of the Nahuas themselves, the ancestors of those Mexica who built Tenochtitlan in 1325. This is stated as plainly as can be in the Aztec records, and should now be conceded by all. The mythical Tula, and all its rulers and inhabitants, are the baseless dreams of poetic fancy, which we principally owe to the Tezcucan poets.

In conclusion, I have no hesitation in repeating the words which I printed some years ago, and which gave considerable offence in certain quarters: "Is it not time that we dismiss, once for all, these American myths from the domain of historical traditions? Why should we try to make an enlightened ruler of Quetzalcoatl, a cultured nation of the Toltecs, when the proof is of the strongest that they are the fictions of mythology? Let it be understood hereafter that whoever uses these names in an historic sense betrays an ignorance of the subject he handles, which, were it in the better-known field of Aryan or Egyptian lore, would convict him of not meriting the name of scholar." *

* *American Hero Myths*, p. 35. The only writer on ancient American history before me who has wholly rejected the Toltecs is, I believe, Albert Gallatin. In his able and critical study of the origin of American civilization (*Transactions of the American Ethnological Society*, Vol. i, p. 203) he dismissed them entirely from historical consideration with the words: "The tradition respecting the Toltecs ascends to so remote a date, and is so obscure and intermixed with mythological fables, that it is impossible to designate either the locality of their primitive abodes, the time when they first appeared in the vicinity of the Valley of Mexico, or whether they were preceded by nations speaking the same or different languages." Had this well-grounded skepticism gained the ears of writers since 1845, when it was published, we should have been saved a vast amount of rubbish which has been heaped up under the name of history.

Dr. Otto Stoll (*Guatemala; Reisen und Schilderungen*, ss. 408, 409, Leipzig, 1886) has joined in rejecting the ethnic existence of the Toltecs. As in later Nahuatl the word *toltecatl* meant not only "resident of Tollan," but also "artificer" and "trader," Dr. Stoll thinks that the Central American legends which speak of "Toltecs" should be interpreted merely as referring to foreign mechanics or pedlars, and not to any particular nationality. I quite agree with this view.

Biela's Comet and the Large Meteors of November 27–30. By Professor Daniel Kirkwood.

(Read before the American Philosophical Society, September 2, 1887.)

The well-known catalogue of Greg, published in the Report of the British Association for 1860, p. 115 *et seq.*, designates the last days of November as one of the dates at which an unusual number of fire-balls and meteoric stones had fallen since the commencement of the nineteenth century. In the Danville Quarterly Review for December, 1861, the gradual dissolution of Biela's comet was suggested as the source of those periodic displays,* and the same theory was again advanced in the author's "Meteoric Astronomy" (1867), pp. 54, 121, and 126–129. The suggestion has also been made independently by others.

We give below the most distinguished star showers derived from the scattered portions of Biela's comet :—

1798. 7 December ; recognized as Andromedes by Newton.
1830. 7 December ; Quetelet's catalogue.
1838. 5 to 7 December ; recognized by Newton.
1850. 29 November ; Quetelet.
1872. 27 November.
1885. 27 November.

From 1798 to 1885, we have eighty-seven years = 6.692 × 13 ; and the series is harmonized in the following scheme :—

1798 to 1838 = 40 years = 6 × 6.66 +
1830 to 1850 = 20 " = 3 × 6.66 +
1838 to 1872 = 34 " = 5 × 6.80.
1872 to 1885 = 13 " = 2 × 6.50.

The dates, it will be observed, indicate considerable extension of the cluster, or rather, perhaps, the existence of several groups.

The remarkable fall of meteoric iron during the shower of Bielids on the 27th of November, 1885,† at once suggests the inquiry whether traces of the same period can be found in the recurrence of fire-balls and aerolites at the identical epoch. The following dates, except the last, are all derived from the catalogue of Mr. R. P. Greg :—

1809. 29 November ; a fireball at Munich.
1810. 28 November, 9.30 P. M. ; an aerolitic meteor at Cape Matapan.

* "The division of Biela's comet into two distinct parts suggests several interesting questions in cometary physics. * * * May not the force, whatever it is, that has produced *one* separation, again divide the parts? and may not this action continue until the fragments become invisible? According to the theory now generally received, the periodic phenomena of shooting stars are produced by the intersections of the orbits of such nebulous bodies with the earth's annual path. * * * May not our periodic meteors be the *débris* of ancient but now disintegrated comets whose matter has become distributed around their orbits?"—*Danville Quarterly Review*, Dec., 1861, p. 637.

† Amer. Journ. of Sci., March, 1887.

1820. 29 November; a very brilliant meteor at Cosenzo, Ionian Isles.
1821. 28 November; a fireball at Naples.
1821. 30 November; a fireball at Delitzsch.
1822. 30 November, before sunset; a fall of several aerolites at Futteh-pore, Doab, India.
1823. 27 November; a fireball at Naples.
1824. 27 November; a fireball as large apparently as the moon, at Prague.
1833. End of November; a fall of aerolites by which a person was killed at Kandahar, Afghanistan.
1834. 29 November; a stone-fall at Raffaten, Hungary.
1834. 30 November; a fireball at Naples.
1839. 29 November, before sunset; a large fireball at Naples.
1842. 30 November; a shower of meteoric stones; specific gravity 3.36; N. E. of Ahmedabad.
1847. 29 November; a brilliant fireball at Bonn.
1848. 29 November; a fireball at Lincolnshire.
1850. 28 November; a fireball at Nottingham.
1850. 29 November; a fireball at London, Oxford, etc.
1850. 30 November; a stone-fall in India.
1859. 28 November; a brilliant detonating meteor, S. W. of Bohemia.
1885. 27 November; the fall of meteoric iron in Mexico (Am. Journ. Sci., Mar., 1887).

These twenty falls may be arranged as follows:—

1809 to 1822	= 13	years	= 2 × 6.50.
1810 to 1823	= 13	"	= 2 × 6.50.
1820 to 1833	= 13	"	= 2 × 6.50.
1821 to 1834	= 13	"	= 2 × 6.50.
1822 to 1842	= 20	"	= 3 × 6.66.
1824 to 1850	= 26	"	= 4 × 6.50.
1834 to 1847	= 13	"	= 2 × 6.50.
1822 to 1848	= 26	"	= 4 × 6.50.
1839 to 1859	= 20	"	= 3 × 6.66.
1859 to 1885	= 26	"	= 4 × 6.50.

The period is apparently well marked, though facts, as with the associated shooting stars, indicate the existence of several clusters moving in orbits very nearly identical. The period is short, thus affording frequent opportunities for studying the group—one of the most interesting with which we are acquainted. The next return may be expected in 1892. It will, of course, be carefully observed.

The comet of Biela was first observed in 1772, but previous traces of its *débris* may not be impossible. Instance the great meteor of December 5, 1762, and the fall of shooting stars on December 5, 1741, referred to in Quetelet's catalogue.

Notices of New Fresh-water Infusoria. By Alfred C. Stokes, M.D., Trenton, N. J.

(Read before the American Philosophical Society, September 16th, 1887.)

Hexamita spiralis, sp. nov. Fig. 1.

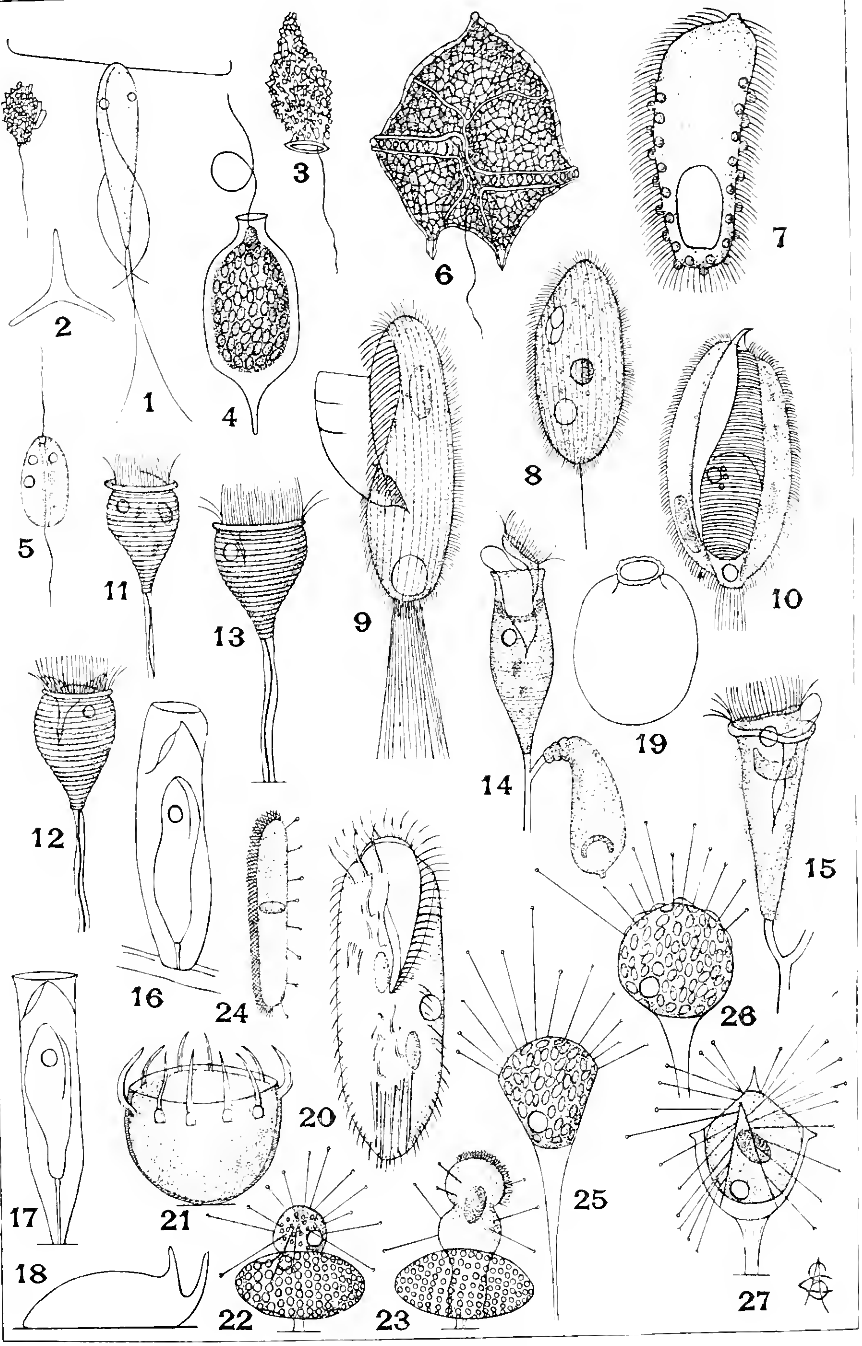
Body elongate obovate, about four times as long as broad, the anterior extremity rounded, the posterior obtusely pointed ; anterior flagella four in number, vibratile, arising close together, their length diverse but exceeding that of the body, the two shortest extended opposite each other at right angles to the body, their distal extremities curved forward ; the remaining two extending backward, each forming a long, loose spiral ; trailing flagella two, arising from the tip of the posterior extremity, and exceeding the body in length ; contractile vesicles two, situated opposite each other in the anterior body-half ; nucleus obscure. Length of body, $\frac{1}{2250}$ inch. *Hab.*—The intestinal canal of the tadpole of the common toad. Movements by rapid rotation on the longitudinal axis.

This differs from previously observed species in the presence of two contractile vesicles, and in the spiral disposition of two of the anterior flagella.

Petalomonas dorsalis, sp. nov. Fig. 2 ; diagram.

Body broadly ovate or suborbicular, colorless, transparent, the length but slightly exceeding the breadth ; the anterior extremity the narrower, evenly or obliquely rounded, occasionally obliquely truncate ; posterior border rounded, sometimes emarginate ; dorsal surface longitudinally traversed by a central, strongly compressed keel-like and upright plane, or broad wing, the superior margin of which is evenly convex ; ventral surface somewhat concave, a transverse optic section of the body presenting a triradiate appearance, the re-entering, dorso-lateral and ventral angles rounded ; oral fossa conspicuous, from which apparently issues a flagellum subequal to the body in length ; nucleus subcircular in outline, placed near the centre of the left-hand body margin ; contractile vesicle single, small, located on the left-hand side of the dorsal ala near the body centre ; endoplasm coarsely granular. Length of body, $\frac{1}{650}$ to $\frac{1}{600}$ inch. *Hab.*—Standing pond water.

This is readily recognizable from *P. carinata*, for which it might perhaps be mistaken, by its much larger size, and by the very conspicuously developed centro-dorsal, upright plane. In *P. carinata* the dorsal elevation is low and ridge-like, and although the lateral surfaces of this part are usually evenly sloping or slightly convex, they are at times noticeably concave. In *P. dorsalis* the dorsal ala is usually as high as one-half the width of the body. The part seems especially liable to deformity, often being observed to be variously indented, or distorted and developed to one side or the other of its normal central position.



Fresh-water Infusoria.—Stokes

Petalomonas sulcata, sp. nov.

Body ovate, colorless, transparent, depressed, less than twice as long as broad, the surface traversed longitudinally, sometimes in a slightly oblique direction, by from eight to ten keel-like ridges, the intervening spaces being concave; anterior extremity narrowly rounded; the posterior truncate, with one, sometimes two, subcentral acuminations apparently formed by the terminal union of the longitudinal carinations; flagellum subequal to the body in length; nucleus and single contractile vesicle on opposite sides of the anterior body-half; endoplasm granular posteriorly. Length of body, $\frac{1}{750}$ inch. *Hab.*—Pond water. Movements not rapid, the oral aperture usually in contact with the submerged object, the flagellum directed in advance, the anterior extremity alone vibrating.

Urceolopsis (*Urceolus*; ὄψις), gen. nov.

Animalcules free-swimming, flask-shaped, soft, flexible and elastic, the entire cuticular surface more or less covered by adherent, irregular and angular sand grains; otherwise essentially as in *Urceolus*.

Urceolopsis sabulosa, sp. nov. Fig. 3.

Urceolus sabulosus, Stokes; Am. Monthly Micr. Journ., vii, May, 1886.

Body flask-shaped, soft, flexible, elastic, normally compressed and somewhat gibbous, about twice as long as broad, widest centrally, obtusely pointed posteriorly, the entire surface more or less covered, often almost concealed, by adherent, irregular and angular sand grains; anterior extremity constricted to form a short neck-like prolongation, the circular border thickened, expanded, and obliquely truncate; flagellum large, equaling or exceeding the body in length; nucleus not observed; contractile vesicle (?) single, laterally placed near the anterior extremity: pharynx apparently extending to near the body-centre. Length of body, $\frac{1}{500}$ inch. *Hab.*—Fresh water with Algæ.

Trachelomonas urceolata, sp. nov. Fig. 4.

Lorica vasiform, about twice as long as broad, the lateral margins slightly flattened, anteriorly produced in a short, subcylindrical neck, the aperture slightly everted, truncate, not oblique; posterior extremity not inflated, produced in an acuminate, tail-like prolongation; endoplasm enclosing numerous, probably amylaceous, corpuscles. Length of lorica, $\frac{1}{500}$ inch. *Hab.*—Pond water.

Trachelomonas verrucosa, sp. nov.

Lorica subspherical, colorless, the entire surface covered with minute, hemispherical elevations; anterior extremity slightly emarginate. Length and breadth, $\frac{1}{1010}$ inch. *Hab.*—Pond water, with Algæ.

Trachelomonas acanthostoma, sp. nov.

Lorica subspherical, brown, the anterior extremity bearing two more or less irregular rows of short, conical spines encircling the orifice, which is not produced, the remaining surface punctate; endoplasm apparently vacuolar. Length, $\frac{1}{694}$ inch. *Hab.*—Pond water.

Anisonema solenota, sp. nov. Fig. 5.

Body sub-elliptical, depressed, less than twice as long as broad, slightly narrowed at the anterior extremity; the posterior border rounded; the frontal margin slightly and narrowly truncate; ventral surface flat, the dorsal longitudinally traversed by a subcentral depression or groove; oral aperture distinct; flagella diverse in length, the vibratile appendage about as long as the body, the trailing twice that length; contractile vesicle double, situated opposite to each other in the anterior body-half, near the median groove; nucleus single, subspherical, subcentrally placed near the left-hand body-margin; endoplasm colorless, transparent. Length, $\frac{1}{1000}$ inch. *Hab.*—Standing pond water.

Protoperidinium limbatum, sp. nov. Fig. 6.

Carapace rhomboidal, depressed, little longer than broad, the postero-lateral margins produced in two, short, acuminate, horn-like processes, the posterior border concave; ventral surface flattened, with a central, longitudinal depression; surface facetted and minutely reticulated, the margins of the carapace and of the equatorial groove having a narrow, colorless, projecting, flattened and reticulate border; flagellum of the lateral groove spiral. Length, $\frac{1}{300}$ inch. *Hab.*—Marsh water, with sphagnum; color, yellow.

Holophrya ornata, sp. nov. Fig. 7.

Body obovate, compressed, slightly curved toward one side, less than three times as long as broad, the anterior extremity rounded, the posterior truncate; cuticular surface not striate, entirely ciliate; the cilia long and fine; oral aperture eccentric, the borders slightly protruding; lateral margins and posterior extremity ornamented by two rows of cuticular, rounded elevations, the series beginning at the middle third of one lateral border, and continued through the middle third of the opposite region, the constituent elevations of one series being alternate with those of the other; contractile vesicle single, large, near the posterior extremity; nucleus obscure; endoplasm coarsely granular. Length, about $\frac{1}{250}$ inch. *Hab.*—Standing pond water. Movements rotatory on the longitudinal axis.

Saprophilus (σαπροφιλος), gen. nov.

Animalcules free-swimming, holotrichous, ovate, soft, flexible and changeable in shape; general cuticular surface clothed with fine vibratile cilia, a single, long, flexible seta projecting from the posterior extremity; oral aperture ventral, supplemented by a vibratile and retractile hood-like membrane.

Saprophilus agitatus, sp. nov. Fig. 8.

Body ovate, compressed, about twice as long as broad, the posterior extremity rounded, the antero-ventral border obliquely truncate; cuticular surface longitudinally striate, the cilia short and fine; oral aperture ovate, ventral, at a short distance from the anterior extremity; the hood-like membrane narrow, widest posteriorly, narrowing to its anterior termination; contractile vesicle single, in the posterior body-half; nucleus subspherical, subcentrally placed. Length of body, $\frac{1}{750}$ to $\frac{1}{560}$ inch. *Hab.*—An infusion containing much decaying animal matter. Reproduction by transverse fission.

The hood-like velum resembles in character and function the oral appendage of *Pleuronema*, widely differing, however, in its vibratile movements, *Pleuronema* having only the power to lower and raise the organ, while the present form possesses the additional ability to rapidly vibrate the appendage. When retracted the latter is, similarly with the hood in *Pleuronema*, folded and stowed away about the posterior and lateral margins of the mouth.

The body is extremely soft, and quite changeable in shape, the latter, however, usually consisting chiefly in the assumption of a subspherical form. It has the power to force itself through small orifices, the body-sarcode flowing almost as freely as a semi-fluid substance.

These animalcules are essentially scavengers, greedily appropriating decaying animal fragments, swarming in crowds around and within the dead bodies of various small aquatic animals. Within the body of a dead *Gammarus* they were crowded in profusion, there rapidly undergoing reproductive fission, the process being probably hastened by the abundance of stimulating food.

Bothrostoma (βοθρος; στομα), gen. nov.

Animalcules free-swimming, heterotrichous, ovate, soft and flexible; peristome-field a more or less obliquely directed longitudinal depression, situated on the left-hand side of the body, extending beyond the body-centre, and continued inward as a short, ciliated, pharyngeal passage; the left-hand border of the peristome bearing a series of large cilia, the posterior portion of the right-hand margin supporting an undulating membrane; a cluster of long setose cilia projecting from the posterior extremity; contractile vesicle and nucleus conspicuous; anal aperture postero-terminal. Inhabiting fresh water.

Bothrostoma undulans, sp. nov. Fig. 9.

Body ovate, about two and one-half times as long as broad, colorless, soft and changeable in shape, the anterior extremity obtusely pointed, the posterior border truncate; cuticular surface longitudinally striate; peristome-field extending obliquely inwards beyond the body-centre; undulating membrane large, often resembling a long anteriorly curved seta, extending from the oral aperture to within one-third of the body-length of the anterior extremity; oral aperture at the posterior termination of the peristome, ovate; pharynx short, ciliate, infundibuliform; posterior setose cilia long and conspicuous; nucleus ovate, situated in the anterior body-half; contractile vesicle large, single, spherical, placed near the posterior extremity. Length of body, $\frac{1}{265}$ inch. *Hab.*—Standing pond water.

Hymenostoma magna, sp. nov. Fig. 10.

Body ovate, depressed, about twice as long as broad, the dorsal surface convex, the ventral flattened and chiefly occupied by the wide, adoral depression or groove which extends from the frontal border almost to the posterior extremity, the latter slightly produced and truncate, a broad tuft of larger cilia fringing the truncation; anterior border narrow, obliquely rounded; left-hand margin of the peristome bearing a series of long, fine cilia, directed across the adoral depression, the left-hand border furnished with an undulating membrane, widest anteriorly and projecting beyond the frontal body-margin as a sinistrally directed, concave acumination; oral aperture near the posterior extremity of the peristome; nucleus ovate, slightly curved, located posteriorly on the right-hand side of the body; contractile vesicle double, one near the posterior extremity, the other near the right-hand side of the body-centre, and formed, after systole, by the coalescence of several small vacuoles; cuticular surface fine striate longitudinally. Length of body, $\frac{1}{225}$ inch. *Hab.*—Standing pond water. Movement a rapid often backward revolution on the longitudinal axis.

This, the second known member of the genus, is readily distinguishable from *H. hymenophora* by the larger body, it being about twice as large as the last mentioned species, by the posterior truncation with its ciliary fringe, and by the form of the peristomal membrane, with its anterior projecting acumination. As in *H. hymenophora* the food masses collect in the left-hand side of the body.

Conjugation has been observed, union taking place between the ventral surfaces of the right-hand body margins.

Vorticella pusilla, sp. nov. Fig. 11.

Body conical-campanulate, less than twice as long as broad, widest anteriorly, tapering thence to the pedicle; constricted immediately beneath the peristome; cuticular surface transversely striate; peristome equaling the body-centre in width, the border thickened; pedicle from five to six times as long as the body; nucleus apparently ovate, anteriorly placed; contracted body subspherical, invaginating the extremity of the pedicle. Length of extended body, $\frac{1}{1300}$ inch. *Hab.*—Pond water; attached to rootlets of *Lemna.* Solitary.

Vorticella mollis, sp. nov.

Body conical campanulate, somewhat changeable in shape, widest anteriorly, tapering posteriorly, the length scarcely exceeding the width; peristome broad, flattened, crateriform, equaling in width the body-length, the border not revolute; cuticular surface very minutely tuberculate; contractile vesicle double; pedicle from sixteen to eighteen times as long as the body; contracted body subspherical. Length of the extended zooid, $\frac{1}{600}$ inch. *Hab.*—Pond water; attached to rootlets of *Lemna.* Solitary.

Vorticella aqua-dulcis, sp. nov. Fig. 12.

Body ovate or pyriform, very slightly changeable in shape, less than twice as long as broad, slightly constricted beneath the peristome border, the cuticular surface strongly and conspicuously striate transversely; peristome more than one-half the body-centre in breadth, but not equaling it, the border thickened, not everted; ciliary disc obliquely elevated; pedicle from two to three times as long as the body. Length of body, $\frac{1}{750}$ inch. *Hab.*—Fresh water; attached to rootlets of *Lemna.* Solitary, or few together. Contracted body obovate.

Vorticella platysoma, sp. nov. Fig. 13.

Body ovate or pyriform, less than twice as long as broad, the anterior body region subspherical, the posterior tapering to the pedicle; cuticular surface transversely striate; peristome equaling the body-centre in width, the border revolute; the ciliary disc not elevated; nucleus band-like, curved, transversely placed in the anterior body-half; pedicle seldom exceeding the body in length. Length of body, $\frac{1}{1125}$ inch. *Hab.*—Pond water; attached to Algæ.

Opercularia allensi, sp. nov. Fig. 14.

Bodies elongate-fusiform or subvasiform, more than three times as long as broad, widest centrally, tapering posteriorly to the pedicle, constricted beneath the peristome, the cuticular surface very finely striate transversely; peristome border everted, minutely crenulate; ciliary disc very obliquely exserted; ciliary circles two; membranous collar large and conspicuous; nucleus band-like, short, curved, transversely placed in the anterior body-half; contracted zooid suddenly pendent, obovate, usually with two or more posterior annulations, and always exhibiting at the anterior border a short, but conspicuous snout-like prolongation; pedicle profusely and dichotomously branching, longitudinally striate, annulate irregularly and at wide intervals, the ultimate divisions very short. Length of body, $\frac{1}{250}$ inch; height of entire colony, $\frac{1}{56}$ inch. *Hab.*—Pond water; attached to Algæ and various aquatic plants.

At first glance this closely resembles *O. nutans* (Ehr.) Stein, great differences being discernible, however, on slight examination. In *O. nutans* the pedicle is strongly and conspicuously annulate; here the annulations are absent or few in number and irregularly placed. The zooids are here transversely striate, while in *O. nutans* they are presumably smooth. In size the two forms are also widely and distinctly different, the bodies of *O. nutans* measuring only $\frac{1}{430}$ inch in length, while in *O. allensi* they are almost twice as large; the height of the entire colony of the former is from $\frac{1}{24}$ to $\frac{1}{9}$ inch, an enormous altitude in comparison with the $\frac{1}{56}$ inch of *O. allensi*. In their contracted state their resemblance is very close.

Opercularia vestita, sp. nov. Fig. 15.

Bodies elongate-conical, soft, flexible and somewhat changeable in shape, less than three times as long as broad, tapering from the region beneath the peristome to the pedicle; cuticular surface, with the exception of the peristome border and ciliary disc, entirely clothed with a coarsely granular, mucilaginous investment; peristome exceeding the body-centre in width, the border slightly revolute; ciliary disc conspicuously exerted, and obliquely elevated; ciliary circles three; vestibular seta conspicuous; contractile vesicle single, spherical, anteriorly placed, apparently within the base of the ciliary disc; nucleus band-like, broad, short and curved; endoplasm granular; contracted body obovate, with several posteriorly developed annulations, and an anterior, snout-like projection; pedicle tree-like, profusely and dichotomously branching, longitudinally striate, becoming chestnut-brown with age; primary pedicle seldom exceeding in height twice the length of a single body, the ultimate branches about one-fifth as long as the zooids, often curved, a single animalcule being stationed on the extremity of each ultimate division. Length of body, $\frac{1}{300}$ inch; height of the entire foot-stalk, exclusive of the zooids, $\frac{1}{40}$ inch. *Hab.*—Pond water; attached to aquatic plants.

Thuricolopsis (*Thuricola*; ὀφις), gen. nov.

Animalcules loricate, the loricæ as in *Thuricola*, with the addition of an internal, narrow, flexible valve-rest, adherent to the lorica wall by one extremity, and projecting arcuately across the cavity to receive and support the descended valve; zooid posteriorly attached to the lorica by a distinctly developed pedicle; otherwise essentially as in *Thuricola*.

Thuricolopsis innixa. Fig. 16.

Thuricola innixa Stokes. Am. Monthly Micros. Journ., Oct., 1882.

Lorica subcylindrical, sessile, from four to five times as long as broad, somewhat attenuate posteriorly, the base of attachment truncate; the frontal border even, sometimes slightly everted; bearing internally, at some distance from the orifice, a valve-like appendage as in *Thuricola valvata*, and an opposite, rigidly attached but distally flexible membranous, setiform organ projecting arcuately inwards, and acting as a support to the descended valve, the wall of the lorica being inflated immediately behind this bristle-like valve-rest; enclosed animalcule pedicellate, projecting, when extended, one-third of its entire length beyond the lorica aperture. Length of lorica, $\frac{1}{150}$ inch. *Hab.*—Pond water; attached to various aquatic plants.

Thuricolopsis Kellicottiana, sp. nov. Fig. 17.

Lorica subcylindrical, sessile, less than four times as long as broad, the posterior region tapering, attenuate, subcylindrical and forming about one-eighth of the entire length; frontal border slightly everted; posterior extremity truncate; valve and bristle-like support essentially as in *Th. innixa*, the lorica wall not inflated behind the valve-rest; enclosed animalcule, when extended, long and attenuate, about one-fourth of its length projecting beyond the lorica aperture; pedicle filiform, from one sixth to one-seventh as long as the lorica; cuticular surface smooth; two zooids frequently occupying the same sheath; nucleus extremely long, narrow and undulate; endoplasm granular; contracted body elongate obovate. Length of lorica, $\frac{1}{115}$ inch. *Hab.*—Pond water; attached to various aquatic plants.

This form was first observed by Prof. D. S. Kellicott attached to aquatic plants, at Corunna, Mich. (*Proc. Amer. Soc. Micros., 1884*), and by him referred to as a variety of *Th. innixa*. It occurs sparingly in the writer's locality in New Jersey, and seems sufficiently distinct to merit a specific title and place.

Platycola cœlochila, sp. nov. Fig. 18.

Lorica broadly ovate, becoming brown with age, less than three times as long as broad, dorsal surface convex; posterior extremity rounded, the anterior obliquely rounded or truncate, produced as a very short, vertical, neck-like prolongation, the margins slightly everted, the aperture transversely oval or subelliptical, laterally prolonged toward the ventral aspect, presenting, in lateral view, the appearance of a deep, rounded excavation; zooid, when extended, protruding for a considerable distance beyond the aperture; nucleus long, narrow, band-like. Length of lorica, $\frac{1}{215}$ inch. *Hab.*—Pond water; attached to the rootlets of *Lemna*.

Lagenophrys patina, sp. nov. Fig. 19.

Lorica nearly orbicular, much depressed, upper surface slightly convex, the lower plane; aperture circular, terminating a short, nearly perpendicular neck-like prolongation, surrounded by a thin, apparently membranous, horizontally projecting border, its margin irregularly and minutely crenulate. Diameter of lorica, $\frac{1}{450}$ to $\frac{1}{500}$ inch. *Hab.*—Pond water; attached to the legs and branchial appendages of *Gammarus*.

In form and size this closely resembles *L. ampulla* Stein, but differs in the absence of the everted and beaded rim projecting in front of the oral aperture in the first-mentioned species.

Histrio erethesticus, sp. nov. Fig. 20.

Body subelliptical, less than three times as long as broad, both extremities rounded, the lateral borders flattened, nearly parallel; lip semicircular; peristome-field reaching to the centre of the ventral surface, the right-hand margin bearing a membrane; frontal styles nine, the three anterior ones largest, the three posterior smallest, setose, inconspicuous; ventral styles five, more or less clustered, two on the right-hand side small, setose; anal styles large, stout, usually rigid, only the second and third on the right-hand side projecting beyond the posterior border; marginal setæ uninterrupted. Length of body, $\frac{1}{170}$ inch. *Hab.*—Shallow pools, with *Lemna* and Algæ.

The animalcule's movements during forward progression are constant but not especially rapid, nor long extended in one direction, but it has a most annoying habit of suddenly darting backward, for a distance seldom exceeding its own length, yet as it is impossible to anticipate the direction of this erratic movement, and as the change of position is extremely rapid, the eye fails to adjust itself soon enough to keep the creature distinctly visible. The Infusorian continues these backward leaps incessantly when not swimming forward, consequently it is a difficult animalcule to study. Occasionally, especially after long confinement, two contractile vesicles become apparent, a small vacuole developing near the centre of the left-hand margin of the peristome, in advance of the large normal vesicle.

Solenophrya odontophora, sp. nov. Fig. 21.

Lorica cup- or bowl-shaped, membranous, hyaline, the height about equal to the breadth, the posterior extremity rounded, the anterior border beneath the even, circular margin bearing from four to twelve attenuate, hollow, variously and inwardly curved, tooth-like processes; enclosed animalcule not adherent to the lorica; endoplasm finely granular. Height of the lorica including the processes, $\frac{1}{1125}$ inch; length of the tooth-like processes, $\frac{1}{2250}$ inch. *Hab.*—Pond water; attached to Myriophyllum.

This form was first observed, and in considerable abundance, about four years ago, but has not since been met with. All the individuals then noted had withdrawn the tentacles, and had become encysted within the lorica. The tentacles have therefore never been seen. These encysted forms were undergoing one stage of reproduction. The entire endoplasm is subdivided into very minute, remarkably active, biflagellate germs.

Acineta bifaria, sp. nov. Figs. 22, 23, 24.

Lorica, in side view, oval, the longest diameter less than twice the height ; seen from above orbicular ; the entire surface minutely tuberculate ; pedicle very short, often only a small, inconspicuous, button-like projection ; enclosed body attached to the posterior extremity only of the lorica, and divided into two unequal parts, the posterior region often entirely filling the cavity of the sheath, occasionally only about one-half filling it, the anterior portion subspherical, habitually extruded beyond the lorica aperture, and bearing the scattered capitate tentacles, the posterior or loricate portion often coarsely and longitudinally striate ; endoplasm granular ; contractile vesicles two, spherical, one situated near the lateral border of the anterior body-half, the other on the opposite side of the posterior or loricated region ; nucleus apparently broadly ovate or subspherical, anteriorly placed ; reproduction by transverse fission of the extruded anterior region, the embryo hypotrichous. Diameter of the lorica, $\frac{1}{500}$ inch. *Hab.*—An infusion of hay.

The first noticeable sign of approaching reproductive fission consists in an increased extrusion of the body substance, speedily followed by the formation of fine cilia on the anterior surface, with the appearance of a transverse constriction subcentrally situated on the extruded portion, as in Fig. 23. This constriction deepens, the cilia increase in length, soon entirely clothing the frontal region aud one lateral margin, and, by the time the division is completed, the posterior border as well. At the final separation of the embryo it is ovate, coarsely granular, with a somewhat conspicuous nucleus. It speedily becomes elongated and flattened, as in Fig. 24, its length exceeding the height of the mature animalcule. The cilia are confined to the extremities and the lower surface, while a few short, capitate tentacles are scattered over the superior aspect. After the departure of the embryo the remaining portion of the mature animalcule withdraws itself into the lorica, as in Fig. 22, the anterior, subspherical region remaining exposed and the tentacles protruded. The latter become fewer in number, but are not entirely withdrawn during the reproductive act. After it they become more numerous.

The presence of the short, button-like pedicle of some individuals gives the lorica an appearance closely resembling that of *Solenophrya*, to which genus they might readily be relegated if not seen scattered among the more abundant and more distinctly pedicellate forms.

Acineta macrocaulis, sp. nov. Figs. 25, 26.

Lorica obovate or subspherical. Lorica obovate, the length only slightly exceeding the width, flexible, continuous, taking the form of the enclosed zooid, the anterior border rounded, the lateral margins almost straight, tapering to the pedicle. Lorica subspherical, the anterior border slightly undulate, the anterior extremity of the pedicle suddenly expanded. Pedicle from seven to nine times as long as the lorica, hollow, its cavity continuous with that of the sheath ; enclosed body usually entirely filling the lorica, soft, changeable in shape, not attached posteriorly to the lorica ; endoplasm granular, enclosing numerous, large, refractive, probably amylaceous corpuscles ; tentacles irregularly distributed at the anterior border, distinctly capitate, exhibiting spiral folds during their retraction ; contractile vesicle apparently single, posteriorly placed near one lateral border ; nucleus not observed. Length, including pedicle, $\frac{1}{100}$ to $\frac{1}{70}$ inch. *Hab.*—Pond water ; attached to Myriophyllum.

Acineta acuminata, sp. nov. Fig. 27.

Lorica broadly vasiform, slightly longer than broad, the posterior border rounded, the anterior continuous, obliquely truncate on each side, and produced centrally in a prominent acumination, the lateral angles also often acuminately prolonged ; the anterior borders on each side separated by a slit-like aperture, and the front wall bearing two narrow, anteriorly converging fissures, for the passage of the tentacles ; pedicle hollow, from one-third to one-half as long as the lorica and communicating with its cavity ; enclosed body subspherical, attached to the lorica anteriorly only and there taking the form of the sheath ; tentacles fine, capitate, scarcely clustered ; contractile vesicle single, spherical, situated near one side of the posterior extremity ; nucleus large, subcentral ; endoplasm granular. Length of lorica, $\frac{1}{500}$ inch ; of pedicle, $\frac{1}{1500}$ to $\frac{1}{1125}$ inch. *Hab.*—Pond water.

The lateral angles are sometimes produced, sometimes rounded ; and occasionally one will be rounded and the other slightly produced. The anterior central acumination has been present in all the forms observed. That only one wall of the lorica should be pierced by the two converging fissures is noteworthy. Corresponding lines on the opposite wall could not be perceived, although careful search was made for them.

Explanation of the Figures.

Fig. 1. Hexamita spiralis.
2. Petalomonas dorsalis. Diagram.
3. Urceolopsis sabulosa.
4. Trachelomonas urceolata.
5. Anisonema solenota.
6. Protoperidinium limbatum.
7. Holophrya ornata.
8. Saprophilus agitatus.
Fig. 9. Bothrostoma undulans.
10. Hymenostoma magna.
11. Vorticella pusilla. Pedicle omitted.
12. Vorticella aqua-dulcis. Pedicle omitted.
13. Vorticella platysoma.
14. Opercularia allensi.
15. Opercularia vestita.

Fig. 16. Thuricolopsis innixa.
17. Thuricolopsis Kellicottiana.
18. Platycola cœlochila.
19. Lagenophrya patina.
20. Histrio erethesticus.
21. Solonophora odontophora.
22. Acineta bifaria.
Fig. 23. A. bifaria. Reproductive fission.
24. A. bifaria. Embryo.
25, 26. Acineta macrocaulis. Pedicle omitted.
27. Acineta acuminata.

Preliminary Report on the Vertebrate Fossils of the Uinta Formation, collected by the Princeton Expedition of 1886. By W. B. Scott and Henry F. Osborn.

(Read before the American Philosophical Society, Sept. 2, 1887.)

The Uinta formation, which was first identified by Prof. Marsh, is one of great interest, as it is just intermediate between the Bridger and the White River groups. It has as yet been comparatively little explored, and much remains to be done, but enough is now known to render possible some account of this most important intermediate fauna.

REPTILIA.

Crocodilus, sp. indet.

Trionyx, sp. indet.

MAMMALIA.

Lemuroidea.

Hyopsodus gracilis Marsh.

Creodonta.

Mesonyx uintensis Scott.

Carnivora.

Amphicyon (?) *vulpinum*, sp. nov.—The probable existence of this genus in the Uinta beds is indicated by a lower premolar and lower sectorial molar. The premolar, probably the third, consists of a high, acute and compressed cone, with rudimentary posterior heel ; a cingulum runs entirely around the crown, and is most conspicuous on the anterior surface. This tooth differs from the premolars of most of the European species of *Amphicyon* in the fact that the main cusp has no accessory tubercles developed upon it. The sectorial molar is canine in character ; the blade consists of three cusps, of which the external is the larger, and the anterior is very low ; the sectorial blade is therefore much less developed than in *Cynodictis*, and hardly more than in *Miacis* ; the heel is low and small and not very distinctly basin-shaped. These teeth are insufficient for a final reference of the specimen, which may possibly belong to *Miacis*, but for stratigraphical reasons I think it more probably a species of *Amphicyon*. *Cynodictis* it certainly is not.

Measurements.

	M.
3d (?) lower premolar, antero-posterior diameter......	.010
" " " transverse "	.004
1st lower molar, antero-posterior diameter.............	
" " " transverse "	

Another flesh-eater, exceeding the lion in size, is indicated by some metatarsals and phalanges. These may belong to the very large species of *Mesonyx* from the same beds, or to something quite different. No determination can be made at present.

RODENTIA.

Plesiarctomys sciuroides, sp. nov.—Rodents have not as yet been announced from the Uinta deposits; representatives of two genera were, however, obtained by the Princeton party, one of which is the *Plesiarctomys* of the Wasatch and Bridger. In this species the molar formula is $\frac{5}{4}$; it differs from the other species of the genus which Cope defines as having the transverse crests of the upper molars "obsolete or wanting," in the structure of the upper molars, which are entirely like those of *Sciurus*, and consist of two external cusps, from which run two transverse crests, meeting internally and forming a V. The first upper premolar is very small and single-rooted. The lower molars are very like those of the Bridger species; there are four marginal tubercles surrounding a median depression; the antero-internal cusp is the highest; a low transverse crest connects the anterior pair of tubercles and a less distinct crest the posterior pair. These crests are better marked than in most species of *Plesiarctomys*. The skull has no post-orbital processes and a very large infra-orbital opening; the cranium is broad and flat, without sagittal crest, the inion low and rounded, the zygomatic arches much depressed and very thin, the cerebral hemispheres are entirely unconvoluted and leave the olfactory lobes and cerebellum exposed completely. This species is very small, less in size than *Plesiarctomys delicatissimus*.

Measurements.

	M.
Length of skull....	.061
Breadth of skull, in front of orbits....................	.025
Length of lower jaw...	.028
Length upper molar series..........................	.013
" lower " "	.012
Lower incisor, antero-posterior diameter..............	.003
" " transverse "	.002

A second species of rodent is represented by a lower incisor and part of the mandible, but as no molars are preserved, the specimen cannot be referred to any genus. The incisor is very much larger than in any known species of *Plesiarctomys,* and equals that of the beaver in size. It may not improbably belong to some ancestral member of the *Castoridæ,* as that family is known to exist in the overlying White River beds.

Measurements.

	M.
Antero-posterior diameter of lower incisor............	.008
Transverse " " "	.0065

ARTIODACTYLA.

Protoreodon parvus, gen. et sp. nov. (?*Agriochoerus* Marsh).—This genus is of interest as being the direct forerunner of the *Oreodontidæ*, which are so characteristic of the American Miocene formations. It differs from *Oreodon* in the structure of the upper molars, which have five cusps, an intermediate one appearing between the anterior pair. The crowns of the upper molars are very wide and the internal crescents separated from the external by a considerable interval, much as in *Agriochoerus.* Both upper and lower premolars are somewhat simpler than in *Oreodon,* and the latter are trenchant, as in *Tragulus.* It differs very radically from *Agriochoerus* in the character of the premolars as well as in the presence of the intermediate cusp in the superior molars. The orbit is not enclosed behind, the cranium is narrower and less rounded and the brain smaller than in *Oreodon.* On the other hand, its relationship with that genus is incontestable ; the lower teeth form a closed series without any diastemata, the lower canine has gone over to the incisor series, and the first premolar has taken on the form and function of the canine, a peculiarity found only among the *Oreodontidæ.* As in that family, the mandible is short, deep, and has an abruptly rounded chin.

The number of digits is uncertain, but is probably v–iv, as is unquestionably the case in *Oreodon ;* the magnum has not moved so far to the radical side, but is more directly under the magnum than in the latter genus. In the tarsus the external and median cuneiforms are fused together as in *Oreodon,* but the line of union is much more plainly marked than in that genus.

Protoreodon parvus: Upper molar series, natural size. The inner cusp of the third premolar has been broken away.

This species was of very small size, much inferior to *Oreodon gracilis.*

Measurements.

	M.
Length upper molar series	? .053
" " premolar series	? .026
" " true molar "	.027
Length lower molar series	.054
" " premolar series	.027
" " true molar "	.027
Antero-posterior diameter, third upper molar	.010
Transverse " " " "	.008
Antero-posterior diameter, third lower molar	.012
Transverse " " " "	.006

Protoreodon (?) *pumilus* (*Agriochoerus pumilus*) Marsh.*—Professor Marsh has described a species of Agriochoerus from the Uinta beds, which more probably belongs to *Protoreodon;* but as the description given is very brief and no mention is made of the very characteristic antero-intermediate cusp on the upper molars, it may possibly be a member of some other genus.

Leptotragulus proavus, gen. et sp. nov.—This genus resembles the White River form *Leptomeryx*, but differs from it in the somewhat less complex structure of the last lower premolar, and in the presence of a strong accessory column between the external cusps of the lower molars. In all probability also this genus had separate metapodials, while in *Leptomeryx* there is a cannon-bone in the hind foot. Apparently the nearest ally of this genus is the *Prodremotherium* of Filhol, with which indeed it may prove to be identical; at present, however, we have judged it best to separate the American species, as aside from the fact that *Prodremotherium* has cannon-bones in both fore and hind feet, the last lower premolar, judging from Filhol's figures,† is somewhat more complex in structure, and less distinctly trenchant than in *Leptotragulus*. The latter is at once distinguished from its cotemporary *Protoreodon*, by the form of the mandible, which is very slender, with tapering chin and diastema behind the canine, while in *Protoreodon* the mandible is deep with abruptly rounded chin and no diastema; a further difference is found in the premolar formula of the lower jaw, four in *Protoreodon*, three in *Leptotragulus*. The premolars resemble most those of the tragulines; the last one consists of a high, sharp and compressed cone, with a very small antero-internal cusp, and a narrow valley on the posterior edge enclosed between two thin plates of enamel; this valley is not complicated by the accessory tubercles found in *Leptomeryx*.

The species *L. proavus* considerably exceeds in size the *Leptomeryx Evansi* of the White River formation, and is somewhat larger than *Tragulus javanicus*. The crowns of the lower molars are low and broad in proportion to their length.

* Am. Jour. Sci. and Arts, 3d Ser., Vol. ix, p. 250.

† Rech. sur les Phosphorites du Quercy, Figs. 265, 266.

The systematic position of this genus can hardly be decided from the material now at command; it may be a forerunner of *Leptomeryx*, the only genus of the White River formation which at all resembles it; it may be an ancestral type of the *Cervidæ*, or a member of the traguline series. These questions must for the present be left open.

Measurements.

	M.
Length lower premolar series	.021
Last lower premolar, antero-posterior diameter	.007
" " " transverse "	.003
First lower molar, antero-posterior diameter	.008
" " " transverse "	.005
Length lower true molar series (second specimen).	.026
Third lower molar, antero-posterior diameter (second specimen)	.012

Professor Marsh has named three genera of Uinta ruminants, *Eomeryx*, *Oromeryx* and *Parameryx**, with one of which *Leptotragulus* may be identical. As, however, no definition of these names has as yet been offered, they cannot be used.

PERISSODACTYLA.

Epihippus uintensis Marsh.†—This genus differs from the Bridger *Pliolophus* in having the last two inferior premolars of the molar pattern.

Epihippus gracilis Marsh.—Some beautifully preserved specimens of this small species are in the collection and show interesting differences from the Wasatch *Hyracotherium*. The characteristic equine cusps at the inner angle of the Vs on the lower molars are more isolated and distinct; the limb bones are proportionately longer and more slender; the carpus is higher and narrower; the magnum is more depressed and like that of *Anchitherium* in shape; there are still four digits in the manus, but No. V is very slender; the ulna is still further reduced. *Epihippus* forms a very interesting transition to the horses of the overlying White River deposits.

Hyrachyus obliquidens, sp. nov.—Specimens of this genus are not at all uncommon in the Uinta deposits, but the only ones which can as yet be satisfactorily determined belong to a species different from any of the known Bridger species. This species is characterized by the last upper molar, which has become exceedingly oblique and very like the corresponding tooth of *Aceratherium;* the antero-external lobe is greatly reduced in size, the external wall of the crown is nearly parallel to the posterior transverse crest and prolonged but little beyond it, so that the posterior valley is almost obsolete, being even less developed than in

* Introd. and Succ. of Vert. Life in America, pp. 29, 30.

† Loc. cit., p. 24.

Hyracodon. The rest of the dentition shows no particular deviation from the usual type, nor are important differences from the Bridger species observable in the skeleton, except perhaps a slight reduction in the relative size of the lateral digits. In size this species about equals *H. agrarius.*

Prothyracodon intermedium, gen. et sp. nov.—This very interesting type is apparently intermediate between *Hyrachyus* and *Hyracodon.* The type specimen consists of a fragment of the superior maxillary containing the fourth premolar and second molar in place, with the alveolus of the first molar. As in *Hyrachyus* the premolar has but a single internal cusp and two transverse crests enclosing a valley. The external cusps are like those of *Hyracodon*, the outer wall of the crown being nearly flat and subquadrate in outline; the two constituent cusps are but faintly indicated, but are somewhat more pronounced than in *Hyracodon.* An antero-external buttress or fold of the cingulum is present, as in both the Bridger and White River genera.

The second molar is essentially the same as in *Hyracodon;* the antero-external lobe is much more reduced than in *Hyrachyus*, and the transverse crests directed more obliquely inwards and backwards; but on the other hand, the projection from the anterior crest into the median valley which is to be seen on all the molars of *Hyracodon* is here wanting.

The present species is quite small; it is about the size of *Hyrachyus agrarius.*

Measurements.

	M.
Fourth upper premolar, antero-posterior diameter......	.010
" " " transverse "	.014
Second upper molar, antero-posterior diameter........	.016
" " " transverse "	.0175

Isectolophus annectens, gen et sp. nov.—This genus is closely allied to *Helaletes* of the Bridger, but its dentition is one step nearer to that of the tapir. In *Helaletes* the antero-external cusp of the upper molars is less reduced and there is less difference between that and the postero-external cusp, than in *Hyrachyus.* This tooth structure would almost suffice to remove *Helaletes* from the *Lophiodontidæ* as defined by Cope. In *Isectolophus* this equality of the external cusps is still better marked, and, more important still, the external wall is extended behind the posterior pillar just as in the tapir, so that this pillar becomes a median thickening of the postero-external cusp, instead of being a thickening of the posterior edge of that cusp, as in *Hyrachyus* and *Helaletes.* The first and second upper molars are thus almost exactly like those of the tapir; the transverse crests are low and thick, and a strong cingulum surrounds the crown. The premolars are probably all simpler than the molars; at all events this is true of the third. The lower molars are like those of *Helaletes,* and the last one has a well-developed heel or third crest; there seems, however, to have been a diastema between the canine and first premolar, though this is not certain, which is not the case in *Helaletes*.

The species is rather small, somewhat larger than *Helaletes latidens* of the Bridger.

Measurements.

	M.
Length upper molar series	.048
First molar, antero-posterior diameter (?)	.015
" " transverse " (?)	.015
Second " antero-posterior "	.015
" " transverse "	.014
Third " antero-posterior "	.016
" " transverse "	.018
Third upper premolar, antero posterior diameter	.012
" " " transverse "	....
Third lower molar, antero-posterior "	.023
" " " transverse "	.011

The study of this genus shows that *Hyrachyus* and *Desmatotherium* cannot be placed in the direct line of tapir ancestry, as we were formerly disposed to believe. Much more probably this line has come down through the genera with trilobed last lower molar, and it is noteworthy that the tapiroids from the White River beds have the third lobe or talon present, though less distinctly marked. These animals have been described by Dr. Leidy,* under the name of *Lophiodon*, from which genus the known specimens do not appreciably differ. But, as Dr. Leidy has suggested, they probably belong to a very different genus, which, when better known, will in all likelihood be found to be intermediate in character between *Isectolophus* of the Uinta and *Tapiravus* of the Loup Fork. According to this view the series of genera would be: *Helaletes*, *Isectolophus*, the White River genus, *Tapiravus* and *Tapirus*.

Amynodon Marsh (*Syn. ? Orthocynodon*, nobis).—Professor Marsh's description of this genus is as follows:† "The skull is intermediate in form between that of a Tapir and a Rhinoceros, but the molar teeth are entirely of the latter type. The premolars are all unlike the molars, and the canines above and below are very large. The incisors are small and the inner one in each jaw is lost in the present adult animal. The lower canines are placed nearly horizontal, and, taken in connection with the rest of the anterior dentition, they prove conclusively that the large lower teeth usually regarded as incisors in *Aceratherium* * * * are really canines." The number of digits is stated to be iv–iii. This description is erroneous in most of the particulars, owing to the fact that it was drawn up before the type specimen had been removed from the matrix and put together, and in this way, even after examining the type ourselves, as

* Ext. Mamm. Faun. of Dak. and Neb., p. 239.

† Am. Journ. Sci. and Arts, Third Ser., Vol. xiv, p. 251.

Professor Marsh kindly allowed us to do, we were formerly led to consider the Bridger species as a distinct genus* (*Orthocynodon*).

The numerous specimens from the Uinta formation now in the Princeton collection show that *Orthocynodon* is very probably identical with *Amynodon*. The premolars are not all unlike the molars, as the third and fourth of the upper premolar series have all the molar elements, but are somewhat smaller; the incisors are present in their full number in the upper jaw; the lower canines are not procumbent but fully erect. We can therefore confirm Professor Marsh's statements only with regard to the pattern of the molar teeth and probably also as to the number of digits.

Amynodon advenus Marsh is the only species as yet known from the Uinta beds, in which, especially in the higher strata, it is very abundant.

Diplacodon elatus Marsh.†—This animal, the largest yet known from the Uinta, is of especial interest as being intermediate between the Chalitherioids of the Bridger (*Palæosyops, Leurocephalus*, etc.), and the gigantic *Menodontidæ* of the White River, as was first suggested by Professor Marsh. The dentition is like that of *Palæosyops*, but the premolars have commenced to assume the molar pattern; there are, however, no traces of the horn-like processes so characteristic of *Menodus*. The skeleton, which is very fully represented in the collection, is massive, and in many respects closely like that of *Menodus*. The cervical vertebræ are short, with opisthocœlous centra and quite long spines; the dorsal vertebræ are heavy and in the anterior region have very long spines, which, however, do not reach the extreme length found in *Menodus;* the lumbars are rhinocerotic in character; the ribs are long, flattened and heavy. The scapula is, like that of *Menodus*, very rhinocerotic, long and narrow, but with more abruptly rising spine and rudimentary metacromion; the humerus is very massive, with strongly developed deltoid hook and supinator ridge; this humerus is a somewhat reduced copy of that of *Menodus;* the ulna is stout for its entire length and has a very prominent olecranon; the radius differs in no essential except size from that of *Menodus;* the carpus is low and broad, the metacarpals and phalanges like those of *Palæosyops*, only stouter. The pelvis is like that of *Palæosyops*, with long, pedunculate and plate-like ilium, which is not everted nearly so much as in *Menodus*, and long, heavy and trihedral ischium; the femur is long and massive, with very prominent third trochanter, and with the rotular trochlea narrower and deeper than in *Menodus;* the tibia is shorter than the femur; the calcaneum has a very long tuber calcis and a narrow cuboidal facet, considerably narrower than in *Palæosyops;* it appears also to possess the distinct fibular facet which is found in *Menodus;* the astragalus is broader and shallower than in *Palæosyops*, and has a more exten-

* Bull. E. M. Museum, No. 3, pp. 1 *et seq.*

† Am. Journ. Sci. and Arts, 3d Ser., Vol. ix, p. 246. Introd. and Succ. Vert. Life, p. 27.

sive bearing upon the cuboid, while it is narrower than in *Menodus*, and has a less extensive contact with the cuboid. The number of digits is apparently iv–iii.

The characters revealed by this skeleton abundantly confirm Professor Marsh's view that *Diplacodon* is to be regarded as the ancestor of *Menodus*, and as a descendant of the Bridger Chalicotherioids.

The Uinta fauna differs in many very important respects from that of the Bridger formation, both in what it possesses and in what it lacks; nevertheless it is on the whole more closely akin to the Bridger than to the White River fauna. The great *Dinocerata* seem to have completely disappeared, as have also the *Tillodonta*; rodents, lemuroids, and creodonts are very much less common than in the Bridger, and what seem to be the first true American carnivores have appeared; perissodactyls of chalicotherioid, lophiodont, equine and rhinocerotic types are still very numerous. But the most remarkable and striking change consists in the extraordinary increase in the number of selenodont artiodactyls, which are exceedingly rare in the Bridger, but in the Uinta are perhaps more abundantly represented, as far as individuals are concerned, than any other group of mammals; in character these artiodactyls are distinctly like those of the White River epoch. As yet no bunodont artiodactyls have been discovered, though they doubtless existed. With the possible exception of *Agriochoerus* (see p. 257), no genus is yet known which is common to the White River and Uinta formations, while several Bridger genera are represented in the latter; there are *Plesiarctomys*, *Mesonyx*, *Hyrachyus*, *Amynodon*, and perhaps others. No perissodactyl in which the premolars have all taken on the molar pattern, and no artiodactyl with coalesced metapodials, is known in this fauna, which thus has a distinctly older facies than the fauna of Quercy,* which, however, agrees with it in the great increase in selenodonts. Schlosser† considers the Uinta fauna as Oligocene, but, as we believe, without good reason, since not a single Miocene genus has been found in it, the genera being all either common to the Bridger or peculiar to the Uinta. The term oligocene is much more properly applied to the overlying White River beds, as has been done by Messrs. Cope and Filhol.‡ It seems, therefore, best on the whole to regard the Uinta as forming the summit of the eocene, as Professor Marsh, who first described its fauna, has done.

Synopsis of the Uinta Fauna.

	Genera.	Species.
Rodentia	2	2
Lemuroidea	1	1
Creodonta	1	1

* Filhol Phosph. du Quercy, pp. 517–554.

† Morph. Jahrb., Bd. xii, p.

‡ Bibl. de l'École d. Hautes Études; Sect. d. Sci. Nat. T., xix, p. 21 (separatim).

	Genera.	Species.
Carnivora (?)	1	1
Artiodactyla	2	3
Perissodactyla	6	7
	13	15

For the very extensive and valuable collections of Uinta fossils now preserved in the Princeton museum, of which a brief account has been given above, we are chiefly indebted to the energy and skill of Mr. Francis Speir, Jr., of New York, who was in charge of the expedition of 1886.

GEOLOGICAL MUSEUM, PRINCETON, N. J., July 12, 1887.

On the Systematic Position of the Mallophaga. By A. S. Packard.

(*Read before the American Philosophical Society, September 2, 1887.*)

The true position of the bird-lice has been in debate for many years, and it is only recently that, in the excellent essay of Grosse,* we have such an exact account of the mouth-parts of these insects, as to enable us to perceive that they have been wrongly referred to the Hemiptera. With the new information afforded by Grosse, who does not himself add any general conclusions as to the systematic position of the Mallophaga, beyond stating that they are not Hemiptera, nor allied to the true lice, we have for our own satisfaction made some comparisons with the Psocidæ, to which, among winged insects, the parasites in question seem nearest allied.

The name *Mallophaga* was first proposed by Nitzsch in Germar's "Mag. der Entomologie," iii, 270, 1812.† In Gerstaecker's "Arthropoden" of Peters and Carus' "Handbuch der Zoologie" (1863), where this group is placed with the lice among the Hemiptera, it is stated that Burmeister regarded the Mallophaga as Orthoptera: "Zwischen welchen und den Hemipteren sie in Anbetracht ihrer Verwandtschaft mit den Läusen ein Uebergangsglied abgeben, ohne füglich einer von beiden Ordnungen direct zugewiesen werden zu können."

In our "Guide to the Study of Insects" (1868), and in subsequent editions, influenced by general usage and also by Melnikow's arguments, based on embryological studies, we placed the Mallophaga among the Hemiptera, next to the true lice. In most, if not all German, Dutch, and French, as well as English text-books, the Mallophaga, if referred to, are described with the true lice. But, in his article, "Insects," in the "Encyclo-

* Beiträge zur Kenntniss der Mallophagen. Von Dr. Franz Grosse. Zeits. für wissen. Zool., xlii, 1885, pp. 530-558. A lengthy illustrated abstract by Prof. G. McCloskey will be found in the American Naturalist, April, 1886, pp. 340-348.

† I am indebted to Dr. Hagen for this reference to Nitzsch's paper.

pædia Britannica," 9th edit., Mr. R. McLachlan claimed that these insects should be regarded as degraded Pseudoneuroptera. This view seems a natural one. Struck by this suggestion, and before reading Nitzsch's essay on the internal anatomy of Atropos, we had been led into comparisons with the Psocidæ, particularly the wingless form Atropos, to which, as we hope to show, with the aid of Grosse's results, the bird-lice are more closely allied than to any other group of insects. Grosse himself, unfortunately does not intimate what his views are as to the exact systematic position of the group under consideration, beyond affirming that they certainly are not Hemiptera.

We will now turn to the conclusions of Melnikow,* derived from a study of the embryology both of the Mallophaga and the true lice. In this essay the author thus sums up his views as to the affinities of the Mallophaga :

"The study of the embryology of the Pediculidæ and Mallophaga affords proof of a complete similarity in the mode of development of these two groups of animals. We are convinced that the similarity urged is seen not only in the identity of the formation of the primitive streak and the relations of the embryonal membranes, but also in other more subordinate features of the development. We have for example perceived that in the lice as well as the Mallophaga a provisional mass of cells is formed before the completion of the blastoderm ; that both have the provisional membrane which the larva leaves behind it in the egg at the time of hatching. Finally we are in a position to state that the beaks of both groups of insects are independently formed of the appendages of the head-segments.

"These, though subordinate processes of development, appear to us to be of more value in the comparison of the insects under consideration than the relations of the mode of formation of the primitive streak and of the embryonal membranes, since the last without doubt is generally common to those insects with an internal primitive streak, but the former must be regarded as the distinctive feature of the insects under consideration.

"If we add to the results mentioned, the fact that the anatomical structure of the mouth-parts in the insects of the two groups agrees in all essential points ; if we add the generally similar external form of these insects, finally their ectoparasitic mode of life, then we need not hesitate to recognize the close relationship of the lice and Mallophaga.

"This conviction is not insignificant, since it affords us the possibility of decisively answering the question as to the systematic position of these insects.

"After the researches of Burmeister it was generally considered that the Pediculidæ belonged to the Hemiptera. The structure of their mouth-parts and the incomplete metamorphosis they undergo are the reasons which confirm such a view.

* Beiträge zur embryonal Entwickelung der Insekten. Archiv f. Natur-Gesch., xxxv 1869.

"But the Mallophaga were regarded by De Geer as a special group, and by Nitzsch and others they were generally referred to the Orthoptera. So far as I am aware, only Gerstaecker, in his "Handbuch der Zoologie," places the Mallophaga at the end of the Hemiptera; still he is inclined to consider the group as a special one, forming a sort of transition from the Hemiptera to the Orthoptera, but without forming a direct connecting link.

"Since until now, we knew only of the biting mouth-parts of the Mallophaga, so the view that they were entitled to be regarded as Orthoptera was completely founded. In the Orthoptera we place those insects with an incomplete metamorphosis and biting mouth-parts. But after the existence of a beak in the Mallophaga has been proved, it becomes evident that they should be regarded as Hemiptera or bugs.

"This conclusion is wholly indisputable when we recall the above mentioned similarity of the Mallophaga with the genuine lice. As to the completeness of this similarity, I will call attention again to the relations of the mouth-parts, which have been cleared up by our embryological studies. We are thereby brought to the conviction that in the lice as well as in the Mallophaga, in their adult condition, no underlip (labium) exists, while the mandibles and maxillæ are present. The only difference in the mouth-parts of the two groups is this: that in the Mallophaga these head-appendages are the functional parts of the mouth-apparatus, while in the Pediculidæ they become rudimentary.

"But such relative differences do not have so great systematic value as to lead us to place so nearly related animals in two different orders.

"From the reasons we have presented we adopt the Linnean view that the Mallophaga belong with the Pediculidæ; we think we are right in regarding both groups as families of the Rhynchota."

From the foregoing facts and conclusions of Melnikow, we felt convinced that he had demonstrated that the Mallophaga were Hemiptera and nearly related to the Pediculidæ. But after a careful reading of Grosse's memoir on the Mallophaga, translated by Prof. McCloskey, we think he is right in considering that these biting lice are not genuine Hemiptera. The very fact, admitted by Melnikow, that the mandibles and maxillæ retain their biting function and do not become rudimentary as in the Pediculidæ, and the fact pointed out by Grosse, that the second maxillæ do exist in the Mallophaga, leads us to regard their louse-like shape as simply adaptive, and that they belong to some other group than the Hemiptera.

If we examine Melnikow's excellent figures we see that after the mouth-parts of the embryo of both the genuine Pediculidæ and Mallophaga are developed, the embryos of the two groups follow different developmental paths. The large clypeal region of the Mallophaga becomes still larger and broader, overhanging and concealing from above the labrum, which is short and broad; on the other hand, in the Pediculus it becomes long, narrow and slender. The mandibles become true biting jaws, while in the Pediculus they become long and slender; the maxillæ become minute and short, of the masticatory type in the Mallophaga, while in the Pediculus they remain large and long (Melnikow, Fig. 371) and of the size and shape of the mandibles; the second maxillæ in Pediculus are, in this stage, as large as in the first maxillæ, while in the Mallophaga they become minute. After the stage indicated by Melnikow's Fig. 37 (Pediculus) and Figs. 32, 33 and 34 (*Trichodectes canis*) the ordinal differences become more marked.

Among the Pseudoneuroptera of Erichson, a group which is so unnatural that it will have to be abandoned, we have after the elimination of the Odonata and the Plectoptera or Ephemeridæ, the families of Perlidæ, Psocidæ, Embidæ, and Termitidæ, which we have associated together in the order *Platyptera*. It is to the wingless Psocidæ that the Mallophaga appear to bear the closest resemblance. If we compare certain Mallophaga, especially those with a small prothorax, such as Goniocotes, Docophorus, etc., with the wingless Atropos, or the wingless young of Psocus, there is a general similarity to the latter in the small thorax, the large oval abdomen and the large head, with the small eyes. But these resemblances are superficial. But, however, with the aid of Grosse's figures of the mouth-parts of the Mallophaga and Mr. E. Burgess' excellent figures of the mouth-parts of the Psocidæ*, three of which we reproduce, we find an unexpected homology, which shows that the Mallophaga are, so to speak, degraded Psocidæ.

One characteristic of the Mallophaga, in general, is the greatly enlarged front or clypeal region of the head, which is vaulted and conceals from above the mouth-parts, and sometimes even the antennæ, with the occasional exception of the labial palpi. In the bird-lice, the lower, rounded edge of this circular clypeal region is applied to the surface on which the animal rests, as seen in Figs. 1 and 5, the labium and mouth-parts not being seen from above, except in some genera where the maxillary palpi project laterally.

In the Psocidæ the position of the head is vertical, as seen in Fig. 10, and the labrum is not covered by the clypeus; but the Mallophaga are unlike these and other insects in having the labrum covered by the clypeus.

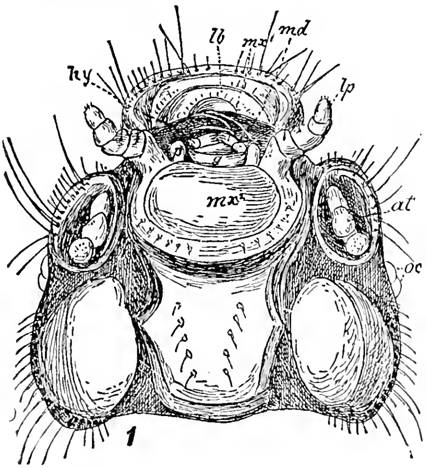
In the shape of the mandibles the Mallophaga closely resemble the Psocidæ, at least as much so as perhaps any other of the biting insects.

Mr. Burgess has figured and described the first maxillæ of Psocus (Figs. 10 and 11) and Atropos (Fig. 12). The cardo and stipes are rudimentary; the latter bearing besides the four-jointed palpus a thick fleshy lobe homologous with the galea or outer maxillary lobe of other biting, ametabolous insects. He also describes at length the peculiar "fork," which has no homologue in the Mallophaga any more than other insects, Mr. Burgess inclining to the view that this is an independent organ. It is to be noticed that, with the exception of the palpi, the maxillæ of the Psocidæ are much atrophied.

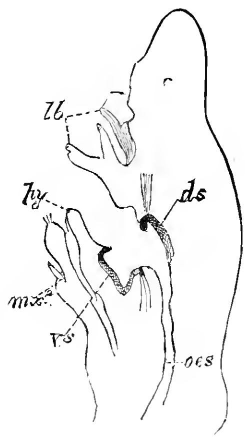
* The Anatomy of the Head, and the Structure of the Maxilla in the Psocidæ. By Edward Burgess. Proc. Boston Soc. Nat. Hist., xix, 291–296, 1878.

In the Mallophaga they are excessively so, there being, if we accept Grosse's statement, apparently no palpi, and the maxilla being reduced to a pair of minute conical appendages, divided into two segments. After careful examination, Grosse says that he has never been able to find the palpi of the first maxillæ which Nitzsch ascribed to the Liotheidæ.*

The labium or second maxillæ of the Liotheidæ, as described and figured by Grosse (Fig. 8), consists of two parts united by a transverse fold. To the mentum are attached the four-jointed labial palpi. In front of the mentum is the ligula or glossa (*g*). In all Liotheidæ, the interna of the ventral end of the oral cavity forms a fold-like duplicature, forming the hypopharynx, Fig. 2 *hy*. In Læmobothrium and Tetrophthalmus this extends forward over the labium, and its lateral borders are strongly bent upwards (Figs. 1, 8 *hy*).



1



2.

FIG. 1.—Under side of head of Læmobothrium. × 30.
FIG. 2.—Median section through head of *Goniodes dissimilis*. × 60.

The two-jointed organs on the sides of the tongue or ligula are called paraglossæ by Grosse (Figs. 7, 8, 9 *p*). In Nirmus and other Philopteridæ there are no labial palpi, the paraglossæ persisting (Fig. 7).

If we now compare the mouth-parts of the Mallophaga with those of the Platyptera we shall find a more or less close homology. In the first place the ligula appears as in the latter forms (Termes and Perlidæ), to be divided, as in Liotheidæ, into four lobes, while the outer pair of lobes, the paraglossæ, are usua ly, if not always, present, even when the labial

* Nitzsch figures them in *Trinotum conspurcatum*, but this can scarcely be correct, for he places the four-jointed papillæ on the blade near its anterior border. In Tetrophthalmus the palps belong, not to the first, but to the second maxillæ. The same is true of *Menopon pallidum*, *Colpocephalum zebra*, a Læmobothrium and a Trinotum, and probably is the case with all the genera and species. McCloskey's Transl.

3.

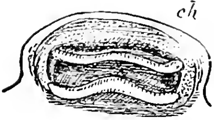


FIG. 3.—Labrum of *Goniodes dissimilis*. × 60.

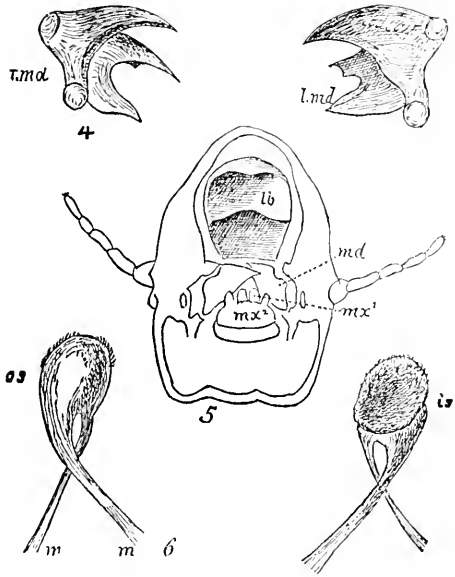


FIG. 4.—Right and left mandibles of Tetrophthalmus. × 60. FIG. 5.—Head of *Lipeurus heterographus*, seen from below. × 60. FIG. 6.—First maxillæ of Tetrophthalmus. × 75.

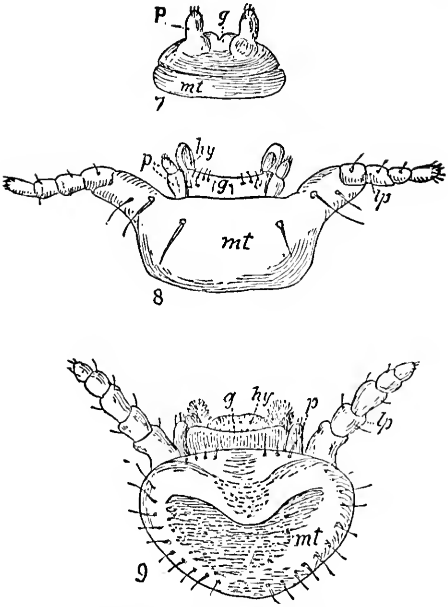
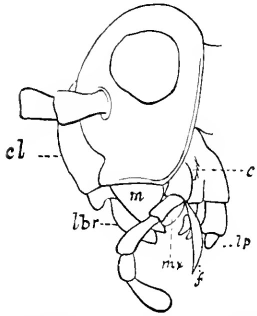


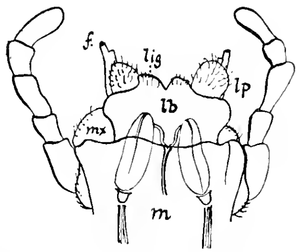
FIG. 7.—Second maxillæ of Nirmus. × 60. FIG. 8.—Second maxillæ of *Tetrophthalmus hilensis*. × 60. FIG. 9.—Second maxillæ of Læmobothrium. × 60.

palpi are atrophied. But while the second maxillæ of the Termitidæ and Perlidæ are well developed, the degraded condition of those of the Psocidæ affords a passage, though not a direct one to be sure (the labial palpi in Psocus and Atropos being simply one-jointed and there being no paraglossæ), to the Mallophaga. We copy, however, the accompanying sketches from Mr. Burgess' paper, so that the reader may compare the mouth-parts of the Psocidæ with those of the Mallophaga.

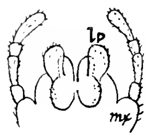
10.



11.



12.



FIGS. 10, 11.—Psocus. 10, side view of the head; *cl*, clypeus; *lbr*, labrum; *m*, mandible; *mx*, maxilla; *f*, fork; *c*, cardo; 11, *m*, mentum; *lp*, labial palpus; *lig*, ligula.
FIG. 12.—Atropos, labium. *lp*, palpus; *mx*, maxilla.—After Burgess.

In the general form of the body, especially the shape of the thoracic segments as compared with the abdomen, the wingless Atropos shows a decided resemblance to the bird-lice. In the first place, the head is in both groups very large, while the thorax shows a greater or less tendency to be merged into, or be less differentiated from, the abdomen. The latter region has ten segments both in Atropos and the Mallophaga. In Atropos there are three, in the Mallophaga two tarsal joints.

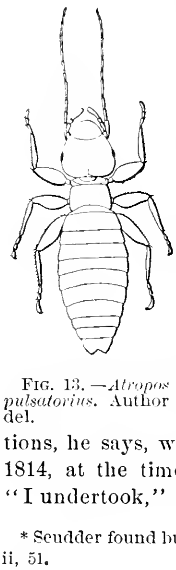


FIG. 13.—*Atropos pulsatorius*. Author del.

The eyes of Atropos are much reduced, there being from three* to seven simple ocelli on each side; in the Mallophaga the greatest number is two on each side.

After the foregoing portion of this paper was written, I read Nitzsch's paper (Germar's "Magazin der Entomologie," Bd. iv, 276–290, 1821) on the internal anatomy of *Atropos pulsatorius*, and found unexpected confirmation of the view we have taken as to the relationship of the Mallophaga to the Psocidæ. His observations, he says, were the result of researches carried on about the year 1814, at the time he was occupied with the study of the Mallophaga. "I undertook," he says, "the dissection of the Psocus, because this in-

* Scudder found but three simple-eyes on a side in an Atropos he examined. Psyche. ii, 51.

sect has some external similarity with those parasites, and because I entertained the idea, that the internal structure of the same might offer some points which would be of value in throwing light on the natural affinity of the insect parasites, at least of the biting species." The following comparisons are taken from Nitzsch's memoir:—

"The digestive canal of *A. pulsatorius* differs from that of the Mallophaga only in the crop and the constantly present upper flap or diverticulum of the stomach. There are four simple, unbranched Malphigian tubes both in *A. pulsatorius* and in the Mallophaga. Of ovarian tubes there are five pairs in *A. pulsatorius*, and in Mallophaga from three (*Liotheidæ*) to five pairs (*Philopteridæ*)." After describing the ovaries and oviduct, he goes on to say: "Herein appears an unexpected similarity between the Psocidæ and the animal insect parasites, for the entire structure of their uterus and the number of their ovarian tubes, also the shape of the egg itself, is like that which had already been described by Swammerdam in the louse, and by myself in the genera Philopterus and Trichodectes. In Liotheum and Gyropus, however, the number of ovarian tubes is somewhat smaller."

In the nature of their food and their manner of taking it there is a close resemblance between the Psocidæ and Mallophaga.

As is well known, the Psocidæ occur on the trunks of trees, fences, old walls, etc., and feed on decaying vegetable matter. "Atropos, as is well known, lives on the paste in old books and boxes, as well as the specimens of entomological cabinets" (Burgess). While the food-habits of the Mallophaga are not fully known, Nitzsch stated that they eat the epidermal products of birds and mammals, and sometimes blood. Grosse found that blood is rarely taken, and only in cases where the hosts (birds) are so injured or diseased as to have blood among their plumage. Leuckart arrived at the same result as to *Trichodectes canis* of the dog. In Læmobothrium, Grosse found the intestine filled with the limbs of its own kind, as if it ate the product of its own moulting.

From the present state of our knowledge then, it seems reasonable to infer that the Mallophaga are nearest allied to the Psocidæ, and are degraded members of the order to which the Psocidæ belong.

It now remains to determine the exact relations of the Mallophaga to the order containing the families of Termitidæ, Embidæ, Psocidæ, etc., and here we are confronted with the difficulty of limiting the order containing these families, which were with other groups placed in the order of Pseudoneuroptera by Erichson. In my essay on "The Systematic Position of the Orthoptera in relation to other orders of Insects,"* I retained, though under protest, this order; at the same time stating, "It is difficult, if not impossible, to satisfactorily characterize by a sharp-cut definition this very elastic order. As regards the thorax, there is no uniformity in the structure that we have been able to discover, nor is there in

* Third Report U. S. Entomological Commission, 1883, pp. 286–345.

the structure of the wings, nor more than a general resemblance in the mouth-parts." I provisionally divided the group into three suborders :—

1. *Platyptera.* Termitidæ, Embidæ, Psocidæ, and Perlidæ (= Corrodentia and Orthoptera amphibiotica in part).

2. *Odonata* (Libellulidæ).

3. *Ephemerina* (Ephemeridæ).

I also added, "It is comparatively easy to give well-grounded differential characters for these three suborders. They are so distinct that they may, perhaps, hereafter be regarded as entitled to the rank of orders, or the Pseudoneuroptera may be dismembered into the Pseudoneuroptera and Subulicornia (Odonata and Ephemerina)."

Without giving the wing characters and after describing on p. 291 the second maxillæ, the Platyptera are defined on p. 292, and the structure of the thorax and abdomen described in some detail on pp. 322–329 (in the latter pages the group is referred to as Corrodentia).

Afterwards, in his Systematisch-Zoologische Studien* (1885), Dr. Brauer boldly divides all the winged insects, the Synaptera (Thysanura) excepted, into sixteen orders. He regards the Perlidæ as the type of a distinct order (*Plecoptera*), while his order *Corrodentia* embraces the Termitidæ, Psocidæ and Mallophaga (the Embidæ are referred to the genuine Orthoptera).

In his description of the Corrodentia, Dr. Brauer frequently refers to the Mallophaga, especially referring to the similarity between the thorax of the Atropina and Mallophaga.

As will be remembered, Burmeister's order *Corrodentia* included the families Termitidæ, Embidæ, and Psocidæ. Under these circumstances the name Corrodentia should be restricted to a subdivision of the order Platyptera.

In 1886, in the fifth edition of our text-book on Zoölogy,† we added the Mallophaga to the Platyptera, which thus included the groups of Mallophaga, Perlidæ, Psocidæ, Embidæ, and Termitidæ. Although Dr. Brauer (following Burmeister who proposed the order Plecoptera for the Perlidæ) separates the Perlidæ from the Corrodentia as restricted by him for the reason that the former (Perlidæ) have numerous Malphigian tubes, are hemimetabolous and perennibranchiate, we are not yet prepared from a study of the trunk characters and of the shape of the second maxillæ, as well as the wings and their mode of folding, to separate the Perlidæ from the other Platyptera.

But once within the limits of the order, it is evident that the Mallophaga, even if degraded Platyptera, should occupy a space distinctly separate from the winged members of the group; in fine, they should be referred to a distinct suborder, equivalent to all the winged forms taken together. Hence the Platyptera may be divided into two suborders :—

I. Mallophaga.

II. Platyptera genuina : Superfamily 1, Plecoptera (Perlidæ) ; Superfamily 2, Corrodentia.

* Aus dem XCI. Bande der Sitzb. der Kais. Akad. der Wissensch. I. Abth., Mai-Heft. Jahrjang 1885.

† See also American Naturalist, Sept., 1886, p. 808.

On the Reptiles and Batrachians of Grand Cayman. *By Samuel Garman, Cambridge, Mass.*

(Read before the American Philosophical Society, October 7, 1887.)

Grand Cayman island is situated in the Caribbean sea, south of Cuba—in round numbers—about two hundred miles, west north-west of Jamaica about the same distance, and not far from four hundred miles east of Yucatan. It is a comparatively recent coral formation and rises but little above the sea. In total length it approaches twenty-five miles, but in width it is less than three.

Consideration of the origin, size and position of Grand Cayman, together with the directions of its currents, winds and traffic, prepares us for the conclusion, reached from study of a portion of its terrestrial fauna, that it has received its land animals, not so very long ago, from the neighboring large islands.

The collection on which this notice is based, purchased by the Museum of Comparative Zoölogy, from Mr. W. B. Richardson, contained one hundred and five specimens, representing in all six species: three lizards, one snake, one toad and one treefrog. One of the lizards, a little Anolis, is nearly related to a species from Jamaica; another, a Gecco, belongs to a Jamaican species, and is hardly distinct enough to rank as a variety; and the third forms a species nearest to one described by Professor Cope from Navassa (eastward from Jamaica) and close to another from Cuba. The snake and the treefrog belong to Cuban species. And the toad ranges from Jamaica to Brazil. There might be more hesitation in calling one of the forms distinct if it were not for its complete isolation. It is because of this, and, also, because of the likelihood that the differences are becoming greater and more numerous with time, that the details of description are so much dwelt upon. Besides, the closeness of the affinities, with forms belonging to the other islands, makes it the more necessary to deal with particulars.

The list includes the following:

Anolis conspersus, sp. n.
Liocephalus varius, sp. n.
Aristelliger prasignis Hallow.; Cope.
Alsophis caymanus, var. n.
Bufo marinus Linn.; Schneid.
Hyla septentrionalis Tschudi.; Blgr.

Anolis conspersus, sp. n.

Head large, about one and three-fourths times as long as broad, longer than the tibia. Forehead concave. Frontal ridges low. Occiput concave. Scales on the sides and top of the head with low blunt keels.

Scales of the supraorbital semicircles enlarged, separated mesially by a single series of scales. Ten to fifteen enlarged keeled supraocular scales, the largest of which is separated from the supraorbitals by a single series of granules. Occipital small, about the size of the ear-opening, separated from the supraorbitals by three or four series of scales. Canthus rostralis sharp, prominent; canthal scales four. Loreal rows five. Six labials to below the centre of the eye. Ear-opening small, vertical diameter much the greater. Gular appendage rather large, the fold reaching as far backward as the axil, less developed in the female. Gular scales flat, with faint indication of an obtuse keel. Body not compressed; a slight nuchal fold in the male; no dorsal fold. Dorsal scales small, granular, smooth or obtusely keeled, a little larger in several of the vertebral rows; ventral scales larger. Limbs moderate; the adpressed hind leg reaches the orbit; digital expansions moderate; lamellæ under phalanges ii and iii of the fourth toe twenty-four. Tail twice as long as head and body, compressed, less in female, edged above with a series of strongly keeled scales. Male with enlarged postanal scales.

Adults yellowish-green to olivaceous, thickly sprinkled with small spots of light color, reddish or brownish in life; tail more uniform; belly bluish, presenting a clouded appearance toward flanks and chin. Goitre blue or purple.

Very young ones are light ashy or grayish on the back, white beneath; somewhat clouded with darker on flanks, limbs, chin and throat. The light spots or freckles first appear on the top and sides of the head, thence gradually spreading backward. Above the pelvis on the back there is a band of light color which narrowing backward extends to the middle of the tail, where it fades. On one specimen there is a small dark blotch at each side of the pelvic band; on the middle of the body there is a small transverse hour-glass-shaped blotch with a smaller rounded spot of white at each side of it on the mesial line; it has a similar mark above the axils, and a dark spot on the occipital shield. On many individuals, old and young, the forehead and cheeks are brown.

This species is closely allied to *A. grahami* as accepted by Dr. Boulenger, whose form of description we have followed, more or less nearly, to facilitate comparisons. *A. conspersus* has a much smaller occipital scale, its canthal and frontal ridges are sharper, it has a single series between the supraorbitals on the crown; it has not the lilac color on tail and limbs, and its goitre is dark blue or purple, instead of crimson with yellow or white margin.

Liocephalus varius, sp. n.

Upper head-scales large, smooth or faintly striate; nasal in contact with the rostral; supraorbitals in contact on the median line; supraoculars six to eight, the majority of which are separated from the supraorbitals by a single series of small scales. Parietals two pairs in one row, the outer of each pair being nearly twice the size of the inner; the inner elongate, narrow, twice as long as broad, separated on the mesial line by the interparietal and, in cases, by a small scale behind it. In front of the interparietal there is a pair of small shields, and in front of them one or more small ones. The number of plates between the supraoculars and interparietal varies from three to five. Two pairs of the supraorbitals are in contact across the forehead behind the frontal. Three cross-rows of plates behind the internasals. Frontal medium, hexangular. A pair of larger prefrontals, in front of which there is a second pair of smaller ones, the two pairs being sometimes separated at their inner angles by a small lozenge-shaped plate. Internasals elongate, narrow, with the acute posterior extremity directed obliquely outward. Auricular scales two to three, broad, upper largest. Scales in front of ear moderately large, smooth. On the sides of the neck the skin is strongly folded, covered with keeled small scales. Dorsal crest low. Dorsal scales mucronate, the keels obliquely turned toward the vertebral line. The scales of the flank are smaller and rather abruptly turned upward. The ventrals are about as large as the dorsals, smooth, broader than long, and rounded on posterior margin. There are forty-one to forty-three rows of scales, counting around the middle of the body. The adpressed hind limb does not reach the eye. Tail feebly compressed, more than one and one-half times as long as the body, with a crest a little stronger than that of the back.

Olive brown, with a metallic lustre, clouded with dark brown, which in earlier stages was apparently arranged in transverse bands. Faint indications of a light band on the upper edge of each flank. Olivaceous beneath, lighter backward and sprinkled or clouded with many small spots of white. Tail ringed with brown, about seventeen rings. Chin and throat clouded or reticulated with olive and white. A light band from the hinder angle of the eye to the angle of the mouth. Lighter scales sprinkled over the body and limbs, both above and beneath.

This species is allied to *L. eremitus* Cope from Navassa, and with it to *L. carinatus* of Cuba and the Bahamas, more than to the others. The distinguishing characters appear in the scales of the head, in the relative sizes of those of the body, and in the coloration.

Aristelliger præsignis Hallowell ; Cope.

Total length of the largest specimen six and a half inches ; snout to vent two and a half.

Half-grown examples are grayish-brown to brownish-gray, white beneath. The top of the head is nearly uniform brown. From each nostril through the eye to the shoulder there is a lighter edged brown band ; these bands converge in approaching the shoulders. From the shoulders backward there are brownish darker edged blotches, each of which presents an angle toward the vertebræ, thus enclosing lozenge-shaped lighter spots on the median line. On the sides of the tail these lateral blotches alternate, or, meeting, form transverse bands of brown. Labials brown, with or without whitish spots. Chin mottled with brownish. The color is darker on the largest specimen ; the light spots of the back continue beyond the base of the tail ; but anteriorly the ground color has become so dark that the spots and bands are obscured.

Hallowell's specimens, from Jamaica, were "uniform brown above with no lines or spots." The circular pupil and the clawless thumb were probably oversights. Such measurements as he gives would make his types smaller than the largest described above. Dr. Boulenger's description, also taken from Jamaican specimens, answers much better to those from Grand Cayman.

Alsophis caymanus.

A. angulifer Bibr.; Cope, var. n.

Body moderate, blunt-angled at the edge of the abdomen ; head distinct, narrowed in front, subquadrangular in transverse section, flattened on the crown ; tail nearly one-third of the total length, slender. Eye moderate. Teeth small, longer and farther apart backward. Scales with two pores, smooth, in seventeen rows ; dorsal longer than broad, outer and caudal as broad as long. Ventrals broad ; in five specimens they number 167, 170, 171, 173, and 175 respectively. Anal bifid. Subcaudals in two series ; in three specimens there are 125, 127, and 129 pairs. Crown-shields nine ; internasals moderate, narrower forward ; prefrontals broader than long, bent downward, and shortened, at the loreal ; frontal about twice as long as broad, truncate in front, narrower and having parallel sides behind the middle, acute-angled between the parietals ; supraoculars large, broad posteriorly ; parietals very large, outer anterior angle in contact with the lower postorbital. Rostral medium, hardly reaching the top of the snout, in contact with six plates. Nostril between the quadrate halves of the small nasal. Loreal small, quadrangular, hinder lower angle acute. One anteorbital, reaching the top of the head, not in contact with the frontal. Two postorbitals; lower in contact with the fifth and sixth labials and the temporal ; upper meeting the supraocular and the parietal. Temporal large, narrow anteriorly, bounded by the lower postorbital, the posterior three labials, and two post-temporals. Of the latter the upper is the larger. Labials eight, third, fourth and fifth in orbit, sixth and seventh very large. Lower labials ten, first pair meeting behind the mental, first six in contact with the submentals, fifth and sixth largest. Mental small, triangular. Submentals two pairs, posterior much longer, each of the anterior meeting five, and each of the posterior meeting two of the lower labials.

Large specimens have a ground color of reddish brown, and the greater number of the scales black-edged or black-tipped ; backward they have irregular spots of dark including one to several scales ; and the belly appears to have been a brick-red in life. The larger ones have transverse blotches of brown under the tail, and numerous white-edged scales similar to those of *Liophis cobella*. Some have vertical bands or blotches of brown anteriorly on the flanks ; farther back these meet on the vertebral line and become transverse bands.

Very young ones are ashy or grayish, with brown puncticulations; the head and posterior margins of ventrals and subcaudals are darker; a white-edged brown band passes from the nostrils, spreading to include the eye, to the eighth labial; and chin, throat and lips are mottled with brownish.

Half-grown are less uniform, and more brown; they have scattered white-bordered scales in the anterior half of the length, faint indications of transverse dorsal bands of brown, and an indefinitely margined brown band across the head from the hinder edges of the orbits.

BUFO MARINUS Linn.; Schneid.

A single quite young individual appears in the collection. Compared with many others of the same size from Jamaica, it is rather more smooth and of lighter color. The Jamaican examples are roughened with sharp points and in general color are dark brown; the spots on the ventral surface are numerous and dark. On the Cayman specimen the color is ashy or grayish, and the spots beneath have a faded olivaceous tint. Spots, glands and warts have similar positions and shapes in both cases.

Nothing can be said of the place whence this species came, it is so generally distributed among the West Indies, from Jamaica southward, and along the coasts of South and Central America.

HYLA SEPTENTRIONALIS Tschudi; Blgr.

In very large specimens the habit is massive and much like that of the toad; the skin is glandular, and, in some, covered with large smooth warts. On young ones the skin is quite smooth. A male, less than one-fourth the size of the females, has a blackish rugosity on the inner side of the first finger.

The color varies from grayish olive to brown, irregularly marked with darker on the back. Ventral surface whitish, with or without spots or cloudings of dark anteriorly. Limbs with transverse bands of brown. In the folds in front of the shoulder the brown takes the form of narrow vertical lines. Behind the thighs and along the flanks there are irregular small spots or reticulations of brown. On small ones there is a white band on the posterior half of the upper lip, a brown one behind each eye through the tympanum toward the shoulder, and a transverse band, concave forward, across the head between the eyes.

No differences are noted between these and others from Cuba.

Mr. Richardson states that the natives reported a crocodile in the swamps. This might be expected from the presence of two species on Cuba, one of which appears also on Jamaica and San Domingo. In completing the list of the Grand Cayman reptiles it will, no doubt, be necessary to add the names of the marine turtles, *Thalassochelys cephalo*, *Chelonia mydas*, *Eretmochelys imbricata*, and *Dermatochelys coriacea*.

On West Indian Reptiles in the Museum of Comparative Zoölogy, at Cambridge, Mass. By Samuel Garman.

(Read before the American Philosophical Society, October 7, 1887.)

The following list includes the snakes, turtles and crocodiles of the collection. A large proportion of them was collected by the writer, on opportunities provided by Prof. Alex. Agassiz; the remainder was secured by purchase from different collectors. Among the species there are a number not previously recognized; the ranges of others have been extended by the localities represented in the series.

In the snakes it is found necessary to place more than the usual stress on variation of the number of rows of scales, or of the number of scutes in the ventral and subcaudal series, since the representatives of a single species on one or another of the small islands may be distinguished by a couple of dorsal rows more or less, or by a few scutes more or less on the lower surface; variations that would have comparatively little value on the mainland, but which here derive importance from their fixity, a consequence of isolation. *Alsophis cinereus*, as compared with *A. rufiventris*, furnishes a good illustration.

TYPHLOPS RICHARDI D. & B.

A specimen from St. Kitts island has twenty rows of scales, in 321 + 13 transverse series. In squamation it differs little from the species as described from St. Thomas.

STENOSTOMA ALBIFRONS Wagl.

One taken at Trinidad has its scales in fourteen rows, in 194 + 19 transverse series. It disagrees with others from Pará in having two broad shields cross the back immediately behind the first three of the median series, which are of the average size.

BOA CONSTRICTOR Linné.

Trinidad.

BOA DIVINILOQUAX Laur.; Dum. & Bibr.

On a couple of these boas from Dominica the transverse series number sixty-five in each case.

UNGUALIA MELANURA Schleg.; Gray.

Cuba. Scales in twenty-seven rows, the outer five of each side smooth; transverse series 214 + 41.

UNGUALIA MACULATA Bibr.; Gray.

Cuba. According to Bibron this form has twenty-five rows of scales, in 200 + 35 to 40 transverse series.

UNGUALIA HAETIANA Cope.

Hayti. Scales in twenty-seven rows; ventral scutes 193 + 38. Loreals and anterior pair of prefrontals fused.

UNGUALIA CURTA, nom. sp. n.

U. maculata Cope, not of Bibron. Cuba. Scales in twenty-five rows; ventrals 154 + 27. Loreals fused with the anterior prefrontals. Prof. Cope's specimens gave the species twenty-three to twenty-five rows, and 142 to 150 ventrals. The markings of this snake are somewhat like those of *U. maculata*. In the dorsal series the blotches have white lateral margins.

XIPHOSOMA HORTULANUM L.; Fitz.

Trinidad, Grenada, St. Vincent, Petit Martinique, Grenadines. The total length of the largest is six feet three inches, of which the tail is thirteen. Excessive variations in color are shown by these examples; one from Trinidad is light yellowish olive clouded with brown, with edges of scales brown, and ventrals yellow blotched with darker. The markings are obsolete on others not nearly so large. One from Grenada has the marks very distinct, black with light borders; a second is similar as regards their shapes but the spots are faint; and a third is nearly uniform brownish, with yellow ventral surface, and an indistinct trace of a blotch here and there. A St. Vincent type is very dark; the blotches are large, black, and continued down the flank as rather broad vertical bars; the top of the head is vermiculated with brown. That from Petit Martinique is very distinctly marked; the ground color is grayish and the blotches are black, with white margins. One from the Grenadines is of the average, another is a uniform dingy yellow, as if the brown pigment had entirely disappeared, leaving no traces of the markings. Dorsal rows 39–43; ventrals 256–285, subcaudals 107–117.

EPICRATES CENCHRIA L.; Wagl.

Trinidad. One of these has a single labial in contact with the eye on each side; on the left it is the sixth and on the right the seventh. Another has the sixth and seventh in the orbit on one side and the seventh and eighth on the other. The markings are very indistinct.

HOMALOCHILUS STRIATUS Fisch.

Hayti.

HOMALOCHILUS STRIGILATUS Cope.

Andros island, Bahamas.

CHILABOTHRUS INORNATUS Reinh.; D. & B.

Bayamon, Porto Rico. This species is very common along the streams on the branches of the trees. It is easily taken by means of a stick bearing a noose of strong twine.

Rhabdosoma lineatum.

Dumeril & Bibron, 1854, Erp. Gen., vii, 105, describe this species from Java. There is no doubt that the specimens described below came from Trinidad; they were taken by the writer near Port of Spain. Prof. Jan has already questioned the locality given by Dum. & Bibr., most likely with reason. Prof. Cope tells me he also has noted the species from Trinidad. The individual variations are so great that we may yet have to include Jan's *R. punctivittatum.*

Body stout, cylindrical; head not distinct from neck, subconical, slightly depressed; tail short, thick, pointed. Eye small, pupil round. Crown-shields nine; internasals small, short; prefrontals large, long, narrow in front, broad behind, entering the orbit; frontal subtriangular, as broad as long, acute-angled between the parietals; supraoculars small, broad; parietals large, wide; nasals divided, nostril in the anterior half, both anterior angles acute. Loreal widest in front, long; entering the orbit in one specimen, not fused with the anteorbital in another. Postorbitals two; temporals 1 + 2, upper elongate. Labials eight, first small, eighth large, fourth and fifth in orbit. Lower labials eight, fourth and fifth largest; submentals one pair, large, in contact each side with first four lower labials, separated from the small mental by the first pair. Scales smooth, broad, in fifteen rows. Anal entire. Ventrals 146, 136; subcaudals thirteen pairs in one, eighteen in the other. Total length 8.5, tail 0.5 inches.

Color light reddish brown, puncticulate with brown. A median narrow streak of brown from the occiput, another on the upper edge of the third and lower edge of the fourth, and another on the upper edge of the first and lower edge of the second rows. Belly white (? red or yellowish in life). Head darker, clouded. On one specimen the edges of the scales are darker.

Liophis cobella L.; Wagl.

Trinidad. Rows 17; ventrals 157; anal bifid; subcaudal 62 pairs.

Dromicus dumerilii.

Calamaria dumerilii Bibr.

Urotheca dumerilii Bibr.

Rows 17; ventrals 153; anal bifid. The specimen agrees well with the description except in the number of ventrals, which was 128, twenty-five less than in the present.

Dromicus cursor LaC.

Martinique. Scales in seventeen rows, with one pore. Ventrals 194, 191, 191, 186, 185. Anal bifid. Subcaudals 106, 103, 101 pairs.

The name *cursor* was given to this species by LaCépède in 1789, Quad. Ovip. et Serp., ii, pp. 96, 280, Pl. xiv, f. 2. Donndorff from this figure and description renamed it *fugitivus* in 1798, Zool. Beytr., iii, 206.

DROMICUS CURSOR, var. PLEII.

Dromicus pleii D. & B.

Martinique, in the low-lands near Fort de France. Rows 17; ventrals 195, 193, 192, 190; anal bifid; subcaudals 107, 104, 101 pairs.

These specimens are much lighter-colored than those from the heights; the colors are more olivaceous, and the bands are as in the original description.

DROMICUS CUBENSIS, nom. sp. n.

Cuba. This is the *D. cursor* of Bibron, but not of LaCépède. Rows 17; ventrals 149, 145, 145, 142, 140; anal bifid; subcaudals 87, 92, 94, 106 pairs. Near the base of the tail some of the scales bear two pores; farther forward but one may be discovered, and anteriorly they become obsolete.

DROMICUS JULIÆ Cope, sp.

Dominica. Rows 17; one pore; ventrals 157, 161, 162; anal bifid; subcaudals 77, 84 pairs.

On a variety of this species found in Marie Galante the marks are not so black as on those from Dominica. Instead of a bright yellow spot near the middle of the scale, the lighter portion is more olive and the coloring is more irregularly placed. Ventrals 161, 164; subcaudals 82, 81 pairs.

DROMICUS ORNATUS, sp. n.

St. Lucia. Rows 17; one pore; ventrals 190, four 191 each, 194; anal bifid; subcaudals 86, 85, 88, 86, 91 pairs.

This handsome serpent is much like the Couresse of Martinique. Its tail appears to be a trifle shorter; its colors distinguish it very readily. From neck to end of tail it has a median band of brown, which on the body is about six scales wide and which contains two rows of round or squarish spots of white larger than a single scale and separated from each other by spaces of like width. On the third row there is a dark stripe in which the scales are marked with a yellow spot. The anterior edges of the ventrals are black. A black band behind the eye; a yellow spot on the lateral edge of each parietal; two or three transverse yellow streaks on the snout. Ground color of labials and lower surface yellowish or white. *D. cursor* has a white vitta at each side of a black band of five or six scales in width; anteriorly the vitta is more or less broken into spots but the included band lacks the two series of spots.

DROMICUS TEMPORALIS Cope.

This appears to be the species figured by Jan and Sordelli under the name of *D. nuntius*. The specimen which served as type of *D. temporalis* has the locality Cuba. It has seventeen rows; pores not visible; ventrals 166; anal bifid; loreal and anteorbital fused on both sides.

DROMICUS PARVIFRONS Cope.

Hayti. Jeremie, Hayti. Rows 19; no pores; ventrals 142 on each of three specimens, 143; subcaudals 113, 118, 113, 119 pairs.

DROMICUS MELANOTUS Shaw, sp.

Trinidad; Grenada. Rows 17; one pore; ventrals 147, 149, 153, 149; anal bifid; subcaudals 59, 62, 59, 65 pairs.

The dorsal black band is five whole and two half scales in width; the white line at each side of it is two half scales wide, as also the black line on the flank; the yellow or pinkish of the abdomen extends over three and a half of the outer rows. Anteriorly the lateral black lines are broken into spots and in the black vertebral band there are small whitish spots.

DROMICUS EXIGUUS Cope.

St. Thomas. Rows 19; ventrals 139, 140; anal bifid; subcaudals 80, 83 pairs. One has the prefrontals fused on the median line.

ALSOPHIS ATER Gosse; Cope.

Kingston, Jamaica. Rows 17; pores 2; ventrals 171, 180, 185; anal bifid; subcaudals 162, 149, 144 pairs.

ALSOPHIS ANTILLENSIS Schleg.; Fitz.

St. Thomas; Hayti. Eight specimens at hand have nineteen rows each; 172 to 181 ventrals; and the subcaudals range from 134 to 142 pairs.

ALSOPHIS ANGULIFER Bibr., sp.

Cuba; Havana, Cuba. Rows 17; ventrals 164, 167, 169, 167; subcaudals 102, 114, 108, 108 pairs.

ALSOPHIS CAYMANUS Garm.

Grand Cayman. A variety of the preceding.

ALSOPHIS RUFIVENTRIS D. & B.

St. Kitts; Saba; Nevis. On each of twenty-two specimens the number of rows is twenty three; the ventrals range from 208 to 220, and the subcaudals 114 to 122. On nine the tail is mutilated. Apparently there is a special cause for the prevalence of the mutilation in particular localities.

ALSOPHIS CINEREUS Garm.

St. Barts; Anguilla. Six from St. Barts have the scales in twenty-one rows; the ventrals ranging from 203 to 207, and the subcaudals from 115 to 122. They are darker than the following. Six from Anguilla have twenty-one rows each; ventrals 201 to 203, and the subcaudals 99 to 115. These are more ashy in color than those from St. Barts, which are darker than the allied species from St. Kitts, Saba and Nevis. They form a variety of the preceding.

Alsophis sibonius Cope.

Dominica. Rows 19; pores two; ventrals 198.

This specimen disagrees in several particulars from the original description. The agreements, however, are so exact, when occurring, that the variations are most likely to prove individual. The temporals are 1–1–2–3, the anterior on each side being divided vertically in such manner as to leave a short piece in contact with the orbitals; the seventh labial is large; each parietal has five or six scales in contact with its outer border. In color it is almost black. A black band waves from side to side on the back, its concavities being marked by triangular spots of white. A series of black spots on the middle of the flank, much fused; a series of smaller ones on the outer edges of the ventrals and on the first row of scales. Forward the ventral surface is yellow with black specks; behind the middle the white disappears on back and belly in a uniform black.

Alsophis melanichnus Cope.

Bayamon, Porto Rico. Rows 17; pores two; ventrals 169, 170; subcaudals 125, 129; loreal pentagonal; lower postorbital very narrow, about one-third as large as the upper; temporals 1–2–3. The narrowness of the lower postorbital is a good distinguishing character. On young specimens the dark-bordered scales are distributed in such way as to form irregular transverse bands, more indistinct in larger ones.

Alsophis pulcher, sp. n.

Testigos island. Rows 17; two pores; ventrals 190; anal bifid. Head distinct, broad behind; body slightly compressed; tail mutilated. Labials nine, fourth, fifth and sixth in the orbit, eighth largest; lower labials eleven, sixth largest. Loreal low, upper edge horizontal. One anteorbital; two postorbitals. Snout rounded, rostral, internasals, and prefrontals convex. Prefrontals bent down to meet the loreal. Loreal region concave. Temporals irregular 2–2–2. Frontal broad and truncate anteriorly, narrow and rounded behind.

Brownish-yellow, darker in front, with a median black edged band of yellowish-brown on the back, five scales and two halves in width. At each side of this there is a yellow band, one scale and two half scales in width, margined by a dark streak. On the flank the yellow band is margined by a dark streak occupying half of each of the second and third rows. Each ventral is marked on its outer-anterior edge by a black spot, which forms a zigzag line along the edge of the abdomen. Belly yellow; chin and throat blotched with dark brown. A dark streak from the nostril through the eye. Toward the neck the amount of black on the scales is much greater and the dorsal band appears as if composed of three.

IALTRIS VULTUOSUS Cope.

Jeremie, Hayti; types. Rows 19; two pores; ventrals 182–188; anal bifid; subcaudals 105, may be a little shortened.

HYPSIRHYNCHUS SCALARIS Cope.

Jeremie, Hayti; type. Rows 19; one pore; ventrals 166; anal bifid.

HERPETODRYAS CARINATUS L.; Boie.

Kingston, St. Vincent. Two specimens. Rows 12, outer smooth; ventrals 173, 164; anal bifid; subcaudals 162, 153 pairs.

HERPETODRYAS BODDÆRTII Seetz.; Schleg.

Kingston, St. Vincent; Trinidad. Rows 17; pores two; ventrals 191, 195, 202, 204, 200, 194, 196, 204; subcaudals 118, 105, 110, 118, 122, 124, 127, 118 pairs.

UROMACER OXYRHYNCHUS Dum. & Bibr.

Hayti. Rows 19; ventrals 200; anal bifid. The bluish-green of the back shades gradually into the light color of the belly; there are no puncticulations; the white line on the flank is narrow, obsolete on the anterior third of the length, distinct on the remainder of the body and the base of the tail. The snout is less sharp than in the variety.

Var. A. Samana, San Domingo.

Rows 19; ventrals 192; anal bifid; subcaudals 199 pairs. Snout acute. Color grass-green; white band on the outer row occupies nearly the whole scale, is very distinct and extends over half the length of the tail; abdomen gray, puncticulate with brown, and with a few scattered small spots of black.

UROMACER INORNATUS, sp. n.

Jeremie, Hayti. Four examples. Rows 17; ventrals 182, 184, 188, 190; anal bifid; subcaudals 201 on the only entire. Snout more blunt than *U. oxyrhynchus*. Color nearly the same on back and belly; bluish-green puncticulate with brown.

UROMACER CATESBYI Schleg.; D. & B.

Jeremie, Hayti. Rows 17; ventrals 163 in three and 165 in the fourth; anal bifid; subcaudals 181 pairs in one, 206 in another.

DRYIOPHIS ÆNEUS Wagl.; Cuv.

One specimen of five from Trinidad has fifteen rows of scales; the others have seventeen. Ventrals 192, 187, 177; subcaudals 177, 164, 162 pairs. One from Testigos islands has nine labials, the fifth and sixth in the orbit; it has seventeen rows, and 181 ventrals.

Leptodeira annulata L.; Fitz.

Trinidad. Rows 19; ventrals 178; subcaudals 90 pairs.

Dipsas cenchoa L.; Wied.

Trinidad. Rows 17; ventrals 247, 233, 247; subcaudals 158, 160, 165 pairs.

Scytale coronatum Schneid.; D. & B.

Grenada. Ventrals 195, 188, 186; subcaudals 73, 86, 85.

Oxyrhopus plumbeus Wagl.; Gthr.

Grenada. Rows 19; ventrals 233.
St. Lucia. Rows 17; ventrals 233, 232; subcaudals 71 pairs.

Elaps riisii Jan.

Trinidad. Ventrals 184, 186, 184; subcaudals 3 + 42 pairs, 17 + 25 pairs, 45 pairs; bands 30 + 9, 25 + 11, 25 + 10. Two postorbitals.

Elaps lemniscatus L.; Schneid.

Trinidad. Ventrals 221; subcaudals 36 pairs; bands 36, eleven groups of three.

Trigonocephalus lanceolatus Oppel.

Martinique. Rows 31, 32, 33; ventrals 217, 220, 223; subcaudals 53, 68, 59 pairs.

Trigonocephalus caribbæus, sp. n.

St. Lucia. Labials 7 to 8; lower labials 8 to 11. Rows of scales 25, 27, 27; ventrals 197, 206, 209; subcaudals 64, 69 pairs. This serpent is more slender than that from Martinique; it has narrower scales and not nearly so many of them. In color the tendency is toward olive, more or less uniform; the brown blotches being almost obsolete in cases. Belly whitish to yellowish, with few or no puncticulations. Individuals vary from light olive with white belly to dark olive-brown with yellowish ventrals.

The Martinique serpent is brown rather than olive; the brown blotches are more distinct, and the puncticulations on dorsals and outer portions of ventrals are abundant; the bellies are yellow. Individuals vary from yellow to black.

This is the *Craspedocephalus atrox* of Lieut. Tyler, 1849, Pr. Zoöl. Soc. Lond., 100, but is not that species, as found on the mainland, to which the name was originally given by Linné, Laurenti, Gray, Fitzinger and others.

TESTUDINATA.

Testudo tabulata Walbaum.

Abundant in the market at Port of Spain, Trinidad. Secured also at St. Vincent and St. Lucia. It feeds readily in captivity and is kept about the houses and carried from place to place much as the more common domestic animals.

Emys rugosa Shaw; Gray.

From the markets at San Juan, Porto Rico, and from Cuba.

Cinosternum sp.

A small turtle, sent by Prof. Felipe Poey, of Havana, possesses characters that separate it from both of the species, *C. pennsylvanicum* and *C. leucostomum*, which it approaches most nearly.

It is elongate; the snout is narrower and more pointed than that of the first-mentioned species. The greatest length of the carapace is exactly four, its greatest width two and three-fourths, behind the middle, the greatest length of the plastron three and nine-tenths, and the width of the plastron across the pectoral shields is one and nine-tenths inches. Anteriorly the plastron is rounded; posteriorly it is truncate, with a shallow notch between the anal shields. The pair of pectoral shields, like the pair of preanals, meet on the median line in a suture of about three-eighths of an inch. A single pair of barbels close together under the lower jaw.

Color light yellowish-olive with darker margins to the shields. Head sprinkled with light spots. A narrow streak of light color passes around the snout on the rostral angle above the eye and along the side of the head to the neck.

Chelonia mydas L.; Schweigger.

At certain feeding grounds among the leeward islands a great many of these turtles are taken for shipment to various ports. In the same resorts "Loggerheads," "Shell turtles," and "Trunkbacks" are said to occur.

CROCODILIA.

Crocodilus rhombifer Cuv.

From Cuba.

Crocodilus americanus Schneid.

The collections contain specimens from Jamaica, Hayti and Cuba.

Memoir of Pliny Earle Chase. By Philip C. Garrett.

(Read before the American Philosophical Society, October 21, 1887.)

Pliny Early Chase was a native of the old Puritan Commonwealth which has probably contributed more than any other to the intellectual life of this country. He was born at Worcester, Mass., on the 18th of August, 1820, and was descended on both sides from the hardy and intelligent yeomanry of New England, most of his ancestors in this country having been farmers. His father, Anthony Chase, was for thirty-four years Treasurer of the county of Worcester and for thirty years President of the Worcester Mutual Fire Insurance Co., and died as recently as 1879 at the advanced age of eighty-eight years. His mother was Lydia Earle, of the neighboring town of Leicester. Her father, Pliny Earle, "made the first cards ever propelled by mechanical power in America, and invented a machine by which the manufacture of them was greatly facilitated;" Dr. Pliny Earle, one of the most distinguished alienists of this country, was her brother; another was Thomas Earle, an eminent philanthropist, member of the Pennsylvania Constitutional Convention of 1837 and candidate of the Liberal Party for the Vice-Presidency in 1840; a third, John Milton Earle, was for many years Editor of the Massachusetts "Spy."

The subject of this Memoir was of the eighth generation in descent from Ralph Earle, who "was on the island of Rhode Island in 1638, was one of the petitioners to the King for permission for the formation of a 'body politic' on that island, and was subsequently a member of their legislative Assembly."

Pliny Earle Chase's early education was received at the Worcester Latin School, the principal of which, at that time, Hon. Charles Thurber, afterwards member of the Massachusetts Senate, preceded his distinguished pupil to the "Silent Land" only a few days. Ex-President John Adams had been a teacher in the same school. Pliny afterwards attended the Friends' School at Providence, R. I., and entered Harvard in 1835, graduating from that University in 1839 with the degree of A. B., and receiving that of A. M. in 1844. "As a boy, he was bright, intelligent, apt and quick in the acquisition of knowledge, but without special precocity. He was always one of the best scholars, but there was nothing that indicated the profundity of intellect manifested in his later years." In a letter to his uncle, he writes, in his Freshman year: "I am chiefly guided in the path which I intend to pursue by an aspiration after such honors as are calculated to be of lasting benefit in forming an acquaintance with the ways of the world and in acquiring *honorable fame.*"

He was then only fifteen years of age, but his career would indicate that he kept this honorable ambition of his boyhood constantly in view throughout life. Edward Everett Hale, who was a Harvard classmate, informs that he was "distinguished for scholarship, especially for mathematical scholarship, in his class at Cambridge. He was one of a special advanced section in mathematics, of which no member had had to take a lesson a second time. They were therefore so much in advance of the great body of the class that, at the end of the mathematical course, they had the advantage of special instruction from Prof. Peirce in higher mathematics. He was interested in all branches of physics. I remember him especially," writes Mr. Hale, "as one of eight observers who made some of the first observations which are on record of the shooting stars. The record will be found in the 'American Journal of Science,' of 1837, and I believe of the 'Comptes Rendus' of the French Academy of the same year. He was a quiet, unobtrusive young man, but a favorite with the class from his uniform courtesy, and a rare sense of humor, which never left him through life." Upon taking his degree at Harvard, he immediately entered the pedagogic profession, at first in district schools in Leicester and Worcester, then in 1840–1 as Associate Teacher in the Boarding-school at Providence, in which he himself had prepared for College. In 1841–2 he taught at Friends' Select School on Cherry street, in Philadelphia, and, from 1842 to 1844, conducted a private school in the latter city. On the 28th of June, 1843, he married Elizabeth Brown Oliver, of Lynn, whose brother, Prof. James E. Oliver, of Cornell University, was a man of kindred tastes to his own. The following two years were spent in New England, where he prepared for publication his first book, the "Elements of Arithmetic, Parts I and II," afterwards published by Uriah Hunt & Sons, of Philadelphia. This was followed, in 1848, by "The Common School Arithmetic." In the course of 1850, in connection with Horace Mann, he prepared and published "Mann & Chase's Arithmetic, practically applied," remodeling the 1st and 2nd parts of the "Elements of Arithmetic" into a new series, which was published by E. H. Butler & Co., Philadelphia.

Dr. Thomas Hill, ex-President of Harvard University, bears the following testimony to the value of his arithmetical works: "Chase's Arithmetic was the best I ever saw. The two books 'Chase' and 'Chase & Mann,' as we called them, were worth all other arithmetics that I ever saw put together. When I first introduced 'Chase' into the public schools of Waltham, I had a hard battle with the committee and with the teachers. They thought it too difficult, etc., but, in less than one year, all were satisfied, and at the end of three years, all enthusiastic. No schools in Massachusetts, and I believe none in the world, equaled our Waltham schools in arithmetic. But the publishers sold the plates to a Boston firm, who had another and inferior book to push, and they melted up the plates of Chase, to my intense indignation." Stronger proof of their merit could scarcely be given. Dr. Hill regarded them not as compilations, such as the common run of arithmetics, but as original contributions to pedagogy, and "classed Mr. Chase not with mere compilers, but rather with the originators, whose work is more akin to Pestalozzi's, and who deserve to rank very high;" and probably no higher testimony could be produced than Dr. Hill's, on this point.

In the fall of 1845, Mr. Chase returned to Philadelphia and conducted a private school for girls, at the same time giving lessons in other schools and in families. In all probability, he would have continued uninterruptedly in the pursuit of that profession, in which he was beginning to earn a measure of the "honorable fame" to which he aspired in his boyhood, had not severe hæmorrhages of the lungs, occurring three years later and continuing, with diminishing frequency, for ten years, compelled him to relinquish teaching. His physicians recommended a life which would allow of more out-door air and exercise, and he entered into a manufacturing business, under the name of North, Harrison & Co.

Two years later, John Edgar Thomson, President of the Pennsylvania Railroad Company, joined the firm as special partner, and a younger brother of Mr. North as general partner, under the firm name of Norths, Harrison & Chase, who conducted a large foundry at Wilmington, Del., with sales-rooms in Philadelphia. In the following year, Mr. Harrison died, and the name was changed to North, Chase & North, and eventually Chase became the head of the firm of Chase, Sharpe & Thomson, the junior of which was Edgar L., a nephew of President Thomson. But although their house engaged in an extensive wholesale trade extending to foreign countries, the practical business element was somewhat deficient in the head of the house, who greatly preferred intellectual pursuits, and, after suffering heavy losses, he finally, in 1866, after having wasted eighteen precious years in uncongenial occupations, sold out his interest in the foundry business. He was at this time forty-six years of age. Prof. Chase has been criticised for too much diversification of pursuits. It was characteristic of this tendency, that for six or eight years prior to abandoning mercantile life, he had given private lessons in the then famous school for young ladies of Prof. Charles Dexter Cleveland; and five years earlier had actually bought the furniture and good-will of Prof. Cleveland, upon the latter's retirement from teaching. This course, while more to the taste of so intellectual a man, did not conduce to the success of the foundry business which he was conducting, and which afterwards, in the hands of a former employé, proved exceedingly profitable, although the closing years of Prof. Chase's connection were the lucrative years of inflation caused by the war of the Rebellion. In the very same year, he also gave up the finishing school for young ladies, his own impression being that "the breaking out of the war interfered with private schools." He did not, however, abandon teaching, and from this time until his death adhered to his chosen profession, pursuing it continuously, if we except two visits to Europe, on the first of which, in 1870, he accompanied a party of young ladies who had been his former pupils and who sought the benefit of his familiarity with the European languages, as well as his agreeable companionship. The second visit was made in the summer of 1883 with members of his own family.

His later days were certainly his best days as a teacher, and while a natural modesty stood in the way of ambition, and he preferred a quiet and unobtrusive life, yet he attained a highly creditable standing in the profession. On the sixteenth of January, 1863, he was elected a member of the American Philosophical Society, to whose Transactions and Proceedings he afterwards became a diligent contributor. He occupied for a time the Chair at the University of Pennsylvania, rendered vacant by the death of Prof. Fraser, and, in 1871, became Professor of Natural Sciences in Haverford College, and remained a member of the faculty of that congenial institution until his death, occupying, after 1875, the Chair of Philosophy and Logic, then established. In 1876 he received the honorary degree of LL.D. from Haverford, on the ground of "his attainments and original researches in Mental and Physical Philosophy." Two years later, in the summer of 1878, after a severe illness, which resulted in the partial paralysis of one foot, and sensibly abated his physical vigor, he removed from Philadelphia to reside in the cottage on the beautiful grounds, in a bit of natural forest, adjoining the magnificent avenue of maples which forms the approach to Haverford College. On this charming spot, in the midst of sweet pastoral scenes, abounding in vegetable life, he had an excellent opportunity to indulge his taste for botany, a favorite pursuit. In 1884 he received the appointment of Lecturer on Psychology and Logic at Bryn Mawr College for Women. He prepared the syllabus and notes for the first course of lectures, which he was to have delivered in the winter of 1885–6, but was never able to deliver them, being overtaken by his final illness during that season. A sharp attack of pneumonia sapped the foundations of a vitality already much undermined, and although he partially recovered and resumed his duties at Haverford, the end was evidently drawing near. During the brief interval of life that remained and in consequence of the absence in Europe of his brother Thomas, who was President of Haverford College, he was made Acting President of that Institution, and held that position when death came, presiding at the Annual Commencement of 1886. His name had been prominently mentioned for the Presidency of Bryn Mawr College at the time of its organization, but the precarious state of his health forbade, although his eminent scholarship, the variety of his learning, and his previous experience in Young Ladies' Schools, strongly commended him for that position.

As a College Professor, he was clear in his demonstrations and attractive; and many are the testimonies of affection and respect borne by his former students, accompanied by acknowledgments of the important influence of his teachings upon their lives. As a disciplinarian, he was mild and easy, inspiring his pupils with love rather than fear; indeed the latter was not an ingredient in his system at all; he governed purely by gentle suasion.

Such is the simple record of a quiet life, the annals of which display no startling passages. If modesty were the opposite of greatness, then he was not great. But there was an unusual combination of great and good qualities in his mind and character, and one of its most conspicuous traits was a rare simplicity, indeed genuine modesty and humility, which is oftenest closely allied to a true greatness in the soul, unconscious of itself and busied with lofty studies of omnipotent power and sublimity. It was through this beautiful quality, which was perfectly natural and unassuming, that he endeared himself much to all of his intellectual associates, whether pupils or companions of his own age.

He had a singularly versatile mind, and a comprehensive and richly furnished memory. His writings included a wide range of subjects, upon each of which he displayed much erudition, and they were full of suggestiveness. It is seldom that a like capacity is found in one mind, both as a linguist and as a mathematician. He read with the help of dictionaries, and was more or less familiar with one hundred and twenty-three languages and dialects, and claimed thorough acquaintance with thirty of them. His knowledge of these was not profound, nor was it marked by the accuracy, in pronunciation and otherwise, which familiar conversation requires. Yet his attainments as a linguist afford a remarkable indication of the scope of his mind and the extent of his memory, and therefore throw an important light upon our estimate of the value of his deeper and more characteristic productions. Occasional contributions to the Proceedings of the American Philosophical Society were made on subjects in Comparative Philology, as the paper "On Radical Etymology," that on the "Mathematical Probability of Accidental Linguistic Resemblances," on "Sanscrit and English Roots and Analogues," on the "Comparative Etymology of the Yoruba Language," and others. His reputation as an analyst was sufficient to induce the sending to him of an obscure cipher from the War Department for translation during the Rebellion, and, on another occasion, of a Coptic inscription. But although his philological attainments were in no wise mean, his pen was most fertile in other directions. Of over 150 papers contributed by him to various learned bodies, most of them to this Society, not more than one-tenth were philological, and the remainder mostly in meteorology, cosmics and physics. Many of these were fragmentary,—studies, as it were, of great themes,—and in undigested groups; they were unfinished, like Michael Angelo's marble groups, and needed the master's hand to give them the perfect expression intended. As he grew older, they took more and more a cosmical direction, and his mind struggled to demonstrate from the harmonies of the universe, as the geologist does from the marvelous narrative of the rocks, a cosmical evolution. Going back to the very sources of development with daring genius, he sought, through proofs of the "Quantitative equivalence of the different forms of force which we call light, heat, electricity, chemical affinity, and gravitation," and original theories of nodal accumulation, the truth of which time may affirm, to establish a common law that "All physical phenomena are due to an Omnipotent Power, acting in ways which may be represented by harmonic or cyclical undulations in an elastic medium." A peculiarity of his mental operations was a singular capacity for seeing harmonies and analogies which did not attract the attention of others. His methods of thinking were swift, and led him to undemonstrated skips in his reasoning which made it difficult to follow him. In the ordinary processes of addition, he footed up columns of eight or ten numbers, extending into trillions, instantaneously, setting down the result from left to right, ending with the units. A certain instinctive or intuitive faculty pervaded his demonstrations, interrupting their purely mathematical character, and making many mathematicians and physicists plausibly skeptical as to the value of his theories.

An eminent scientist at one time spoke of him as "the Kepler of this century," and there was a certain resemblance, in the tentative methods pursued by him, to those by which his great prototype discovered the astronomical laws upon which his fame is based.

Prof. Kirkwood writes : "The just value of his contributions to science cannot at once be determined. It must be said, however, that his hypothetical conclusions were so often in close agreement with well-known facts, as to leave the impression that his theories must have a foundation in truth."

Prof. Herschell, referring to his paper on "The Results of Wave Interference," bears this testimony : "From a direction of research probably as distant and distinct as possible from the late Prof. Chase's, at least in its origin, I have reached results which the contents in this case, of Prof. Chase's papers, confirm and corroborate so amazingly, that all question of the real validity of views, however incongruous they may perhaps be to each other in particulars, by which identical results of such surprising characters have been arrived at by us both, in perfect independence, is banished completely and forever from my mind. Prof. Chase's writings and discoveries will constantly gain in note and consequence by wider and longer consideration and perusal ; and they will surely never cease to have leading uses for consultation and for purposes of instructive study, among those who aim and strive to unmask more laws of energy's unitary operations, if possible as prominent and predominating as those which his discoveries have disclosed."

An American philosopher, who, while somewhat uncertain how to estimate him, says he is hopeful that the future will reveal the value of Prof. Chase's labors, speaks thus of his later work : "It may prove prophetic of developments that will take us a long step below our present philosophy of things—or it may not. Time will show. If the new developments do come, my feeling is, that they will help to bring the heavens and the earth nearer together, by showing that beneath the seemingly ultimate facts of matter, gravitation, conservation of work, things that may seem to pertain to no other life of ours than this—that beneath these, and nearer to the ultimate reality, there lies an order of things that may well serve as the physical basis of this and the next life alike."

Prof. Chase, although, as we have already said, very modest in his estimates of himself, was confident that his conclusions pointed in the right direction. Yet he did not claim mathematical demonstration for his theories, and while his papers abounded in formulæ, they were only partly mathematical even in form. There was an element of imagination, of speculation and of intuition. The harmonies are not always perfect, links are missing; very probably some of them will prove to be accidental, while others, with their profound inductions, will remain firmly planted upon the rock of truth. Indeed, they have claims, not only to coincidence with the conclusions of other philosophers, derived from different data, and reached through other channels, but even to verification as predictions. Dr. Chase regarded the series of twelve papers contributed to the London, Edinboro' and Dublin Philosophical Magazine as containing, to quote his own words, some of his "most important discoveries in confirmation of the nebular hypothesis, including nine verifications of intra-mercurial planets and of harmonies of solar and planetary rotation that he had predicted some years prior to the discovery." These "verifications of intra-mercurial planets" should rather be designated "Confirmations from other sources of his opinion predicting them." These special articles comprised the 1. Cosmical Activity of Light; 2. Equilibrating Forces of the Solar System; 3. Planetary Interaction; 4. Our Binary Star and its Attendants; 5. Correlations of Central Force; 6. Ætherial Nodes; 7. Momentum and Vis viva; 8. Undulation; 9. Criteria; 10. Radiation; 11. Watson's Intra-mercurial Planet; and, 12. Predictions. The titles of these papers sufficiently indicate their character and his claims of original discovery, which are further elucidated by such others, appearing elsewhere, as "The Gamut of Light," "The Music of the Spheres," "The Beginning of Development," "Planeto-taxis," and "Photo-dynamic Notes." Regarding light as the primal manifestation of force, and the Almighty fiat, "Let there be light" as the order for movement in the cosmic element, out of which all the complex development of the universe has grown, he felt after and sought to discover the fundamental laws whose universal application might pervasively explain all material forms and forces. Thus his investigations were not limited to the relations of the great forces of light, gravity, electricity, etc., but his speculations on the harmonies extended to the laws which govern chemical affinity and to ordinary material things. This much may be said as to these investigations: that

1. Whatever may be the ultimate conclusions of Science as to the precise nature and extent of the evolution, there has been an evolution from the simpler and more comprehensive conditions of matter, into the more complex and multiform.

2. It is reasonable to suppose that this entire evolution has been in accordance with some general law.

3. The discovery of that law is probably within the reach of the human mind.

It was after this law that Prof. Chase was searching; the character of his mind was one that eminently fitted it for the investigation; and future researches may show his work to have been founded in fact and correct inference, and that he was in advance of his age and above the heads of his critics. The respect in which his writings have been held in Great Britain has been attested by their publication in the "Philosophical Magazine." His essay on "The Numerical Relation between Gravity and Magnetism" received, in 1864, the Magellanic Premium from this Society.

The detached and fragmentary character of his scientific productions, their real profundity, and the limited number of those who could follow him in his rapid evolution of thought on these subjects, have led many scientific men to regard his speculations with doubt, and some, who had little or no personal acquaintance with their author, accord them no scientific value. But Prof. Chase was least of all a hypocrite or a charlatan, and those who knew him best will most unhesitatingly recognize his deep sincerity. He was an humble seeker after truth, with the lamp of a strong intellect. The obscurity of his logic belongs not altogether to the writer, but to his theme. There was nothing obscure about his ordinary style. When he wrote upon familiar topics it was clear and cogent, rising sometimes into flights of eloquence. It is to be regretted that he has not himself been able to put into compact and comprehensible form his studies on cosmical and molecular forces as applied to astronomical and interplanetary relations, and no less the profound, though fragmentary notes, which his mind threw off in later scintillations. But they were not completed, and though much more than gropings after the facts of infinity, can not lay claim to perfect and final demonstration. Whatever title his name has to rank among the greatest on the rolls of science, however, no one who knew his work will deny him an eminent place.

The loftiness of conception and inspiring suggestiveness of his writings, his extensive learning, his great industry and productiveness, his boldness and success in dealing with the problems of the unknown world, entitle him to distinction. Aside from his deeper and favorite themes, the range of subjects ably treated by his pen was notable. Among these may be remarked such familiar topics as Bricks, Paper, Ink, Ceramics, Artificial Iron Works.

Some of his rules for weather prediction were embodied by the U. S. Signal Service in its "Manual for Observers," and the observations of the Bureau have indicated the importance of anti-cyclonic storm centres, to which he first called attention. He claimed the discoveries of "a parabolic connection between the nearest fixed star and the solar system, of harmonic undulations which have influenced the arrangement of planets and of spectral lines, and of the quantitative equivalence of the different forms of force." He made many observations upon rainfall, and in a series of papers, "demonstrated the meteorological influence of the moon," regarding "the evidence of important lunar modifications, both in the amount and in the frequency of rain, as unmistakable."

A leading characteristic of Prof. Chase was the quiet and unwavering faith with which he adhered to the Bible record, and to Evangelical Christianity. Through all mutations, throughout his active studies of the material world, and of the great forces of Nature, he was unshaken in his belief in the spirituality of religion, and its real and necessary relation to the same Omnipotent Power, who originated the cosmos. He accepted the Christian theory of salvation absolutely and without qualification as Divine. That which many scientists are led to doubt, seemed clear to him, and all facts were of necessity parts of one stupendous whole. He was a religious man, not only by intellectual conviction ; but the fruits of piety were manifest in his daily life, especially towards its end, in an unaffected gentleness and sweetness of temper, a freedom from assumption, and a general submission of his actions to the Divine government and guidance. Wealth had few attractions for him, his tastes inclining him to count it loss if it interfered with science and religion, even if he had had any gift for accumulating, which he had not. Born in the Society of Friends, he held throughout life their belief, and of later years frequently preached to the little congregation at Radnor, of which the Haverford students and Professors formed a part. Nor was his pen idle upon religious themes, and those affecting the prosperity of the sect he loved. He read an able paper before this body on "The Philosophy of Christianity," and his lecture "On Denominational Education in the Society of Friends" was a lucid argument of much power in its favor. He was wont to press the view that God was ever acting on the soul of man to give it right direction, as well as in the phenomena of nature. His faith was not so much in doctrinal propositions, as in God himself, as revealed in Christ, in Nature, in History, and in Man's reason and conscience. But while firm in his own convictions, he was broad and charitable to others, and sought to find any ground of common truth upon which he and those who differed most widely from him could stand. His opinion was candid, and open daily, like Dr. Arnold's, to change with the advances and discoveries of science ; yet he always retained an abiding confidence that Science and Revelation would be found really to harmonize. His personal trust in a present Omnipotence enabled him to meet all the vicissitudes of fortune with a more than philosophic composure and content. While his philosophy was pervaded with religion, his religion was no less filled with philosophy, and the lustre of his life presents a shining example to those who survive him of evolution "more and more unto the perfect day," when at last the "mortal shall have put on immortality."

Octonary Numeration, and its Application to a System of Weights and Measures. By Alfred B Taylor, A.M., Ph.M.

(Read before the American Philosophical Society, October 21, 1887.)

For many years strong and persistent efforts have been made by the advocates of the French metrical or decimal system, to have its use made obligatory in the United States, to the exclusion of the heterogeneous tables of weights and measures now existing. Its use has been legalized in Great Britain since 1864, and in the United States since 1866.

"On the first of January, 1879, a new Act went into force," (in England) "by which it is made unlawful to buy or sell by other than imperial measures, and no provision is made for the adoption of the metric system."*

Its progress in either country has been very slow.

At the meeting of the British Association for the Advancement of Science in 1887, Mr. Ravenstein, of the Geographical section, while strongly advocating the metric system, stated that "while the English foot is used by 471 millions of people, the metre is used by only 347 millions of people." But the selection of a system evidently should not be made because a greater number of people use the one or the other, nor on account of the cost of the change in money or in temporary inconvenience, but it should be made on the intrinsic merits of the system.

The zealous votary of the metric system can acknowledge no defects; the offspring of the world's best science, it must be as perfect as it is beautiful, and only prejudice, ignorance and stolidity can stumble on obstructions, or refuse entire allegiance to its beneficent sway. The real difficulties in the way of its success are fully realized alone by those who have given a careful and unbiassed attention, not merely to the various schemes proposed for simplifying or harmonizing national weights and measures, but to the practical operation of such reforms when actually applied to the daily life of human masses. And thus it occurs that what to the enthusiast is the foremost virtue of the French system, is, in the view of the thoughtful student of facts, its most insuperable disadvantage.

The objections to it have been sufficient up to the present time to prevent its adoption, and it is the opinion of very many persons that it can *never* be satisfactorily adopted.

Many different projects in remedy of the existing and acknowledged evils have been suggested; some more practicable, others more systematic; and unfortunately these two classes appear to bear an inverse ratio to each other.

The substitution of decimal multiples and divisions, conformably to our established arithmetical notation, has been advocated; and various standards or units have been proposed, such as the inch, the foot, the grain, the

* "*New Remedies*," Vol. viii, p. 192. New York, 1879.

pound, the pint, the gallon, the cubic inch, the cubic foot, etc., but none of these projects has met with much favor.

The most feasible plan for arriving at a satisfactory and authoritative determination of so vital an issue would appear to be the appointment of an international commission, with England, Russia and the Germanic States (with France as well, if practicable), comprising the highest representative talent, not alone from the ranks of the physical philosopher and geometrician, but as well from the classes of merchants, machinists and civil engineers; from those most interested and most skilled in the subject, for the purpose of organizing and developing an acceptable and permanent system of weights and measures.

Among the labors of such a commission, a very needful one would be to institute a careful and impartial investigation into the exact state and working of the metric system among those nations which had tried it. Assuming nothing, rejecting nothing, accepting nothing, as the groundwork of the future, the commission should endeavor, from a comprehensive survey of all the conditions and all the possibilities involved, to elaborate a scheme best suited to the wants of man, and therefore best entitled to the acceptance of the nations.

If the final verdict were in favor of a uniform octonary system, it would not be difficult to establish it. If, on the contrary, such a commission should agree to adopt the present French system, their decision would go far to silence all further discussion; the result would be well worth the labor and delay it might cost. No people would receive the system with greater alacrity, or master its details with more facility and promptitude than those of the United States; not merely from their general intelligence and mental versatility, but from their long training in the use of their decimal monetary system.

Such a conference among nations having so many fraternal ties, seems to be eminently proper in every sense, and surely will not be regarded, at this day, as a visionary or illusive expectation.

The origin of weights and measures is not known, and can be only conjectured. Their need was contemporaneous with the infancy of the human race.

Man in a state of nature would, in his strife for existence, seek food, clothing and shelter from the inclemency of the weather. He would kill animals for their flesh, and use their skins for clothing. The adaptation of skins to this purpose would require measures of some kind to be used. Those naturally suggesting themselves would be the finger, the breadth of the hand, the span, the cubit (or extent from the tip of the elbow to the end of the middle finger), the arm, and the fathom (or extent from the extremity of one middle finger to that of the other, with extended arms). So in the construction of a habitation, however rude, whether of logs, or of earth and stones, he would find need for the use of measures, and some of the above would no doubt supply his needs. Distances traversed in his walks about his habitation would naturally suggest to him measures of length, and none of those mentioned would conveniently supply his want. Here he would probably use the foot or the pace, and it would not naturally occur to him to use the same measure, or the same scale of proportions and numbers to clothe his body and to mark the distance of his walks. Here, then, is a source of diversity in the standards of linear measure, flowing from the difference of relations between man and physical nature. It would be as inconvenient and unnatural to measure a bow and arrow, for instance (among the first implements of solitary man), by his foot or pace, as to measure the distance of a day's journey, or a morning's walk to the hunting ground, by his arm or hand. These natural standards are never lost to individual man in any stage of society. There are probably few persons living who do not occasionally use their own arms, hands and fingers to measure objects which they handle, and their own pace to measure a distance upon the ground.

The need of measures of capacity would not be felt at quite so early a period of man's history as measures of length, yet they would be rendered necessary by the nature of liquids, and for the admeasurement of those substances which nature produces in multitudes too great for numeration, and too minute for linear measure ; of this character are all the grains and seeds, which from time to time, when man becomes a tiller of the ground, furnish the principal materials of his subsistence. But nature has not furnished him with the means of supplying this want, in his own person, and as his first measures of capacity he would probably employ the egg of a large bird, the shell of a mollusk, or the horn of a beast. The want of a *common* standard not being yet felt, these measures would be of various dimensions ; nor is it to be expected that the thought would ever occur to the man of nature, of establishing a proportion between the size of his arm and his cup, of graduating his pitcher by the size of his foot, or equalizing its parts by the number of his fingers. The necessity for the use of weights comes still later. It is not essential to the condition or comforts of domestic society. It presupposes the discovery of the properties of the balance ; and originates in the exchanges of traffic after the institution of civil society. It results from the experience that the comparison of the articles of exchange, which serve for the subsistence or the enjoyment of life, by their relative extension, is not sufficient as a criterion of their value. The first use of the balance and weights implies two substances, each of which is the test and standard of the other. It is natural that these substances should be the articles most essential to subsistence. They will be borrowed from the harvest and the vintage ; they will be corn and wine. The discovery of the metals, and their extraction from the bowels of the earth, must, in the annals of human nature, be subsequent, but proximate, to the first use of weights ; and when discovered, the only mode of ascertaining their definite quantities will soon be perceived to be their weight. That they should themselves immediately become the common standards of exchanges, or otherwise of value and of weights, is perfectly in the order of nature ; but their proportions to one another, or to the other objects by which they are to be estimated, will not be the same as standards of weight and standards of value. Gold, silver, copper and iron when balanced each by the other in weight will present masses very different from each other in value. They give rise to another complication, and another diversity of weights and measures. The balance, or scales, in a rude form, are known to have been in use from very early times. The Greeks, as appears from the Parian chronicle, believed weights, measures, and the stamping of gold and silver coins to have been alike the invention of Phidon, ruler of Argos, about the middle of the eighth century B. C.

The weights or counterpoises used in weighing were probably obtained by taking equal bulks, roughly determined, of some material of comparatively uniform density, such as brass or iron; but to render them more accurate and definite it became necessary to call in the aid of more accurate measures of capacity; and the weight of a known volume of pure water, at a known density, is now the criterion universally resorted to for determining the standard of weight. This supposes that the volume or cubic contents are correctly known; and since contents or capacity can be practically expressed only in terms of the cube of a length, and area in terms of the square of a length, it follows that to obtain exact units of measure of all kinds, it is necessary first to fix, and then to be able to reproduce with the greatest possible exactness, the unit of length. Absolutely invariable standards of weight and measure have not been, and in the nature of the materials to be dealt with, cannot be attained; while to secure and reproduce measures of given sorts, the results of which shall be correct and uniform to within the least practicable degree of variability, is a problem upon which a vast amount of scientific research, ingenuity and labor has been expended.

When the legislator has the subject of weights and measures presented to his contemplation, and the interposition of law is called for, the first and most prominent idea which occurs to him is that of uniformity; his first object is to embody them into a system, and his first wish to reduce them to one universal common standard.

In England, from the earliest records of parliamentary history, the statute books are filled with ineffectual attempts of the legislature to establish uniformity.

Of the origin of their weights and measures, the historical traces are faint and indistinct; but they have had from time immemorial, the *pound*, *ounce*, *foot*, *inch* and *mile*, derived from the Romans, and through them from the Greeks, and the *yard*, or *girth*, a measure of Saxon origin, but as a natural standard different from theirs, being taken not from the length of members, but from the circumference of the body, and hence a source of diversity. The yard, however, very soon after the Roman conquest, is said to have lost its original character of girth; to have been adjusted as a standard by the arm of King Henry the First; and to have been found or made a multiple of the foot, thereby adapting it to the remainder of the system.

In 1266, the first positive attempt was made to change the common weight into the troy,* under the name of the weight of assize; a statute 51. Henry III enacted "that an English penny called a sterling round, and without any clipping, shall weigh 32 grains of wheat, from the middle of the ear, and 20 pence to make an ounce, 12 ounces a pound, 8 pounds a gallon of wine, and 8 gallons of wine a bushel of London, which is the eighth part of a quarter." This penny weight was divided into 24 grains.

But neither the present avoirdupois, nor troy weights, were then the standard weights of England. The foundation of the system of 1266 was the penny sterling, which was the 240th part of the *tower pound;* the sterling or easterling pound which had been used at the mint for centuries before the conquest, and which continued to be used for the coinage of money until the eighteenth year of Henry the Eighth, 1527, when the troy pound was substituted in its stead. The tower pound weighed 360 grains (or $\frac{1}{16}$) less than the pound troy, and the penny, therefore, weighed $22\frac{1}{2}$ grains troy.

The philosophers and legislators of Britain have never ceased to be occupied upon weights and measures, nor to be influenced by the strong desire for uniformity. They found a great variety of standards differing from each other, and instead of searching for the causes of these varieties in the errors and mutability of the laws, they ascribed them to the want of an immutable standard from nature. They felt the convenience and the facility of decimal arithmetic for *calculation;* and they thought it susceptible of equal application to the divisions and multiplications of *time, space* and *matter.* They despised the primitive standards assumed from the stature and proportions of the human body. They rejected the secondary standards taken from the productions of nature most essential to the subsistence of man; the articles for ascertaining the quantities of which weights and measures were first found necessary. They tasked their ingenuity and their learning to find, in matter or in motion, some *immutable* standard of linear measure which might be assumed as the single universal standard, from which all measures and all weights might be derived. In France their results have been embodied into a great and beautiful system. England and America have been more cautious.

Among the earlier measures of length used by various nations are found such as the "finger's length," the "digit" (second joint of the forefinger), the "finger's breadth," the "palm," the "span," the "cubit" (length of forearm), the "nail," the "orgyia" (stretch of the arms), the "foot," the "pace," etc., and the names of these measures,

* When the troy weight was introduced into England is not known. It was introduced into Europe from Cairo in Egypt about the time of the Crusades, in the 12th century. Some suppose its name was derived from *Troyes*, a city in France, which first adopted it; others think it was derived from *Troy-novant*, the former name of London.

their almost constant recurrence among different nations, and the close approximation in length of such as have, like the foot, more nearly acquired the character of arbitrary measures, alike establish the fact that in its origin, measurement of length was by the application of parts of the human body. In some parts of the East the Arabs, it is said, still measure the cubits of their cloth by the forearm, with the addition of the breadth of the other hand, which makes the end of the measure ; and the width of the thumb was in like manner formerly added at the end of the yard by the English clothiers. The advantages of such measures for popular use are that they are known by observation and readily understood, and in an average way always capable of being recovered, when more arbitrary standards might be wholly lost. But their great disadvantage is extreme variableness, especially when directly applied ; and in the gradual progress of men's minds toward exactness of conception and reasoning, three successive plans of insuring greater accuracy have been devised, and two at least have secured permanent adoption.

The first is that of obtaining a uniform standard by exchanging the measures by parts of the body for conventional or arbitrary lengths, which should represent the average, and which were to be established by law.

The second plan is that of making accurate comparisons of the various standards of each given sort in a country. Attempts of this kind appear in England to have been commenced under the auspices of the royal society in 1736 and 1742 ; in the former year by a comparison of the English, French and old Roman standards ; and in the latter by the determination (by George Graham) of the length of a pendulum beating seconds at London, to be equal to 39.1393 inches, and the construction of a standard yard. Of this, under the direction of the House of Commons, Mr. Bird (a celebrated optician) prepared two accurate copies, respectively marked "standard yard 1758" and "1760," and intended for adoption as the legal standards. He determined and prepared also the pound troy, the original of that now in use. Of these two standards, no intentional alteration has since been made ; so that these or their derivatives are now in use in England and the United States.

The third proposed step toward rendering measures exact has reference rather to the means of making the standards recoverable in case they should be lost. In the definite pursuit of this purpose the French philosophers of the time of the Revolution took the lead, and devised the metric system, in which the unit of length is derived from the dimensions of the earth, and the units of capacity and weight are made dependent upon the former, while the whole has decimal multiples and subdivisions. The celebrated commission concentred within itself the physical and mathematical science of France, but there was one science unfortunately not there represented ; the science of human nature. Looked at from a purely arithmetical standpoint, the problem of measures suggested but one solution, that of the decimal digits. Abstract mathematics could furnish no inducements to binary or octonary divisions or progressions.

So early in our national existence as the year 1790, the illustrious Jefferson, then Secretary of State, in obedience to a resolution of Congress calling upon the Secretary to propose a plan or plans for establishing uniformity in the currency, weights, and measures of the United States, presented a report recommending a decimal system of metrology, and its derivation from a natural and permanent standard of length.

Instead of taking the ordinary pendulum of 39 inches, he proposed the second's rod of 5 feet, then generally known as Leslie's pendulum rod. A simple straight rod, without the bob or ball, suspended at one end, has, as is well known, its centre of oscillation at a distance of two-thirds of its length from its point of suspension; or, in other words, is one-half longer than the common loaded pendulum vibrating in the same time. Such a rod vibrating seconds is 58.72368 inches long; dividing this into five equal parts, Mr. Jefferson took this fifth part, or 11.744736 inches as the length of the new "foot," and from this by decimal multiples and subdivisions he presented a series of tables of weights and measures.

When we reflect that the system of metrology here displayed was perfected by Mr. Jefferson before any steps had been taken by the French government toward the decimal re-organization of weights and measures in that country, we must regard it as a memorial in the highest degree creditable to the judgment and contriving skill of its author; and as one of many illustrations of the varied activity of his mind, and of the interest he ever felt in all schemes for human improvement. The great superiority of his proposed scales of measure, to those in common use, cannot be questioned; and their adoption would have been a signal public benefit. The tables presented by him form a connected and complete system, each depending directly upon the one preceding, and necessarily flowing out of it, and all determined from a single and invariable natural standard by a very simple and beautiful mode of derivation.

In this respect, however, the French system is by far the best of all that have yet been devised. Starting with a carefully measured quadrant of the earth's meridian, and dividing it into ten million parts, this system presents us with a "metre"* as a universal standard to which all others may be referred. Indeed, if a decimal system of weights and measures is to be ultimately adopted, there appears to be none that has such just claims to our acceptance as that of the French; and although it would be much more difficult of popular introduction than a simple decimalization of our own divisions, and therefore less "practicable," there can be no doubt that it would be in every way superior, both in regard to the precision of its measures, and the simple and philosophical character of its divisions; besides all which it has the immense advantage of being already introduced and in successful practical operation throughout the great Republic of France; and every extension of its use would be an important step in the progress toward a uniform system among all nations.

* Equal to 39.370788 inches; very nearly the length of the second's pendulum, and not much longer than our yard.

Beautiful and simple as this system appears, and clear as its nomenclature is to those familiar with the Greek and Latin tongues, it is yet open to animadversion on practical grounds, in that its language is that of the philosopher, and not of the tradesman or the business man. To all but classical scholars—that is, to the large majority of men—the terms used in the French tables are difficult and unmeaning; to be acquired and appreciated only by a laborious effort of abstract memory, and even when thus acquired, constantly liable to be confounded and mistaken. Its metres and litres, its myriametres and myrialitres, its decigrammes and decagrammes, are admirably contrived to bewilder the uninitiated, but of all possible devices are the least adapted to the common uses of daily life. To obtain a ready and direct apprehension of the values of different denominations of measure, it is necessary that each should be recognized as an independent unit, without reference to its fractional or multiple derivation. Thus, "ounces" or "inches" are at once seized upon by the mind as distinctive standards of value; and the fact that these terms both signify "twelfths" (being derived from the Latin "uncia") never enters into our contemplation when using them. The coin a "cent" has come to signify a "one" and not a "hundredth." What is really needed then for the popular service, is a set of names, brief, easy, and distinctive by a wide separation of sound, however arbitrary or unmeaning may be their origin. In this view of the matter, the rude and indefinite vulgarisms of "grains" and "scruples," "feet" and "rods," "gills" and "gallons" are infinitely preferable to the scientific jargon of *centigrammes* and *milligrammes*, and *hectogrammes* and *kilogrammes*. In fact, the French system has totally ignored all units, excepting the single one selected as the standard for each table. Thus in weight, the French cannot be said to have any other measure than the gramme; and instead of resorting to the dead languages for so familiar a thing as a simple numeration table, it would be much better to speak of and write down, the multiples or divisions of this weight as a thousand or a hundred grammes, or as so many hundredths or thousandths of a gramme. This, in plain English (or plain French), would be understood by every one, and would just as conveniently express everything that is contained in the high-sounding terms we have characterized as "scientific jargon."*

An almost unmanageable difficulty in the introduction of the French

* While thus strongly expressing our objection to the *nomenclature* of the French tables (whose very fault is its excess of system), it would be unjust not to acknowledge, and ungenerous not to admire, the catholic sentiment which dictated it. The eminent philosophers to whom belongs the honor of developing a metrology by far the most perfect that has yet been devised, felt as if they were legislating for the civilized world. Desirous that all might have the benefit of their labors, they rejected all the familiar terms employed in France, and naturally resorted to the great storehouse from which the scientific world has ever been accustomed to draw its technical phraseology; exhibiting in this, their anxiety to adopt a language which might be acceptable to all nations. Unfortunately it is suited to none. The language of science cannot be that of the shop and the market-place.

system has been found in the adoption of the nomenclature; there is a natural aversion in the mass of mankind to the adoption of words, to which their lips and ears are not from their infancy accustomed. Hence it is that the use of all technical language is excluded from social conversation, and from all literary composition suited to general reading; from poetry, from oratory, from all the regions of imagination and taste in the world of the human mind. The student of science in his cabinet easily familiarizes to his memory and adopts without repugnance words indicative of new discoveries or inventions, analogous to the words in the same science already stored in his memory. The artist, at his work, finds no difficulty to receive or use the words appropriate to his own profession. But the general mass of mankind shrink from the use of unaccustomed sounds, and especially from new words of many syllables.

Should these measures be therefore introduced, we should strongly urge the entire abolition of the French nomenclature, and the complete naturalization of the different scales by the substitution of more familiar terms from our vernacular tongue.

In the advancement of physical science no nation has taken a higher position, or exhibited a more fertile activity, than France. Hence it has become necessary for every English and American physicist to familiarize himself with the French units and standards of scientific research and discovery, if he would avail himself of their benefits or information. This again has induced a considerable employment of the same scales by the English and American *savants*, in repeating or extending the foreign experiments. It is not remarkable, therefore, that the scientific world generally, both in this country and in England, should desire to see this system universally prevail. Very few scientific men have given the subject of popular weights and measures any special attention, and of those who have, it is believed that a very small proportion will be found to advocate the unqualified adoption of the metric system.

A decimal system applied to weights and measures must result in failure as regards the convenience of such a system or its adaptation to popular wants, and this want of adaptation arises, not from any defect in the plan on which it is established, but from inherent defects in the decimal system of numeration.

The introduction of any new system of weights and measures, to take the place of one long established and in general use, will be found a troublesome and difficult exercise of legislative authority. There is indeed no difficulty in enacting and promulgating the law, but the difficulties of carrying it into execution are always great.

Of all the difficulties to be overcome, however, perhaps the greatest is the abandonment of old and familiar units or standards.

"Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property ; to every transaction of trade and commerce ; to the labors of the husbandman ; to the ingenuity of the artificer ; to the studies of the philosopher ; to the researches of the antiquarian ; to the navigation of the mariner, and the marches of the soldier ; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is rivetted in the memory by the habitual application of it to the employments of men throughout life. Every individual, or at least every family, has the weights and measures used in the vicinity and recognized by the custom of the place. To change all this at once, is to affect the well-being of every man, woman and child in the community. It enters every house, it cripples every hand."

The failure that attends the introduction, and the objections that have so far prevented the adoption of the metric system in Great Britain and in the United States, notwithstanding the strenuous and untiring efforts of its advocates, sufficiently attest the need of some other scheme, which, while possessing the advantages claimed by that, may be free from its disadvantages and defects.

Great Britain has shown such a determined opposition to the metric system, that, in the International Monetary Conference held in Paris in 1867, she refused even to negotiate in reference to unity of coinage, and her delegates stated "that until it should be incontestably demonstrated that the adoption of a new system offered superior advantages justifying the abandonment of that which was approved by experience and rooted in the habits of the people, the British government could not take the initiative in assimilating its money with that of the Continent."

She maintains the most complex system of measures, weights and coinage now in use among civilized nations ; she persistently rejects the decimal system and adheres to the complex division of pounds, shillings and pence, a system abandoned by the United States in their rejection of colonial dependence.

A very strong objection to accepting the metre, either directly or indirectly, as our national standard of length is the want of absolute precision in the rule itself. It has been shown by the investigations of able mathematicians, that the metre is not an exact expression of its theoretical value, and as the result of more extended geodetic measurement up to 1875, that the quarter of the meridian is equal to 10,001850 metres, and that consequently the metre is too short by $\frac{1}{5400}$ part of its length. This unfortunate and vital defect in the French metre nullifies almost entirely its value as a natural standard, and defeats the principal object of its establishment—the facility of its perfect restoration in all future time should the existing material standards be destroyed. The metre is just as arbitrary a standard as the yard ; the only real thing about it is the platinum rod in the public archives in Paris, and this has no advantage over the English standard kept in the British exchequer.

The kilogramme has in like manner been found to differ from its assumed value by some small fraction, in consequence of the great difficulty attending exact determinations of this kind.

Our weights, measures and coins at present correspond much more nearly with the English than with the French standard. Our commerce with Great Britain is very much greater than with any other nation, and we should certainly commit a great error in adopting the metric system unless Great Britain should consent to adopt it also.

Our adoption of the metric system, and the consequent change of our linear unit, would sever our uniformity with Great Britain, a country with which perhaps three-fifths of our foreign commerce is transacted, besides which it would entail great inconvenience and much greater expense than is generally imagined. The measurements of every plot of ground in the United States have been made in acres, feet and inches, and are publicly recorded with the titles to the land according to the record system peculiar to this country. What adequate motive is there to change these expressions into terms which are necessarily fractional, and in which those foreign nations, whose convenience it is proposed to meet, have no conceivable interest? What useful purpose is subserved by designating a building lot 20 × 100 feet in the form 6.095889 × 30.479448 metres?

Besides this, the industrial arts during the last fifty years have acquired a far greater extent and precision than were ever known before. Take, for instance, the machine shop, in which costly drawings, patterns, taps, dies, rimers, mandrils, gauges and measuring tools of various descriptions, for producing exact work, and repetitions of the same with interchangeable parts, are in constant use. It has been calculated that in a well-regulated machine shop, thoroughly prepared for doing miscellaneous work, employing two hundred and fifty workmen, the cost of a new outfit adapted to new measures would be not less than one hundred and fifty thousand dollars, or six hundred dollars per man.*

Supposing full consent were obtained for using metric measures in all new machinery, how slow and difficult would it be to make the change. A very large proportion of work consists in renewing worn parts; where, then, are the new measures to come in? The immense plant of railway motive power in the United States is all made to inches and parts. At what time can a railway company afford to change the dimensions of the parts of a locomotive engine? At no time, because the change would require to be simultaneous in the whole stock. It is true that the old dimensions might be adhered to, and called by metric names, putting 0.0254 metres, or 25.4 millimetres for one inch; but this would be only an evasion, not a solution of the problem.

A practical defect in the working of this system, which has been demonstrated by experience, is its incapability of binary divisions; a defect which of course attaches equally to every decimal scale; and one which

* "The Metric System in our Workshops," etc., by Coleman Sellers. Journal of the Franklin Institute, Philadelphia, June, 1874.

has always strikingly displayed itself wherever this scale has been brought into popular use, for the estimation either of lengths, bulks, weights or values. In our own country the decimal scale has been applied only to the currency, and we find that in spite of the legal division of the *dollar* into tenths, and its seeming establishment by the coinage and circulation of *dimes*, the people persist in cutting it up into quarters, eighths, sixteenths, and even thirty-seconds, to the utter neglect of the coins actually established by law, and to the inconvenience, confusion, and loss, resulting from the necessary involvement of interminable and unmanageable fractions.

For all the transactions of retail trade the eighth and sixteenth of a dollar are among the most useful and convenient divisions, and although our government has never coined them, their want has been continually felt, thereby showing the insufficiency of our much admired and boasted decimalization of moneys to meet the actual wants and necessities of trade and daily business life. So far, therefore, from our decimal currency possessing the excellencies that have so often and so inconsiderately been ascribed to it, it has but the single merit of facility of computation. A single division of the number 10 brings us at once upon a prime number; and as the twelve pennies of the English shilling are far more convenient to the tradesman, than the 10 cents of the American dime, so the 12 inches of our present foot can never be usefully replaced by the 10 centimetres of the decimetre.

Many have supposed that this is all a matter of practical indifference, and that it merely requires the decisive sanction of legislative authority to accustom a people to any set of subdivisions. Such an opinion, however, exhibits both a blindness to the lessons of all experience, and an inattention to many of the most important and subtle theoretical considerations affecting the relations of value and our apprehension thereof.

Binal progression may be regarded as pre-eminently the natural scale of division. This fundamental fact is indeed illustrated in the very origin of the word *division*. The binary scale is in the first place the lowest and simplest of all the geometrical progressions. It is that of which we have the most ready and precise conception; indeed, it may be said to be the only one of which we have any accurate appreciation beyond the second or third term.* It is that by which we most rapidly and nearly approach any vague quantity we may desire to employ; hence its universal use in trade. It is that which in any system of independent units of measure (as in weights, or coins) furnishes us with the means of representing the greatest range of particular values, by the smallest number of pieces. It is that which affords us the easiest practical measure; thus we can fold a string, a sheet of paper, or any other flexible material, or we can cut an apple, or a loaf bread, at once and

* Thus, 1, 2, 4, 8, 16, 32, 64, etc., can be readily apprehended as repeated doublings, while 1, 3, 9, 27, 81, etc., leave the mind confused in the attempt to follow up successive triplings.

with great precision into halves, quarters, and eighths, while we should have to make repeated trials to divide the same into thirds or fifths, and then attain the result only tentatively and approximately. And lastly, it appears to be the most natural of scales, from the very common use of the two hands in separating objects into pairs.*

Such being the claims, then, of the binary scale of geometrical progression, and such its obvious advantages over all others, it is not surprising that this should be found to be practically the prevalent mode of distributing the more common weights and measures throughout the world, whatever may be the multiples or divisions enacted by law.

The Roman weights in general use throughout the empire (that is, throughout the civilized world) for some centuries after the Christian era, were by means of intermediate subdivisions (introduced by the common consent of traders) practically distributed upon a binary scale. So with the divisions in universal use at the present day; we find that a nest of avoirdupois weights comprises $\frac{1}{4}$ oz., $\frac{1}{2}$ oz., 1 oz., 2 oz., 4 oz., 8 oz. and 16 oz., or 1 pound, and sometimes a 2-pound weight and a 4-pound weight; and by this scale of binal progression or division, almost everything is purchased at retail. Our yardsticks are found to be divided not into the legal feet and inches, but into halves, quarters, eighths and sixteenths. Precisely so with the inch, which is never divided into its primitive "three barleycorns," but almost always, like the yard, by the binal scale into eighths and sixteenths, though occasionally divided for particular purposes into twelfths, or into tenths. The operation of this great law is quite as strikingly exhibited in France, where the popular necessities have compelled the introduction of binal divisions, not recognized by the established decimal scales, nor, indeed, strictly compatible therewith.

Mr. Peacock, in his admirable treatise on "Arithmetic," in the *Encyclopedia Metropolitana*, thus sums up his review of the French system: "The decimal subdivision of these measures possessed many advantages on the score of uniformity, and was calculated to simplify, in a very extraordinary degree, the arithmetic of concrete quantities. It was attended, however, by the sacrifice of all the practical advantages which attend subdivisions by a scale admitting of more than one bisection, which was the case with those previously in use; *and it may well be doubted whether the loss in this respect was not more than a compensation for every other gain.*" This deliberate judgment is from the author of perhaps the

* "The classification by pairs which nature points out would suggest the simplest mode of reckoning. Counting these pairs again by two, and repeating the procedure, we arrive by progressive steps at the radical terms, 4, 8, 16, etc." (*Edinburgh Review* for May, 1811, Vol. xviii, p. 185).

The celebrated Leibnitz, so eminent as a mathematician as well as a philosopher, struck with the simplicity and peculiar capabilities of this scale, proposed and strongly urged the introduction of Binary Arithmetic. He showed that the Binary system, in addition to its extreme facility, possessed peculiar value in discovering the properties of numbers, and in constructing tables, etc. He did not, however, recommend it for general use, from the increased number of figures required to express ordinary amounts.

most thorough and philosophical treatise on arithmetic in our language, and such a statement certainly deserves our most serious consideration.

The masterly and comprehensive report on the subject of weights and measures, made to Congress in 1821 by Mr. Adams, when Secretary of State, contains the following judgment: "The experience of France has proved that binary, ternary, duodecimal and sexagesimal divisions are as necessary to the practical use of weights and measures, as the decimal divisions are convenient for calculations resulting from them; and that no plan for introducing the latter can dispense with the continued use of the former. * * * From the verdict of experience, therefore, it is doubtful whether the advantage to be obtained by any attempt to apply decimal arithmetic to weights and measures, would ever compensate for the increase of diversity which is the unavoidable consequence of change. Nature has no partialities for the number ten; and the attempt to shackle her freedom with them will forever prove abortive."

So in the interesting paper of Dr. Ellis (in the *American Journal of Pharmacy*, Vol ii, page 202), the French decimal system is thus referred to: "Every one is struck, at the first glance of this system, with the beautiful simplicity which it derives from decimal arithmetic. It appears, however, to have been overlooked, that, although decimal arithmetic is admirably designed to facilitate the calculation of mere number, it is not equally well suited to the divisions of material things."

Much to the same effect has been the result of the commission appointed lately in England to consider the subject of a decimal coinage. The commissioners, after a full discussion and investigation of the subject, have very recently reported against any change; their report being drawn up in the form of a series of twelve resolutions. The seventh resolution is as follows: "That as regards the comparative convenience of our present coinage, and of the pound and mill scheme, for the reckonings of the shop and the market, and for mental calculations generally, the superiority rests with the present system, in consequence, principally, of the more convenient divisibility of 4, 12, and 20, as compared with 10, and the facility for a successive division by 2; that is, for repeated halving, in correspondence with the natural and necessary tendency to this mode of subdividing all material things; and with the prevalence of binary steps in the division of our weights and measures."

In the view, then, of this pervading law or principle of all human metrology, so well established, and so distinctly recognized, it becomes an obvious necessity, in adopting a decimal scale, to engraft upon it, the divisions of halves and quarters, at least (and in the case of the more commonly employed units, of eighths), if we would adapt it to the demands of the people, or if we would hope for its permanent establishment. It is true that this would involve a considerable number of subordinate divisions between one denomination of measure and the next below it, as it would be requisite to have separate and distinctive weights, for instance, for the unit (whatever it might be) for one and a quarter of the unit ; for two, for two and a half, and for five ; and it is also true that the fractional values thus introduced would not be directly referable to the ordinary computations of decimal arithmetic—thus adding, somewhat, to the complexity and trouble of otherwise very simple calculations; but this is a fault, not of the binary divisions themselves, but resulting from a radical and incurable defect in the decimal system. So long as we continue to count, to add, subtract, multiply, and divide by tens, so long must we submit to this inconvenience (undoubtedly a serious one) or we must choose the greater evil of abandoning all attempts at uniformity and consistency of system, and continue, as heretofore, to measure and to weigh by heterogeneous tables, while we perform the necessary operations of comparing, compounding, and distributing these values, by a method or ratio entirely dissimilar ; entailing upon ourselves the waste of time, labor, and patience, consequent upon a petty scheme of eternal and superfluous reductions.*

This horn of the dilemma is that which has been accepted by the coinage commission of England, to which a reference has just been made. The eleventh resolution of the Commissioners' Report is : "That the advantages in calculation and account keeping, anticipated from a decimal coinage, may, to a great extent, be obtained without any disturbance of our present coinage, by a more extensive adoption of the practice now in use at the National Debt Office, and in the principal assurance offices, viz., of reducing money to decimals, performing the required calculations in decimals, and then restoring the result to the present notation." With our experience of a decimal coinage (notwithstanding its imperfections), this is not the horn likely to be selected by Americans in attempting a reform in weights and measures.

An expedient has been suggested by some, for facilitating division in decimal notation, which is ingenious, and deserves a notice. The project is to adopt a uniformly decimal system of weights and measures, but to estimate entirely by "cents"—by simply suppressing every alternate denomination ; thus, while reckoning decimally, we should traffic only centesimally. Our practical application of this method in all our money transactions, in which dimes are entirely suppressed in the market (though still having their place in the columns of the ledger) and our estimates made in *dollars* and *cents*, familiarizes our minds to the process, and enables us to see how such a system might be indefinitely extended, by the simple device of counting by double places of figures. The French table of weights would stand thus :

100 deci-milligrammes make ....1 centigramme.

*"Perhaps it may be found by more protracted and multiplied experience, that this is the only 'uniformity' attainable by a system of weights and measures for universal use ; that the same material instruments shall be divisible decimally for calculations and accounts ; but in any other manner suited to convenience in the shops and markets ; that their appropriate legal denominations shall be used for computation, and the trivial names for actual weight or mensuration" (Adams's Report).

100 centigrammes	make	...............1 gramme.
100 grammes	"	...............1 hectogramme.
100 hectogrammes	"	...............1 myriagramme.

This suppression of the alternate denominations would have the advantage of abolishing the very objectionable terms *decigramme* and *decagramme*. Instead of the extreme awkwardness of taking one quarter of a gramme ($2\frac{1}{2}$ decigrammes), we are furnished with the value in whole units, by taking twenty-five centigrammes, just as we say twenty-five cents instead of two and a half dimes.

Simple and taking as this proposal is, it is not free from serious objections. It, in fact, complicates rather than simplifies, by giving a very wide range for estimating values. While it thus multiplies the units, and enlarges the interval between them tenfold, it only furnishes us with a single additional bisection, namely, the quartering. An eighth would still require a fractional expression. Its benefit, therefore, bears no proportion to the increased trouble and confusion involved. The necessity universally felt for quaternal and octaval divisions, would infallibly operate here as it has in our currency; and we should constantly hear of $37\frac{1}{2}$ hundredths of a pound; $62\frac{1}{2}$ hundredths of a pint, etc., which would be, in no respect, better than $3\frac{3}{4}$ tenths, or $6\frac{1}{4}$ tenths. The truth is, we need more frequent denominations than decimal ones, rather than more distant stepping-stones; and for some purposes, even the binary ratio of progression is not too slow. In looking over the various tables of weights and measures prevailing throughout Europe, it will be found that a large majority of the factors are 2, 4, and 8, with occasional resort to 3 and 6—the number 4 being, perhaps, the favorite number for the more customary denominations.*

Amid the conflicting claims of the numerous plans proposed for simplifying and uniting our incongruous metrology, there appears, at first sight, so much of irreconcilable contrariety, that it might be concluded that a combination of the respective advantages contemplated was hopeless and impossible; and that we were only left to a choice of evils. A more careful scrutiny will however discover a philosophy in these very discrepancies, and furnish the elements of a practical concord. On the one side, the convenience of a system of divisions or multiples conforming exactly to that by which we are compelled to perform all arithmetical operations, is so obvious, and so universally recognized,† that the advocates of an entire decimalization are certainly justified in their zeal. On the other hand, the necessity of binal progression and division, though not so generally ack-

* This is rendered very apparent on turning over the pages of Woolhouse's little work on the "Weights and Measures of all Nations." No. 101, of Weale's Rudimentary Series.

† "The great improvement of having but one arithmetical scale for reckoning integers and fractions of every kind. * * * is one so obvious, and, withal, so little difficult, that it is a matter of surprise that it should not have been attempted till near a thousand years after decimal arithmetic was first introduced into Europe" (*Edinburgh Review* for January, 1807, Vol. ix, page 373).

nowledged, is by all who have given the subject a careful study, so fully appreciated, as being, at least, as fundamental as that of the decimal scale, that those who urge the retention of all such denominations as are measured by the powers of 2, are no less justified. Which policy must, then, be sacrificed?

"The elementary principle of decimal arithmetic," says Mr. Adams, "is supplied by nature to man within himself, in the number of his fingers. Whatever standard of linear measure he may assume in order to measure the surface or the solid, it will be natural to him to stop in the process of addition, when he has counted the tale equal to that of his fingers. * * * But while decimal arithmetic, thus for the purposes of computation, shoots spontaneously from the nature of man and of things, it is not equally adapted to the numeration, the multiplication, or the division of material substances either in his own person, or in external nature. The proportions of the human body, and of its members, are in other than decimal numbers. The first unit of measures for the use of the hand is the cubit, or extent from the tip of the elbow to the end of the middle finger; the motives for choosing which are, that it presents more definite terminations at both ends, than any of the other superior limbs, and gives a measure easily handled and carried about the person. By doubling this measure, is given the *ell*, or arm, including the hand and half the width of the body, to the middle of the breast; and by doubling that, the *fathom*, or extent from the extremity of one middle finger to that of the other, with extended arms—an exact equivalent to the stature of man, or extension from the crown of the head to the sole of the foot. For subdivisions, and smaller measures, the *span* is found equal to half the cubit, the *palm* to one-third of the span, and the *finger* to one-fourth of the palm. The *cubit* is thus, for the mensuration of matter, naturally divided into 24 equal parts, with subdivisions of which, 2, 3, and 4, are the factors; while for the mensuration of distance, the foot will be found equal to one-fifth of the pace and one-sixth of the fathom" (*Adams's Report*).

"The fingers," says Dr. Lardner, "were naturally the first objects which presented to the mind the idea of number; and they furnished, also, a set of natural counters by which the number of things might be marked and expressed. The fingers, being continually in view, familiarized the mind with the contemplation of every number of objects not exceeding ten. It was natural, therefore, that ten should be adopted as the number of objects to form the first group. * * * Although ten has been so generally adopted as the *radix* of systems of numeration, as to leave no doubt of its origin, yet it is not the only one which has been used, nor is it the only radix having a natural origin. The fingers of one hand rendered the number five familiar to the mind, before the conception of ten as a distinct number presented itself. It was even more natural and obvious, that the fingers should be contemplated as two groups of five, than as a single group of ten" (*Treatise on Arithmetic*, Book i, chap. i, p. 5-6).

The gradual and successive development of these scales, is so well set forth in Mr. Peacock's valuable treatise, that perhaps no apology is necessary for a somewhat lengthened extract from it, even at the cost of some repetition.

"The decimal scale of numeration is not the only one which may be properly characterized as a natural scale. In numbering with the fingers we might, very naturally, pause at the completion of the fingers on one hand; and registering this result by a counter, or by any other means, we might proceed over the fingers of the same hand again, or with the fingers of the second hand, and register the result by another counter, or replace the former by a new counter which should become the representative of ten. * * * Again. the scale of numeration by twenties has its foundation in nature, equally with the quinary and denary scales. In a rude state of society, before the discovery of other methods of numeration, men might avail themselves, for this purpose, not merely of the fingers on the hands, but likewise of the toes of the naked feet; such a practice would naturally lead to the formation of a *vicenary* scale of numeration, to which the denary, or the denary with the quinary, or the quinary alone, might be subordinate. * * * Of other systems of numeration, the binary might be considered as natural, from the use of the two hands in separating objects into pairs, and from the prevalence of binary combinations in the members of the human body; but the scale of its superior units increases too slowly to embrace within moderate limits the numbers which are required for the ordinary wants of life, even in the infancy of society. * * * As the necessity of numeration is one of the earliest and most urgent of those wants which are not essential to the support and protection of life, we might naturally expect that the discovery of expedients for that purpose should precede the epoch of civilization, and the full development and fixing of language. That such has been the case, we shall find very fully and clearly established, by an examination of the numerical words of different languages; for, without any exception which can be well authenticated, they have been formed upon regular principles, having reference to some one of those three systems which we have characterized as natural; the quinary scale, whenever any traces of it appear, being generally subordinate to the denary, and, in some cases, both the quinary and denary scales being subordinate to the vicenary. In some cases, also, we shall find, from an examination of primitive numerical words conveying traces of obsolete methods of numeration, that the quinary, and even the vicenary scales have been superseded altogether by the denary" (*Encyclopedia Metropolitana*, art. "Arithmetic," Vol. i, p. 371).

Decimal arithmetic thus appears to be coëval and coëxtensive with the human race. It is, indeed, perhaps, the most universal of human institutions—at least as universal as language itself. From this universality, most writers have called it the "natural" system; but on examining the question whether the number *ten* possesses any intrinsic excellence or convenience to recommend it—any peculiar fitness as a ratio of geometrical progression, we find but one answer—it has none. It differs from any other number only in quantity, not in quality. So far from its presenting any merit or advantage over its compeers, it is almost the last number which a true science of arithmetic would have selected for the important function of a radix of numeration. Its universality flows simply from the fact that the necessities of man impelled a selection, in the very earliest infancy of the race, long before the invention of letters, and while yet a language was but slowly being formed; and the selection comes to us stamped with the crude impress of a most irrelevant accident. Had the six-fingered giant slain by Jonathan (2 Samuel xxi, 20) lived early enough to be the father of the first unreasoning tribes, we should have had a duodecimal arithmetic; or if, like the fowls of the air, we had usually but four toes to our extremities, we should now have been able to calculate only octavally; and in either event we should have been much more skillful computers than we are at present. *

Decimal numeration is "natural" then, only in the sense that *ignorance* is natural. The fingers have no more real or "natural" relation to the properties of number, than have any other organs or divisions of the human body; and mathematically or philosophically considered, the *digit* is, therefore, no more a typical *unit* than a tooth (of which there are thirty-two), or the leg of a spider (of which there are eight), or the petal of a flower (of which there may be any number). Nor have any but the most ignorant races—those without a literature and an alphabet—ever occasion to group and tally by their fingers. Only from unlettered savages could such a scale, therefore, have deen derived.

It has been a favorite theory with a certain class of thinkers that primitive man was a highly civilized being—"a scholar and a gentleman;" and that the decay of states, and the decline of civilizations so unfortunately frequent in his history, but manifest his prevailing tendency to degeneration. Our universal arithmetic furnishes us with one of the most striking refutations of such a fancy. Wherever over the broad earth, the decimal scale exists, there have we the enduring monument of the ancestral savage—counting by his fingers or his naked toes.†

* "There can be no doubt that if man had been a twelve-fingered animal, we should now possess a more perfect system of numeration than we do. Whatever be the radix of the scale, it would always be a convenience to be able to subdivide it with facility, without resorting to the more refined expedient of fractional language" (*Lardner's Arithmetic*, chap. i, p. 21).

† The German word for ten—*zehen*—signifies "toes," being the plural of the word, *zehe*, We do not generally or readily recognize this intellectual association in our own language; and yet the Saxon word—*ta*—a "toe," is in the plural *tan*. The *daktul* (δακτυλος) of the Greeks, and the *digit* (digitus) of the Romans, which signified either "finger" or "toe," appear evidently affiliated to the *deka* (δεκα) of the one and the *decem* of the

Had any intelligent forethought ever presided over the inception of a numerical scale—had any comprehensive conception of the uses and purposes of figures, in any single instance guided the selection of a ratio for their multiplication—that ratio must inevitably have been something else than *ten ;* the duplication of an odd number—incapable of any other division—neither a square, a cube, nor other power of any integer—and in its successions among the most inefficient for the expression of fractional values, or for the extraction of roots. And if among the patriarchs of the human family, a rational scale had ever been so devised, some traces of this wiser system must have been found, to give a "sign" and memento of man's pristine elevation.

"The number ten," remarks Mr. Anderson, in his treatise on Arithmetic, "has been adopted by every civilized nation for the radix of the numerical scale. It has no peculiar advantages to recommend it, and seems to have been selected for that important function, merely because it expresses the number of the human fingers. We must regret that a circumstance so totally unconnected with every scientific consideration, should have determined an elemental principle, of the last importance to one of the most abstract, as well as one of the most useful of all the sciences; and that the decimal notation should still be retained, notwithstanding its evident imperfections, and the superior claims of other scales" (*Edinburgh Encyclopedia ;* edited by Sir David Brewster, art. "Arithmetic," Vol. ii, page 411).

An able and philosophical writer in the *Edinburgh Review* holds very similar language. "Ten has indeed," he observes, "no advantage as the radix of numerical computation; and has been raised to the dignity which it now holds, merely by the circumstance of its expressing the number of a man's fingers. They who regard science as the creature of pure reason, must feel somewhat indignant that a consideration so foreign and mechanical, should have determined the form and order of one of the most intellectual and abstract of all the sciences" (*Edinburgh Review*, for January, 1807, Vol. ix, page 376).

A large number (perhaps even a large majority) of the well-educated have been accustomed to regard the decimal system as possessing a peculiar beauty and expressiveness, from the great facility with which the ordinary operations of arithmetic are performed by it. Indeed, after laboring at the tedious and troublesome reductions of compound num-

other; although the genealogy (as in English) was probably more ancient than the languages themselves. So uniform are the laws of mind and matter, that we have only to select some rude and isolated tribe of modern savages to discover with a naturalist's confidence, the exact process of development in numeration, with the aborigines of our race, milleniums on milleniums ago. Klaproth, in speaking of the inhabitants of the peninsula of Kamtschatka, says: "It is very amusing to see them attempt to reckon above ten; for having reckoned the fingers of both hands, they clasp them together, which signifies ten; they then begin at their toes and count to twenty; after which they are quite confounded, and cry "Matcha," that is, where shall I take more?" (*Sprachatlas*, page 16.)

bers (consequent upon other scales of progression) unfortunately so often required to be made, the relief of a simple addition or multiplication in the homogeneous units of our common scale, is too striking not to excite a feeling of admiration for the easier process. It appears not to be generally considered, however, that this facility of computation is in no respect due to the series of "tens" by which we count, but is derived exclusively from the admirable notation in which the series has been clothed, and through which alone, we are in modern times made acquainted with it; and from the perfect conformity of the notation to the series. Any other scale will be found to exhibit an equal facility, if the same notation be employed, and made to correspond strictly with the selected scale. If, like the old Arabian philosophers, or like the ancient Greeks and Romans, we were compelled to calculate by a set of *alphabetic* numerals, we should be able to better realize how much we are indebted to that simple and yet grand invention of India, the "cypher figures," or the set of figures with the device of local value.* This system of numerical language presents us with a formula of geometrical progressions, so illimitable in range, and yet so perfect in its conciseness and distinctness, that it transcends all conception that the ingenuity of man in all coming time shall ever be able to improve it.

Though from a remote antiquity familiar to the Hindoos (that wonderful people from whom the civilized world has derived so much), it was wholly unknown to the nations of the earth until comparatively modern times; having been first introduced into Arabia, less than a thousand years ago, and from thence by slow and successive centuries into the various languages of Europe.

However much the Arabian philosopher to whom belongs the honor of having first transplanted the Sanscrit Arithmetic into his own country, may have been impressed with its great power and beauty, he could hardly have appreciated, to its full extent, the importance and magnitude of the gift he was instrumental in presenting to the civilized world; a transfer which Sir John Bowring in his "Decimal System" (chap. ii, p. 22) has characterized as "the greatest step ever made towards the introduction of a universal language among the nations of the world." The Hindoo numerals, from the channel of their introduction into Europe, were generally called the "Arabic figures"—a title they still commonly retain, though it is one hardly just to the people with whom these figures had their origin.

Now although this Hindoo notation has never been popularly applied to any other than the decimal scale, it is obviously a formula of universal applicability; and if made use of to express a system of figures with any other radix than *ten*, would give the same facility to all calculations performed by that system.

Abstracting, for a moment, all specific value from the terms "units," "tens," "hundreds," and "thousands," and regarding them merely as

* See note A, page 357.

symbols of *local value* (designating only the orders of units), we may exhibit in a tabular form, a series of scales, with the successive increments of value for each place, according to the radix, or ratio of geometrical progression selected. In the following table the letter "U" in the top line denotes a "unit;" that is, any figure which may occupy a single place:

TABLE OF ARITHMETICAL SCALES.

Hindoo Notat'n	U.	UO.	UOO.	UOOO.			
Scale.	Units.	Tens.	Hundreds	Thousands.	Radix	Logar'm	Places
Binary.........	1	2—	4—	8—	2	.301	$\frac{10}{3}$
Ternary........	1—2	3—	9—	27—	3	.477	$\frac{25}{12}$
Quaternary	1—3	4—	16—	64—	4	.602	$\frac{5}{3}$
Quinary	1—4	5—	25—	125—	5	.699	$\frac{10}{7}$
Senary.........	1—5	6—	36—	216—	6	.778	$\frac{9}{7}$
Septenary.....	1—6	7—	49—	343—	7	.845	$\frac{20}{17}$
Octonary.......	1—7	8—	64—	512—	8	.903	$\frac{10}{9}$
Novenary......	1—8	9—	81—	729—	9	.954	$\frac{20}{19}$
Denary	1—9	10—	100—	1000—	10	1.000	1
Duodenary.....	1—11	12—	144—	1728—	12	1.079	$\frac{25}{27}$
Quaterdenary...	1—13	14—	196—	2744—	14	1.146	$\frac{50}{57}$
Senidenary.....	1—15	16—	256—	4096—	16	1.204	$\frac{5}{6}$
Octonidenary...	1—17	18—	324—	5832—	18	1.255	$\frac{4}{5}$
Vicenary.......	1—19	20—	400—	8000—	20	1.301	$\frac{10}{13}$
Tricenary......	1—29	30—	900—	27000—	30	1.477	$\frac{25}{37}$
Quadragenary..	1—39	40—	1600—	64000—	40	1.602	$\frac{5}{8}$
Quinquagenary.	1—49	50—	2500—	125000—	50	1.699	$\frac{10}{17}$
Sexagenary	1—59	60—	3600—	216000—	60	1.778	$\frac{50}{89}$

The number of places for each scale is inversely as the logarithm of the radix.

The most striking feature displayed by such a comparison of the different scales is the rapid increase of value in the higher ratios, as compared with the lower. While the *ternary* scale, for example, requires four figures to express so small a number as 27, the tricenary scale expresses one thousand times as many, by the use of no more places. The very first inquiry would, therefore, naturally be (in the absence of any other consideration), which would be found more convenient—a very small radix, or a very large one.

The first and lowest scale of the series—the *binary*—presents, with some disadvantages, many very remarkable advantages. In the first place it requires but a single figure, 1 (together with the cipher for determining its place), to express with facility and precision all the values within the reach of figures.* According to the law of the Hindoo notation, by

* It was in reference to this curious property of the scale, that a medal struck in honor of Leibnitz, and to commemorate his invention of the binary system, bore on its reverse, the striking inscription: "Omnibus ex nihilo ducendis sufficit Unum." Unity being very commonly regarded as the symbol of the Deity (*Peacock's Arithmetic*, Encyclopedia Metropolitana, Vol. ii, page 392).

which every zero multiplies all the value that precedes it, by the amount of the radix, it results that the addition of a cipher to the figure 1, would of course multiply it by two (instead of by ten as in our common system)—the addition of two ciphers, by two times two, or four (instead of by a hundred)—the addition of 3 ciphers, by eight; of 4 ciphers, by sixteen; of 5 ciphers, by thirty-two, etc. The first fifteen numbers would read thus: 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111.* The present year, 1887, would require eleven places of figures to express it; namely, 11101011111. Fifty places of figures (or 1 and 49 ciphers) in the binary system, would require but fifteen places of figures in the decimal system. One hundred places of the binary (1 and 99 ciphers) would require thirty places of the decimal. So that the former system would involve, on an average, the constant employment of about three and a third times more figures in all our arithmetical operations, than the latter system, or that in common use. This increased expenditure of time and manual labor would evidently be a very serious inconvenience. On the other hand it must be considered that the writing down of any given mass of figures, in only two characters (always either 1, or a cipher), would be much more easy and expeditious than if the mass consisted of ten different characters; so that the actual increase of trouble should be set down at probably not more than *double* that we have at present. This much quantitatively. But in the quality of the work done, the difference will be found immensely in favor of the binary scheme. In the first place no tables would be required to be committed to, and retained by, the memory; either of addition, of subtraction, of division or of multiplication; not even the fundamental "twice two make four." Every form of calculation would be resolved into simple numeration and notation. In fact, calculation as an effort of mathematical thought, might be said to be entirely dispensed with, and the labor of the brain to be all transferred to the eye and the hand. A perfect familiarity with the notation of the scale, and with the simple rules of position, would enable the operator to determine in every case by mere inspection whether the next figure should be a 1, or an 0. It follows that the only errors possible in such a work would be the merely clerical ones of the eye or hand; and when we reflect that a large majority of the arithmetical errors committed are usually those of the brain, fatigued or bewildered by the constant strain upon the attention and memory, this consideration of the increased accuracy of such a system is one of the very first importance in estimating its value. To many, the relief it proffers in exchanging head-work for hand-work will appear no trifling recommendation; and it may well be doubted, whether in all important and lengthy calculations, the binary system would not be found to afford a real economy of labor, instead of an increase as has been generally supposed.

It has been previously noticed, that the great Leibnitz, the rival of

* See note B, page 359.

Newton in the invention of the "Differential Calculus," proposed this system and zealously urged its adoption; although he thought that for more common purposes it would be found too prolix. "De Lagny took the trouble of constructing logarithms on the principles of this arithmetic, as being more natural than those usually employed. * * * He even proposed to substitute binary arithmetic for logarithms, affirming that it was more simple and expeditious, and conducted to the object in view in a less indirect manner" (*Anderson's Article on Arithmetic, in Brewster's Edinburgh Encyclopedia*, Vol. ii, pp. 376 and 409). The same writer adds that "Dangicourt has applied the binary notation with greater success to progressions, and proved that the laws of a series may be detected by it more easily than by any other scale." This results, it may be as well to state, from the fact that "circulating periods" of figures return far more frequently in this scale than in any other.

The *Ternary* scale, although it is also a very simple scale, has nothing else to recommend it; being incapable of integral bisection, and having very nearly the redundancy of the binary scale, without one of its advantages. It may be regarded as one of the most objectionable of all the scales; and indeed none of the odd numbers could, for a moment, be accepted as a suitable radix of notation.

The *Quaternary* scale, as derived from the second power of the binary scale, has many of its excellences. While it employs less than half the number of digits, of the common or denary scale, to task the memory and attention, it requires only about five places of figures, for three of the latter. It combines, therefore, great simplicity of structure, with a moderate range of notation, and would form a very convenient and practicable system of numeration; while it would furnish an admirable scale of division for weights and measures of all kinds. It is said by Balbi, that a very low and ignorant tribe of Indians in South America—the Guranos—had names for only four digits, and that after counting these a second time (to eight) they were unable to proceed any further. The correctness of this account appears, however, to be exceedingly doubtful. It is remarkable, too, that Aristotle mentions a tribe of Thrace as being unable to count beyond four—a statement equally incredible.

The *Quinary* scale, whose notation would require ten places for seven of the *denary*, has nothing to recommend it; and yet from the accident of man being afflicted with five fingers, it has generally formed the basis of the scale in common use, and traces of it are to be found in perhaps a majority of the nations of the earth. The numerals of Malay and Java were anciently, for the most part, quinary, in subordination to the vicenary grouping. A trace of this system is also seen among the ancient Greeks, in their word πεμπαζεσθαί (to count by fives); as it is among the Romans in their notation of numbers above 5, 15, etc. The Persian term for "five" is *pendja;* and *pentcha* signifies the expanded hand. Among the South Sea Islanders, the inhabitants of New Caledonia and the Hebrides, as well as the barbarous tribes of Northeastern Asia, the quinary scale appears still to prevail. The central tribes of North America show also traces of this digital period ; and they are frequent among the innumerable languages of Africa. Thus with the Jalloffs, the word for "five"—*juorom*—signifies the "hand." So with the Foulahs, the Jallonkas, the Fellups, etc. There are no examples, however, of the number five ever having been used as a true radix of notation ; that is, as a direct ratio of continued progression ; 5 — 5 × 5 (25) ; — 5 × 5 × 5 (125), etc. The quinary scale has seldom gone further than 20.

The *Senary* scale would require about seventeen places of figures for thirteen of the common scale ; and its notation would therefore have about a one-third greater extent. Though not one of the most desirable scales, it would be much superior to the denary system. The simplification arising from the reduction of its digits, would much more than counterbalance the extension consequent on the increase of its places. Like the denary scale, it admits of but one bisection ; but it possesses the great superiority of admitting at the same time of a trisection. No examples of this scale are to be met with ; although it is said to have been at one time decreed in China, by the caprice of an Emperor, who had conceived some astrologic fancy for the number six.

The *Octonary* scale approaches very nearly to the common scale in its capability of expression, as it requires on an average but one-ninth more places of figures to represent any given amount ; that is, ten places of this scale would be equivalent to nine places of the denary. Being derived from the third power of the binary scale, it possesses most of the advantages of that system ; though not its admirable simplicity. Like the quaternary, it admits of continued bisection down to unity ; and, of course, of indefinite bisection below 1, by the simple expedient of an inverted, or negative notation (as in decimal fractions). As a perfect cube, it has peculiar advantages both as a radix of numeration, and as a ratio of progression or of division for weights and measures ; and in the latter respect particularly, there is, perhaps, no other number that would so well express the average range of a convenient metrical multiple.

The *Denary* scale* may be said to present a tolerably convenient mean between the prolixity of a very small radix, and the intricacy of a very large one ; besides which, it possesses the immense advantage of a universal establishment. But beyond this, there is nothing to be said in its behalf. Intrinsically, it is one of the most imperfect and troublesome scales which could be selected. Still, the inconveniences of the system should be very serious and very apparent, and the claims of any rival scheme very unquestionable, to justify the advocacy of a change, which

* The name "Decimal," by which our present system of arithmetic is commonly designated, appears not to have a perfect propriety. The terms "Octaval," "Nonal," "Decimal," "Duodecimal," etc., are derived from the Roman "*ordinals*," and belong to the series Primal, Secundal, Tertial, Quartal, etc. The idea really involved is not that of relation to a *tenth*, but of a relation to a grouping *by tens*, and would require the term "denal" or "denary"—from the Roman "distributive" numerals, of which the terms "binary," "ternary," etc., commence the series.

would root up all our established forms and habits of calculation—which would destroy the accumulated products of centuries of industrious thought and toil—which would entail upon us generations of new labor to attain even the same standard of tabular detail, and statistical information, now possessed; and which, more than all, would wholly demolish, and perhaps hopelessly, that uniformity so essential to the language of scientific investigation, and so universally conceded to be one of the most important aims and results of every project of metrical or numerical improvement.

Upon this basis must the question of so radical a revolution rest. But if it is shown that uniformity in many other relations than those of simple number, and no less vital to the interests and welfare of the race than this boasted uniformity of figures, has constantly and irretrievably been sacrificed to this great idol—if it is established by the voice of all experience that neither national nor international standards of length, of weight, of area, of volume, or of value, of any single subject, in short, to which these figures can be usefully applied, have ever the slightest hope of obtaining a general authority under the dynasty of this "universal" power—then must it be dethroned, for very uniformity's sake, and a new dispensation introduced, developed from such principles, and invested with such attributes, that it may rationally be expected to gain at length a universal ascendancy, through the concurrent approval and adherence of all intelligent nations. For the attainment of a real uniformity, there seems no other process or alternative; and for such an attainment, no sacrifice of temporary convenience could be held to be too great. The faults of the denary system are too radical to be amended—too obnoxious to be endured. Sheltered by the inertia and conservatism of inveterate habit, it has been tolerated already much too long. The unskillful contrivance of an early age, it is all unsuited to the wants or uses of an adult manhood of the race.

The *Duodenary* scale has over the denary the advantage of allowing two bisections, and, at the same time, like the senary scale, of admitting of a trisection. Its variety of factors, 2, 3, 4, and 6, give it a much greater power of expressing fractional values than any scale below it, or immediately above it; and it has accordingly been always found a convenient and favorite number for metrical divisions. The acres, the feet, and the pounds of the Romans were all divided by 12; as are the foot, and the Troy pound, still with us. The signs of the Zodiac, the months of the year, and the hours of the day, have illustrated the number from the remotest antiquity. In the old French measures of length, not only the foot was divided into 12 inches, but the inch into 12 lines, and the line into 12 points. The "dozen," the "gross" or (12^2) and even the "great gross" (or 12^3) are widely used in trade at the present day for the package of a variety of articles. From the many acknowledged advantages of the duodenary scale, it has found frequent and warm advocates for its adoption as a system of numeration. In the necessity of two additional integers, it would offer however a considerable increase of complexity and mental labor; while the economy of places in notation could scarcely be regarded as appreciable—25 of the duodenary being required for 27 of the denary. As compared with the octonary, it would require 5 places, where the latter would require 6; so that while its digits are more by fifty per cent, the excess of the other in places is only twenty per cent. But there are far more important considerations than these, which unfortunately oppose themselves to the adoption of this system, as the best substitute for the denary, notwithstanding its admitted features of superiority.

The most fatal objection to the radix 12, is that it permits only a single bisection beyond that given by the radix 10. The quality of continued divisibility, we regard as paramount to all others; not merely for the convenience of art and trade, universal as their requirements are, but even for many scientific purposes; and however valuable the property of a *varied* subdivision (as that furnished by the duodenary scale), experience has fully demonstrated, what is clearly seen by theory, that no aliquot parts can ever be as widely useful as the binal fractions. Another objection to the 12 scale, somewhat allied to this, is that the number is not a *power* of any integer—a point, as we shall discover, of no slight importance. In this respect, it may be remarked, the number nine (awkward and inconvenient as it undoubtedly would be as the basis of an arithmetic) would have several advantages over the number ten, and even over the number twelve. A third objection to the scale under consideration, which, though not so striking, is yet no less real: the radix is too large. On the simple score of size, there must be somewhere in the indefinite range of scales, a point where we should expect to find the most convenient medium between the inexpediences of opposing difficulties; and although this most advisable limit of magnitude may not admit of very precise determination, the question is one of too great consequence in the comparisons we are making, not to deserve a special attention.

The *Seni-denary* scale presents many excellent points, the number 16 being both a square, and a fourth power, and admitting of indefinite division by two. Its only disadvantage is the incommodious number of digits it would require; while its notation would yet economize only a single place of figures in every six places required by the denary scale.

The *Vicenary* scale furnishes no single point of merit which could recommend it to our acceptance, unless its divisibility by four should be regarded as giving it a superiority to the denary. With an exceedingly troublesome and unwieldy range of digits, it would reduce the extent of our common notation only from 13 to 10 places. Man was, however, unfortunately born with 20 extremities, or branches to his limbs, and hence traces of what may be designated a rudimentary vicenary scale, are to be met with among many nations, both ancient and modern. In ancient Phœnicia and Palmyra, the system of numbering by twenties, as far as the hundred, prevailed; and from these nations it was derived by the Celtic languages, in all of which its remains are still found. Among the Scandinavians, also, is found a vicenary numeration. The Greenlanders, having counted fingers and toes in periods of five, designated the number 20 by the word *innuk*, which signifies a "man." If they have occasion to proceed higher, the expression for 40 is *innuk arlak*—"two men"—etc. A similar method existed among the Aztecs of ancient Mexico; as well as among the tribes of South America. The Teutonic races retain in their languages the traces of the ancient "score," and in parts of England, counting by scores, or twenties, is still quite usual. The translators of our Bible have frequently (though by no means uniformly) introduced this mode of enumeration. Thus we have "three-score and ten" (Ps. xc, 10)—"three-score and twelve" (Numb. xxxi, 38)—"three-score and fifteen" (Acts vii, 14)—"three-score and seventeen" (Judges viii, 14), etc., etc. The mode of numbering still in common use in France also exhibits a very remarkable retention of the antiquated vicenary system.*

This scale is not, as might be supposed, an extension of, and attempted improvement upon, the decimal system. On the contrary, it almost universally preceded it; and its employment belongs to the very earliest and rudest stage of barbarian society. It betrays a period of human intelligence, so destitute of all resource, that fingers and toes must all be pressed into service, to meet the common wants of number; and when these have been exhausted, there has been found among some tribes, no power of thought or word or symbol for aught beyond. It indicates a period long before a conception of any expedient for numerical expressions had dawned upon the savage brain; and hence there is no example of the vicenary scale having ever been extended even as far as to the second place of figures, or to 20 times 20; nor probably even beyond one hundred. It is evident that when the necessity for expressing larger numbers began to be felt, the cumbrous scale of added "toes." must soon be dropped, and the range restricted to the more manageable mechanism of the ten "fingers." And, accordingly, we find the imperfect vicenary to be always overlaid by the denary, with glimpses of the former still appearing through its supplanter.

The *Sexagenary* scale deserves notice only from its historical interest in having been from a very remote antiquity employed for particular purposes among the people from whom we derive our arithmetical notation—

* "The French nomenclature is for the most part purely decimal. The decimal system is observed from twenty (*vingt*) to sixty (*soixante*); here we find a vestige of an old vicenary scale. Seventy, instead of being *septante*, as the decimal system would require, is *soixante-dix* (sixty-ten); seventy one, *soixante-onze*, (sixty-eleven); seventy-two, *soixante-douze* (sixty-twelve), etc. Eighty, instead of being *octante*, is *quatre-vingt*, or four twenties, and ninety is *quatre-vingt-dix* (four twenties ten); ninety-one, *quatre-vingt-onze* (four twenties eleven), etc. Thus twenty becomes the radix of the system from sixty to a hundred." (*Lardner's Arithmetic*, page 11.)

an employment which has been perpetuated throughout Europe and America, to the present, in the smaller divisions of time and of the circle. This scale is of course far too cumbrous in the range of its units to have ever had a true notation, or to be ever possible as an actual system, founded on its own radix. With its enormous complication of figures, it would still require about $\frac{9}{16}$ (or more than half) of the places of the common system to express its values. It has been found very useful, however, in its limited application, both from the rapidity of its progressions, and from the remarkably varied range of divisibility it permits. The number 60 is divisible by 2, by 3, by 4, by 5, by 6, by 10, by 12, by 15, by 20, and by 30 ; and has indeed the greatest number of aliquot parts of any number below 96.

Our "minutes" and "seconds" of the degree and of the hour have thus an Oriental origin. In India, however, from whence the scale was derived, these divisions, as applied to time, had not the same value as with us ; as there the day itself was divided into 60 parts, called *guries* (hours of 24 minutes), each *gurie* into 60 parts, called *polls* (minutes of 24 of our seconds), and lastly each *poll* into 60 *mimiks*, or twinklings of an eye (four-tenths of a second). It is believed that this division of time is retained by the Hindoos to the present day. They also employ a period of 60 years, as we do the century.

In its astronomical application this scale has been found exceedingly useful. The properties of the circle require that it should frequently be divided into sixths, as well as into quarters ; the sixth being, as is well known, the radial arc, or that whose chord is exactly equal to radius. The zodiacal or ecliptic circle of the heavens had, from the earliest antiquity, been divided into twelfths, a period representing approximately the movement of the sun during one lunation. As this comprised very nearly 30 days, the "sign" became naturally divided into 30 degrees ; and this expresses so closely the arc of the earth's orbit described in one mean solar day, that when the earth is moving slowest (or at its aphelion), it falls but three minutes within one degree, and when it is moving fastest (or at its perihelion), it exceeds the degree by only a single minute. The radial arc of two "signs," or 60 degrees, suggested its own subdivisions. Hence was derived the table of 60 seconds to the minute, 60 minutes to the degree, and 60 degrees to the sextant—6 of these completing the circle. This system, answering so well the requirements of various division, was introduced from India into the Alexandrian school by the illustrious Ptolemy,* who did so much toward giving astronomy a scientific form. The sexagenary scale has never, however, been computed by any other than a denary radix. It must excite surprise, therefore, that the Hindoo notation of the scale was not also introduced by Ptolemy at the same

* Although the sexagesimal arithmetic is commonly ascribed to Ptolemy, it is probably an Eastern invention. The Indians, to this day, employ the sexagesimal division of time" (*Edinburgh Encyclopedia*, art. "Arithmetic").

time; and the world thus put in possession of this grand invention eight centuries earlier than it was by the Arabic importation.*

In our survey of the principal scales, from which alone a selection could be made for popular uses, we have found that there are certain incidental, but opposing advantages, incompatible with each other; and that no scale, therefore, could possibly furnish a maximum of every condition that might be thought desirable. Thus the binary scale affords so admirable a simplicity, beauty and facility, that it would have to be regarded the perfect system, if its redundant employment of figures (the necessary consequence of its simplicity), did not render it unsuited to the small and constant calculations required in the daily course of trade. On the other hand the manifold divisions permitted by the sexagenary scale give it convenient qualities, impossible to the lower scales; but here we find a complication so onerous that it would appall the most inveterate of calculating monomaniacs.

The conditions, however, that are really most essential to an arithmetical radix, are so few and precise, and their requirements so imperative, that there is little difficulty in deciding upon "the best possible scale of numeration." The first consideration would naturally have regard to the size of the radix, in order to assign certain limits within which our scale is to be found. To realize a maximum convenience, it must be neither too large, nor too small. We have seen that while the notation of places (and the consequent labor of transcription) diminishes very slowly with the ascending scales—the tax upon the mental faculties increases in a far more rapid ratio. The labor of mere *calculation*, which may be estimated at zero for the binary scale, advances materially, and in a compound ratio with every figure added to the radix. Were we then required to choose between any two scales—separated by a considerable interval, that is, between a very small one and a very large one (no other insuperable objection being supposed), we should adopt, unhesitatingly, the smaller one. The advantage imagined by some, of the great expressiveness of a rapid increase of value, is wholly illusory. It needs comparatively very few figures, in any case, to carry us not only beyond all true conceptions of

*The Greeks, like the Hebrews, Arabs, and all other nations excepting the Hindoos, employed an alphabetic numeral; and it is a somewhat curious circumstance that our modern character for the cipher was derived not from India or Arabia, but from Alexandria. The Hindoos indicated the cipher place by a simple dot (.), and the Arabians, in borrowing their system, did the same; until the sexagenary system, introduced by Ptolemy so many centuries before, supplied them with a new character. This philosopher, finding a frequent occasion to mark the absence of a particular denomination (as "no minutes," or "no seconds"), in order to avoid mistake employed the first vacant letter of the alphabet for that purpose. As the Greek numeral for 60 is the letter ξ, all those which followed would be useless for the sexagenary scale; hence the next letter, *o* (omicron), naturally became the empty counter. This notation became established by long habit among the astronomers of Alexandria, Constantinople, and Arabia; and finally crept into the Hindoo system of numerals. Thus to the accidental position of the Greek letter *omicron*, which happened to represent *seventy*, we are indebted for the present form of our modern cipher as a circle, instead of a decimal period.

magnitude, but beyond all rational requirement of any real calculations we can devise. There is, in the law of continued geometrical progression, even on its lowest scale, a power so overwhelming, that we feel we have no extra wonder or admiration left to spare, upon these "infinites of higher order," and confess to a predilection not to travel at such dizzying speed.

The world has had some centuries of experience in the denary arithmetic. We are all familiar with the laborious and tedious discipline by which its practice is acquired ; and we are all conscious of the exertion of thought demanded to perform a lengthy operation in figures. When we consider the amount of time bestowed in training youth in this branch of learning (and yet the fact that not one-half so trained are really expert in calculation), we must record it as our deliberate conviction, that *the denal radix is too large.* We believe that a lower figure would give the true desideratum—the *minimum* of labor. Nay, as between the scale of ten and that of six, we incline to the opinion that the latter would be found the more convenient notation. Its labor, both of acquisition and of exercise, would certainly be far less than half, while its figures in use would be only about a third more. *A priori,* we might expect that a scale established in rude and inexperienced times (were it not that it was really determined by an arbitrary and extraneous circumstance) would be too large in its ratio of progression—rather than too small ; and that a more enlightened age would find it convenient to reduce it ; just as we have seen to occur with the vicenary and the denary scales, in their early history.

The second essential that should be demanded in a radix is that it must admit of indefinite bisection, or, in other words, that it must be found among the powers of two ; namely, 4, 8, or 16. As 4 is probably too small, and 16 certainly too large, we have the octonary scale alone left to satisfy our most vital two conditions of a medium size, and a complete divisibility. The concurrence of these qualities in any one scale, and in that one alone, is sufficient to establish its claims against all competitors. There is but one scale which could have any pretensions to be considered a rival, or which would be likely to find intelligent advocates ; and that is the duodenary. Much stress has been laid upon the number of its aliquot parts. That this quality is a highly useful one, we frankly acknowledge, but yet, as we maintain, not nearly so useful as that other quality this radix lacks, the facility of successful halving. The number 12 is not a power ; the number 8 is a cube ; an important advantage in several respects, but particularly in the application of this scale to a system of metrology, from the simple relations thereby established between the measures of length and those of volume—by which both weights and measures of capacity are determined. All that has been said on the subject of the denary being too large a scale, applies with much greater force against the duodenary. And, finally, we believe that a large majority of the mathematicians would give their vote unhesitatingly in favor of the octonary arithmetic. It appears to combine advantages of the very first importance, and those impossible in any other scale. While perfectly adapted to the highest requirements of science, it is as exactly suited to the trivial wants and petty occasions of our daily life. It possesses a degree of simplicity the most attainable without a sensible increase of figuring. The simple suppression of the largest two digits of our common system (8 and 9) throughout every place of figures, would be found to reduce the working labor by at least one-half. In choosing between a radix of a second power (as 4), and one of a third power (as 8), the latter would for several reasons be preferred. It would undoubtedly be advantageous for it to be at the same time both a square and a cube. But unfortunately we can meet with no such favored number, until we reach the period 64. Our octonary radix is, therefore, beyond all comparison the "*best possible one*" for an arithmetical system.

After this somewhat tedious preparatory exposition, we now propose to briefly develop the scale of numeration thus selected; and to derive from it an ideal system of measures, based throughout upon the leading ideas of the French system; availing ourselves, as we believe, of every beauty and refinement offered by it, and avoiding every difficulty and defect inherent in it. Let us attempt to employ our proposed scale of number in the first place, by putting it in an intelligible form. Although we might readily discriminate between the octonary and the denary notation by the simple expedient of using a somewhat different type, of our common figures (suppressing the 8 and the 9), yet even with this device, the association of local value is so strong that it would not be easy to avoid confusion of idea in attempting to read and understand the unfamiliar conversion. It will be found much easier, therefore, to devise a set of characters for the octonary scale; which should be entirely distinct both from the letters of the alphabet, and from our ordinary figures. To assist us still more in reading them, these characters might be made significant symbols, by the number of lines employed in the construction of each, though this would be a matter of very little importance in a form of character that should be permanently adopted. The characters should all be simple; they should all have the same size, for the obvious convenience of typographic "dress;" and they should be so distinctive, that no one could easily be mistaken for another. Let us then represent *one* by L; *two* by C; *three* by G; *four* by F; *five* by P; *six* by E; and *seven* by B; the cipher having no intrinsic value, may very well continue to be still represented by O. Our eight *digits*, then (if we must still use so barbarian and unmathematical a designation),* would stand thus: OLCGFPEB.

In reading these octonary numbers, a distinctive name for each, as

* It has been sometimes remarked by advocates of the octonary arithmetic, that if our stupid ancestors had only used their thumbs as the counters of the digits, they would have found that they had but eight fingers, and we should then have had the octaval period—"founded in nature." It may be supposed from the preceding discussion of this subject, that we attach but little importance to such a consideration.

well as for the places occupied by them, would become even more necessary than a distinctive form. The terms "ten," "hundred," "thousand," especially, are too essentially decimal in their origin, and too ineffaceably stamped by usage in their significance, to permit their use in any novel application. The names, like the symbols, should be both as simple and as distinct as possible. The simplest name is a monosyllable, containing but one consonant and one vowel sound. Let this then be the rule of our numerical vocabulary. It will be convenient and even advisable to preserve a resemblance to the popular numerical language, that the analogy of structure may be the more apparent. The word one will naturally give us the French "un;" two will give us "du;" three will give us "the;" the consonant sound being really a simple one, although requiring two letters in our language. The word "tre" would have been better, as being very near the Latin tres, the Greek treis and the original Sanscrit tri;* but the double consonant excludes it under our rule.

* It is a matter of curious philological interest to trace the Sanscrit or ancient Indian parentage of all our modern European languages, especially in the names of the numerals. In this particular the different vocabularies of the numerous and wide-spread races,—of the Celtic, the Romaic, the Sclavonic and the Gothic, with its two great families of the Scandinavian and the Teutonic, appear only as dialects of each other. The names of the first ten numbers, in a few languages, are here selected, mainly from the Introduction to Bosworth's Anglo-Saxon Dictionary:

Sanscrit.	Persian.	Greek.	Roman.	Welsh.	Gothic.	German.	Saxon.	English.
Aika	*yika*	*eis, en*	*unus*	*un*	*ains*	*ein*	*an*	*one*
Dwan	*du*	*duo*	*duo*	*dau*	*trai*	*zwei*	*twa*	*two*
Tri	*seh*	*treis*	*tres*	*tri*	*threis*	*drei*	*threo*	*three*
Chatur	*chehaur*	*tessares*	*quatuor*	*pedwar*	*fidvor*	*vier*	*feower*	*four*
Pancha	*pendj*	*pente*	*quinque*	*pump*	*finf*	*fünf*	*fif*	*five*
Shash	*shesh*	*hex*	*sex*	*chwech*	*saihs*	*sechs*	*six*	*six*
Saptan	*heft*	*hepta*	*septem*	*saith*	*sibun*	*sieben*	*seofen*	*seven*
Ashta	*hesht*	*okto*	*octo*	*wyth*	*ahtau*	*acht*	*eahta*	*eight*
Navan	*nuh*	*ennea*	*novem*	*nau*	*niun*	*neun*	*negon*	*nine*
Dashan	*deh*	*deka*	*decem*	*deg*	*taihun*	*zehen*	*tyn*	*ten*

That these Sanscrit terms should have been so widely diffused, while yet no traces of the Hindoo arithmetical notation should ever have been found outside of India, would seem to show that this derivation was antecedent to the formation of a written language, or, at least, prior to the invention of the *cipher*. A nomenclature may be easily transmitted orally by tradition; a notation could be communicated and preserved only by records.

To the Sanscrit we are indebted for the denominations of our lowest two coins. From the Sanscrit *Sata* or *Shatum* (a hundred), through the Latin *centum*, we obtain our "cent;" and from the Sanscrit *Dasa or Dashan* (ten), through the Latin *decem* and the French *disme* or *dime*, we obtain the name of our "ten-cent piece."

The word *four* will give us "fo;" but for five, in order to avoid a consonant recurrence, we shall have to resort to the original Sanscrit, *pancha*, which will give us "pa." Our *six* will give us "si" or "se;" but for our next number, as we can derive no satisfactory help from English or Latin, Greek or Sanscrit, we are driven to some arbitrary syllable. As seven is the last of our series, we may accept the single independent term with less reluctance; and that its sound may be as distinctively marked as possible, let us call it "ki."

Here, then, we have assigned for each of the numerals "a local habitation and a name."

L *Un;* C *Du;* E *The;* F *Fo;* P *Pa;* G *Se;* B *Ki.*

Our decades—twenty, thirty, forty— offer us the very suitable and simple suffix "ty" to designate our octades. Our hundred suggests the syllable "der" as a convenient designation of the third place of figures; and our thousand will give us "sen." And here we may improve upon our present mode of expressing "places" by employing these distinctive suffixes as independent nouns, significant of a particular order of units, without reference to any special or intrinsic value. Thus a simple unit would indicate any figure occupying the first place; a Ty would indicate any figure occupying the second place; a Der any figure occupying the third place, etc.

But mindful of that prudent law—"economy of means"—and not to burden our infant scheme with too great a load of unfamiliar nomenclature (always the greatest obstacle to the reception of any novel system), let us resort to combinations of these simple suffixes, instead of applying a new term to each new place of figures. By this means we shall be required to introduce new terms only at the successive and advancing powers of each great unit. Thus using "Ty" for the second place, and "Der" for the third place, we may very well employ the word "Ty-der" for the fourth place, "Sen" for the fifth place, "Ty-sen" for the sixth place, "Der-sen" for the seventh place, and "Ty-der-sen" for the eighth place. Here is a pause; and to do honor to the number *eight*, this should comprise one independent period of figures; to be followed by a new term, the analogue of our Million.* We cannot derive a convenient suffix, however, from this term; we shall therefore have to coin a new one. Let us call our great figure Kaly. We have thus the progression: One "Ty" squared is one "Der;" one "Der" squared is one "Sen;" one "Sen" squared is one "Kaly," the intermediate places being expressed by the obvious compounds of these words. Or to illustrate the series proposed by our own decimal terms, it is as though having assigned eight places

*Our *Million*, the square of the Roman *Mille*, is a comparatively modern word; and useful as it is now universally esteemed, it appears on its first introduction to have met with but little favor. "Bishop Tonstall, who has discussed at great length the Latin nomenclature of numbers, speaks of the term *million* as in common use, but he rejects it as barbarous" (*Peacock's Arithmetic*).

of figures instead of six for our million origin, we should reach it by this scale: Tens, hundreds, ten-hundreds, thousands, ten-thousands, hundred-thousands, ten-hundred-thousands, millions; the "ten-hundreds" and the "ten-hundred-thousands" being interpolated places.

Words manufactured to meet a new want have always a somewhat barbarous and uncouth sound, until familiarized by custom; and are usually received but slowly and with reluctance. Unless they can boast a pedigree and a history, they must expect from the world, like other parvenus, no very cordial greeting. From the habits of thought of a very large majority of mankind, it is found so much easier to use old words in a double sense, than to accept the precision of a new phraseology, that there is little doubt the octonary notation could be much more readily taught (except to children) by simply erasing the figures 8 and 9, from the common arithmetic. That it is more philosophical, however, to assign to everything its own appropriate name, can scarcely need a formal statement; and if the system now proposed have the high claims and merits we have represented, no apology is required for the attempt to clothe it in a fitting garb. We here present accordingly the numeration table, as resulting from the names we have just above suggested:

Numeration Table.

ᒪ, Un	= 1	ᒪᒪ, Unty-un	= 9	Cᒪ, Duty-un	= 17	Єᒪ, Thety-un	= 25
C, Du	= 2	ᒪC, Unty-du	= 10	CC, Duty-du	= 18	ЄC, Thety-du	= 26
Є, The	= 3	ᒪЄ, Unty-the	= 11	CЄ, Duty-the	= 19	ЄЄ, Thety-the	= 27
F, Fo	= 4	ᒪF, Unty-fo	= 12	CF, Duty-fo	= 20	ЄF, Thety-fo	= 28
P, Pa	= 5	ᒪP, Unty-pa	= 13	CP, Duty-pa	= 21	ЄP, Thety-pa	= 29
Б, Se	= 6	ᒪБ, Unty-se	= 14	CБ, Duty-se	= 22	ЄБ, Thety-se	= 30
Θ, Ki	= 7	ᒪΘ, Unty-ki	= 15	CΘ, Duty-ki	= 23	ЄΘ, Thety-ki	= 31
ᒪO, Unty	= 8	CO, Duty	= 16	ЄO, Thety	= 24	FO, Foty	= 32
Fᒪ, Foty-un	= 33	Pᒪ, Paty-un	= 41	Бᒪ, Sety-un	= 49	Θᒪ, Kity-un	= 57
FC, Foty-du	= 34	PC, Paty-du	= 42	БC, Sety-du	= 50	ΘC, Kity-du	= 58
FЄ, Foty-the	= 35	PЄ, Paty-the	= 43	БЄ, Sety-the	= 51	ΘЄ, Kity-the	= 59
FF, Foty-fo	= 36	PF, Paty-fo	= 44	БF, Sety-fo	= 52	ΘF, Kity-fo	= 60
FP, Foty-pa	= 37	PP, Paty-pa	= 45	БP, Sety-pa	= 53	ΘP, Kity-pa	= 61
FБ, Foty-se	= 38	PБ, Paty-se	= 46	ББ, Sety-se	= 54	ΘБ, Kity-se	= 62
FΘ, Foty-ki	= 39	PΘ, Paty-ki	= 47	БΘ, Sety-ki	= 55	ΘΘ, Kity-ki	= 63
PO, Paty	= 40	БO, Sety	= 48	ΘO, Kity	= 56	ᒪOO, Under	= 64

It will be seen by this table that we have no peculiar word corresponding to the "ten" of the denary scale; and this is regarded as an advantage, not only in being more systematic, but in giving greater precision of expression and idea. Instead of using the same word to indicate both a place, or local value (as the "ten-place") and a specific number, we are furnished with two distinct words—"Ty" designating the place and "Unty" specifying one in the ty-place, as "Duty" specifies two in the ty-place. All that is needed to carry out this system is to add a table of places.

NOTATION TABLE.

Units.	Ties.	Ders.	Tyders.	Sens.
L Un	L0 Unty	L00 Under	L000 Untyder	L,0000 Unsen
C Du	C0 Duty	C00 Duder	C000 Dutyder	C,0000 Dusen
Ɛ The	Ɛ0 Thety	Ɛ00 Theder	Ɛ000 Thetyder	Ɛ,0000 Thesen
F Fo	F0 Foty	F00 Foder	F000 Fotyder	F,0000 Fosen
P Pa	P0 Paty	P00 Pader	P000 Patyder	P,0000 Pasen
G Se	G0 Sety	G00 Seder	G000 Setyder	G,0000 Sesen
Ɵ Ki	Ɵ0 Kity	Ɵ00 Kider	Ɵ000 Kityder	Ɵ,0000 Kisen

Tysens.	Dersens.	Tydersens.	Kalies.
L0,0000 Untysen	L00,0000 Undersen	L000,0000 Untydersen	L,0000,0000 Unkaly
C0,0000 Dutysen	C00,0000 Dudersen	C000,0000 Dutydersen	C,0000,0000 Dukaly
Ɛ0,0000 Thetysen	Ɛ00,0000 Thedersen	Ɛ000,0000 Thetydersen	Ɛ,0000,0000 Thekaly
F0 0000 Fotysen	F00,0000 Fodersen	F000,0000 Fotydersen	F,0000,0000 Fokaly
P0,0000 Patysen	P00,0000 Padersen	P000,0000 Patydersen	P,0000 0000 Pakaly
G0,0000 Setysen	G00,0000 Sedersen	G000,0000 Setydersen	G,0000,0000 Sekaly
Ɵ0,0000 Kitysen	Ɵ00,0000 Kidersen	Ɵ000,0000 Kitydersen	Ɵ,0000,0000 Kikaly

The Unkaly is the eighth (or untieth) power of Unty. Its value is 16,777216; and it requires but one more figure to express this large amount, than is required by the denary scale. A second place of figures is not lost by our new system—that is, its notation does not exceed that of the common system by two places, until the number 8589,934592 is reached; these 10 figures requiring 12 (namely L and eleven ciphers) in the octonary scale to represent their value. If this should appear surprising to any, it must be remembered, that although at 8, and at 64, an additional figure is required by the octonary system, yet after 10, and 100, the denary also requires this additional figure; and considering this, we shall find that the two scales are *equal* in the number of places occupied—from 1 to 7, inclusive—from 10 to 63, inclusive—from 100 to 511—from 1000 to 4095—from 10,000 to 32,767—from 100,000 to 262,143—from 1,000000 to 2,097151—from 10,000000 to 16,777215—from 100,000000 to

134,217727—and for the last overtaking, from 1000,000000 to 1073,741823. After this long-continued chase, the octonary scale at the next figure, or 1073,741824 (Under-Kaly) loses a place which is never regained. It may not be uninteresting to add, that this scale does not obtain an excess of *three* places until it reaches the enormous number of 9 trillions, 223372 billions, 036854 millions, 775808, these 19 figures being expressed by L and 21 ciphers. This amount diminished by a single unit, or by the last figure 8 being exchanged for a 7, is expressed in the octonary system by 21 *kis* (8) which would be an excess of only *two* places of figures.

Turning from this comparison of the relative powers of the two scales, to their relative simplicity, as exemplified by the octonary multiplication table, we shall find the contrast here as striking as was their parity on the other hand remarkable.

MULTIPLICATION TABLE.

	C	E	F	P	6	0
C	F					
E	6	LL				
F	L0	LF	C0			
P	LC	L8	CF	EL		
6	LF	CC	E0	E6	FF	
8	L6	CP	EF	FE	PC	6L

The mere inspection of this table is sufficient to show, that the time and labor of acquiring it would not be half that required for committing to memory our received form ; and this facility of acquisition would include almost a corresponding degree of readiness in its use. Figures, like furniture stored in the chambers of the brain, require a constant attention and arranging, to be kept in state for use ; and the amount of care and trouble unconsciously bestowed upon them, must be proportioned to the number of the pieces after which we have to look. It is no idle boast, therefore, to say that a child could be taught a thorough knowledge of the four great rules of arithmetic, and a ready skill in their practical applications, through the octonary system, in one-half the time required for obtaining an equal knowledge and skill by the common system. Nor is this simplification of arithmetical operations its only merit. The danger of error increases rapidly with the increasing complexity of the numeric scale; and there is no doubt that our new system would ensure an increase of accuracy, at least equal to its ratio of simplicity. And if to this were added the facility which would result from constructing all our tables of weight and measure upon this scale (a scale so admirably suited to them)—and thereby entirely discarding the whole tedious and troublesome practice of "reduction," from our Arithmetic—the economy of time and labor would be something quite astounding.*

Our exposition of the subject of numeration has been so extended that neither time nor space will now permit us to illustrate the practical working of the arithmetical system here proposed. It is evident, however, that we are here equipped with a mechanism fully adequate to the resolution and expression of all arithmetical operations. Framed by a strict analogy with our present system, it affords us every facility and advantage that this can boast; and differing from it only in the number of its integers, it relieves us entirely from the difficulties and embarrassments which have ever been the opprobrium of our decimal scale. Merely to exhibit the form and method of our scheme, we may here indicate that the present year, "1887," would, in the octonary style be expressed ЄPЄB—*Thety pader and thety-ki.* The diameter of the earth (7925 miles) would be expressed L.BЄ6P—*Unsen, Kity theder sety-pa;* or in feet (41,847,188) C,ЄBP0,F6CF— *Dukaly, thety kider patysen, foty seder duty-fo.*

We now proceed as rapidly as possible to the application of this improved numeration to the determination and distribution of a system of weights and measures. Of all the systems of metrology yet perfected, or even proposed, that of the French is, in the philosophical character of its standards, as well as in the ingenuity, simplicity and precision of its details, undoubtedly by far the most admirable and the most worthy of our imitation. "The French System," says Mr. Adams in the excellent Report on Weights and Measures from which we have already more than once had occasion to quote, "embraces all the great and important principles of uniformity which can be applied to weights and measures. *But that system is not yet complete; it is susceptible of many modifications and improvements.* Considered merely as a labor-saving machine, it is a new power offered to man incomparably greater than that which he has acquired by the new agency which he has given to steam. It is in design the greatest invention of human ingenuity since that of printing. But

* "It is impossible to estimate with any degree of accuracy," says Mr. Nichol, "the amount of labor annually thrown away by the nation at large, while persisting in performing the manifold computations necessary to its gigantic commerce and industry, by means of a series of tables so needlessly complicated and imperfect as those now in use. But the waste of time and loss of money must be something quite enormous, while every day it becomes greater and greater. Were the different denominations of weights, measures and money brought into harmony with the fundamental principle of our common arithmetic, it may be safely affirmed that the labor of commercial and professional calculations would be reduced much below one-half of what is now expended in this direction, while the risk of errors would be diminished in a still greater ratio" (*Encyclopedia of the Physical Sciences*, art. "Weights and Measures," page 778).

like that and every other useful and complicated invention, it could not be struck out perfect at a heat. Time and experience have already dictated many improvements of its mechanism. But all the radical principles of uniformity are in the machine. * * * *Uniformity* of weights and measures—permanent, universal uniformity, adapted to the nature of things, to the physical organization and to the moral improvement of man —would be a blessing of such transcendent magnitude, that if there existed upon earth a combination of power and will adequate to accomplish the result by the energy of a single act, the being who should exercise it would be among the greatest of benefactors of the human race. The glory of the first attempt belongs to France. France first surveyed the subject of weights and measures in all its extent and all its compass. France first beheld it as involving the interests, the comforts and the morals of all nations, and of all after ages. * * * In freely avowing the hope that the exalted purpose first conceived by France may be improved, perfected and ultimately adopted by the United States and all other nations, equal freedom has been indulged in pointing out the errors and imperfections of that system, which have attended its origin, progress and present condition."

Looking at the French *metre* simply as a practical material standard, the first criticism we would naturally have to make upon it, is that it gives us a measure most unfortunate in its size.

In selecting a standard of measure (without any reference to its ideal derivation) two considerations of very obvious and primitive notice impose a tolerably definite limit as to what should constitute the length of a useful, popular measuring rule. The first is that it should be conveniently portable,* if not in a pocket, at least in a satchel, or upon the thigh ; the second is that when held by one hand in careful and precise position for taking or giving measures its two ends should each be distinctly within accurate view, and within easy reach of the free hand for minute marking without any constraint or effort of the body. These two conditions,

*"Perhaps for half the occasions which arise in the life of every individual for the use of a linear measure, the instrument to suit his purposes must be portable and fit to be carried in his pocket * * * For all the ordinary purposes of mensuration, excepting itinerary measure, the metre is too long a standard unit of nature. It was a unit most especially inconvenient as a substitute for the foot, a measure to which, with trifling variations of length, all the European nations and their descendants were accustomed. The foot-rule has a property very important to all the mechanical professions which have constant occasion for its use; it is light and easily portable about the person. The metre, very suitable for a staff, or for measuring any portion of the earth, has not the property of being portable about the person; and for all the professions concerned in ship or house building, and for all who have occasion to use mathematical instruments, it is quite unsuitable. It serves perfectly well as a substitute for the yard or ell, the fathom or perch, but not for the *foot*. This inconvenience, great in itself, is made irreparable when combined with the exclusive principle of decimal divisions. The union of the metre and of decimal arithmetic rejected all compromise with the foot. There was no legitimate extension of matter intermediate between the ell and the palm, between forty inches and four. This decimal despotism was found too arbitrary for endurance " (*Adams's Report on Weights and Measures*).

which would both be assigned on perhaps one-half the occasions of its familiar use, render it tolerably manifest that its length should be not less than twelve inches, and while certainly excluding the yardstick and the metre, would probably designate the carpenters' two foot rule as reaching the maximum limit of practicable length. Both the French metre and our yardstick are very awkward and inconvenient standards, being too long for all ordinary purposes of mensuration, excepting itinerary measure, and as a popular standard utterly worthless except on the counter of the draper. Moreover, we would naturally select such a rule as we would measure our houses by, or the furniture within them; such a rule as the carpenter would cut off or lay off his boards by; such a rule as the mechanic could use in his workshop or the machinist handle in fitting his engines. Theoretically it matters little whether our unit of reference be the inch or the mile, but for the practical business of daily life it becomes a matter of the very highest importance that our unit of measure should be such a one as shall have the most convenient and universal application.

Two standards only have ever had a general use and currency—the *cubit* and the *foot*. Both derived from the human person, it is natural they should be found the most useful measures for the common wants of the person. The cubit may be said to be almost a natural standard; and it is the most ancient of measures, while it is still prevalent throughout the orient. Universal, or nearly so, throughout the nations of antiquity—it was the common measure of the Israelites, and is referred to in their earliest records. The ark is measured in cubits (Gen. vi, 15), and the height of the flood is in cubits. Goliath's height was six cubits and a span. The temple of Solomon is measured in cubits; and walls of cities are measured by the same (2 Kings xiv, 13). The foot appears to be a much later standard of measure. Introduced by the Greeks and Romans, it has prevailed in modern times wherever the Roman influence has been felt.

If the foot has been found a more manageable multiple of both the pace and the fathom or its half—the ell—than the cubit, we are disposed to regard the latter as the more beautiful and useful rule, and the more convenient unit of length. Certainly the occasions are not unfrequent, when we need the addition of a few inches to our foot-rule to measure common objects. At all events, in selecting a standard, adapted to the popular wants, it may be regarded as tolerably manifest that its length should not be less than a foot, and that it should not exceed two feet—the common carpenters' rule. The cubit is the mean between these extreme limits.

This consideration brings us to the derivation of the standard. "In all the proceedings," says Mr. Adams, "whether of learned and philosophical institutions, or of legislative bodies, relating to weights and measures within the last century, an immutable and invariable standard from nature, of linear measure, has been considered as the great desideratum for the basis of any system of metrology. It is one of the greatest merits of the French system to have furnished such a standard for the benefit of all mankind. * * * In the establishment of the French system, the pendulum, as well as the meridian, has been measured ; but the *standard* was, after a long deliberation, after a cool and impartial estimate of the comparative advantages and inconveniences of both, definitively assigned to the arc of the meridian, in departure from an original prepossession in favor of the pendulum." A writer in the *Edinburgh Review* for January, 1807, remarks: "Three different units fell under the consideration of these philosophers, to wit, the length of the pendulum, the quadrant of the meridian, and the quadrant of the equator. If the first of these was to be adopted, the commissioners were of opinion that the pendulum vibrating seconds in the parallel of 45 degrees deserved the preference, because it is the arithmetical mean between the like pendulums in all other latitudes. They observed, however, that the pendulum involves one element which is heterogeneous, to wit, time ; and another which is arbitrary, to wit, the division of the day into 86,400 seconds. It seemed to them better that the unit of length should not depend on a quantity, of a kind different from itself, nor on anything that was arbitrarily assumed. The commissioners therefore were brought to deliberate between the quadrant of the equator, and the quadrant of the meridian ; and they were determined to fix on the latter, because it is most accessible, and because it can be ascertained with the most precision" (*Edinburgh Review,* Vol. ix, p. 379).*

That this selection was wise at the time it was made, cannot be doubted. That it would be wiser now to select the equator, can, perhaps, be made equally evident. By the modern methods of electro-magnetic determination of longitude, an arc of the equator could now be ascertained with as much accuracy, as one of a meridian, and perhaps with even greater precision. A national, or what would be far nobler, an international commission, liberally endowed with every needed equipment, for measuring in South America, and in Africa, arcs of the equator—if possible entirely across either continent; and also (what would be very important) one through the opposite island Borneo—is an enterprise due to the enlightened spirit and scientific progress of the age, and would be one worthy of the united wisdom and resources of the three greatest nations of the world. The determination of the precise figure and dimensions of our globe—that fundamental problem of practical astronomy—is one of such transcendent importance, that no outlays should be regarded as injudicious or misapplied that would offer the prospect of even a slight improvement in the accuracy of our results.

The equator is, in the first place, undoubtedly the true girth and measure of the earth ; and the circumference should always be understood to be this natural measure, unless otherwise specified. In the next place, the meridian not being a circle (owing to the polar flattening of the earth) no two degrees of its quadrant have exactly the same value ; which renders the estimates of its degrees exceedingly awkward. According to the com-

* See note C, page 360.

putations of Mr. T. J. Cram (*Silliman's Journal of Science* for 1837, Vol. xxxi, page 230), one degree of latitude at the pole is equal to 69.39759375 miles, while one degree at the equator is only 68.70859375 miles—a difference of more than two-thirds of a mile! In addition to all this there is some reason for doubting whether different meridians are uniform in length and curvature. An arc of the meridian south of the equator, measured in 1752, by Lacaille (at the Cape of Good Hope) gave very unsatisfactory results.

But through the reductions of various eminent mathematicians we have now the equatorial circumference of the earth as well and accurately determined as any other measure of it. The two best and most recent determinations of the earth's equatorial diameter, are those of Bessel and Airy, who, by independent calculations, agree in the value 7925.6 miles, and differ only by 234 feet! Bessel making it 41,847,192 feet, and Airy, 41,847,426 feet. The mean of these results will give us 131,467,196 feet, as probably a very close measure of the earth's equator. We have every reason, therefore, for deducing our standard of measure from this line—the only true circle by which the earth is circumscribed; we have none for going back to the irregular meridian.

In no particular has the decimal principle of the French system proved so signal and utter a failure as in its application to the division of the circle. We have already noticed that the sixth part of the circle is one of its fundamental divisions—one which cannot be neglected for any theoretical advantage of adherence to system. We have seen, moreover, how admirably our present division of the quadrant into ninety parts or degrees answers all the various purposes required. In adding ten more degrees to the whole, so as to make an even hundred, the French philosophers sacrificed completely its primary and beautiful relations. The sextant no longer had a possible expression in the centesimal scale. A very brief experiment demonstrated what should have been clearly anticipated without it, that the new degrees were wholly impracticable. This part of the system was therefore speedily and universally abandoned,* and yet this was really a surrender of the very foundation of the metrical division.

The *metre* had been made the 10 millionth part of the quadrant, that the new degree might represent just 10 myriametres; but the abolition of this ideal degree left the myriametre (and with it of course the metre) a most inconsequential and unmeaning unit. So that now the kilometre no longer represents a minute, and the decametre a second, as was its original plan and purpose.

The selection of the meridian necessarily involved a reference to its natural fraction, the quadrant—the distance from pole to equator; but had

* "The new metrology of France, after trying it [the principle of decimal division] in its most universal theoretical application, has been compelled to renounce it for all the measures of astronomy, geography, navigation, time, the circle and the sphere; to modify it even for superficial and cubical linear measure, and to compound with vulgar fractions in the most ordinary and daily uses of all its weights and all its measures" (*Adams's Report*).

the equator been the standard chosen, inasmuch as it has no such natural measure, the sextant of it might just as properly have been made the starting unit as its quadrant. And this would have escaped the principal difficulty ; for the sextant will easily supply us with a multiple of the quadrant, though the latter may not conversely so readily commensurate the former. Instructed by such distinguished failures, let us then start with the sextant of the equator as our prime unit of measure. We shall thus be able to select a final modulus or rule, mainly with reference to its most desirable length—no longer trammeled by the compounding of binary and ternary divisions. Ten million metres made the quadrant. Our octonary scale is also furnished with its grand unit (the eighth power of the octade), which for want of a better name we have christened *unkaly* (L,0000,-0000). The sextant of the equator is $21,911199\frac{1}{3}$ feet, or 262,934392 inches. This divided octavally into *unkaly* parts, gives us the quotient, $15\frac{2}{3}$ inches, *almost exactly our ideal measure!* Midway between the two great rival standards of olden time, the cubit and the foot, it seems the very compromise of differences, the harmonizer of conflicting systems, and supplies us with a "module" perfectly suited to every requirement of popular mensuration. It needs but the application of octonary multiples to complete a metrology simple and unexceptionable.

Before giving the table, however, it will be proper to suggest a slight modification in the divisions of the circle, as a subject controlling, to some extent, the details of our linear measures. Should the degree retain its present value as the 360th part of the circle, we should advocate strongly the employment of this unit of the equatorial circle, as the origin of our new standard of measure. Dividing the degree into *undersen* parts (L00,0000), we should have a module about one inch longer than that previously obtained, and somewhat nearer, therefore, to the ancient cubit. Its exact length would be 16.717 inches.

The number 60, however, approaches so near to the octonary *under* (64) that the temptation would be very strong to reduce degrees, minutes and seconds to the simplicity of the general notation, unless there appeared some strong reason for retaining the present sexagenary scale. But there is no special occasion for dividing small arcs into thirds or sixths, that gives this ancient and venerable system any advantage comparable to that we should have of adding up or subtracting degrees, minutes and seconds by a single operation, instead of resorting as now to reduction. On the contrary, the need of frequent binal division is here, as with other values, very apparent ; and in this respect the number 60 is very defective, as it permits but two bisections. The mariners' compass affords us a good illustration of the convenience experienced in a continued bisection of angles.* There would therefore be a positive benefit in substituting

* The cardinal points dividing the circle into quarters—each quadrant is divided into halves or octants, each octant into halves and quarters called "rhumbs" or "points" (8 in the quadrant), and finally each of these points into halves and quarters ; the rhumb or point being 11° 15′, and the quarter rhumb or point 2° 48′ 45″.

the number 64 for 60. This would interpolate 4 degrees into the sextant, or 6 degrees into the quadrant; making the right angle to be expressed by 96° instead of 90° as at present. This, then, is the table we should propose; in which, it will be seen, the present values of arc are not so altered as to disturb appreciably our long-established ideas of degree, minute and second.

DIVISIONS OF THE CIRCLE.

LOO	(64)	tertials	make	1 second	=	0″.823974
LOO	(64)	seconds	"	1 minute	=	52″.734375
LOO	(64)	minutes	"	1 degree	=	$(\frac{15}{16})^\circ$ or 56′15″
LOO	(64)	degrees	"	1 sextant	=	60°
LFO	(96)	degrees	"	1 quadrant	=	90°
COO	(192)	degrees	"	the semicircle	=	180°
BOO	(384)	degrees	"	the circle	=	360°

One obvious advantage of this scale, in addition to its simplification, would be to bring the azimuth compass into harmony with the mariners' compass, by giving them common measures. As the latter divides the quadrant into 8 "points" or "rhumbs," each of these would be LF° (12 degrees) instead of 11° 15′, as at present; and the quarter-point would be C° (3 degrees) instead of 2° 48′ 45″.

The zodiac, or ecliptic circle, has from time immemorial been divided into 12 "signs." This would be found a very convenient unit to be applied to such arcs generally, as would also the smaller unit of its quarter, or LO°, the eighth part of the sextant. As there is no name for this, let us give it the name of "arc" (made technical and specific), a name not inappropriate, since it is about the smallest arc we can readily distinguish from a straight line. This would give us the following scale:

LO°	(8 degrees)	=	1 arc	=	7° 30′
FO°	or 4 arcs	=	1 sign	=	30°
BO°	" 6 arcs	=	1 octant	=	45°
LOO°	" 8 arcs or 2 signs	=	1 sextant	=	60°
LFO°	" 12 arcs or 3 signs	=	1 quadrant	=	90°

Should the above scheme of graduation for the circle be accepted, it will give an admirable simplicity to our table of lengths, which without further preface is herewith subjoined :

Table of Linear Measure.

		1 point	=	($\frac{1}{260}$ inch nearly)				0.0038 ins.
LO (8) points	make	1 line	=	($\frac{1}{33}$ " ")				0.03 "
LO (8) lines	"	1 dent	=	($\frac{1}{4}$ " ")				0.245 "
LO (8) dents	"	1 digit	=	(2 inches ")				1.959 "
LO (8) digits	"	1 MODULE	=	($15\frac{2}{3}$ " ")			1 ft.	3.672 "
LO (8) MODULES	"	1 rod	=			3 yds.	1 ft.	5.37 "
LO (8) rods	"	1 chain	=			27 yds.	2 ft.	7. "
LO (8) chains	"	1 furlong	=			222 yds.	2 ft.	8. "
LO (8) furlongs	"	1 mile	=		1 mile,	23 yds.	0 ft.	5. "
LO (8) miles	"	1 league	=		8 miles,	1 yds.	0 ft.	3. "
LO (8) leagues	"	1 *degree*	=		64 miles,	1480 yds.	2 ft.	5. "
LO (8) *degrees*	"	1 *arc*	=		518 miles,	1286 yds.	1 ft.	11. "
LO (8) *arcs*	"	1 *sextant*	=		4,149 miles,	1493 yds.	0 ft.	4. "
G (6) *sextants*	"	the *circumference*	=		24,899 miles,	158 yds.	2 ft.	

The table of lengths proper terminates with the league ; the denominations following being those of arc. From the derivation of the standard, however, they coincide with precise measures, and are therefore properly included in the table.

The "point" gives a dimension about equal to that of a section of a human hair, or of a very fine grain of sand, and may be considered about the limit of visible magnitude. It is therefore a very suitable origin of linear value, while it is an equally appropriate point of departure for microscopic measurements. The "dent" and the "digit" would be convenient measures for small articles. While this new *metre* gives us one of the most convenient rules that can be devised, the "rod" furnishes us with a highly useful ten-and-a-half foot measuring pole, and eight times this measure gives us the best "chain." But the peculiar beauty of the new Module is, that it precisely corresponds with the *tertial* of the new degree. *Under* Modules make one second (the "chain"); *Under* seconds make one minute (the "mile") ; *Under* minutes make one degree ; and *Under* degrees—the Sextant. Or, progressing by the successive squares—*Unty* Modules make the rod ; *Under* Modules make the chain ; *Unsen* Modules make the mile ; *Unkaly* Modules make the Sextant.

As referred to the French measures, we have for the value of our principal new denominations the following : the "line" = 0.77746 *millimetres;* the "dent" = 6.21975 *millimetres ;* the "digit" = 4.9758 *centimetres ;* the "module" = 3.98064 *decimetres*; the "rod" = 3.18451 *metres*; the "chain" = 2.54761 *decametres*; the "furlong" = 2.03809 *hectometres*; the "mile" = 1.63047 *kilometres*; and the "league" = 1.30437 *myriametres*.

For those measures in most common use, that is for those clustering immediately around the Module, it would doubtless be found highly convenient to give denominations to the halves and quarters; and thus conform them to the universal popular tendency to binary divisions. We therefore propose the following supplementary table; not to be on any account incorporated with the preceding, nor in any respect to modify it; but to retain always its subordinate character.

2 dents	make	1 nail		0.48975	ins.
2 nails	"	1 inch		0.9795	"
2 inches	"	1 digit		1.959	"
2 digits	"	1 hand		3.918	"
2 hands	"	1 span		7.836	"
2 spans	"	1 Module		15.672	"
2 Modules	"	1 ell	2 ft.	7.344	"
2 ells	"	1 fathom	3 ft.	2.688	"
2 fathoms	"	1 rod	10 ft.	5.376	"

Our tables of area, or surface measure, would of course be derived directly from our linear measures, by the familiar law of squares.

TABLE OF SQUARE MEASURE.

LO (8) digits square,	or	LOO (64)	square	digits,	make	1	square	Module:
LO (8) Modules	"	" LOO (64)	"	Modules,	"	1	"	rod:
LO (8) rods	"	" LOO (64)	"	rods,	"	1	"	chain:
LO (8) chains	"	" LOO (64)	"	chains,	"	1	"	furlong:
LO (8) furlongs	"	" LOO (64)	"	furlongs,	"	1	"	mile.

For popular purposes, however, it would be necessary, or convenient, to have more numerous denominations of area measure; and a less rapid progression than that of *unders*, given in the above merely geometrical table of perfect squares. We therefore propose to insert intermediate values, so as to give our table the systematic or octonary form.

TABLE OF AREA—OR SURFACE MEASURE.

		Mile	Acres	Yards	Feet	Inches.
1 sq. Module	=				1	101.615
LO (8) square Modules, make 1 *lot*,	=			1	4	92.92
LO (8) *lots*, " 1 sq. rod,	=			12	1	23.364
LO (8) square rods, " 1 *plat*,	=			97	0	42.9
LO (8) *plats*, " 1 sq. chain,	=			776	2	55.3
LO (8) square chains, " 1 *acre*,	=		1	1370	1	10.42
LO (8) *acres*, " 1 sq. furlong,	=		10	1280	8	83.4
LO (8) square furlongs, " 1 *district*,	=		82	567	5	91.27
LO (8) *districts*, " 1 sq. mile,	=	1	16	4541	0	10.

The intermediate (alternate) denominations of this table are not *perfect squares;* hence it was thought more correct to assign terms to them indicative of their superficial character without the use of the prefix "square." We observe here one advantage that would result from the radix of numeration being a perfect square. The square root of 8 is 2.828427124; or √LO, = C.6POLL8LP6; hence this value would represent in any given units, the side of a square equal to LO (8) of the square units. Thus the side of a square "lot" would be C *Modules*, 6 *digits*, P *dents*, 0 *lines*, and L *point*. The side of a square "plat" would be C *rods*, 6 *Modules*, P *digits*, 0 *dents*, L *line*, and L *point*. The side of a square "acre" would be C *chains*, 6 *rods*, P *Modules*, 0 *digits*, L *dent*, L *line*, and 8 *points*. And the side of a square "district" would be C *furlongs*, 6 *chains*, P *rods*, 0 *Modules*, L *digit*, L *dent*, 8 *lines*, and L *point*. A very simple parallelogram is however afforded us, which gives with precision the dimensions of these respective areas. Thus a "district," as a land measure, is a rectangular space of ground, measuring two furlongs in one direction, and four furlongs in the other; an "acre" a similar space of ground measuring two chains in one direction by four chains in the other; a "plat," a space measuring two rods in one direction, by four rods in the other; and a "lot" is in like manner a surface of two Modules by four Modules. This table presents, therefore, the simplest ratios of superficial measure which could be devised; and would be found admirably adapted to every purpose of mensuration. For smaller surfaces, it is probable that the following supplementary table would prove a useful resort:

								Yards	Feet	Inches.
4	square	dents	make	1	square	nail	=			0.239858
4	"	nails	"	1	"	inch	=			0.959433
4	"	inches	"	1	"	digit	=			3.837735
4	"	digits	"	1	"	hand	=			15.350941
4	"	hands	"	1	"	span	=			61.403766
4	"	spans	"	1	"	Module	=		1	101.615
4	"	Modules	"	1	"	ell	=		6	118.460
4	"	ells	"	1	"	fathom	=	3	0	41.841
4	"	fathoms	"	1	"	rod	=	12	1	23.364

For measuring volume, we would naturally employ simply the cubes of the preceding denominations; while the contents of such cubic metres respectively, of distilled water at its maximum density, would as obviously furnish the measures of weight. Throughout these derivative tables, we propose to adopt the MODULE as the universal standard. In this respect our linear unit is very greatly superior to the *Metre*, which, from its inconvenient size, has been made practically a standard only of lengths. The *Are* (the unit of surface) is derived, not directly from the *Metre*, but from the *Decametre;* the *Litre* (the unit of capacity) is derived from the cube of the *Decimetre;* and lastly, the *Gramme* (the unit of weight) is derived from the cube of the *Centimetre.* The greater simplicity of our project is manifest in this contrast.

TABLE OF VOLUMES.

								Cubic Feet.	Cubic Inches.
				1	cubic	dent	=		0.01468
10 (8)	cubic	dents	make	1	"	nail	=		0.11747
10 (8)	"	nails	"	1	"	inch	=		0.93977
10 (8)	"	inches	"	1	"	digit	=		7.51817
10 (8)	"	digits	"	1	"	hand	=		60.14537
10 (8)	"	hands	"	1	"	span	=		481.16296
10 (8)	"	spans	"	1	"	MODULE	=	2.22760	
10 (8)	"	MODULES	"	1	"	ell	=	17.82085	
10 (8)	"	ells	"	1	"	fathom	=	112.56680	
10 (8)	"	fathoms	"	1	"	rod	=	1140.53441	

This simple scale of volumes or bulks, derived directly from our smaller linear table, gives a good illustration of the great beauty and convenience flowing out of the employment of a radix of numeration which is a perfect cube. Each of the cubic measures of the above table has for the dimensions of its side two of the linear values above it.

The practical conveniences of simple and direct relations between lengths, weights, and measures of capacity are certainly too obvious and too great, to be lightly thrown away. Thus, where we are furnished with a measure, the root of whose cube is precisely a measuring rule in common use (one of the many advantages which result from an octonary scale of weights and measures), the benefit is by no means trivial; the farmer can always, without any calculation, make himself a cubical box (whether to supply, or to verify a measure) whose capacity shall be fully as accurate as the "bushel" he may purchase—even admitting that such a process may not have the precision that would satisfy the experimental philosopher. And this is a benefit which would attach equally to every unit of measurement in the scale. Whenever so radical a change is contemplated as the introduction of new divisions or denominations of measure, the importance of adopting at the same time the most useful or convenient standards that can be devised, is too eminent to justify a moment's hesitation in throwing aside everything that has not some intrinsic value to plead for its preservation.

TABLE OF DERIVATIVE MEASURES.

The	cubic	dent	gives	the	morsel	measure	and the	carat	weight.
"	"	nail	"	"	lignle	"	"	scrap	"
"	"	inch	"	"	cup	"	"	semy	"
"	"	digit	"	"	gill	"	"	unce	"
"	"	hand	"	"	quart	"	"	libra	"
"	"	span	"	"	octa	"	"	stone	"
"	"	MODULE	"	"	MODIUS	"	"	PONDUS	"
"	"	ell	"	"	pipe	"	"	ton	"
"	"	fathom	"	"	butt	"	"	load	"
"	"	rod	"	"	hold	"	"	keel	"

This table furnishes us with a complete system. It needs but a simple calculation to exhibit our weights and measures in full. Our measures of capacity with their respective values are as follows :

Table of Capacity Measure.

						Galls.	Pts.	Oz.	Drs.	Minims.
				1 parvum	=					.488
10	(8)	parvums	make	1 morsel	=					3.905
10	(8)	morsels	"	1 ligule	=					31.244
10	(8)	ligules	"	1 cup	=				4	9.955
10	(8)	cups	"	1 gill	=			4	1	19.64
10	(8)	gills	"	1 quart	=		2	1	2	37.
10	(8)	quarts	"	1 octa	=	2	0	10	4	56.
10	(8)	octas	"	1 Modius	=	16	5	4	7	35.
10	(8)	Modiuses	"	1 pipe	=	133	2	7	4	41.
10	(8)	pipes	"	1 butt	=	1066	3	12	5	56.
10	(8)	butts	"	1 hold	=	8531	6	5	7	28.

Our language is unfortunately but very poorly supplied with terms expressive of capacity; and as the existing names for the smaller liquid measures used by the apothecary ("fluid-drachm" and "fluid-ounce") are exceedingly objectionable, from their reference to the incongruous standard of weight, we are compelled to reject them, although we have no appropriate denominations to substitute. The word "morsel" is perhaps sufficiently indeterminate to answer the purpose; and the Roman *ligula*, a small measure of about a spoonful, supplies a convenient term, having the same recommendation. The "cup," which is equally indefinite, represents about a half-ounce. The *Modius* of the Romans was about the quarter of a bushel; the term has been selected as a suitable one for indicating a standard *measure*, and also as suggesting its dimension, as the cube of the Module. The circumstance that it is here applied to a much larger volume than it was originally is comparatively unimportant.

As referred to our common table of "dry measure," as it is called, the new "quart" is equal to 1.79 pints; the "octa" is equal to 7 quarts and one-third of a pint, or about one-twelfth less than a peck; the new "Modius" contains 3849.3 cubic inches, and is therefore equal to one bushel, 3 pecks, 1 quart and half a pint, or to very nearly 1¾ bushels, the U. S. bushel containing 2150.4 cubic inches; the new "pipe" is equal to 14 bushels, 1 peck, 2 quarts and half a pint, and the new "butt" is equal to 114 bushels, 2 pecks and 2 quarts.

In the French measures our "quart" is very nearly equal to the *litre*, being .9855 of a *litre*; our "octa" = 7.884 *litres*, and our "Modius" = 63 *litres*.

It may not be out of place to mention here (as exhibiting an interesting and very early anticipation of our octonary scale of measures in England) that by the act of 51st Henry III (1266), it was declared that "8 pounds [of wheat] do make the gallon of wine, and 8 gallons of wine do make a London bushel, and 8 London bushels do make the quarter."

Our proposed system of weights forms but a corollary from the preceding table of capacity measures; a Modius of pure water forming the standard unit, which we therefore call our *Weight* or *Pondus.* Taking the value of the cubic inch of distilled water at maximum density at 252,745 grains (the weight adopted by Mr. Hassler for the U. S. standard), the Modius or cubic Module would weigh 972891.328 grains, or 138 pounds, 15 ounces, 329.22 grains avoirdupois. This will give us the following table:

TABLE OF WEIGHTS.

				Av. lbs.	Oz.	Grains.
		1 mite	=			0.464
LO (8) mites	make	1 carat	=			3.711
LO (8) carats	"	1 scrap	=			29.69
LO (8) scraps	"	1 semy	=			237.52
LO (8) semies	"	1 unce	=		4	150.178
LO (8) unces	"	1 libra	=	2	2	326.42
LO (8) libras	"	1 stone	=	17	5	423.91
LO (8) stones	"	1 PONDUS	=	138	15	329.22
LO (8) PONDUSES	"	1 ton	=	1111	14	8.76
LO (8) tons	"	1 load	=	8895	0	70.08
LO (8) loads	"	1 keel	=	71160	1	123.14

While the "Pondus" is the standard of determination, the "libra," as the unit of weight in most common use, would be the secondary or derivative standard. Since *Under* "libras" make the "Pondus," this corresponds to our present hundred-weight. The new "ton" is not quite half a ton, and the "load" is very nearly 4 tons.

The "keel" is one-half larger than the English keel (a weight used only for coal), which is equal to 21 tons 4 cwt., and of which twenty make a "ship load." Or the English keel is two-thirds of our "keel," as above given.

Estimated by the French weights, our "scrap" = 1.924 *grammes;* our "semy" = 1.5393 *decagrammes;* our "unce" = 1.2314 *hectogrammes,* and our "libra" = .98514 kilogramme.

It would probably be found convenient to distribute the more popular or frequently used weights (those from the "scrap" to the "libra") upon the binary scale; but as the divisions of halves and quarters practically accomplish this, it seems hardly necessary to suggest a series of intermediate denominations.

In the new standard of length here proposed and developed, we believe that every excellence of the French standard has been carefully preserved, and all its imperfections as successfully avoided. Starting from the same general principles by which that was obtained, we have made no departure from the details of its derivation, not required by the plainest and soundest deductions of experience, philosophy and common sense. Does the French method propose an *aggravated* yard as a convenient unit, we show the superiority of the cubit. Does it (on good grounds at the time) select an elliptical meridian, as its origin of measure, we show still better grounds for preferring the equatorial circle. Does it look (almost necessarily) to the quadrant as a natural unit, we show the greater propriety of the sextant. Does it rest on a thoroughly decimal basis, we show the most cogent reasons for adopting an octonary distribution. Does it find a fitting divisor only in the seventh power of its decimal radix, we accidentally find it in a great arithmetical unit—the eighth power of the octade. Does it finally give as its finished product, an imperfect *Metre,* we offer for acceptance a perfect *Module.*

The system of metrology derived from this new standard has in it nothing that is arbitrarily assumed. Each part of it is dependent upon every other, and each part flows from each, by a logical and systematic necessity. The whole is thus a perfect unit, simple and complete—comprehending every relation of dimension and of weight, and adequate to every purpose of precision, the minutest as well as the grandest.

We have thus endeavored to unfold with as much conciseness as was compatible with a clear presentation of the subject, what is regarded as the best possible method of fulfilling all the varied and difficult conditions required in an acceptable system of weights and measures, as well as the most effectual means of promoting that great desideratum of international commerce, an ultimate uniformity of standards among the nations of the earth. The serious and radical defects of our existing systems have been briefly noticed, and from the experience thus acquired the essential and practical wants of the community have been incidentally pointed out. As the result of this investigation, it is believed that there is no other practicable solution of the problem; for the attainment of a real uniformity, there seems to be no other process or alternative. No disadvantage would follow the adoption of this plan, save that of the disturbance and confusion necessarily consequent upon every change, and which must form the price of every valuable reform.

If it be urged that the introduction of still another system of weights and measures, and one having no common unit with either the French or the English system, would be only adding to the existing diversity of standards, instead of tending to that great scheme of uniformity so cherished by the philanthropist, we have to reply that, if the system proposed be really of all the best adapted to the needs not only of one, but of all nations, then is the prospect of a general uniformity most reasonably to be anticipated *from* its introduction. If neither the metrology of England (which is also ours), nor yet that of France, is ever likely to obtain a universal conquest, some better scheme alone remains to give us a hope of ultimate success. Such a scheme is here presented. Founded upon the simplest and yet most comprehensive basis, it contains nothing that could be regarded as in any respect peculiar to one locality or latitude, or more suitable for one nation than for any other. Encumbered by no abstruse nomenclature, it aims at no superfluous verbal uniformity, but leaves each people to employ such designations of its units as may appear to each most easy and familiar.

Mr. Adams, after his unequaled analysis of the English system of measures, in view of its close agreement with our own, discountenances all attempts at a premature innovation. Without approving in his report of the introduction of the French system, he thinks it would afford the best prospect of securing "uniformity;" and remarks, "were it even possible to construct another system on different principles, but embracing in equal degree all the great elements of uniformity, it would still be a system of diversity with regard to France, and all the followers of her system. And as she could not be expected to abandon that which she has established at so much expense, and with so much difficulty, for another possessing, if equal, no greater advantages, there would still be two rival systems with more desperate chances for the triumph of uniformity."

On the contrary, it is believed, that provided a new system could be framed, which *had* demonstrably "greater advantages" than her own, France would be among the first of nations to hail its advent and to welcome its adoption. A nation to which belongs the honor and the glory of having been the first to invite the fraternal co-operation of other powers, and the first to work out with unwearied science, skill and labor, a comprehensive organization of that ideal metrology—unrivaled in its philosophy and symmetry—cannot be the last to appreciate any real improvement of that economy; or to submit to any sacrifice which should promote the realization of such improvement. Nor could the entire abandonment of that which has cost so much be accounted too great a sacrifice, if only through it could be accomplished that magnanimous design to which it owed its origin. It would have to be looked upon as a costly but invaluable experiment—as a great and necessary progression to an end, by which alone was rendered possible any higher attainment. The system here elaborated is but a development of *that.*

A project which contemplates the entire subversion of the existing arithmetic, with its immense stores of fact and formula, is certainly a most startling proposal; and is one which will doubtless be regarded by the majority of persons as a scheme chimerical and impossible. We are impressed with a calm conviction that it does not even offer any real difficulty. The enormous labor of reconstruction involved, we seek not to deny or to underrate. But this is a trouble which must always be commensurate with the greatness of the reformation. This necessity would, however, most probably stimulate to the development and perfection of that most usetul ally, the calculating machine. Rendered simpler in its construction by the very system which should require its services, and made popular and general by the new demand, it seems not improbable that a single century of the octonary empire would place the world on a higher platform than it would even reach without it. Such has been the usual history of difficulty and of success. A national government has but to *will* it to ensure its establishment; and after the first impediments of custom were surmounted, we nothing doubt, that the facility and manifold conveniences of the new *regime* would form its most powerful support, and its surest recommendation to popular favor.

If the octonary system have the germ of vitality, here imagined, its adoption by any one of the great nations of Christendom would as surely pave the way to its universal prevalence, as did the introduction of the Hindoo notation, and of the Gregorian calendar. Nor are the obstacles which so long delayed those great reforms, either as numerous or as serious at the present day, as they were in by-gone centuries. The tone and temper of the times—intellectual, moral, and political—differ widely from those of our ancestors; and in our common school system we have a moral mechanism for the inoculation of new truth, untried and unknown in all past ages.* Whenever the octonary numeration should be definitely established by political authority, we would immediately have all young children instructed for a year or two, only in the octonary arithmetic—as furnishing the easiest and most rational introduction to the knowledge of figures. And not until after a complete mastery of this arithmetic should they be taught the use of decimals—still required for a considerable period to enable reductions to be made from the old style to the new. This would be attended with no more labor than is the additional study now of ordinary Algebra; while in the distinctive languages of the two scales would be found a safeguard against all danger or difficulty, in confounding the one value with the other.

* In the interesting report made to the Secretary of the Treasury, Dec. 30, 1856, by Prof. Bache, Superintendent of Weights and Measures, it is well remarked in relation to the facility of introducing a decimal system, that "One generation would nearly suffice to effect this change, if, as in Holland, the new weights and measures were introduced through the schools. The children of the country becoming familiar with them in the primary schools, seeing the actual material standards of length, capacity and weight at frequent and stated times in early youth, and retaining that familiarity as they passed into the higher schools, would be readily prepared for their universal use when reaching mature life."

The economy of time and labor which the system of octonary computation would infuse throughout the myriad commercial details daily entering into the life of a busy and enterprising people, cannot be estimated, and could not easily be exaggerated. The popular wonder would be no smaller under the daily workings of this wiser system, that decimals could have prevailed so many centuries—than is our wonder now that the demands of trade could possibly have been satisfied by the awkward and complex Roman scale of numeration.

The objections naturally brought against any disturbance of the existing order of accountancy (backed on the other hand by the indolent and dilatory plea that we and our ancestors from earliest time have found it to answer quite "well enough") are precisely those which have uniformly opposed and retarded the introduction of every improvement. We are informed by Sir John Bowring, in his interesting sketch of the Exchequer system of England, that in quite recent times, Lord Granville strongly resisted the abolition of the Latin phraseology, and the substitution of the Hindoo numerals for the Roman, in the keeping of the public accounts, on the ground that the continuance of the accustomed system was necessary to preserve the comprehension of preceding records !*

The only question upon the subject that can be acknowledged as worthy of discussion, is that which regards the beneficial character of the revolution. "Is, or is not, the change proposed a real improvement?" If it be —if it be not only an improvement, but of all projected schemes the best— then we assert the bolder logic—*its adoption is only a question of time!* Prejudice, timidity or indolence, insensibility to the interest of the future, or superstitious reverence for the gray-haired follies of the past, may each or all oppose their ineffectual resistance; they may indeed postpone for a century or two the benefit to be enjoyed; they may indeed throw in the scale the added labor of accumulated work to be undone, but what is "best" shall surely, in the end, secure its empire.

To the objection urged by some that the advantages to result are too remote, and that even were the new arithmetic now inaugurated, the present generation could not expect to have the full and peaceful enjoyment of its alleged conveniences, we would reply that such has been the case with every really great reform. The rewards of far-reaching benefactions are never for the present. We are in possession now of many

* "It is indeed scarcely credible, that the perplexing and entangled manner of keeping accounts by the Roman numerals in the same barbarous style which was practiced before the Norman Conquest, was maintained at the Exchequer almost down to the present day; and the introduction of the English language and the Arabic numerals was successfully resisted by no less a personage than Lord Granville, on the ground that if the barbarous usages of our ancestors were reformed, it would be difficult to understand the accounts, and the records of departed time; and hence he argued for the necessity of perpetuating a system of complication, confusion and imperfection, not on the common plea of the superior wisdom of our ancestors, but in full acknowledgment and appreciation of the ignorance of the custom which was originally instituted, and which had continued to reign triumphant among the Exchequer records" (*Bowring's Decimal System, Chap. vii, page* 124).

priceless blessings whose first and feeble preparations were planned in former, unenjoying ages. Shall we reap the rich fruits grown from the unselfish providence of ancestral culture, and shall posterity be less favored? Patriotism and humanity reject the doubt. The octonary algorithm is pregnant with such great and widespread benefits—benefits to extend throughout all coming time, that its acquisition should be estimated as cheaply purchased by whole generations of transitional confusion.

The measure thus imperfectly advocated is by no means a new one. It is an incident of the highest interest and moment in the reign of that distinguished monarch, Charles XII of Sweden, that he not only contemplated the introduction of an octonary arithmetic, but that he commissioned Swedenborg (at that time celebrated for his scientific and mathematical attainments) to draw up the necessary details of the plan for establishing this system, together with an octonary scale of weights, measures and coins throughout his kingdom.* It appears that the premature death of the king very shortly afterward, alone prevented the consummation of this most sagacious and philosophic enterprise. But for this untoward circumstance this admirable mechanism would have thus been put into practical operation more than a century and a half ago! Had it proved as successful as there is every reason to suppose it would, who can estimate the influence this engrafting would have had upon the present mathematical condition of Europe? Might we not now have been in the full and assured enjoyment of that happier system? The subject of this improved numerical notation had doubtless often occupied the minds of mathematicians long before this time, but this is probably the first occasion on which a deliberate and well-designed attempt was ever made to give it a practical existence and establishment. As such it is an event of no trivial importance, and must be regarded as ever memorable in the history of arithmetical reform.

In contemplating the practical working of this untried system, and forming an estimate of the character of the change required in the popular habits of thought, comparison and judgment, there can be no doubt that the octonary scale could be generally introduced with far greater facility, and made thoroughly familiar in a much shorter time, in its application to the divisions of money, weight and measure, than it could be in its more abstract application to the operations of universal numeration; that in advance of the arithmetical reformation, it would be found highly expedient to introduce the simple and convenient system of weights and measures here proposed, as the best preparation for the successful introduction of the other.

Even were the octonary arithmetic (with all its own intrinsic excellences) not to be adopted, we still urge that these measures would be worthy of an independent establishment. After the variety of arithmetical reductions to which we are now accustomed under our present incongruous

*See note D, page 364.

tables, the uniform reduction of a single scale, which would alone be required in the new order, would give a very great simplification and relief, and would in every probability be found upon the whole to entail less inconvenience than that which would remain, with even the perfect decimalization of our various measures. So that even under the disadvantages of a decimal dispensation there can be little doubt it could easily be shown that our new system would still, in view of all the circumstances, be the "best possible" one for popular use, and would most completely furnish the elements of a perfect uniformity.

The system in use in this country has three units: The Yard, consisting of 36 inches; the Troy pound, consisting of 5760 grains, and the Wine gallon, containing 231 cubic inches; these units being entirely independent of each other. Upon these units our various tables of weights and measures have been constructed without regard to regularity or fitness for the practical purposes to which they must be applied, or without any approach whatever to uniformity or similarity in the various multiples or divisions of the units.

Any comprehensive and strictly philosophical system, as before stated, can have but one unit, which must give law throughout. That unit will most naturally be a linear measure, and whatever its derivation, where a change is made, "the coincidences between the old and new ratios will necessarily be rare. The best that can be done is to choose such a unit as will produce the most of these."

In consideration of the strong desire of very many persons to retain our present units, or at least the unit of measure, it is believed that the adoption, as our standard, of the English *inch* or multiple of it, the inch being the thirty-sixth part of the standard yard, which is also our standard yard, with an octonary distribution of the various tables of weights, measures and coins, although less philosophical and scientific than the plan just proposed, would be much more readily accomplished. This would leave undisturbed all linear measures of Great Britain and of the United States, and would possess all the essential elements for a successful adoption by both countries.

A specified number of inches might be taken as the standard, and from this all other measures, including those of surface, capacity and weight, derived; or if it should be considered preferable to retain the grain weight instead of the linear unit, the side of a cube containing a weight of water equal to a specific number of grains, might be taken as the standard.

The grain is a standard so widely used, and in medicine especially is one of so great value as the exponent of so much knowledge and experience, that it should not be lightly set aside, and its surrender is a sacrifice which ought to be compensated by very undoubted advantages. So far as medicine and pharmacy are concerned, it would seem to be the most important unit to be preserved. Not only is it at present the recognized measure of the physician and pharmacist throughout a great portion of Europe, that in which chiefly is embodied the long acquired experience and accumulated knowledge of the healing art, the laboriously ascertained and accurately observed relations and values of all the more active portion of the Materia Medica, but it is the measure which, outside of the medical and pharmaceutical professions, is the one almost universally employed as the unit of comparison for all minute investigations and precise determinations.

If either one should be adopted, the other would have to be abandoned; and upon a careful consideration, notwithstanding the great importance of the *grain*, it is believed that the inch would be retained with less disturbance and with much greater advantage than the grain. Should the metric system be adopted, both the inch and the grain must be discarded.

Within a few years past various schemes have been proposed for promoting uniformity, but unless some one of them could be universally adopted, the confusion and complication would be increased instead of being diminished.

Prof. Oscar Oldberg has proposed for adoption by pharmacists and physicians, a new system based upon the "*Gramme*;"* he proposes to divide the gramme into sixteen parts called "grains," thus making a new grain, a little smaller than our present grain; four grammes to make a drachm, 8 drachms to make an ounce, and 16 ounces to make a pound; the pound would thus consist of 8192 new grains, or about 7900 troy grains.

Even if this scheme should be adopted universally by pharmacists and physicians, which does not appear probable, it would but increase the difficulties under which we are now laboring; it would only add one more to our already long list of tables of weights and measures to be learned.

There is no good reason why pharmacists or jewelers, or any other class of individuals, should have a special scale of weights and measures; many of the evils experienced by them are those prevailing in all departments, and no improvements or reform can be either efficient or enduring which do not look to the welfare of the whole. It will be found impossible to give exclusive and confined attention to the weights and measures of any one profession; there is absolute necessity of conformity among all the measures of trade and commerce, and of the reference of all to common laws and to a single standard.

These remarks will also apply to the scheme proposed by Mr. Wm. L. Turner for the use of pharmacists, published in the Proceedings of the Pennsylvania Pharmaceutical Association, 1886.

Mr. Turner proposes to divide the "*Gramme*" into 15 parts called "grains;" to make the ounce equal to 500 of these grains, and the pound equal to 14 ounces, or equal to about 7200 troy grains.

Before attempting any change it should be well considered whether we have attained all the benefit within our reach, or whether at no greater cost we might not reap the advantages of a far more perfect system.

*Manual of Weights and Measures. By Oscar Oldberg, Pharm. D. Second edition. Chicago, 1887.

We would therefore propose to select for our "Module" a 16-inch rule instead of one of 15.672 inches, as suggested on page 338; all the tables as before given would remain unchanged in regard to their divisions and proportions, but of course the values would be slightly modified.

The Table of Measures of Capacity, and Weights, on page 355, shows the divisions and multiples of the "Modius" based upon this 16-inch Module, with their equivalents in Apothecaries' or Wine measure, and in cubic inches; also the divisions and multiples of the "Pondus," with their corresponding Avoirdupois weights, and the connection between the measures and weights.

A great beauty resulting from the use of a cube number for a metrical radix, with octaval divisions, is shown by this table. It will be observed that the Modius and all of its multiples and divisions are *perfect cubes;* and each one has a precise linear standard for the side of its cube; thus, the Modius is the cube of the Module (or 16 inches); the Octa is the cube of 4 digits (or 8 inches); the Quart is the cube of 2 digits (or 4 inches); the Gill is the cube of 1 digit (or 2 inches); and so it is with every ascending or descending measure of capacity; and the weight of the contents of these measures gives us a precisely corresponding series of weights.

To illustrate the contrasted awkwardness and complexity of a decimal system of measures, let the French "*Litre*" be selected. The *Litre* is the cube of the *decimetre.* Ten *litres* make one *dekalitre,* and if we would seek the cubic measure of this quantity, we shall find by a troublesome process of extracting the cube root, that 2 decimetres, 1 centimetre, 5 millimetres, and a decimal fraction .44347, and so on interminably, will give us an approximation to the length of the side, within an assignable limit of error. In other words, although there certainly is a cubic vessel, that shall contain exactly 10 *litres,* it is not within man's art of mensuration to tell precisely what the size of that cube must be. If, on the other hand, it were required to find the dimensions of a vessel holding exactly 8 *litres,* we know that a cube of 2 *decimetres* will give the measure with absolute precision; or, if on the descending scale, it were required to find the size of a vessel holding exactly one-eighth of a *litre,* the cube of 5 *centimetres* gives us the perfect solution.

By the simple device of using multiples of one, two, and four times the size of such of these weights or measures as may be desirable, the use of fractions is entirely avoided, and a perfect system of weights and measures is supplied, by which any conceivable amount can be easily and accurately weighed or measured. Another beauty in our system is that it gives a maximum range of expression with the minimum number of pieces.

Of the weights in our table, those in ordinary use by the pharmacist, jeweler, etc., would be the *mite,* the *carat,* the *scrap,* the *semy,* and the *unce.* Weights of once, twice, and four times the quantity of each of these, or in all 15 weights, would enable us to weigh any possible quantity of *mites,* from one (which is less than half a grain) to 16170 grains; that is to say, we could weigh 32760 different quantities; these 15 weights

Table of Measures of Capacity, and Weights.

Measures.		Wine Measure. Galls.	Pts.	Oz.	Drs.	Minims.	Cubes.	Cub. Inches	Weights.	Avoirdupois. Pounds	Oz.	Grains.
	1 Parvum					.519	$\frac{1}{8}$ ins.	$\frac{1}{512}$	1 Mite			.4936
8 Parvums	1 Morsel					4.15	$\frac{1}{4}$ "	$\frac{1}{64}$	1 Carat			3.949
8 Morsels	1 Ligule					33.2	$\frac{1}{2}$ "	$\frac{1}{8}$	1 Scrap			31.593
8 Ligules	1 Cup				4	26.	1 "	1	1 Semy			252.745
8 Cups	1 Gill			4	3	29.	2 "	8	1 Unce		4	271.96
8 Gills	1 Quart		2	3	3	59.	4 "	64	1 Libra	2	4	425.68
8 Quarts	1 Octa	2	1	11	7	54.	8 "	512	1 Stone	18	7	342.94
8 Octas	1 Modius	17	5	15	7	18.	16 "	4096	1 Pondus	147	14	118.52
8 Modiuses	1 Pipe	141	7	15	2	24.	32 "	32768	1 Ton	1183	2	73.16
8 Pipes	1 Butt	1135	7	10	3	12.	64 "	262144	1 Load	9465	1	147.78
8 Butts	1 Hold	9087	5	3	1	36.	128 "	2097152	1 Keel	75720	10	307.24

would take the place of the following 19 weights, which are now used to accomplish nearly an equivalent purpose, viz: $\frac{1}{2}$ grain, 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 60, 120, and 240 grains troy together with avoirdupois weights of 1, 2, 4, 8 and 16 ounces. These 19 weights make a total of 14104 grains, and would consequently be sufficient to weigh any number of half grains from 1 to 28208.

Upon examination of the above table, it will be seen that the *mite* is very nearly equal to half a grain, the difference being $\frac{64}{10,000}$, or about $\frac{1}{156}$th of a grain; *two mites* being about $\frac{1}{78}$th less than one grain; one *carat* is very nearly equal to 4 grains, being about $\frac{1}{20}$ grain less. One *scrap* is about $1\frac{1}{2}$ grains more than the half drachm. One *semy* is 34 grains more than half an ounce avoirdupois, or $12\frac{3}{4}$ grains more than half an ounce troy; while four *unces* are equal to $18\frac{1}{2}$ ounces avoirdupois nearly.

Of the fluid measures the *ligule* is equal to half a fluid-drachm and 3.2 minims; *two ligules* being 6.4 minims more than a fluid-drachm, or the medicinal teaspoonful; the *cup* is equal to 4 fluid-ounces and $3\frac{1}{2}$ fluid-drachms; 4 *gills* are equal to 1 pint and $1\frac{3}{4}$ fluid-ounces, and the new *quart* is equal to two pints and $3\frac{1}{2}$ fluid-ounces.

The smaller of these weights and measures assimilate so nearly with our present divisions, that for most practical purposes in medicine, pharmacy, etc., the difference would be inappreciable. It is true that all the valuable knowledge that clusters about the grain weight, in statistics of all kind, would have to be recalculated in the new weights, but as has before been stated this is a necessary consequence of *any* alteration in our unit.

If instead of retaining our linear unit, the inch, we had selected the grain weight, all of our weights would have been in even grains, while our measures would have been fractional quantities; in this case, instead of taking the inch, we would take the length of one side of a cube of water weighing at its greatest density 256 grains; such a cube would vary very slightly from a cubic inch; its side would measure 1.004334 inches; sixteen times this length would give us a "*Module*" equal to 16.069344 inches, and our "*Pondus*" would weigh 149 lbs., 12 oz. and 326 grains; our "*scrap*" would be exactly 32 grains, our "*carat*" exactly 4 grains, and our "*mite*" exactly half a grain.

It is believed that the scheme here proposed, independently of its merits, would less disturb our present system of weights and measures than any that has yet been proposed, and would be, therefore, more easily introduced and willingly accepted.

And has not the time arrived in the general progress of commercial and international intercourse, and the rapid advance of our country in science, wealth and power, when her voice should be heard in an important matter like this! Should not our Congress invite all nations to appoint suitable persons to be their representatives in a universal convention to be assembled for the purpose of devising and establishing a system of uniform weights and measures, practically applicable to the need and use of all peoples of the earth?

Such action could not fail to meet with a response due to the importance of the subject; and if the great object be attained, to lead to results productive of vast and lasting benefit to the human race.

These suggestions are offered for the purpose of promoting discussion, investigation, and consideration of the subject in all its bearings, in the hope that when the time arrives in which a change must be made, and such a time will inevitably come, that a system may be adopted which has been, or can be demonstrated to possess the greatest advantages, and is admitted to be, of all schemes proposed, the truest, the wisest, the best.

NOTE A.

"The triumph of the art of calculation, and that to which mainly the modern system of numerical computation owes its perfection, consists in the 'device of place,' by which all necessity for distinguishing the nature of the units signified by any symbol is superseded. Like many other inventions of the highest utility this, when known, appears to arise so naturally and necessarily out of the exigencies of the case, that it must excite unqualified astonishment how it could have remained so long undiscovered. * * * That the honor of the invention of a system which produced such important effects as well on the investigations of science as in the common concerns of commerce, should be claimed by many contending nations, is what would naturally be expected. * * * All Arabian authors on arithmetic appear to agree that the first writer of that country upon this system of arithmetic was Mohammed ben Muza, the Khuwarezmite, who flourished about the year 900. This writer is celebrated for having introduced among his countrymen many important parts of the science of the Hindoos, to the cultivation of which he was devotedly attached; and among other branches of knowledge thence derived, there is satisfactory evidence that this species of arithmetic was one. From the time of Mohammed ben Muza the figures and modes of calculation introduced by him were generally adopted by scientific writers of Arabia, although a much longer period elapsed before they got into common popular use, even in that country. They were always distinguished by the name *Hindasi*, meaning the Indian mode of computation. * * * At the beginning of the eleventh century the use of the Arabic notation had become universal in all the scientific works of Arabian writers, and more especially in their astronomical tables. The knowledge of it was of course communicated to all those people with whom the Moors held that intercourse which would lead to a community of scientific research. In the beginning of the eleventh century the Moors were in possession of the southern part of Spain, where the sciences were then actively cultivated. In this way the use of the new arithmetic was received into Europe first in scientific treatises. A translation of Ptolemy was published in Spain in 1136, in which this notation was used; and after this period it continued in general use for the purposes of science. Notwithstanding the knowledge and practice of this superior notation by scientific men, the Roman numerals continued to be used for purposes of business and commerce for nearly three centuries, and it was only by slow and gradual steps that the improved notation prevailed over its clumsy and incommodious predecessor. The first attempt to introduce it for the purposes of commerce was made by a Tuscan merchant, Leonardo Pisano, in 1202. Having traveled in Barbary, he there learned the method of Hindoo arithmetic, and, struck with its superiority over that to which he had been accustomed, he determined that his countrymen should no longer be deprived of the benefits of it. He accordingly published his treatise in the Latin language; in which he professes to deliver a complete doctrine of the numbers of the Indians. * * * A considerable period, however, was necessary to introduce this system into the common business of life. The extensive commerce maintained by the Italian States directed their attention to the subject at an earlier period than other nations; and although, for scientific purposes, the date of the introduction of the Arabic numeration into Spain is earlier than that of its appearance in Italy, yet its use for the common business of life prevailed at a much earlier period among the Italian States than in any other nation of Europe" (*Lardner's Treatise on Arithmetic*, Book i, ch. ii).

The Hindoo numerals are found in various manuscripts of Italy bearing the dates 1212, 1220, 1228. But none are found in England till nearly two centuries later. Chaucer, the poet, who died in 1400, alludes to them in one of his poems as "*the figures newe.*"

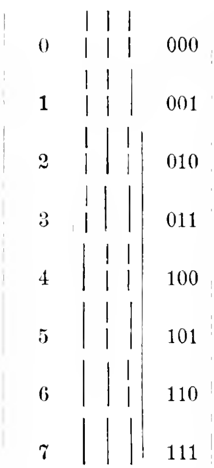
According to Sir John Bowring ("Decimal System," pages 23–30), the first calendar in the English language in which the Hindoo numerals are employed, bears the date of "1431," and the earliest date known on a tombstone in these figures is "1454," the tombstone being that of "Elen Cook," in the church at Ware. The first English book which bears its date in these figures is the "*Rhetorica Nova*, Gulielmi de Saona, 1478." And in seals only one example has been found anterior to the sixteenth century, which bears the date 1484. "The Roman figures lingered longer in England," adds Bowring, "than in any other part of the European world, having found an asylum in the dark and dull regions of the Exchequer" (page 26). "It is indeed scarcely credible that the perplexing and entangled manner of keeping accounts by the Roman numerals, in the same barbarous style which was practised before the Norman Conquest, was maintained at the Exchequer almost down to the present day. * * * In addition to this strange and absurd system of Exchequer book-keeping, tallies continued to be used down to the year 1782. It was only in the year 1831 that the Committee on Public Accounts, of which I was the secretary, recommended the utter and complete abolition of the ancient system and the adoption of the Indian numerals. It was in consequence of this change that in the year 1835 the *tallies* were ordered to be burnt; a conflagration which led to the destruction of both Houses of Parliament—the Exchequer in which the tallies were kept having formed a part of the ancient edifice of St. Stephen's" (*Sir John Bowring's Decimal System*, pages 124–125).

Delambre regards it as a fact humiliating to the pride of human genius that the discovery of the true notation of numbers by nine digits and zero should have escaped the sagacity of the illustrious geometers and mathematicians of ancient Greece. "The Hindoos," says Peacock, "consider this method of numeration as of divine origin. The invention of nine figures with the device of place being ascribed to the beneficent Creator of the universe. Of its great antiquity amongst them there can be no doubt, it having been used at a period certainly anterior to all existing records" (*Encyclopedia Metropolitana*). It can be traced back with certainty at least four centuries before its appearance among the Arabs, and as Lardner well remarks, since "none of these Hindoo authors claim either for themselves or their predecessors the invention of this method of enumeration, but always mention it as being received from the Deity, we may infer that it was practised in that country beyond the limits even of tradition." The Indian origin of our numerals being thus so well established, there is a manifest impropriety in continuing to designate them as the "Arabic figures," as is constantly done in our school arithmetics. Let us give honor where honor is due.

Note B.

It is remarkable that this binary system, according to the opinion of many, was used in China, four thousand years ago, by Fohi, the founder of the empire. A tablet of great but unknown antiquity, called the Cova of Fohi, marked with a series of variously broken lines, and held in superstitious reverence by the Chinese, as containing the mystery of a divine wisdom, has been found to be completely deciphered by the notation of binary arithmetic. When Leibnitz had extensively circulated his scheme or invention through the various scientific journals, and by means of his own correspondence—it appears to have found its way even to China, and to have attracted the attention of a Jesuit missionary at Pekin, named Bouvet. This ecclesiastic, engaged at the time in the study of the Chinese antiquities, discovered and immediately communicated to Leibnitz, with much exultation and enthusiasm, the surprising fact that his system furnished a perfect key to the mysterious lines upon the ancient Cova—hitherto inscrutable, or interpreted only by the speculations of the most extravagant mysticism. The lines of Fohi are arranged in an octagonal form, so as to make the ends approach: each set of the eight series being disposed on a side of the octagon.

These lines transferred from the Cova tablet, and placed in a straight line, are here represented. The row of figures in front expresses the value of each compound symbol, the other figures, which represent the binary notation, manifestly exhibiting a perfect correspondence with the symbols throughout.



"These figures of eight cova," says Mr. Peacock, (in the *Encyclopedia Metropolitana*), "are held in great veneration, being suspended in all their temples, and though not understood, are supposed to conceal great mysteries, and the true principles of all philosophy, both human and divine."

This inscription is exceedingly interesting as exhibiting a true example of that philosophic notation, the device of the cipher—and the determination of value by place. The absence of any other traces of such a notation in China, and its well-known antiquity in India, where it had been so fully elaborated, would lead to the suspicion that it was to this latter country that Fohi was indebted for this curious record of ingenious thought. It appears that Bouvet was fortunate enough to find, subsequently, a Great Cova, in which these markings were carried to a period eight times the extent of the Small Cova. In the *Edinburgh Encyclopedia*

(Article "Arithmetic"), it is stated in reference to this subject, that Father Bouvet, who first suggested this explanation and communicated it to Leibnitz, afterward procured, during his residence in China, the *Great Figure of Fohi*, which extends as far as 64. The exact coincidences which he still found to prevail between the combinations of these lines and the figures of the binary notation, left no doubt with regard to the justness of his conjecture; and we cannot help remarking that the restitution of the true sense of those characters, after so long an interval of time, is a very singular fact in the history of science.

Note C.

It is interesting to trace the history of the gradual development, in modern times, of the grand but difficult project of obtaining from nature a constant and universal standard of length. It is obvious that no such objects of ultimate reference as the human foot, or arm, or cubit, or as "thirty-six barley corns round and dry," can be regarded as natural standards, since they are wholly useless for the purpose of any precise determination. And all measures derived from them are purely arbitrary, as their authority is obtained from positive enactment, merely, and not from any agreement with their nominal originals. Hence it is not at all surprising that "cubits" and "feet" come to signify anything the civil power may enact; the former of these denominations ranging through every gradation of value, from the *covid* of 14½ inches to the royal Egyptian *cubit* of 25½ inches, and the latter from the Pythic foot of 9¾ inches, to the Geneva foot of 19 inches. Nor would it ever be possible from such sources, to reproduce a lost standard, with even the rudest approach to exactness. As Mr. Adams has well remarked, "For all the uses of weights and measures in their ordinary application to agriculture, traffic, and the mechanic arts, it is perfectly immaterial what the natural standard to which they are referable may be. The foot of Hercules, the arm of Henry the First, or the barley-corn is as sufficient for the purpose as the pendulum, or the quadrant of the meridian" (*Report to Congress*).

"The first attempt at fixing such a standard as should be accurate and universal, both as to place and time, is due to the inventive genius of the celebrated Huyghens. That philosopher demonstrated that the times of the vibrations of pendulums depend on their length only. * * * Hence he conceived that the pendulum might afford a standard or unit for measures of length" (*Edinburgh Review*, Vol. ix, page 373). It was in his "Horologium Oscillatorium" (published about 1670), that Huyghens proposed the use of the seconds' pendulum as a universal and perpetual measure; this length to be divided into three equal parts; and this third part (about 13 inches) to be called the *horary foot*.

The celebrated Picard, who first measured from Paris to Amiens in 1669, an arc of the meridian in France, making the degree equal to 68.945 miles (a measurement memorable as having furnished Newton with the means of verifying his grand theory, incapable of determination from the pre-existing data), also proposed in 1671, in agreement with the idea of Huyghens, that the pendulum beating seconds should be adopted as the unit of length. Picard has the merit of having first thrown out the suggestion that the diurnal rotation of the earth ought to affect the oscillation of the pendulum, and that it ought to vibrate more rapidly toward the poles than toward the equator. He accordingly tried the pendulum at Uranibourg, at Paris and at Cette, but was not fortunate enough to discover any sensible difference. Roemer also found the length the same at London.

Richer, however, in the same year, 1671, or early in 1672, while engaged in the duties of his commission at Cayenne, on observing the length of the seconds' pendulum at this place (lat. 4° 56′ north of the equator), found it sensibly shorter than at Paris (48° 50′ north), the difference being about a line and a quarter. Richer's discovery that the pendulum varied in length with the latitude, deprived it of that uniform character considered so necessary in a linear *standard*.

The Abbe Gabriel Mouton, a distinguished mathematician who flourished at the same time, appears to be the first who suggested a measure derived from the earth. He proposed, almost simultaneously with the publication of Huyghens, a *decimal system of measures* based on the value of a minute of arc, as derived from Riccioli's length of a degree. This minute of the degree he called a *miliare*, the thousandth part of which he called a *virga*, equal to 5 feet 4⅛ inches. We have here the germ of the present French metrology.

Cassini, who in 1718 repeated the measurements of a meridian made by Picard (extending his arc, however, further south, namely, from Paris to Dunkirk, and making the degree 69.119 miles), proposed the earth's radius as the unit of length. He afterward in his book, "*De la Grandeur de la Terre*," proposed as a unit the six-thousandth part of a minute of a degree of a great circle of the earth, a measure very nearly equal to the foot.

In 1748 M. de la Condamine (who had recently returned from measuring a degree at the equator in Peru), in a memoir read before the Academy of Sciences, resumed the idea of the pendulum as the unit of length, proposing that it should be taken as beating seconds at the equator, as the most notable line of latitude, and as one likely to avoid all the prejudices which might arise from national jealousy were the latitude of any particular place selected. We see from this the anxiety felt to secure a standard which might be common and uniform among nations.

On the 15th of January, 1790, in accordance with President Washington's recommendation, the House of Representatives

"Ordered, That it be referred to the Secretary of State to prepare and report to this House, in like manner, a proper plan or plans for establishing uniformity in the currency, weights and measures of the United States."

On the 15th of July of that year the House of Representatives received from the Secretary of State (Mr. Jefferson) his report of the proper plan for establishing the desired uniformity, as requested by the House.

In this elaborate report the Secretary proposed "that the standard of measure be a uniform, cylindrical rod of iron of such length as, in latitude 45°, in the level of the ocean, and in a cellar or other place, the temperature of which does not vary through the year, shall perform its vibrations in uniform and equal arcs in one second of mean time."

Starting from this standard, he proposes two distinct plans for the consideration of the House, that they might, at their will, adopt the one or the other exclusively, or the one for the present and the other for the future time, when the public mind may be supposed to have become familiarized to it.

The first plan was *to define and render uniform and stable the existing sys-*

tem; to make the foot to bear a definite ratio to the standard pendulum rod; to reduce the dry and liquid measures to corresponding capacities by establishing a single gallon of 270 cubic inches, and a bushel to be equal to eight (8) gallons, or 2,160 inches—that is, to one and one-fourth cubic feet; to make the ounce to be the weight of one-thousandth part of a cubic foot of water; to retain the more known terms of the two kinds of weights in use, reduced to one series; and to express the quantity of pure silver in the dollar in parts of the weight so defined.

The second plan was to reduce "every branch to the same decimal ratio already established in coins, and thus bring the calculation of the principal affairs of life within the arithmetic of every man who can multiply and divide plain numbers."

Except in the length of the fundamental unit, and in the nomenclature, this was essentially that of the metrical system of France.

These two plans were sharply opposed to each other, and it was to be expected that the desire for a decimal division, and symmetry of system on the one hand, and the reluctance to make a violent change on the other, should elicit no little discussion.

This report was communicated to the Senate in December of that year and referred to a committee. That committee reported on the 1st of March, 1791, that, "as a proposition has been made to the National Assembly of France for obtaining a standard of measure which shall be invariable, and communicable to all nations and at all times; as a similar proposition has been submitted to the British Parliament in their last session; as the avowed object of these is to introduce an uniformity in the measures and weights of the commercial nations; as a coincidence of regulation by the Government of the United States on so interesting a subject would be desirable, your committee are of opinion that it would not be eligible, at present, to introduce any alteration in the measures and weights which are now used in the United States." This report was adopted.

In 1790, Talleyrand proposed to the constituent Assembly of France, that in view of the great diversity and confusion in the weights and measures of the country, a commission should be appointed for the purpose of consulting with a similar commission from the English Government, upon the subject of establishing a uniform international system of metrology, founded upon a single and universal standard. The proposal alluded to the only two natural standards which presented themselves, viz., the measure of the earth and the pendulum, and expressed a decided preference for the latter. The result of this movement was the appointment of Borda, Lagrange, Laplace, Monge, and Condorcet, as commissioners to examine into and report upon the subject. After a careful consideration of the three plans submitted, namely, the pendulum, a quarter of the equator, and a quarter of the terrestrial meridian, they very judiciously agreed in decidedly recommending the latter; regarding the pendulum as an unsuitable standard, whether taken at forty-five degrees of latitude or at the equator.

The attempt to enlist the co-operation of England proved abortive. "The operation of changes of opinion there," says Mr. Adams, "is slow—the aversion to all innovations deep. More than two hundred years had elapsed from the Gregorian reformation of the calendar, before it was adopted in England. * * * After a succession of more than sixty years of inquiries and experiments, the British parliament have not yet acted in the form of law" (*Report to Congress*).

Just five hundred years after the statute of 17th Edward II (A.D. 1324), enacted that "three barley-corns round and dry, make an inch—twelve inches make a foot," etc., the first change was made in the legal definition of the foot. By the act of 5th George IV, c. 74 (1824), it is declared "the standard yard is the distance between the centres of the two points on the gold studs in the straight brass rod now in the custody of the Clerk of the House of Commons, whereon is engraved 'Standard yard, 1760,' the brass being at the temperature of 62 degrees of Fahrenheit's thermometer." "The Yard, if lost, defaced, or otherwise injured, may be restored by comparing it with the pendulum vibrating seconds of mean time in the latitude of London, in a vacuum, on the level of the sea, the yard being in the proportion of 36 inches to 39.1393 inches of the pendulum." This was the first attempt to refer the English foot to a natural standard.

Ten years afterward, or in 1834, the contingency provided for by this statute actually occurred by the burning of the Houses of Parliament; in which conflagration the celebrated brass standard of Bird was destroyed. Although the only actual legal standard was thus lost, no attempt was made to restore it by the pendulum, as provided by law; but the mean of several different standards, including one belonging to the Royal Astronomical Society (fortunately the Astronomical Society had procured a most carefully prepared copy of the imperial standard yard, and the Mint was in possession of an exact copy of the pound), was selected as giving the nearest approximation to the legal standard yard.

A commission was appointed by the British Government, in 1838, "to consider the steps to be taken for the restoration of the Standards of Weight and Measure." The commissioners in their report, made in 1841, say: "We are of opinion that the definition contained in the Act 5, Geo. IV, c. 74, ss. 1 and 4, by which the standard yard and pound are declared to be respectively, a certain brass rod and a certain brass weight therein specified, is the best which it is possible to adopt. Since the passing of the said act, it has been ascertained that several elements of reduction of the pendulum experiments therein referred to are doubtful or erroneous; thus the reduction for the weight of air was erroneous; the specific gravity of the pendulum was erroneously stated, the faults of the agate plates introduced some degree of doubt, and sensible errors were introduced in the operation of comparing the length of the pendulum with Shuckburgh's scale, used as the representative of the legal standard. It is evident, therefore, that the course prescribed by the act would not necessarily reproduce the length of the original yard. Several measures however exist, which were most accurately compared with the former standard yard. And we are fully persuaded that, with reasonable precautions, it will always be possible to provide for the accurate restoration by means of material copies which have been carefully compared with them, more surely than by reference to any experiments referring to natural constants." And the report concludes by recommending "that the standard of length be defined by the whole length of a certain piece of metal or other durable substance, supported in a certain manner, at a certain temperature; or by the distance between two points or lines engraved upon the surface of a certain piece of metal or other durable substance, supported in a certain manner and at a certain temperature; but that the standard be in no way defined by reference to any natural basis, such as the length of the pendulum vibrating seconds in a specified place. * * * That the standard of weight be defined by a certain piece of metal or other durable substance," etc.

It thus appears as the result of this last commission in England, that the people of that country are disposed to abandon all attempts at obtaining a natural standard, and to recur to the authority of an arbitrary rod or piece of metal, whose length has been derived from prescriptive custom. It should be considered, however, that after a natural standard has been obtained, we still have all the means of its material perpetuation, suggested in the commissioners' report. And no foreign community is ever likely to accept as an authoritative unit of measure, a certain brass rod manufactured in England, and incapable of any more precise definition.

Mr. Baily was selected to prepare the new standard, having five copies of the preceding on which to base his comparison; on his death, in 1844, Mr. Sheepshanks continued the necessary observations. Of several standard copies finally prepared by him, each being a square inch bar, of a bronze consisting of copper with a small percentage of tin and zinc, 38 inches in length, with half inch wells sunk to the middle of the bar, one inch from each end, in which the lines defining the yard are drawn on gold plugs—six were finally selected and reported by the commissioners in March, 1854. Of these, the one marked "Bronze 19" was selected as the parliamentary standard yard, the remaining five being deposited, along with copies of the standard of weight, with as many public institutions and scientific bodies. These standards were legalized in July, 1855; and in case of loss of the parliamentary copy, it was provided that the standard should be restored by comparison of the other selected copies, or such as might be available.

Bronze bar No. 11 which has the standard length at a temperature of 61.79° has been presented to the United States, and is the actual standard of comparison.

In addition to the difficulties of obtaining from the pendulum the reconstruction of a lost standard, as above indicated, it is not unimportant to note that there is an original uncertainty in the determination of its length, of nearly the thousandth part of an inch. "We cannot venture to say that the clock's rate in a given day, can be determined certainly to within one-tenth part of a second, although the comparisons have been made at an interval of 24 hours. Seeing then that the *free* pendulum is compared with the clock only over a small fraction of the day, it is a great deal to expect that *its* daily rate can be ascertained to within one second of time. A change of one second per day in the rate of a clock, corresponds to a change of $\frac{1}{43200}$, in the length of the pendulum, which is about $\frac{1}{1100}$ of an inch, or $\frac{1}{43}$ of a millimetre; and therefore we may regard this distance as indicating the probable limit of exactitude" (*Encyclopedia Britannica*, 8th edition, Vol. xvii, page 384, article "Pendulum," by Edward Sang).

Note D.

The only account we have been able to obtain of the important movement of Charles XII toward superseding the decimal by the octonary system, throughout Sweden, is that contained in a volume entitled "A Compendium of the Theological and Spiritual Writings of Emanuel Swedenborg" (royal octavo), published at Boston by Crosby & Nichols, 1854. In the life of Swedenborg, prefixed to the "Compendium," it is said: "In 1719 he published four works; first, '*A Proposal for fixing the value of Coins and determining the Measures of Sweden, so as to suppress fractions, and facilitate Calculations.*' After which he was commanded by his Sovereign to draw up an Octonary Computus (a mode of computing by eighths), which he completed in a few days, with its application to the received divisions of Coins, Weights, and Measures: a disquisition on Cubes and Squares, and a new and easy way of extracting Roots; all illustrated by appropriate examples" (Life, p. 9). As Swedenborg devised for his "Octonary Computus," both a set of characters and of new names, we were exceedingly anxious to have enriched this Paper with their representation. We have failed, however, to find any clue to these early publications in any of the public libraries or private collections to which we have had access. The only additional reference to the subject in the volume above referred to, is contained in a letter from Swedenborg to M. Nordberg, written after the death of Charles XII, which appears to detail the monarch's first conception of the project of a reformation in the popular system of numeration. An extract giving all that relates to the subject of octonary computation, is here copied:

Letter of M. Swedenborg, Assessor of the Board of Mines, to M. Nordberg, Author of the History of Charles XII.

"SIR:—As you are now actually engaged upon the Life of Charles XII, I avail myself of the opportunity to give you some information concerning that monarch, which is perhaps new to you, and worthy of being transmitted to posterity. * * * Conversing one day with the King upon arithmetic, and the mode of counting, we observed that almost all nations, upon reaching ten, began again; that those figures which occupy the first place, never change their value, while those in the second place were multiplied ten-fold, and so on with the others; to which we added that men had apparently begun by counting their fingers, and that this method was still practised by the people; that arithmetic having been formed into a science, figures had been invented which were of the utmost service; and, nevertheless, that the ancient mode of counting had been always retained, in beginning again after arriving at ten, and which is observed by putting each figure in its proper place.

The King was of opinion that had such not been the origin of our mode of counting, a much better and more geometrical method might have been invented, and one which would have been of great utility in calculations, by making choice of some other periodical number than 10. That the number 10 had this great and necessary inconvenience, that when divided by 2, it could not be reduced to the number 1, without entering into fractions. Besides, as it comprehends neither the square, nor the cube, nor the fourth power of any number, many difficulties arise in numerical calculations. Whereas, had the periodical number been 8, or 16, a great facility would have resulted, the first being a cube number of which the root is 2, and the second a square number of which the root is 4; and that these numbers being divided by 2, their primitive, the number 1 would be obtained, which would be highly useful with regard to money and measures, by avoiding a quantity of fractions. The King, after speaking at great length on this subject, expressed a desire that we should make a trial with some other number than 10. Having represented to him that this could not be done unless we invented new figures, to which also names altogether different from the ancient ones must be given, as otherwise great confusion would arise, he desired us to prepare an example in point. We chose the number 8, of which the cube root is 2, and which being divided by 2, is reduced to the primitive number 1. We also invented new figures, to which we gave new names, and proceeded according to the ordinary method; after which we applied them to the cubic calculations, as well as to money, and to measures. The essay having been presented to the King, he was pleased with it" (*Appendix to Life, etc.*, pp. 123, 124).

On the so-called Alaguilac Language of Guatemala.

By D. G. Brinton, M.D.

(*Read before the American Philosophical Society, Nov. 4, 1887.*)

In his valuable treatise on the ethnography of the Republic Guatemala, Dr. Otto Stoll classes the Alaguilac language, once spoken by a tribe resident on the Motagua river in that country, among the languages of unknown affinities, *Sprachen unbekannter Stellung;* and he also adds, that at the time of his visit to the vicinity—now about five years ago—the tongue was entirely extinct, being supplanted by the Spanish.*

It were greatly to be regretted that any language or dialect should perish completely, leaving no record behind it by which we can assign its place in the linguistic scheme. I am happy to say, this is not the case with the Alaguilac. I have in my hands materials from several sources from which to identify this now extinct tongue, and also to cast some interesting glimpses on the ancient civilization of the tribe which once spoke it. These sources are:—

I. Four leaves in folio, originals, from the archives of the Parish of San Cristobal Acasaguastlan, dating from 1610 to 1637, in bad condition, but mostly legible.

II. A collection of words and phrases obtained in 1878 by Francisco Bromowicz from an Indian woman at the village of

* Stoll, *Zur Ethnographie der Republik Guatemala*, s. 172. Also, *Guatemala, Reisen und Schilderungen*, s. 304.

San Augustin Acasaguastlan, named Dolores Corral, then supposed to be one hundred years old or over, and the last of her tribe who could recall the native tongue. Bromowicz appears to have visited the village on the instigation of Don Juan Gavarrete, the well-known Guatemalan antiquary, or of Dr. C. H. Berendt, or of both.

III. Several *informes* of Don Eligio Pais, municipal judge of Chiquimula, and of the cura or parish priest of San Cristobal Acasaguastlan, Don José Inocente Cordon, dated in 1878.

With these means I am enabled to throw sufficient light on the affinities of the Alaguilac language, and add something to our knowledge of the archæology of the locality.

First, a few words on its geographical location.

The parish of San Cristobal Acasaguastlan is situate on the Motagua river in Guatemala, department of Chiquimula, forty-five miles northwest of the city of Guatemala. Its dependencies are the hamlets of Chimalapan, Usumatlan and Tecolutan. About eight miles to the east of it, is the parish of San Augustin Acasaguastlan, whose inhabitants formerly spoke the same tongue.

In the letter descriptive of this region sent to the King of Spain, in 1576, by the Licentiate Diego Garcio de Palacio, he says briefly, "in the valley of Acacevastlan is spoken the Tlacacebastleca."* In the list of languages current in Guatemala as given by the historian Juarros, at the beginning of this century, no such tongue is mentioned, but in place of it, apparently, he names the *Alaguilac*.† The ordinary native tongue of that part of the valley is the Chorti, a dialect of the Maya of clear affinities, and all the surrounding tribes belong to the Maya stock.

At present, as we have seen, travelers agree in the statement that all the Indians of Acasaguastlan speak Spanish only, and the Alaguilac is reckoned therefore among the extinct tongues of America.

The place-names mentioned in these accounts are clearly of Nahuatl origin. Acasaguastlan‡ is a slight modification of *acaga-*

* *Carta de Garcia Diego de Palacio*, p. 20. Ed. Squier.

† *Historia de Guatemala*, Tom. ii, p. 85.

‡ The term given by Palacio—Tlacacebastleca—is a derivative under the ordinary rules of Nahuatl grammar from Acaçacatlan, the termination *eca* being the plural of the *suffix gentilis*, *ecatl*, and the prefix *tla*, meaning here the thing possessed by or peculiar to these people.

catlan the place of rushes or reeds; Chimalapan is compounded of *chimalli*, a shield, with the post-position *pan*, in or at; Usumatlan means the place of monkeys, from *ozumatl*, monkey, and *tlan*, locative ending; and Tecolotan, the place of owls, from *tecolotl*, owl, and *tlan*. The word Alaguilac is stated in the MSS. before me to be the Mexican name of a species of edible fruit; though were it not for this authority, one might suppose it to be from the *nomen gentile*, *atlacuilecatl*, which means "the people who live at the place of drawing water" (*atl*, water, *cui*, to take, *ecatl*, terminatio gentilis).

Evidently, therefore, we find ourselves in a Nahuatl colony, one of those which were scattered through Central America, like the Pipiles of Escuintla, and the Nicaraos in Nicaragua. It has been shown recently that this active race extended its settlements almost to the isthmus of Panama, and established a colony on the borders of the Chiriqui Lagoon.*

Everywhere they carried with them reminiscences of that advanced culture which they had developed in the Valley of Mexico. This is manifest to-day by the superior make of pottery and the fragments of stone and brick edifices which mark the site of their ancient abodes.

Acasaguastlan is no exception to this rule. In the *informe* of the worthy cura above mentioned, he writes as follows:—

"At the confluence of the Rio Grande de Acasaguastlan [*i. e.*, the Motagua river] with that of Teculutan, which is to the east of this parish, there are some prominent and remarkable relics of a dense native population, which prove this to have been the capital of a province. There are neat, level pavements which lead from the buildings to the river. The buildings themselves indicate that they were towers or pyramids. The base is circular and they must have had an altitude of fifty Spanish yards (varas). At present they are covered with lofty trees, and the ruin on the promontory, now the highest, is sixteen or twenty yards in height. In the midst of these edifices, at the place named, there is a large open space, circular in form, like a plaza. A continuous row of mounds extends from these edifices and pyramids, on both sides of the main river, to the village of Acasaguastlan.

* A. Pinart, in the *Revue d'Ethnographie*, Tome vi, p. 121, identifies the Seguas Indians of the Chiriqui Lagoon with the Nahuas.

One of these has been demolished, and proved to be of stone, yielding as much as two hundred perches, without counting the cement. Each of them contains an arch either complete or in ruins. In the one mentioned, three small arches were found, constructed with some symmetry, but it was not ascertained whether the material was joined by lime, as at present it looks more like clay. Portions of the wall were smoothly plastered and some nearly erased paintings were visible. In the structure were found earthen pots, some roughly made, others of excellent workmanship, and with them incense burners, such as the Indians use at the present day in their Brotherhoods (cofradias). There were also found pieces of brick, much like foreign brick, meal-stones in the shape of large shells, arrow points of glass [*i. e.*, volcanic glass, obsidian], and human bones. No one has taken special interest in investigating these remains, and I have known persons who seemed quite intelligent pass by them without awarding them the least attention, and as if they did not see them. Finally, I add that I am assured that no precious metal has been discovered in them, although they may have had antimony, which the Indians used to polish their earthenware as it is quite lustrous."

Such is the interesting description furnished by the parish priest, and it reveals plainly that the ancient race of Acasaguastlan belonged among the more highly cultivated nations of the continent.

I have not found in the historians of Guatemala the records of the first exploration of this portion of the valley of the Motagua, nor in later travelers the account of any visit to these ruins. It would be of especial interest to determine whether they approach the distinctively Mexican or the Maya style of architecture. The presence of the arch points to the latter, but this architectural element was not altogether foreign to the former.

Fifty miles as the bird flies, lower down the Motagua river, are located the remarkable ruins of Quirigua, with their elaborately carven monoliths, twenty feet or more in height. According to the most recent observers,* these relics present evidences of an antiquity greatly exceeding that of Copan or Palenque, both which venerable sites had long been deserted at the period

* See *Copan und Quirigua*, by Heinrich Meye and Dr. Julius Schmidt, Berlin, 1883.

of the Conquest. The valley of the river Motagua, therefore, was probably one of the centres of Central American civilization, and a study of its archæology might prove peculiarly productive.

The reduction and conversion of the tribe dwelling at Acasaguastlan probably took place before the middle of the sixteenth century. The intelligent members of the community were taught to read and write their native tongue, and the records in my hands are by native scribes, who kept these notes or accounts in order to submit them from time to time to their civil or ecclesiastical superiors.

These records are in a dialect of Nahuatl closely akin to that of the Pipiles of Escuintla and the neighborhood. Both dialects are but slight modifications of the tongue as spoken in its purity in the Valley of Mexico. Perhaps much of the apparent difference is due to an uncertain orthography and the inexpertness of the writers.

The subjoined extracts from the archives under the dates 1610, 1634, 1636 and 1637, will show conclusively that the Nahuatl was the current tongue of the parish at that time. The entries relate to fines which were imposed on the natives for various misdemeanors, and of which the civil officers were obliged to pay a portion from time to time to their superiors. The receipts of these superiors are entered in Spanish in the archives and present the honored autographs of Juan de Montoya and G. de Mendieta.

Although various Spanish words occur, and the imperfect handwriting as well as the poor condition of the MSS. render these specimens less satisfactory than could be wished, it will nevertheless be apparent at a glance that the dialect is a tolerably pure Nahuatl, such as was common in Mexico a century after the Conquest.

Extracts from the Parochial Archives of San Augustin Acasaguastlan.

Y nipan 20 de Octubre 1610 años niman in teguantin S^or^ Don Fra^co^ Castro Bernabe de Chaves Christobal Hernandez attos Ju^o^ Perez niço Melcjior Perez tiri Gaspar Lopez Chuvuru Augustin Hernandez rexidores nican vticchiuaque condenat yei tupilhuan ypanpa onomictique (two words illegible) ica ce ciuat itoca Magdalena ica iztaca tibi vquichiuaque yuan nican Catalina Curmi quezqui ipanpa vticpenaltique vquitali ome tostones Gaspar ci timal vquitali chiquacen tomin Catalina Curmi yuan Di° Salualtierra vquitali chiquacen tomin quezquiz ypanpa vneci nican macuili tostones.

* * * * * * *

Y nipan ome tonalli mesti de Mayo 1634 años ticpenaltique yei ciuatlque ipanpan omoqualantique ypan ytequiuh yquiti ce yc xi ticmati ypalta ermita sancta vneci nican mª Ju°na ce ynamic Frᶜᵒ cucu, ce ynamic P° mendes ce ynamic X°bal Herᵈᶻ yuqui ticpenaltique vneci nican matlacti tomin Andres Mendes Alcalde Gaspar Lopez Chucuru Alcalde Dg° herᵈᵉᶻ D° Felipe Regidores noyxpan neuatl Baltasar de Gabes escribano cabildo.

* * * * * * *

1636 años.

Y nipan 24 de Abril 1636 años ypan vticpenaltique ome tupiluan omo tatani Justia ypanpa omohaçi ychau nican ciuatl vquitatani Justia X°ual permesso yuqui vneci yca auilnemiliz yeuatl ipanpa vticpenaltique X°ual Ruy mucuc yuan bernaldina yuqui ypanpa vneci nican chiquacen tostones teuantin alcaldes Frᶜᵒ caynac Diego Felipe yuan Regidores Anton mucho x°ual brᵐᵉbico Miguel Estorca Regidores.

* * * * * * *

Y nipan 23 tonali mesti de Junio 1637 años ypan vticpenaltique ome tupiluan omotatani Justiª nican X°ual axpal ypanpa can qui talili y ciuauh yuqui vtictatanique ytic nican tu cabildo auin quitoua X°bal ypan vniquita vquia ce tacatl nochan ayac vniquixmati quitoua vqui melaua nican y ciuauh melauac yeuat X°bal herᵈᵉᶻ ypanpa yeuat niquixmati opa espa ni mauilli yuan quitoua to yxpan teuantin altos Regidores yuqui ypanpa ticpenaltique vneci nican naui tostones can ixquich nican timoticmatique x°bal chururu Diego Felipe alcaldes gaspar macaua Ju° lopez a lo cauil Juª basqz Regidores no yxpan neuat Baltesar de Chabes es° cabildo.

* * * * * * *

The words collected by Mr. Bromowicz number about 150, and according to the *informes* accompanying his report, were obtained from the only person then living in the region who could recall the tongue of former generations. In the ten years which have elapsed since his visit, Dolores Corral has, doubtless, been gathered to her fathers, and the words of this vocabulary remain to us as the sole monument of the original speech of her tribe. Fortunately they are sufficient in number and clear enough in their affinities as to leave no doubt concerning their linguistic affinities. I present them in one column, arranged in alphabetical order, and by their side, their correspondents in the pure Nahuatl of the Valley of Mexico.

Comparative Vocabulary of the Alaguilac and Nahuatl.

Alaguilac of San Augustin Acasaguastlan.	*Nahuatl.*
Achko, above,	aco
achpoco, much,	ixachi
achtko, monkey,	quauhchimal
aktakaki, deaf,	nacatzatza
aschka, day,	tlacatli
at, water,	atl
atemet, a louse,	atemitl
atenko, spring, well,	(atenco, full of water)
atschi, man (vir.),	oquichtli
checheltek, red,	chichiltic
cholo, toad,	tama-çolin
chuvechka, far,	uehca
culut, a scorpion,	colotl
echegat, wind,	ehecatl
este, blood,	eztli
iagak, nose,	yacatl
ictle, good,	yectli
ikschi, foot,	ixitl
ima, hand,	maitl
imits, leg,	metztli
imperao, bad (Span. *imperito*),	
inachtaval, wing,	atlapalli
inagas, ear,	nacaztli
inenguajo, root,	nelhuayotl

ischko, eye,	ixtololotli
ischte, thread (Span. pita, the thread obtained from the Manguey),	ichtli
isoko, nest (of a bird),	çolli
istak, white,	iztac
istat, salt,	iztatl
istet, nail (of fingers or toes),	iztetl
isutschio, flower,	xochitl
itekses, egg,	tetototl (from *tetl*, stone, *tototl*, bird)
iti, mouth,	from *itia*, to drink. The Nahuatl for mouth is *camatl*
itscha, house,	chane
itschkat, cotton,	ichcatl
itsulteko-kali, roof,	cenacaltia (*lit.*, to shade the house, *calli*)
kaits, shoes,	cactli
kiskuetspal, iguana,	
koehko, horn,	quaquauitl
koets, naguas (skirt),	cueitl
kot, tree,	quauitl
kotoschte, skin, leather,	cuetlaxtli
kott, firewood,	quauitl
kuat, snake,	coatl
kujol, jakal, coyote,	coyotl
kumit, pot, jar (olla),	cumitl
kusti, yellow,	coztic
meste, moon,	meztli
metat, metate,	metlatl
mischte, clouds,	mixitl
misto, cat,	miztli
munantse, mother,	mo-nantzin (thy mother)
muss, fire,	tlecocomoctli, flame
musta, to-morrow,	moztli
mutuchtsé, squirrel,	
mutsungal, hair,	mo-tzuntli, thy hair
nagat, flesh, meat,	nacatl
nekte, sweet,	necutic
neschta, ashes,	nextli
niamigi, thirsty,	ni-amiqui, I am thirsty

nimikukua, sick,	ni-mocuiqui, I am sick
notapetschko, bed,	no-tlapechtli, my bed
numitschi, fish,	no-michin, my fish
numpa, near,	ompa
nupiltsi, son,	no-piltzin, my son
nusiguapiltsi, daughter,	no-ciua-piltzin, my female child
pallo, dog (Spanish, *perro*),	
piltzinte, child,	piltzintli
pisti, hungry,	napizti
pittatsi, father,	tatzin
pokte, smoke,	pochotl
puran, plantain (Spanish, platano),	
sachti, wax,	
sagat, leaf of a tree,	zacatl, straw, grass
sajuli, a mosquito,	çayulin
schali, sand,	xalli
schigal, jicaro,	xicalli
schinamit, town,	chinamitl
schuguscho, sour,	chichic
schupanta, rain,	chachapani, to rain heavily
schuschuk, green,	xoxoctic
sesek, cool,	cecec
sigwat, woman,	cihuatl
sinti, maize,	cintli
soguitz, mud,	çoquitl
tali, earth, ground,	tlalli
taloa, yesterday,	yalhua
taschi, tortilla,	tlaxcalhuia
tecumat, calabash,	tecomatl
tekpe, flea,	tecpin
temesch, lime,	tenextli
teng-uej, very big,	cenca-uey
tepitschi, little,	tepiltan
tepitschil, grown-up child,	tepiltzin
teschuste, coal of fire,	tlexochtli, a spark
tet, stone,	tetl
tiltek, black,	tliltic
timaga, bat,	
temutalpa, a bee,	temoli

teng-totonki, very warm,	cenca-totonia
tepitschi, small,	
totonki, warm,	totonia
tschikaguaste, comb,	tziquauaztli
tschitschik, bitter,	chichic
tsigat, an ant,	tzilazcatl
tuschte, rabbit,	tochtli
tutuli, a chicken,	tototl
tutumuschti, ear of corn,	totomochtli (the dried husk or shuck of corn)
uchte, path, road,	otli
uej, big,	huey
uiste, thorn,	uiztli
umasat, deer,	mezatl
umit, bone,	omitl
unka, to-day,	axcan
tsotsogal, water pitcher,	tzotzocolli
tsunteko, head,	tzontli
tuak, night,	youalli
tucha, leaf of maize,	tocyzuatl
tutot, bird,	tototl
tugat, a spider,	tocatl
tun, sun,	tonatiuh

Phrases in Alaguilac.

Unka at, there is water.
Akten at, there is no water.
Schiwaka, come here.
Kapatia, Where goest thou?
Schuiesmaga muss, Give me some fire.
Qualiga taschi, Bring tortillas.
Qualiga se plato, Take the plate.
Queschki que tscho, How much is it?
Kalen-it agua, I want to eat.
Schitagua, Eat.

Numerals.

Alaguilac.	*Nahuatl.*
1. se	ce
2. umi	ome
3. jei	yei
4. nagui	nahui
5. makuil	macuilli
6. tschikuasi	chiquace
7. tschikume	chicome
8. tschikwei	chiculy
9. matakticumi	chicunaui
10. matakti	matlactli
20. sempual	cempvalli

The Nahuatl which I have placed in the comparative list represents that tongue in its oldest and purest form as given in the Dictionary of Alonso de Molina, printed in 1571. The comparison leaves no doubt whatever, that the Alaguilac was a quite pure form of the Nahuatl, and when we allow for the difference in the orthography of Bromowicz, who writes as a German, from that of Molina, the variation is surprisingly little. In the phrases the *schi* represents the usual Nahuatl imperative form *xi*, the *x* in that tongue having the sound of the German *sch* and the English *sh* in "she."

The only change which has taken place in the numerals is in the number nine, the substitution for *chicunaui*, "one hand and four fingers," of *matakticumi;* but I have no doubt this was a piece of forgetfulness on the part of the venerable Dolores, and that she gave the word for twelve, *matlactliome* (10 + 2), instead of that for nine.

Two questions will arise in the mind of the critical reader: 1. Did any other language exist at Acasaguastlan to which the name Alaguilac could have been applied? If not, and allowing it to have been merely a slightly altered form of the Nahuatl, was it introduced into that locality before or after the Conquest?

To the first of these questions, we may safely reply with a clear negative. There is not a native proper name in the vicinity but belongs either to Nahuatl or Chorti. There is not the slightest evidence in the Nahuatl vocabulary of the influence of any *tertium quid.* We may positively exclude the supposition of a third, wholly lost and unknown tongue, and unhesitatingly identify the "Alaguilac" of Juarros, with the "Tlacabastleca" of Palacio, and both with the ordinary Nahuatl.*

With this identification the last remaining problem in the aboriginal linguistics of Guatemala is solved. We may now confidently say that there was not a tribe found anywhere on its surface by the first explorers of whose linguistic affiliations we are ignorant. Every one can be assigned to its proper ethnographic group so far as this is practicable by a knowledge of its dialect.

As to the second query, whether this Nahuatl colony immigrated before or after the Conquest, we are without positive evidence. But the letter of Palacio, written in 1576, from observations extending over years previous to that date, indicates distinctly that the language of Acasaguastlan had a recognized and independent existence in his day, and, therefore, that the people who spoke it had been found in place when the Spaniards first mapped out the land.

This colony of Nahuas, which had wandered into the upper valley of the Motagua river, was probably an off-shoot from the extensive settlements which their kindred possessed on the Pacific slope in the present Department of Escuintla, some eighty or ninety English miles distant.

The Classification and Phylogeny of the Artiodactyla. *By E. D. Cope.*

(Read before the American Philosophical Society, October 7, 1887.)

This suborder is well defined, and embraces numerous forms, many of which are living. Although it includes much variety of type, the differences shade into each other so that there is considerable difficulty in expressing the natural system in form. The usual division is into the Omnivora and Ruminantia, which are, in the language of Kowalevsky, the

* The language called the "Apay" mentioned by Palacio as spoken at Acasaguastlan has been identified by Dr. Stoll as the Chorti (*Zur Ethnographie der Rep. Guatemala*, p. 106).

Bunodonta and Selenodonta. The latter names are very expressive of the dental characteristics of the two groups (tubercle and crescent bearing), but not having priority, they have come into use as the adjectives bunodont and selenodont, to describe the types of molar crowns to which they refer. But the divisions themselves can no longer be maintained, in view of the numerous extinct forms now known to connect them. Not only do transitions occur, but they occur at different points. Thus Dichobune is the bunodont which corresponds with the selenodont Cænotherium; and Chœropotamus corresponds in the same way with Hyopotamus, Anthracotherium standing between. If it be desirable to name the natural groups into which the families fall, names enough exist in works on the subject, but the divisions they have been applied to are not exactly in accordance with the present writer's views of their true relations. These are presented in the following table. In this work I have been much aided by the Papers of Turner and Flower, which appeared in the Proceedings of the Zoölogical Society, of London, for 1850 and 1875; and of Gill in Smithsonian Miscell. Collec. 1873.

Before presenting the tables and phylogenetic diagrams, the author wishes to make an explanation. Statements as to the phylogeny of a given group, as family, or genus, are intended to apply to them *as defined in the present paper in the tables;* in other words, the phylogenies represent the history of particular structures. There is a tendency among writers, even with some of the best, in considering questions of phylogeny, to restrict their attention to some particular species of a genus, or genus of a family, and to consider all the minor peculiarities of said species or genus, whether appropriate to the wider question before them or not. In brief, I have not attempted to present any phylogeny of species. It will be long before we have the necessary material for that.

I. Superior molars tritubercular (Pantolestoïdea).

Molars bunodont; four digits.............................*Pantolestidæ.*

II. Superior molars quadritubercular with an intermediate fifth.

1. Three digits (Anoplotheroïdea).

Intermediate tubercle anterior.........................*Anoplotheriidæ.*

11. Two or four digits (Anthracotheroïdea).

A. The intermediate tubercle posterior.

Four digits; molars bunodont...........................*Dichobunidæ.*
Four digits; molars selenodont.........................*Cænotheriidæ.*

AA. The intermediate tubercle anterior.

Four digits; one series of V's below...................*Anthracotheriidæ.*
Two or four digits; two series of V's below...............*Xiphodontidæ.*

III. Superior molars quadritubercular, without an intermediate fifth.

A. Molars bunodont (Suoïdea).

Four digits...*Suidæ.*
Two digits...*Elotheriidæ.*

AA. Molars with cross-crests (Listriodontoïdea).

Premolars different from molars........................*Listriodontidæ*.

AAA. Molars selenodont (with four crescents above).

α. Inferior molars with one series of crescents (Merycopotamoïdea).

Premolars unlike molars..................... ....*Merycopotamidæ*.

αα. Inferior molars with two series of crescents.

β. Superior premolars (except premolar four) with one crest (Cameloïdea).

γ. "Fourth premolar like molars below, with three crests above."

Two digits only (four? in Agriochœrus)..................*Dichodontidæ*.

γγ. Fourth premolar entirely different from molars.

δ. Navicular and cuboid bones distinct from each other.

ε. Superior incisors present.

No cannon bone ; a vertebrarterial canal..................*Oreodontidæ*.

No vertebrarterial canal ; no cannon bone................*Poëbrotheriidæ*.

No vertebrarterial canal ; a cannon bone.................*Protolabidida*.

εε. No superior incisors (except incisor three).

No vertebrarterial canal ; a cannon bone ; superior p. m. iv with external and internal crests....................................*Camelidæ*.

Like Camelidæ, but superior p. m. iv a simple cone ....*Eschatiidæ*.

δδ. Navicular and cuboid bones coössified.

All premolars but No. iv without internal crescent...........*Tragulidæ*.

ββ. Superior premolars 2–3–4 with internal as well as external crest; a naviculocuboid bone; no superior incisors (Boöidea).

Superior p. m. ii without internal crescent...................*Moschidæ*.

Superior p. m. ii with internal crescent.

Horns permanent, originating distinct from skull..............*Giraffidæ*.

Horns permanent, processes of the skull.................. .....*Bovidæ*.

Horns periodically shed.............................. ......*Cervidæ*.

Of the preceding sixteen families, ten are extinct. The six families with living representatives are the Suidæ, the Tragulidæ, the Camelidæ, the Moschidæ, the Cervidæ, the Giraffidæ and the Bovidæ.* Thus none of the primary divisions, I and II, have recent representatives. But few of them in fact (some Cænotheriidæ and Anthracotheriidæ) survived the Eocene epoch. Division III is, on the other hand, characteristic of Miocene and recent time, except that some specimens of Gelocus of the Tragulidæ have been found in Upper Eocene beds. Several genera of Tragulidæ,

*Antilocapra is sometimes separated from the Bovidæ as the type of a family, because it is said to sometimes shed its horny horn-sheath. This character, were it really normal, has no significance sufficient for the establishment of a family division.

with Elotherium and Poëbrotherium and Oreodon, belong to Oligocene beds.

Tubercular or bunodont molars are of prior age to selenodont molars, phylogenetically speaking. Of the former, the tritubercular type, it has already been shown, is ancestral to the quadritubercular type. Pantolestidæ are then clearly ancestral to all known Artiodactyla, and are themselves probably the descendants of the lost Amblypoda Hyodonta, whose existence I have anticipated on hypothetical grounds. Of the remaining families which are constructed on the quadritubercular basis, there are two types, as represented in divisions II and III of the preceding table. The intermediate or fifth lobe is especially characteristic of Eocene Artiodactyla. The intermediate tubercles exist in the Pantolestidæ, and one of them is preserved in the families of division II; but in group *A* it is the posterior one, and in group *AA* it is the anterior one. In the Suidæ and Elotheriidæ, which are permanently bunodont, the intermediates are either lost or so divided as to lose their distinctive character. In Elotherium traces of both the intermediates are visible, but they are obscure. The genetic relations of the families with five lobes to those with four are supposed by Schlosser to be direct and ancestral. This looks probable in the case of the Merycopotamidæ of the latter group, which has inferior molars like those of Hyopotamus of the former group. Whether the remaining families of division III *AAA* (see table) (four-lobed) came off from the families of division II (five-lobed) is uncertain. It is probable that the fifth and sixth (or intermediate) tubercles were present in all primitive Artiodactyla, but they may have been lost, as in the Suidæ, in the bunodont stage, which gave origin to III *AAA*, so as to be wanting from the earliest four-lobed selenodont ancestors. Of the two types of II, the division *A* (Dichobunoïdea) is supposed by Schlosser to have been the ancestor of the true selenodonts (III *AAA*), but excepting in the case of Merycopotamidæ this has not yet been demonstrated. Scott suspects with reason that the quinquetubercular Protoreodon is the ancestor of the quadritubercular Oreodon.

Leaving this debatable question, I refer to the family of the Anoplotheriidæ. The remarkable structure of the feet discovered by Gervais, and shown by Schlosser to belong to this family, distinguishes it at once from all families of this and all other orders.

The second digit is well developed in both feet, and stands inwards at a strong angle to the other toes. A rudimental fifth is present in the manus, but not in the pes. The latter is therefore tridactyle. The third and fourth digits are equal in the pes, but the third exceeds the fourth in the manus, giving an entirely perissodactyle character. Some didactyle forms have been placed in this family, but this is inadmissible on ordinary taxonomic principles. The divergent inner toe is supposed to have supported a web, useful in an aquatic life. As remarked by Schlosser, the origin of the Anoplotheridæ is entirely obscure as yet, the only ancestor yet known being the Pantolestidæ. It is probable that some unknown member of the Anthracotheroidea, which had bunodont teeth, may form one of the missing links. Cebochœrus offers the proper type of dentition, and the number of toes (four, Schlosser) is also appropriate, but whether there are any structural obstacles to its being ancestral to the Anoplotheriidæ I do not know.

Anthracotheriidæ can be properly supposed to have descended from a type of Pantolestidæ with well-developed lateral toes, by the addition of the fourth tubercle, and the loss of the posterior intermediate ; while the Dichobunidæ have had the same origin, the posterior intermediate cusp being preserved. The Xiphodontidæ may be supposed to have come off from the Anthracotheriidæ by the usual process of diminishing the lateral digits and developing both sets of crescents in both superior and inferior molars. This family carried the specialization of the five tuberceled type farther than any other.

The Suoïdea have come off from the Pantolestoïdea by the addition of the fourth (posterior internal) tubercle to the superior molars. Some genus with better developed lateral (second and fifth) digits than Pantolestes must have been the ancestor. Such a form will be discovered. It has been already anticipated by Schlosser.*

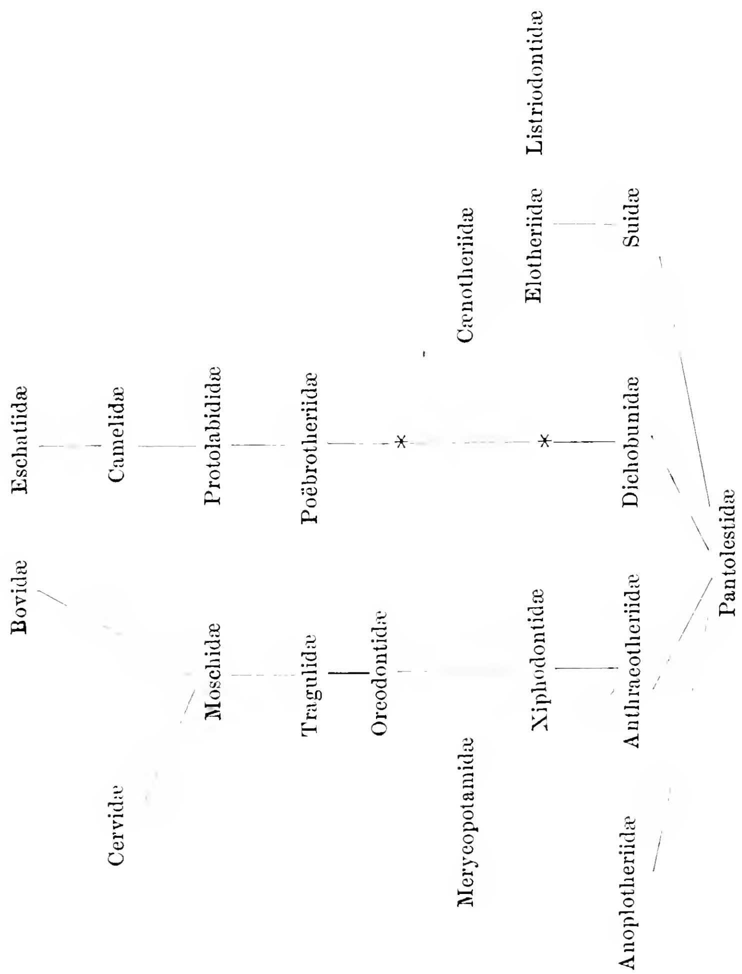
It is evident that the Listriodontidæ form a special short side branch, with a type of molar teeth, especially in the lower series, resembling some of the Perissodactyla. The nearest approach to it is seen in the genus Platygonus of the Suidæ, which has more complex premolars. Here the four cusps of the quadritubercular bunodont type are fused together into transverse crests. The limbs of Listriodon are unknown.

It is a circumstance confirmatory of the view that the Cameloïdea and Boöïdea are descendants of the Anthracotheroïdea rather than of the Suoïdea, that no genus of the latter superfamily shows the least tendency to assume a selenodont structure of the molars. It is therefore not unlikely that the two groups named may have had the history of the Merycopotamoïdea already referred to. They did not probably come from the Merycopotamoïdea themselves, since the geological age of the latter is too late. Of course, however, members of this group may be yet discovered in earlier formations.

The problems of the phylogeny of the remaining groups are less difficult, and have been largely solved by the investigations of Kowalevsky and Schlosser. Tragulidæ have been derived from Oreodontidæ with simpler premolar teeth than the typical forms, (*e. g.* Dorcatherium and Lophiomeryx). In turn they have given origin to primitive Bovidæ (Cosoryx) through Gelocus, which have then branched off into specialized Bovidæ on the one hand, and Cervidæ on the other. The Poëbrotheriidæ have originated from some family with diminished lateral digits, perhaps the Dichobunidæ, various intermediate genera being yet unknown. They

* Morphologisches Jahrbuch, 1886, p. 77.

are the direct ancestors of the Protolabididæ, the camels, and the Eschatiidæ. These relations may be expressed in the following table:

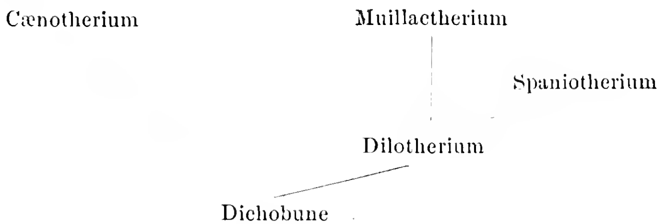


Of Pantolestidæ but one genus is known. The premolars are all simple in the upper jaw, except the fourth which has one external and one internal tubercle.

The structure of the premolars in Anoplotherium is complex for so primitive a type, and the third superior has an internal crest as well developed as in some of the Boöïdea. To the Anoplotheriidæ are referred, besides Anoplotherium, Diplobune of Fraas and Dacrytherium, Mixtotherium and Mixochœrus of Filhol. But the structure of the feet of the latter genera is unknown. In Mixtotherium the fourth premolar is more, and the others less complex than in Anoplotherium.

The known genera of DICHOBUNIDÆ are Dichobune of Cuvier, with Spaniotherium and Dilotherium of Filhol, in which the intermediate tubercles are less developed than in Dichobune. They are related to the two selenodont genera of CÆNOTHERIIDÆ, Cænotherium and Muillactherium. The latter differs from the former in the absence of the intermediate crescent from the last superior molars. The species of Cænotherium differ in the absence or presence of a short diastema in the dental series, and in its position in the lower jaw, whether behind the first or second premolar.

The Dichobunid bunodont genera are ancestral to the Cænotheriid selenodont genera in the following fashion :

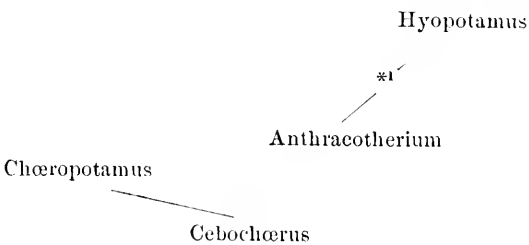


This family terminated with the selenodont genera, which, as Schlosser remarks, left no known descendants.

The ANTHRACOTHERIIDÆ present but few variations. Four genera are known, which differ as follows :

Entirely bunodont ; no diastemata ; canines developed. *Cebochœrus* Gerv.
Cusps of superior molars little flattened ; diastemata ; canines large *Chœropotamus* Cuv.
Cusps of superior molars flattened ; no diastemata ; canines large *Anthracotherium* Cuv.
Cusps of superior molars crescentoid in section ; diastemata ; canines large in males.. *Hyopotamus* Owen.

The three genera last named cannot, as Schlosser remarks, be related in direct lines, but through common ancestors ; as may be shown thus :



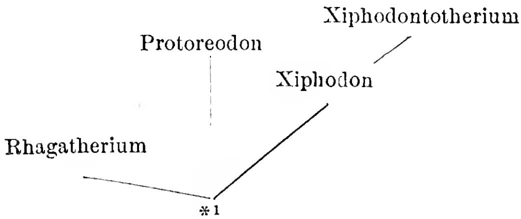
The ancestral genus is bunodont, without diastemata, and with well-developed canines. The hypothetical genus (1) is selenodont, with short diastema, and well-developed canines.

The certainly known genera of the XIPHODONTIDÆ are four, which differ as follows:

Molars bunodont; diastemata; canines large.........*Rhagatherium* Pict.
Molars selenodont; diastemata; canines medium.*Xiphodontotherium* Filh.
Molars selenodont; no diastemata; canines not distinct in form *Xiphodon* Cuv.
Molars selenodont; no diastemata; superior canine developed; inferior p. m. 1 functioning as canine..................*Protoreodon* S. & O.

Cryptomeryx Schl. probably belongs here.

The relations of these genera are clearly somewhat like those of the preceding family. The bunodont condition of the molars of Rhagatherium is primitive, while its diastemata are the reverse. The continuous dental series of Xiphodon is primitive, while the detailed structure of the molars is advanced. These relations may be thus shown:



The hypothetical genus 1 is simply a bunodont without diastemata, and with well-developed canines.

The pigs, SUIDÆ, are an old family, although no genus is known prior to Miocene time. The genera present considerable variety among themselves, but some of the existing genera differ very little from some of the earliest. The greatest diversity is seen in the modifications of the incisor and canine teeth. The following represents the characters:

I. Metapodials fused proximally (Dicotylinæ).

a. Premolars like molars.

Premolars $\frac{3}{3}$; cusps of molars separate...................*Dicotyles* Cuv.
Premolars $\frac{3}{3}$; cusps of molars united into partial cross-crests *Platygonus* Lec.

II. Metapodials distinct (in some unknown); molars without cementum; incisors normal (Suinæ).

a. Fourth premolar with one external tubercle.

Four superior premolars..............................*Thinohyus* Marsh.
Three superior premolars ... .*Chænohyus* Cope.

aa. Fourth superior premolar with two external tubercles.

ββ. Superior canines decurved.

Superior canines small..........................*Hyotherium* Von Myer.

βββ. Superior canines recurved.

Molars with four much plicate tubercles on each..*Hippohyus* Cautl. Falc.
Molars with numerous irregular accessory lobes ; premolars $\frac{4}{4}$..*Sus* Linn.
No accessory lobes ; premolars $\frac{2}{2}$......................*Babirussa* Cuv.

III. Metapodials distinct ; superior incisors reduced in number ; molars reduced in number, and the valleys filled with cement (Phacochœrinæ).

Superior incisors one ; premolars none ; molars $\frac{2}{2}$, with numerous tubercles ; superior canines recurved.................*Phacochœrus* Cuv.

IV. Metapodials distinct, distally keeled behind only ; inferior incisors straight, subcylindric (Hippopotaminæ).

Six lower incisors ; orbit closed................*Hexaprotodon* Caut. Falc.
Four lower incisors ; orbit closed...................*Hippopotamus* Linn.
Two lower incisors ; orbit not closed..................*Chœropsis* Leidy.

The absence of intermediate types renders the determination of the phylogeny of the genera as yet impracticable. The main features may however be foreshadowed. The most generalized form is Thinohyus, since its dentition is in all respects the most simple, while it preserves the full number of teeth. It may readily have given origin to the Dicotyline line on the one side, and Sus and its immediate allies on the other. Babirussa is another derivative from the same center. Phacochœrus may have come from some ally of Sus, since it carries to a great extreme the peculiarities of the latter genus. The ancestry of Hippopotamus is less easily determined. Its imperfect distal metapodial keels, which only exist on the posterior face of the condyle, bespeak for it an ancient ancestor. Its molar type is merely a complication of the quadritubercular, while the characters of its canines are an exaggeration of those of the primitive forms already mentioned. Several other genera, as Dicotyles and Sus, display the decumbent incisors which prepare the way for the remarkable straight digging incisors of Hippopotamus. The genus Chœropsis eases the passage backwards. These relations may be expressed as follows :

Chœropsis — Phacochœrus — Platygonus
|
Hippopotamus — Dicotyles
|
Hexaprotodon — Babirussa — Sus

Hyotherium — Chænohyus
|
Thinohyus

But one genus of Elotheriidæ is known. The character of the feet, reduced to but two metapodials in a bunodont genus of the Lower Miocene or Oligocene, surprised Kowalevsky, who first determined the fact, and has excited similar feelings in other naturalists. But the precocious diminution of the lateral digits has been already observed in various primitive genera, as Pantolestes and Dichobune, and from one or perhaps both of these forms Elotherium was derived. In its dental characters it is of the simple suilline type. The type early ceased to exist, its latest forms being American, and some of them rivaled the rhinoceroses in dimensions.

The Listriodontidæ and Merycopotamidæ include but one genus each, though others probably will be discovered. I therefore turn to the Oreodontidæ which embraces a larger number of forms. Its characters are as follows:

Dentition: superior incisors present; molars selenodont. Cervicals with the transverse processes perforated by the vertebrarterial canal. No alisphenoid canal. Ulna and radius, and tibia and fibula distinct. Metapodial bones four on each foot, with incomplete distal trochlear keels. Lunar bone not supported by magnum. Navicular and cuboid bones distinct. The details of the structure express various affinities. The axis is intermediate between that of the suilline and ruminant Artiodactyla; the other cervicals are suilline, while the remaining vertebræ are ruminant. The scapula is ruminant, not suilline; while the humerus is like Anoplotherium. The radiocarpal articulation is intermediate between that of hogs and ruminants. The unciform supports the lunar bone. The sacrum is ruminant, the ilium suilline. The femur and tarsus are much like those of the peccary.

The known genera of this family are the following:

A. Orbit complete; premolars four, the fourth with one external crescent. First premolar below functioning as canine.

a. No facial vacuities.

Premaxillaries distinct; otic bullæ not inflated; five digits in manus *Oreodon* Leidy.

Premaxillaries distinct; otic bullæ inflated; four digits in manus *Eucrotaphus* Leidy.

Premaxillaries coössified; otic bullæ inflated........*Merycochœrus* Leidy.

aa. Facial vacuities present.

Premaxillaries coössified, dentigerous; vacuities prelachrymal only *Merychyus* Leidy.

Incisors six above, persistent; vacuities prelachrymal and prefrontal; nasal bones much reduced.....................*Leptauchenia* Leidy.

Incisors very few, caducous; vacuities very large......*Cyclopidius* Cope.

AA. Inferior premolars three. True inferior canine functional.

Inferior incisors one on each side......................*Pithecistes* Cope.

Starting from Oreodon as the ancestral form, Eucrotaphus follows at a little distance. The presence of the pollex observed by Scott in Oreodon proves that it must be referred to a five-toed common ancestor with Dorcatherium. The enlarged bullæ are added in Eucrotaphus, and the coössified premaxillaries in Merycochœrus and Merychyus. The latter commences the facial vacuities, which reach such huge proportions in Leptauchenia and Cyclopidius. The loss of the incisor teeth from both jaws, and diminished size, indicate that decadence is going on in Cyclopidius, but the last term is reached in Pithecistes. Here not only incisors but a premolar disappears. This family, once powerful in numbers, size and strength, disappeared with the Upper Miocene period in North America. These relations may be thus displayed. A common ancestor with Dorcatherium is assumed. This will be a genus like Protoreodon S. & O., but without the caniniform inferior p. m. i of that genus, and probably with the fifth crescent of the superior molars. Agriochœrus may have been derived from the same.

Pithecistes
|
Cyclopidius
|
Leptauchenia
|
Merychyus
|
Merycochœrus
|
Coloreodon — Eucrotaphus
| — |
Agriochœrus — Oreodon

Dichodon — (Tragulidæ)

Dorcatherium

The geological positions of these genera are as follows :

	No. of Species.	White River Epoch.	John Day Epoch.	Ticholeptus Epoch.	Loup Fork Epoch.
Oreodontinæ.					
Oreodon Leidy	3	——			
Eucrotaphus Leidy	3	——	——		
Merycochœrus Leidy	8		——	——	
Merychyus Leidy	6			——	——
Leptauchenia Leidy	3			——	
Cyclopidius Cope	2			——	
Pithecistes Cope	3			——	

The Dichodontidæ are allied to the Oreodontidæ and Tragulidæ in the simple form of the premolars, excepting the fourth in both jaws. These resemble, according to Schlosser,* the milk teeth of other ruminants in the genus Dichodon. For the present I associate with this European genus, the American Agriochœrus and Coloreodon, in which the last lower premolar resembles a true molar, and the last upper has two external Vs as in a true molar. The structure of the feet in these genera is unknown, but in Dichodon they are supposed to consist of the two median digits only, which do not form a cannon bone.† It is safe to conclude that the American forms do not possess a cannon bone, and as the presence or absence of lateral digits is not always a family character, I leave them provisionally in the Dichodontidæ to which they are in any case nearly allied. They agree also in the resemblance of the inferior canine to an incisor tooth, but the first premolar is caniniform in the American genera, which it is not in Dichodon. The genera differ as follows :

I. First inferior premolar caniniform.

Premolars three.. *Coloreodon* Cope.

Premolars four. ....*Agriochœrus* Leidy.

II. First inferior premolar not caniniform.

Premolars four.. *Dichodon* Owen.

In this instance the genus of more modern type, Dichodon, is the oldest in time (Upper Eocene), the other genera being Lower Miocene. These types have been derived from some common ancestor of the family of Oreodontidæ as here defined. Dichodon may be a descendant of Lophiomeryx, and Agriochœrus be derived from an ancestor in common with that genus and Dorcatherium (for diagram see under Oreodontidæ).

The Tragulidæ has a good many extinct genera, and the genus Tragulus is represented by several living species. It is difficult to separate this family from the Oreodontidæ, and the only character which appears to be

* Beiträge z. Kenntniss d. Stammesgeschichte d. Hufthiere u. Versuch einer System der Paar- u. Unpaarhufer. Morphologisches Jahrbuch, 1886, p. 56.

† The Diplopus of Kowalevsky is supposed to be Dichodon, by Schlosser.

available is the development of a naviculocuboid bone in the posterior foot. If this character be not used, then the two families will form a single natural division. This definition includes in the Tragulidæ the Gelocidæ of Schlosser, a result inevitable on any exact system. The genera remaining, of which the limb structure is known, are defined as below. Several other genera are known from teeth, as Micromeryx, Phaneromeryx, Rutitherium, etc., but since their feet are not described, I am compelled to omit them.

I. Both metatarsals and metacarpals distinct; molars brachyodont (Hypertragulinæ).

a. Lateral toes behind.

Anterior internal crescent of inferior molars represented by a conical cusp..*Lophiomeryx* Pom.

Interior crescents of inferior molars developed.......*Dorcatherium* Kaup.

aa. No lateral toes behind.

Diastemata in both jaws.........................*Hypertragulus* Cope.

II. Metatarsals forming a cannon bone; metacarpals distinct; molars brachyodont (Gelocinæ).

a. Lateral digits of the manus, none of the pes.

Superior premolars with a small internal tubercle......*Leptomeryx* Leidy.

aa. No lateral digits.

Four lower premolars.................................*Gelocus* Aym.

Three lower premolars..........................*Bachitherium* Filhol.

III. A metatarsal cannon bone; metacarpals forming a cannon bone; molars brachyodont (Tragulinæ).

a. Lateral digits well developed.

Premolars entirely simple.............................*Tragulus* Briss.

aa. Lateral digits weak.

Four inferior premolars, the posterior with branch ridges; superior premolar 3 with strong cingulum.............*Amphitragulus* Pomel.

Three inferior premolars, the posterior with branch ridges; superior premolar 3 with strong cingulum, elongate.*Prodremotherium* Filhol.

IV. Metatarsals and metacarpals unknown; molars hypsodont (Hypisodontinæ).

A diastema behind p. m. 2; canines not distinct.........*Hypisodus* Cope.

Of these genera, those with the metatarsals separate, and the simplest premolar teeth, must be the most primitive and nearest the Oreodontidæ.

Dorcatherium, also an existing genus, has four well-developed digits, and is nearest the Oreodontidæ. The only difference between that family and the present one being the presence and absence of the naviculocuboid bone respectively, Dorcatherium must be placed on the Tragulid side of the line. Probably extinct genera will be found which will connect this genus more intimately with the Oreodontidæ, for the slight complication of the premolars of the extinct genera of the latter, testify to earlier members with simpler ones. Lophiomeryx and

Hypertragulus must be associated with Dorcatherium on account of the lack of cannon bone. Lophiomeryx has an inferior type of inferior true molar, and like Dorcatherium has four toes on all the feet. Hypertragulus displays greater specialization in the absence of lateral digits from the posterior feet. The ulna is also coössified with the radius, and there is a naviculocuboid bone. The premolar teeth are nevertheless very simple, and are separated by diastemata in both jaws. It must be regarded as a modified descendant of Dorcatherium on one side of the main line of descent.

In the next group the metatarsals have united while the metacarpals remain separate. This is the case in Leptomeryx of the American Oligocene. In Tragulus the premolars are much simpler than those of the other genera of Section III, and simpler than those of Leptomeryx, so that these two forms must have been derived from an ancestor which combined the simplicity of both forms. For this we must again recur to Dorcatherium, and I therefore insert this genus at the base of the following diagram. With its entirely prismatic molars Hypisodus has one element of superiority, but the number of its superior premolars is unknown.

Prodremotherium | Bachitherium

Amphitragulus | Gelocus

Tragulus | Leptomeryx

Hypertragulus

Dorcatherium

Lophiomeryx

Of the Poëbrotheriidæ there are two genera. These differ as follows:

First premolar of upper jaw elongate and with two roots *Poëbrotherium* Leidy.

First upper premolar short and with a simple conic root *Gomphotherium* Cope.

The phylogenetic relations of these genera correspond with their relative geological positions. In Gomphotherium from the John Day (Middle) Miocene, the first premolar is much reduced, probably soon to be aborted, as is the case in later genera of the line, among the Camelidæ. In Poëbrotherium it displays an unusual development, like that of some Tragulidæ.

With the Poëbrotheriidæ we commence a series of families characterized by the absence of the vertebrarterial canal, or the line of the camels proper.

The direct connection with the families previously described is not yet known. The indications point to the Oreodontidæ, but no approach to the cervical vertebræ of the Poëbrotheriidæ has yet been found in that family.

Messrs. Scott and Osborn have described a mammal, from the Bridger Eocene of Wyoming, as a probable member of the camel series, under the name of *Ithygrammodon cameloides*. It is only known from two premaxillary and a part of one maxillary bones. The former are slender and bear a complete set of incisor teeth, which are followed by a large canine. It is probable that this genus belongs in the camel series, but it cannot yet be positively affirmed.

Ancestral to the Camelidæ is the genus Protolabis Cope, which agrees with Procamelus, the earliest genus of that family in most respects, but differs decidedly in having a full set of superior incisor teeth. In this genus we reach the stage, in tracing back the ancestry of the camels, which we find represented by Oreodon, or the Gelocus in the line of the cattle and deer. It is probable, though not certain, that in Protolabis the metapodial bones are combined into a cannon bone as in the Camelidæ. If so it differs materially from its predecessor, the genus Pœbrotherium, and must be regarded as the type of a special family, the PROTOLABIDIDÆ. But one genus of this family is known up to the present time. Its remains occur in the Ticholeptus beds of Oregon and the Loup Fork beds of Nebraska and Kansas.

In the CAMELIDÆ we begin to realize the characters of the latest Artiodactyla, the ruminants. But they differ from the typical forms of these, the Boöïdea, in three important points of the osteology, viz., in the absence of a canal of the cervical vertebræ which in other Mammalia encloses the vertebral artery; the presence of an incisor tooth on each side of the upper jaw; and thirdly, the incompleteness of the keels of the distal ends of the metapodial bones. This character and that of the presence of incisors, are primitive conditions common to all the early Mammalia. The peculiar cervical vertebræ constitute a specialization, but whether degenerate or progressive remains to be ascertained. In one respect this line exhibits a high specialization, which is present at the earliest known period of its history. This consists in the reduction of the lateral (II and V) metapodial bones, so that but two functional toes remain. This condition has been reached by the more typical artiodactyles after a much longer lapse of time, for most of the extinct and recent types display lateral digits in a well-developed or rudimentary condition; in but few of them have they totally disappeared. In another respect the line of the camels attains a higher specialization than that of the typical ruminants, although its beginning is that which is common to the entire suborder. This is in the dentition. The reduction in numbers of teeth shown by Owen to characterize the historical succession of all Mammalia, is carried further in the molar series of camels than in any hoofed order; for in the final term or genus, Eschatius (Cope), there is but one premolar left in the upper jaw, and that is reduced to a simple cone. The true molars never reach the complexity of those of the other line, of the Bovidæ or oxen, nor do they become prismatic as in that family, but retain the short crown well distinguished from long roots, which belongs to all the earlier Mammalia.

The successional reduction in the numbers of premolar teeth in the family of the Camelidæ is shown in the following table.* There is seen in the genera Protauchenia and Palauchenia a tendency to an increase of complication of the fourth inferior premolar :

I. Premolar teeth $\frac{4}{4}$.

Premolar I separated by diastema.................... *Procamelus* Leidy.

II. Premolar teeth $\frac{4}{3}$.

Premolar II below wanting............... .... *Pliauchenia* Cope.

III. Premolar teeth $\frac{3}{2}$.

Fourth inferior premolar triangular...................... *Camelus* Linn.

Fourth inferior premolar composed of two crescents, which enclose a lake (an inferior premolar three?)................ *Palauchenia* Owen.

Fourth inferior premolar composed of two crescents, with two posterior tubercles behind them.................... *Protauchenia* Branco.

IV. Premolar teeth $\frac{2}{1}$.

Fourth premolar below triangular..................... *Auchenia* Illiger.

V. Premolar teeth $\frac{1}{1}$.

Fourth superior premolar composed of two crescents. . *Holomeniscus* Cope.

The only genera which include existing species are Camelus and Auchenia, the camels and llamas respectively. It may be remarked that the latter genus, which is confined to the new world, is more specialized than Camelus, which is restricted to the old world.

The succession of these genera in connection with the two preceding families, may be presented as follows :

	No cannon bone.	Cannon bone present.			
	Incisor teeth present.	Incisors one and two wanting.			
	4 premolars.		3 prem's.†	2 prem's.	1 prem'r.
Lower Miocene	*Gomphotherium*				
Upper Miocene		*Protolabis*			
		Procamelus			
			Pliauchenia		
Pliocene and recent				*Camelus*	
					Auchenia

This table shows that geological time has witnessed, in the history of

* From Proceedings Amer. Philosoph. Soc., 1884, p. 16.

† In lower jaw.

the Camelidæ, the consolidation of the bones of the feet and a great reduction in the numbers of the incisor and premolar teeth. The embryonic history of these parts is as follows: In the fœtal state all the Ruminantia (to which the camels belong) have the cannon bones divided as in Poëbrotherium; they exhibit also incisor teeth, as in that genus and Protolabis. Very young recent camels have the additional premolar of Pliauchenia. They shed this tooth at an early period, but very rarely a camel is found in which the tooth persists. The anterior premolar of the normal Camelus is in like manner found in the young llama (Auchenia), but is shed long before the animal attains maturity. I may add that in some species of Procamelus caducous scales of enamel and dentine in shallow cavities represent the incisor dentition of Protolabis.

In greater detail, the extinct American forms of this line are distributed as follows:

	Eocene.		Miocene.				Pliocene.
	Wasatch.	Bridger	White River.	John Day.	Ticholeptus.	Loup Fork.	Equus.
Pantolestes Cope....	5	1					
Ithygrammodon S. O.		1					
? Stibarus Cope......			1				
Poëbrotherium Leidy			2				
Gomphotherium Cope				1			
Protolabis Cope......					1	2	
Procamelus Leidy...						6	
Pliauchenia Cope....						2	
Holmeniscus Cope...							3
Eschatius Cope......							2

The total number of genera, nine; of species, twenty-six.

The development of the brain displays the same progress that has been shown by Lartet and Marsh to have taken place in other lines of Mammalia. The figures which I have given of the brain, show that while *Procamelus occidentalis* is inferior to the camel in the size and development of the convolutions of the hemispheres, it is in advance of the *Poëbrotherium vilsoni* in these respects.

The development of the camels in North America presents a remarkable parallel to that of the horses. The ancestors of both lines appear together in the Wasatch or lowest Eocene, and the successive forms develop side by side in all the succeeding formations. Camels and horses are standard types in all our Tertiary formations; and they must be learned by any one who wishes to distinguish readily the horizons one from the other. The horse-forms are more numerous in all the beds, in individuals as well as in species. Both lines died out in North America, and of the two, the camels only have certainly held their own in South America. The history of the succession of horses in Europe, although not as complete as that in America, extends over as wide a period of time.

Not so with the camels. There is no evidence of the existence of the camel line in the old world prior to the late Miocene epoch ; and so far as the existing evidence goes, the new world furnished the camel to the old.

Camelidæ only appear in South American palæontology in the genus Auchenia, in Pliocene time, in the Pampean beds. The best known species are *Auchenia weddellii* and *A. intermedia* of Gervais. It is curious that M. Ameghino, in his report on the fauna of the Miocene age found on the River Parana, which contains the ancestors of so many Pliocene genera, finds none that stand in that relation to the llamas.

The ESCHATIIDÆ includes a single genus represented by large species of North America and Mexico.

We now reach the division of the Artiodactyla, which is especially characteristic of the present period ; the Boöïdea, or, as it is sometimes called, the Pecora. It embraces more numerous species than any existing division of the Ungulata, and presents considerable difficulties to the zoölogist who would represent the relations of its contents. As a division it is however well defined by the following peculiarities.

The third and generally the second superior premolar teeth possess an internal crest as well as the fourth. The inferior premolar teeth have oblique transverse crests. The keel of the distal extremity of the metapodial bones extends to the front of the condyle. The lateral metapodials are represented by their extremities only, the middle portion having disappeared. The median pair are united into a cannon bone. There are no superior incisors. The odontoid process of the axis vertebra is trough-shaped. The stomach is divided into three or four parts.

The lowest family of the series is that of the MOSCHIDÆ. In its hard parts it differs from the other Bovidæ in the simplicity of the anterior (second) superior premolar, which is without the internal crescent found in the other Boöïdea. In this respect it is intermediate between that division and the Cameloidea, where the fourth premolar only possesses the internal crescent. But two genera of Moschidæ are known, Dremotherium from the Lower Miocene of France, and the living Moschus. Both lack horns and have well-developed canine teeth. The origin of this group is clearly from the Tragulidæ, and the genus of that family which approaches nearest to it is Amphitragulus, which indeed only differs from it in dentition in the imperfection of the internal crest of the third superior premolar. In turn, Dremotherium must be regarded as ancestral to Palæomeryx, the most primitive genus of the Bovidæ.

The GIRAFFIDÆ differ (see table of families) in the mode of attachment of the horns. These are originally separate from the skull, but become attached to it like the epiphyses on the extremities of the bones of the skeleton. Their dental characters are like those of the Cervidæ and the lower Bovidæ, the molars being short crowned or brachyodont. It may be that the condition of the horns in Giraffa represents the mode of origin of the horns of the Bovidæ, and that the genus is simply to be reckoned a primitive type in that family. The specialization of the long neck and fore legs would not exclude it from that family. It is merely an adaptation for the habit of browsing on the foliage of tall trees. In the extinct species of its single genus, Giraffa, these characters are found in a less degree than in the existing one. The most obvious distinction between the BOVIDÆ and the Cervidæ is in the differing character of the bony processes of the skull, used for offense and defense. But where horns are wanting, as is the case with some genera, these distinctions fall to the ground. The horn-type of the Bovidæ is more primitive than that of the Cervidæ, since the horny process is permanent in the former, and is shed and reproduced annually in the latter. The dental type is, however, never so specialized in the deer, as is the case with the highest genera of Bovidæ, remaining always distinctly rooted, while in Bos and some other genera of the latter they become prismatic. But the lower genera of Bovidæ do not differ from Cervidæ in this respect.

In accordance with these facts the bovine ruminants appear a little before the cervine, though authors generally refer the earliest genera to the latter division. Such are the genera Dicrocerus and Cosoryx,* which appear in the latest Miocene beds. Dicrocerus only differs from Palæomeryx in the possession of horns, which resemble those of deer, but which were, according to Schlosser, never shed, a fact which compels its location in the Bovidæ. In Cosoryx the horns have the same character in this respect, but the teeth are antelopine, or prismatic. It is clearly to be placed in the Bovidæ with Antilocapra (the prong-horn), and it is closely allied to Dicrocerus. Here we see that the point of origin of the two families was from a common ancestor, and that this ancestor was, as has been already expressed by Schlosser, the genus Palæomeryx. Nearly related to this point of departure are the Sivatherium, Bramatherium, and Hydaspidotherium. As they do not shed their horns, they cannot be referred to the Cervidæ. In their covering with the integument, Cosoryx probably possessed a character of Giraffa, which is a primitive stage of the essential character of the horns of the Bovidæ. Perhaps the retention of the primitive dermal character of this investment, instead of its metamorphosis into horn, might be regarded as a basis for a distinct family, the Cosorycidæ. But it is highly improbable that this covering remained in Sivatherium and Bramatherium, whose horns were apparently perfectly naked. It is doubtful whether all these animals can be retained as distinct from the Bovidæ, and I therefore place them in two subfamilies of that family. The Cosorycinæ, which will include Cosoryx and Blastomeryx, are characterized by the sheath of the horns being dermal; the Sivatheriinæ by the absence of any sheath whatever. The synopsis of genera will then be as follows:

1. No horns in the male.

Molars brachyodont..................... ....*Palæomeryx*† Von Meyer.

* Leidy, Cope; Procervulus Gaudry.

† Should *P. eminens*, type of Palæomeryx, have possessed horns, as suspected by Schlosser, the generic name must take the place of Dicrocerus below, and be replaced by one of the various names which apply to hornless species.

II. Horns covered with skin (Cosorycinæ).

Teeth brachyodont; no frontal excrescence............*Blastomeryx* Cope.

Teeth prismatic; no frontal excrescence..................*Cosoryx* Leidy.

III. Horns naked (Sivatheriinæ).

Teeth brachyodont; two pairs of horns, all separate *Sivatherium* Cautl. Falc.

Teeth brachyodont; two pairs of horns; those of the anterior pair from a common base...........................*Bramatherium* Cautl. Falc.

Teeth brachyodont; one pair of horns, from a single base *Hydaspitherium* Lydd.

Teeth brachyodont; one pair of horns, from distinct bases *Dicrocerus* Lart.

IV. Horns covered with a horny sheath; teeth hypsodont (Bovinæ).

α. No internal column of true molars.

β. No lateral ungues. (Nasal bones normal; postzygapophyses single.)

Horn-sheath furcate..................................*Antilocapra* Ord.

Horn-sheath simple..................................*Nanotragus* Sund.

ββ. Lateral ungues present.

γ. Nasal bones separated from maxillary and lachrymal bones.

Horns simple, one pair..*Saga* Gray.

γγ. Nasal bones more or less in contact with lachrymal or maxillary bones.

δ. Posterior postzygapophyses single. (Numerous species not examined.)

ε. Inferior premolars three.

Horns one pair..*Antidorcas* Gray.

εε. Inferior premolars four.

Horns two pair....................................*Tetracerus* H. Smith.

Horns one pair; last inferior molar with four columns..*Neotragus** Gray.

Horns one pair; last inferior molar with five columns.... *Ovis*† H. Smith.

δδ. Posterior postzygapophyses double.

Horns one pair; inf. mol. 3 with five columns..............*Capra* Linn.

αα. One or more superior true molars with a median internal column.

Dorsal postzygapophyses single.......................*Ægocerus*‡ H. Sm.

Dorsal postzygapophyses double............................*Bos*‖ Linn.

A great number of names have been given to groups of species of the Bovinæ, especially within the limits of the genus Ovis of H. Smith. Here the various forms of sheep and antelopes have been distinguished

* *N. saltianus* type. This character is derived from authority to which I cannot now refer. I have not seen it.

† Includes the following supposed genera: Antilope, Gazella, Cervicapra, Oreotragus, Cephalophus, Strepsicerus, Damalis, Alcelaphus, Nemorrhædus, Rapicapra, Caloblepas, Haplocerus, Ovibos, Ovis, and Anoa.

‡ Includes the following supposed genera: Eleotragus, Ægocerus, Oryx, Addax and Portax.

‖ In *Bos americanus* the postzygapophyses are single except on the last lumbar.

as genera and named accordingly. So far as concerns the skeleton, further subdivisions than those indicated in the above table do not appear to exist, and none have been pointed out. The divisions proposed appear to be rather those of one extensive genus. The modifications of the skull have reference to the position of the horns. These are processes of the frontal bones, and are placed at points from above the eye to the posterior angle of the facial plane of the skull. In the latter case this angle approaches very near to the supraoccipital crest or inion, and the parietal bone is reduced to an exceedingly narrow band between the frontal and occipital bones (Rütimeyer).* Forms with anterior horns and well-developed parietal bone are *Ovis gazella* and *Tetracerus quadricornis*, while the *Ovis gnu* displays the parietal extremely reduced, and become chiefly lateral in position. As regards the forms of the horns themselves, they present no important differences, but are angular and revolute in the section Ovis, and cylindric in the division Antilope. In the latter they vary in direction from straight to spiral or curved in different directions. Within the genus Ovis the end of the muzzle is naked or hairy, the latter in the typical forms and in those inhabiting northern and alpine localities generally. Those species that inhabit grassy or desert plains have the end of the nose naked.

Within the genus Bos modifications are observed parallel to those in the genus Ovis. The frontal bones with the horn processes are produced more and more posteriorly until the parietal bones are reduced to a narrow band across the posterior part of the skull. The bisons have the horns most anterior; then follow the buffalos, and the extreme is reached in the true oxen, of which the domesticated animal is the type.

The following table will give an idea of the phylogeny of the Bovidæ :

Sæga Bos Tetracerus Sivatheriinæ Cervidæ

Ovis Antilocapra Dicrocerus

Cosoryx Blastomeryx

Palæomeryx

The hornless Palæomeryx has given origin to the horned Boöidea ; on the one hand to the brachyodont (Blastomeryx, etc.), and on the other to the hypsodonts (Cosoryx, etc.). A cornification of the integument in a fork horned Cosoryx produced Antilocapra, while the same process in a simple-horned Cosoryx produced Ovis. The development of this type has undergone the three principal modifications indicated by the three genera which succeed upwards. In Sæga an extraordinary development of the muzzle takes place, which causes a change in the relations of the nasal bones. In Tetracerus another pair of horns is developed in front of

* Die Rinder der Tertiär-Epoche ; Abh. Schweiz. Pal. Gess., v, 1878.

the usual pair. Bos develops complications of the molar teeth in both jaws.

On the brachyodont side the development of the dermal covering of the horns of Blastomeryx is arrested, and naked horned types follow. In the Sivatheriine group no further change follows except complication of the horns. In the Cervine group, on the contrary, the habit of shedding them becomes fixed, and a new family has its origin.*

Of the CERVIDÆ or the Boöïdea which shed their horns, the genus Cervus is one of the earliest with which we are acquainted. Undoubted species of the genus occur in the Pliocene, and Upper Miocene species are also referred to it. As species from the Lower Pliocene (*C. matheroni* Gerv.) are referred to Capreolus, those of the Miocene may not be true Cervi. Their structure is not sufficiently known to determine this point. The arrangement of the genera is as follows. The three primary divisions were established by Brooke.

I. Lateral metapodials complete only distally, and supporting deer claws (Telemetacarpi).

a. Nasal passages posteriorly two, separated by vomer (Cariaci)

Horns simple spikes.................................... *Coassus* Gray.
Horns more or less furcate.. .... *Cariacus* Gray.
Horns palmate..... .... *Rangifer* H. Smith

aa. Nasal passage posteriorly one, not divided (Capreoli).

No horns.. *Hydropotes* Swinh.
Horns furcate; no postantler.......................... *Capreolus* Gray.
Horns palmate; no postantler.......................... *Alces* H. Smith.
Horns palmate; a postantler........................... *Cervalces* Scott.

II. Lateral metapodials represented by proximal splints only; nasal passage not divided (Plesiometacarpi). (Cervi.)

Frontal cutaneous glands; horns furcate.................. *Cervulus* Blv.
No frontal glands; horns simple.................... *Elaphodus* M. Edw
No frontal glands; horns furcate......................... *Cervus* Linn.
No frontal glands; horns palmate...................... *Dama* H. Smith.
Horns furcate; brow antler greatly exceeding beam, (Gill)
Elaphurus M. Edw.

The phylogeny of these genera cannot be fully known until the skeletons of the extinct genera and species have been obtained. It is, however, certain that the short series of genera included in each of the three divisions (II *a* and *aa*, and III), are genetic series; and also that division I is ancestral to both II and III, although perhaps by an extinct genus differing in some respects from Moschus. These relations can be thus expressed:

* I have described the probable mode of origin of the deciduous horns of the deer in Report U. S. G. Survey, W. of 100th Merid., iv. p. 348, 1877.

Capreoli Cervi

Cariaci

Cosorycinæ

Moschinæ

Or thus:

Rangifer Cervalces Alces Dama

Cariacus Capreolus Cervus Cervul

Coassus Hydropotes Elaphodus

Moschus Blastomeryx

*

Each of the genetic series commences with a genus with no or very simple horns. The next genus or stage presents branched horns, sometimes of great complexity. The last term in each is the palmate horn, where a greater or less number of the tines unite to form a plate. These series, as is well known, correspond with the history of the growth of the horns in successive years of the life of each species.

None of the genera of this family are extinct except Cervalces Scott.

The following series may approximate a correct representation of the phylogeny of the genus Bos, expressed in genera.

Bos Ovis (sens. lat.) Cosoryx	Bovidæ.
Palæomeryx Dremotherium	Moschidæ.
Amphitragulus Gelocus Leptomeryx Dorcatherium	Tragulidæ.
*	
Anthracotherium Cebochœrus	Anthracotheriidæ.
*	
Pantolestes	Pantolestidæ.

In conclusion I would remark the fact that the gradual approaches in character to the Bovidæ by the recent and extinct genera and families, furnishes one of the most admirable illustrations of the law of progressive specialization by evolution known to me.

Note.—Professor Gill has presented in his system of the Mammalia some reasons why the Suidæ should be more exactly defined than I have given above. In the Suinæ and Phaochœrinæ the postglenoid process is wanting or rudimental, and the mandibular condyle is flat and triangular. In the Dicotylinæ and Hippopotaminæ the postglenoid process is well developed and the condyle is subcylindric, as is also the case in Elotherium. I therefore place the two subfamilies named in a family separate from the Suidæ, under the name Hippopotamidæ, to which it is possible that Elotherium should be united as a third subfamily.

Biographical Notice of Isaac Lea, LL.D. By Joseph Leidy, M.D., LL.D.

(Read before the American Philosophical Society, November 18, 1887.)

In accordance with the custom of this Society, which requires that a record shall be made of the claims of its deceased members to remembrance, at the request of our President, I have prepared a brief sketch of one who was distinguished among us, our late much respected fellow-citizen and friend, Isaac Lea, LL.D. A more detailed memoir than the one I offer seemed supererogatory from the fact that only a short time previous to his death, there was published in the Bulletins of the United States National Museum, a volume containing a Biographical Sketch of Mr. Lea, comprising fifty-nine pages; and a Bibliography of his publications with a synopsis of the material therein contained, comprising 278 pages, prepared at the request of the Smithsonian Institution, by Mr. N. P. Scudder. To this source I have conveniently applied for much of the information of my notice.

Isaac Lea was born March 4th, 1792, in Wilmington, Delaware. His grandparents, John and Hannah Lea, came from Gloucestershire, England, and accompanied William Penn in his second visit to this country. They were members of the Society of Friends, among whom they were noted as ministers. The father, James Lea, was a merchant, and at the age of fifteen Isaac went to Philadelphia to engage in a similar pursuit. In 1814, the country being at war with England, Isaac joined a volunteer rifle company, which offered its services to the Governor of the State in case of need. As the services were not required, the company was soon disbanded; but in consequence of Isaac joining it, he lost his birthright in the Society of Friends.

At an early age Isaac showed a love for natural history, in which he was encouraged by his mother, who was herself fond of botany, and interested her children in its study. At an early period also he became acquainted with Lardner Vanuxem, who had similar tastes, and together the young men studied mineralogy and geology, in the pursuit of which they made frequent excursions.

In 1815 Mr. Lea was elected a member of the Academy of Natural Sciences of Philadelphia, which had been founded only three years previously. He subsequently from time to time took an active part in the affairs of the institution; and from his ample pecuniary means he liberally contributed towards its objects in the promotion of natural history. From 1853 to 1858 he occupied the position of President of the Academy. In 1817 he published in the Journal of the Academy the first of his numerous communications on natural history, entitled "An account of the minerals at present known to exist in the vicinity of Philadelphia."

In 1821 Mr. Lea was married to Miss Frances A. Carey, an accomplished lady, the daughter of Mathew Carey, a well-known publisher and a writer on political economy. He also became a member of the firm of M. Carey & Sons, which at that time was the most extensive publishing house in the United States; and he continued with this and the successive firms until he retired from the business in 1851. Mr. Scudder remarks that few men have been more happy in their married life, which reached through fifty-two years, when the death of Mrs. Lea occurred, leaving her greatly afflicted husband together with two sons and a daughter.

In 1828 Mr. Lea was elected a member of the American Philosophical Society, in which for many years he took an active part; for some time serving as one of its Vice-Presidents and as Chairman of the Publication and Finance Committee.

In the spring of 1832, together with his family, he went to Europe and visited England, France and Switzerland; returning the following autumn. In June, 1852, in company with his wife, daughter and sister, he again went to Europe, visited England, France, Germany, Austria and Italy, and returned in November, 1853. In these trips, while taking advantage of the opportunity to examine and study the favorite subjects of his special research in the great museums, he was everywhere received with the most friendly attention by eminent naturalists and others.

In 1852 Harvard University honored Mr. Lea with the title of LL.D. In 1860 he presided at the meeting of the American Association for the Advancement of Science, held at Buffalo, N. Y. As an evidence of his continued interest in all that concerns the cause of natural science, when upwards of ninety-two years of age, at the meeting of the Association and its guests of the British Association in Philadelphia, in September, 1884, he invited the members to visit him at his summer residence at Long Branch, N. J., where he had the pleasure of receiving and entertaining about two hundred.

Mr. Lea, as usual with men of distinction who have made themselves known by their scientific labors, was enrolled as an associate in numerous learned societies abroad and at home.

He reached the advanced age, within a few months, of ninety-five years, retaining to the last his intellect and his interest in his family, in science and everything that had rendered him happy during life. He died December 8th, 1886.

Mr. Lea was an enthusiastic student and an ardent lover of nature, and though like most other people occupied for many of the best years of his life with the exacting cares of business, he always found leisure successfully to pursue his studies and investigations in natural history. He was especially interested in mineralogy, geology and palæontology, but above all delighted in and devoted most time to the study of the fresh-water Mollusca, for which a favorable opportunity was afforded in the fact that the great rivers of this country are particularly rich in these animals and had been but imperfectly explored at the time of his taking up the study.

To all the subjects indicated and to others Mr. Lea has contributed to our knowledge; but to the last one in an eminent degree not excelled by other naturalists. The record of this knowledge is contained in numerous communications, for the most part published in the Transactions of the American Philosophical Society and the Journal of the Academy of Natural Sciences of Philadelphia. Mr. Lea was a most acute and accurate observer and a most painstaking and conscientious investigator. Of the fresh-water and terrestrial Mollusca, Mr. Lea has described upwards of sixteen hundred new species of about fifty genera. The descriptions are given in the most comprehensive manner with exhaustive detail, and are accompanied with admirable illustrations. He was enabled to make this large contribution to our knowledge from the fact that his name became everywhere known as the leading authority in this department of conchology, and collectors in every land eagerly submitted to him all specimens supposed to be new or otherwise of scientific interest which came into their hands.

Of Mr. Lea's labors relating to the extensive family of fresh-water Mollusca, the Unionidæ, Prof. Owen, of England, has expressed himself in the following words: "You have set a noble example of persevering devotion to the elucidation and making known to your fellow-men, of the portion of God's creation selected by your judgment, taste and opportunities for your studies. You will leave a grand and enduring monument of what one man may accomplish under such conditions, and I trust you may enjoy many years cheered by the retrospect of past labors, and by the grateful estimation in which they are held by the naturalists and lovers of science in both hemispheres."

Mr. Lea's chief contributions to geology and palæontology are found in the following works:

Contributions to Geology. 8vo. Philadelphia, 1833; 227 pages and 228 figures. This is one of the earliest and most extensive contributions to a knowledge of the geology and fossils of the Tertiary formations of this country. The work relates to the formations of Alabama, Maryland

and New Jersey, and contains descriptions of two hundred and twenty-eight new species of fossil Mollusca, together with a few other fossils.

Notice of the Oolitic Formation in America, with descriptions of some of its Organic Remains. Published in the Transactions of this Society in 1841. It relates to the formation in New Grenada and Cuba, and contains descriptions and figures of upwards of twenty new species of Ammonites, Trigonia, Terebratula, etc.

On Fossil Footmarks in the Red Sandstone of Pottsville, Pa., published in the Transactions of this Society in 1852. An earlier notice is given in the Proceedings of 1849. In this is described the tracks of an amphibian vertebrate to which Mr. Lea gave the name of *Sauropus primævus*. The fossil was discovered by Mr. Lea in the Red Sandstone of Formation No. 11, below the Coal Measures, of Roger's plan, of the Geological Survey of Pennsylvania. The report of the discovery at the time excited considerable interest among naturalists from the circumstance that the specimen was the earliest evidence of the existence of air-breathing vertebrates.

Description of a Fossil Saurian of the New Red Sandstone Formation of Pennsylvania. Published with illustrations in the Journal of the Academy in 1852. This gives a description of a saurian reptile to which Mr. Lea gave the name of *Clepysaurus pennsylvanicus*, based on some fossil bones discovered at Milford, Lehigh county, Pa., the first at that time found in the Triassic formation of this country.

Mr. Lea took the advantage of his opportunities to make a full collection of the objects of his study and investigation, and this, with the exception of the collection of Tertiary fossils, which was presented to the Academy of Natural Sciences during his life-time, he has bequeathed to the National Museum at Washington, where it will be preserved for the study and admiration of future naturalists.

Stated Meeting, September 2, 1887.

Present, 9 members.

President, Mr. Fraley, in the Chair.

Correspondence was submitted as follows:

Letters of envoy from the Madras Observatory; Physikalisch-Central-Observatorium, St. Petersburg; K. P. Akademie der Wissenschaften, and Physikalische Gesellschaft, Berlin; Académie Royale des Sciences, Lettres et Arts, Modène; Musée Guimet, Paris; Meteorological Office and Statistical Society, London; Harvard College, Cambridge, Mass.; United

States Geological Survey and Smithsonian Institution (Bureau of Ethnology), Washington; Observatorio Meteorologico Central, Mexico; California Academy of Sciences, San Francisco.

Letters of acknowledgment from the Institut Egyptien, Cairo (123, and asking for 86, 87, 88); Natural History Society, Odessa (96–123); Comité Géologique, St. Petersburg (123); Observatoire de Tashkent (96–124); Deutsche Geologische Gesellschaft, Berlin (120–123); Naturwissenschaftlicher Verein, Bremen (121–124); Naturforschende Gesellschaft, Emden (124); Prof. Dr. Paul Albrecht, Hamburg (124); Naturhistorische Gesellschaft, Nürnberg (121–123); Verein für vaterländische Naturkunde in Würtemberg, Stuttgart (117–121); Istituto Veneto d Scienze, Lettere ed Arti, Venezia (114–116); R. Academia de la Historia, Madrid (123, 124); Académie Royale des Sciences de Lisbonne (115, 116, 117); Observatorio Astronomico Nacional Mexicano, Tacubaya (124); Canadian Institute (125); Horatio Hale, Clinton, Canada; Geological Survey of Canada, Ottawa (125); Society of Natural History, Portland, Me. (125); New Hampshire Historical Society, Concord (125); Prof. C. H. Hitchcock, Hanover (125); Boston Athenæum, Society of Natural History, Historical Society, Public Library, American Academy of Arts and Sciences of Massachusetts, Messrs. S. P. Sharples, D. Humphreys Storer, Boston (125); Museum of Comparative Zoölogy, Mr. Robert N. Toppan, Cambridge (125); Free Public Library, New Bedford (125); Dr. Pliny Earle, Mr. Benj. Smith Lyman, Northampton (125); Essex Institute, Salem (125); American Antiquarian Society, Worcester (125); Rhode Island Historical Society, Franklin Society, Providence (125); Connecticut Historical Society, Hartford (125); Yale College Library, Prof. Elias Loomis, New Haven (125); New York State Library, Albany (125); Buffalo Library, Society of Natural Sciences, Buffalo (125); Dr. Edward North, Clinton, N. Y. (125); Profs. T. F. Crane, B. G. Wilder, Ithaca (125); New York Hospital, Astor Library, Historical Society, Columbia College, University of the City of New York, Prof.

John I. Stevenson, Prof. Henry M. Baird, Messrs. James Douglas, John Ericsson, New York (125); Oneida Historical Society, Utica (125); United States Military Academy, West Point (125); Messrs. J. C. Martindale, William John Potts, Camden (125); New Jersey Historical Society, Newark (125); Dr. G. H. Cook, New Brunswick (125); Prof. W. H. Green, Princeton (125); Historical Society of Pennsylvania, College of Pharmacy, Numismatic and Antiquarian Society, College of Physicians, Library Company of Philadelphia, Hon. Wm. D. Kelley, Revs. Geo. D. Boardman, Jesse Y. Burk, H. Clay Trumbull, Drs. F. A. Genth, Wm. H. Greene, G. H. Horn, W. W. Keene, Isaac Norris, Jr., C. Newlin Peirce, Ruschenberger, W. H. Wahl, Profs. John Ashhurst, Jr., F. A. Genth, Jr., S. W. Gross, H. V. Hilprecht, J. P. Lesley, John Marshall, Messrs. W. S. Baker, Edwin A. Barber, John H. Brinton, Isaac Burk, Thos. M. Cleemann, Wm. Morris Davis, Patterson DuBois, H. H. Houston, Wm. W. Jefferis, Francis Jordan, Jr., G. deB. Keim, A. E. Lehman, A. S. Letchworth, Thos. Meehan, C. Stuart Patterson, Robert Patterson, Henry Phillips, Jr., Franklin Platt, Theo. D. Rand, G. B. Roberts, L. A. Scott, Henry D. Wireman, Jos. Zentmayer, Philadelphia (125); Dr Robert H. Alison, Ardmore (125); Prof. Jas. C. Booth, Haverford College (125); Mr. P. F. Rothermel, Linfield (125); Dr. Chas. B. Dudley, Altoona (125); Rev. Jas. A. Murray, Carlisle (125); Rev. Thos. C. Porter, Prof. J. W. Moore, Easton (125); Pennsylvania State Library, Harrisburg (125); Mr. Ario Pardee, Hazleton (125); Mr. John Fulton, Johnstown (125); Linnæan Society, Lancaster (125); Mr. John F. Carll, Pleasantville (125); Messrs. P. W. Sheafer, Heber S. Thompson, Pottsville (125); Dr. F. A. Randall, Warren (125); Hon. Washington Townsend, Mr. Philip P. Sharples, West Chester (125); Wyoming Historical and Geological Society, Wilkes-Barre (125); United States Naval Institute, Annapolis (125); Maryland Institute, Prof. H. B. Adams, Baltimore (125); Smithsonian Institution (91, 93, 104, 125 and two cases of exchanges), United States Geological Survey, Signal Office, Surgeon-General's Office, United States Naval Observatory, Patent

Office, Gen. M. C. Meigs, Drs. J. S. Billings, J. H. C. Coffin, Albert S. Gatschet, Asaph Hall, C. V. Riley, Messrs. Chas. A. Schott, Wm. B. Taylor, Washington, D. C. (125); Virginia Historical Society, Richmond (125); Leander McCormick Observatory, Prof. J. W. Mallet, University of Virginia (125); Elliott Society of Sciences and Art, Charleston (125); Georgia Historical Society, Savannah (125); Prof. E. W. Claypole, Akron, O. (125); Cincinnati Observatory, Society of Natural History, Prof. J. M. Hart, Cincinnati (125); Rev. Henry S. Osborn, Oxford, O. (125); Dr. Robert Peter, Lexington, Ky. (125); Prof. J. L. Campbell, Crawfordsville, Ind. (125); Prof. Daniel Kirkwood, Bloomington, Ind. (125); Chicago Historical Society (125); Rantoul Literary Society (125); Profs. Henry S. Fricze, Alexander Winchell, Ann Arbor, Mich. (125); State Historical Society of Wisconsin, Madison (125); Kansas Historical Society, Topeka (125); University of California, Profs. John and Joseph LeConte, Berkeley (125); California Academy of Sciences, Prof. George Davidson, San Francisco, (125).

The following societies, etc., were at request placed upon the Exchange List to receive the Society's Proceedings from No. 96:

Natural History and Antiquarian Society of Penzance; Physiological Society of Berlin; Royal Library, Brussells; Verein für Erdkunde, Metz; Wagner Free Institute of Science, Philadelphia; Voigtländischer Alterthumsforschender Verein, Hohenleuben, Saxony; Linnean Society of New South Wales, Elizabeth Bay.

A letter was read in relation to a portrait of Humboldt, offered for sale to the Society, and the President was authorized to appoint a committee to ascertain what members are desirous of subscribing to the purchase of same for presentation to the Society.

The Observatorio Meteorologico Magnetico Central, Mexico, requested by letter Proceedings 102, 103, 104, 106, 107, 108, 116; on motion the request was granted.

Letters accepting membership were read from:

Dr. Henry Kiepert, Berlin.

Miss Helen C. de S. Abbott, Philadelphia.
Mr. Joseph S. Harris, Philadelphia.
Mr. William Henry Rawle, Philadelphia.
Prof. Albert H. Smyth, Philadelphia.
Prof. James Tyson, M.D., Philadelphia.
Prof. William Powell Wilson, M.D., Philadelphia.
Mr. Henry D. Wireman, Philadelphia.
Mr. Wm. T. Barnard, Baltimore, Md.

Circulars were presented as follows:

From Dr. A. de Bausset, Chicago, in relation to his proposed aerial polar voyage in June, 1888.

From the Australasian Association for the Advancement of Science, to be held November 10, 1886.

From the Academia Regia Nederlandica enclosing its Programma Certaminis Poeticæ, 1888, with award of prizes.

From the Committee on the Centennial Celebration of the settlement of the Northwest, to be held at Marietta, Ohio, April 7, 1888.

A communication was presented from Dr. Genth, enclosing corrections of some *errata* that had occurred in printing his paper.

Accessions to the Library were reported from the Asiatic Society of Japan, Yokahama; Physikalische Gesellschaft, Deutsche Geologische Gesellschaft, K. P. Akakemie der Wissenschaften, Berlin; Prof. H. Carvill Lewis, Heidelberg; K. Sächsische Gesellschaft der Wissenschaften, Leipzig; Deutsche Gesellschaft für Anthropologie, etc., Geographische Gesellschaft, München; Verein für vaterländische Naturkunde in Würtemberg, Stuttgart; Prof. F. Sandberger, Würzberg; Société Helvétique des Sciences Naturelle, Genève; Société Vandoise des Sciences Naturelle, Lausanne; Académie R. de Copenhagen; K. Zoologisch Botanisch Genootschap, 'S. Gravenhage; Société Malacologique de Belgique, Bruxelles; Académie R. des Sciences, etc., de Modena; Società Toscana di Scienze Naturali, Pisa; R. Comitato Geologico d'Italia, Roma; R. Istituto Veneto di Scienze, etc., Venezia; British Association for the Advancement of Science, Zoölogical Society, London; Penzance Natural History and Antiquarian Society, Plymouth; Royal Dublin Society; South African Philosophical Society, Cape Town; Royal Society of Canada, Montreal; American Oriental Society, Boston; Albany Institute; Meteorological Observatory, Academy of Sciences, American Chemical Society, New York; Franklin Institute, Prof. Edwin J. Houston, Mr. Henry Phillips, Jr., Mr. E. V. d'Invilliers, Philadelphia; United States Geological Survey, United States National Museum, National Academy of Sciences, Dr. Francis Wharton, Washington, D. C.; Wisconsin Historical Society, Madison; Editor of "The American Antiquarian," Chicago; University of California, Berkeley; Deutsche Wissenschaft-Verein zu Santiago de Chili.

Photographs for the Album were received from Prof. Giuseppi Sergi, Rome; Prof. Henry M. Baird, New York; Prof. Edward North, Clinton, N. Y.; Rev. George Dana Boardman, Drs. Isaac Norris, Jr., Wm. Thomson, and Mr. Patterson DuBois, Philadelphia.

The committee to examine the paper on the *Datames Magna*, reported it worthy of publication, and was on motion discharged.

Announcement was made of the deaths of the following members:

Prof. S. F. Baird, Washington, D. C., August 19, 1887, æt. 65.

Charles Rau, Washington, D. C., July 25, 1887, æt. 61.

Jean Victor Duruy, Paris, August, 12, 1887, æt. 76.

Alvan Clark, August 22, 1887, Cambridgeport, Mass., æt. 84.

Rt. Rev. William Bacon Stevens, Philadelphia, June 11, 1888, æt. 73.

Dr. N. A. Randolph, Philadelphia, August 21, 1887, æt 30.

On motion, the President was authorized to appoint suitable persons to prepare the usual obituary notices of Dr. Randolph and Bishop Stevens. [Subsequently the President appointed Rev. Jesse Y. Burk for Bishop Stevens and Dr. Rothrock for Dr. Randolph.]

Communications were presented through the Secretaries as follows:

1. "On Biela's Comet and the Large Meteors of November 27–30," by Prof. Daniel Kirkwood, Bloomington, Ind.

2. "On the Systematic Position of the Mallophaga," by Prof. A. S. Packard, Providence, R. I.

3. "Preliminary Report on the Vertebrate Fossils of the Uinta Formation Collected by the Princeton Expedition of 1886," by Profs. W. B. Scott and Henry F. Osborn, Princeton, N. J.

Dr. D. G. Brinton read a paper entitled "Were the Toltecs an Historic Nationality?"

Pending nominations Nos. 1156, 1159, 1164, 1169 and 1170 were read.

The President reported that he had received and paid over to the Treasurer $132.11, the July interest from the Michaux legacy.

Mr. Price offered the following resolutions, which were unanimously adopted:

Resolved, That J. Sergeant Price, Treasurer, be authorized to assign and transfer unto the Board of Reconstruction Trustees of the Philadelphia & Reading Railroad Co., and The Philadelphia & Reading Coal and Iron Co., the loans of The Schuylkill Navigation Co., belonging to the American Philosophical Society and to the Trustees of the Building Fund of the American Philosophical Society, in accordance with the terms and conditions of the proposition of June 22, 1887.

Resolved, That the Treasurer be and he is hereby authorized to receive payment of one thousand dollars, of the loans of the City of Philadelphia, now standing in the name of the Society, and belonging to this Society, and maturing July 1, 1887.

And the meeting was adjourned by the President.

Stated Meeting, September 16, 1887.

Present, 5 members.

President, Mr. FRALEY, in the Chair.

Letters of envoy from Société de Littérature Finnoise, Helsingfors; Voigtländischen Alterthumsforschenden Vereins, Hohenleuben; K. Sächsische Gesellschaft der Wissenschaften, Leipzig; Statistical Society, London; California Academy of Sciences, San Francisco; Observatorio Meteorológico Central, Mexico; Observatorio Nacional Argentino, Cordoba.

Accessions to the Library were reported from the Société de Littérature Finnoise, Helsingfors; Société Impériale des Naturalistes, Moscow; Comité Geologique, Académie Impériale des Sciences, St. Petersburg; Prof. G. vom Rath, Bonn; Gartenbauverein, Darmstadt; Senckenbergische Naturforschende Gesellschaft, Frankfurt a. M.; Voigtländischer Alterthumsforschender Verein, Hohenleuben; Zoologischer Anzeiger, Leipzig; Verein für Erdkunde, Metz; Académie R. de Belgique, Bruxelles; R. Accadémia dei Lincei, Rome; Société de L'Enseignement Supérieur, Paris; Philosophical and Literary Society, Leeds; Royal Cornwall Polytechnic Society, Falmouth; Royal Society, Royal Statistical, Geological, Astronomical, Meteorological Societies, Society of Antiquaries, Linnean Society, London; American Philological Association, Boston; American Antiquarian Society, Worcester; "American Journal of Science," New Haven; Historical Society, College of Pharmacy, Library Company, Publishers of "The American Naturalist," P. H. Law, Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Publishers of "American Chemical Journal," "American Journal of Philology," Baltimore; United States Naval Institute, Annapolis; Bureau of the Mint, Bureau of Labor, United States Geological Survey, Smithsonian Institution, Washington, D. C.; California Academy of Sciences, San Francisco; Publishers of "Boletin de Estadistica del Puebla."

A letter was read from the Academy of Fine Arts, requesting the loan of portraits for its approaching exhibition.

On motion, it was

Resolved, That the Curators be empowered to loan to the Academy of Fine Arts, such paintings as it may desire for its *Exhibition of Historical Portraits,* taking proper guarantees for the safe keeping and safe return of the same.

A paper was presented, through the Secretaries, by Dr. A. C. Stokes, of Trenton, N. J., on some "New Fresh Water Infusoria."

Pending nominations Nos. 1156, 1159, 1164, 1169 and 1170 were read.

A communication from the Committee on Library, on the subject of modernizing the Library, was presented, and, on motion of Mr. Law, it was resolved, that the Committee on Finance be requested to incorporate into its estimates for the coming fiscal year an appropriation of five hundred dollars, to be expended in the purchase of modern works of reference and value.

On motion of Dr. Ruschenberger, the Society ordered that the building of the Society should be kept locked on September 16, 1887, to avoid danger to the property of the Society from the vast crowds likely to be assembled in Independence Square to witness the closing exercises of the Centennial Celebration of the Adoption of the Federal Constitution.

The President reported that he had appointed as the Committee on the Purchase of the Humboldt Portrait, Messrs. Philip C. Garrett, D. G. Brinton and Horace Jayne.

On motion of Mr. Phillips, the Society requested the President to prepare for the Records of the Society a minute that should commemorate the celebration that had taken place in Philadelphia, on September 15, 16, 17, 1887, of the Centennial of the Adoption of the Federal Constitution.

And the Society was adjourned by the President.

Stated Meeting, October 7, 1887.

Present, 20 members.

Vice-President, Dr. RUSCHENBERGER, in the Chair.

Dr. Tyson and Mr. Harris, newly elected members, were presented to the Chair and took their seats.

Correspondence was submitted as follows:

Letter of envoy from L'Académie R. des Sciences, Amsterdam.

Letters of acknowledgment from L'Académie R. des Sciences, Amsterdam (122, 123); Royal Society, Royal Institution, Linnæan, Royal Meteorological, Chemical, Geological Societies, London; Geological and Natural History Survey, Ottawa, Canada; Prof. O. C. Marsh, New Haven, Conn.; Prof. C. A. Young, Princeton, N. J.; Prof. C. H. F. Peters, Clinton, N. Y.; Vassar Brothers' Institute, Poughkeepsie, N. Y.; Rev F. A. Muhlenberg, Philadelphia; Profs. Lyman B. Hall, Isaac Sharpless, Haverford, Pa.; Lackawanna Institute, Scranton, Pa.; Prof. M. H. Boyè, Coopersburg, Va.; Mr. Horatio Hale, Clinton, Ontario, Canada; Mr. Everard F. im Thurn, Pomeroon River, British Guiana (125).

Accessions to the Library were received from Government Botanic Garden, Adelaide; Prof. Clemens Winkler, Leipzig; Publishers of "Der Naturforscher," Tübingen; K. Akademie van Wetenschappen, Amsterdam; Sociètè Hollandaise des Sciences, Harlem; Osservatorio di Torino; Sociedade de Geographia, Lisboa; British Government, Meteorological Office, London; Prof. Joseph Prestwich, Oxford; Prof. H. Carvill Lewis, Manchester, Eng.; Natural History Society, Montreal, Canada; Brooklyn Entomological Society; New Jersey Historical Society, Newark; University of Pennsylvania, D. G. Brinton, William Pepper, Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Baltimore; United States Fish Commission, Department of State, War Department, Hydrographic Office U.S.N., Public Opinion Co., Washington, D.C.; Leander McCormick Observatory, University of Virginia; Col. Charles C. Jones, Jr., Augusta, Ga.

A photograph for the Society's Album was received from Dr. C. A. Oliver.

Prof. Cope presented a communication for the Proceedings upon the "Classification and Phylogeny of the Artiodactyla."

The Secretaries presented two communications from Mr. Samuel Garman (Cambridge, Mass.), on the "Reptiles and Batrachians of Grand Cayman" and on "West Indian Reptiles in the Museum of Comparative Zoölogy (Cambridge, Mass.)."

Pending nominations No. 1156, 1159, 1164, 1169 and 1170 were read.

A communication was read from the Committee on Library, in reference to the operation of the resolution of the Society, of January 7, 1887, and on motion of Dr. Horn, the Society resolved that the resolution of request of January 7, 1887, should be rescinded.

Mr. Ames suggested that in the absence of papers intended for the Proceedings or for the Transactions, the meetings of the Society should be enlivened and enriched by unwritten communications; that members should report the best results of their reading and reflections on subjects of science and philosophy.

Mr. Fraley, in reply to a question, described the social and conversational features of the Society's meetings after adjournment in earlier times.

Mr. Ames made reference to the recent address of the President of the British Geological Society, on "The Relations of Mind and Matter," after which a discussion ensued, participated in by Messrs. C. G. Ames, Philip H. Law and Prof. E. D. Cope.

And the Society was adjourned by the President.

Stated Meeting, October 21, 1887.

Present, 26 members.

President, Mr. FRALEY, in the Chair.

Prof. Smyth, a lately elected member, was presented to the Chair and took his seat.

Correspondence was submitted as follows:

A letter, dated September 10, 1887, from the Geographical Society of Lisbon, announcing the death of its President, M. d'Aguiar.

Letters from Prof. Joseph Prestwich and Sir Richard Owen, giving change of address.

A letter from the New York Academy of Medicine, asking exchange of publications, which on motion was granted.

A letter of envoy from the Meteorological Office, London, Eng.

Letters of acknowledgment from R. Saxon Society of Science, Leipzig (125); Philosophical Society, University Library, Cambridge, Eng. (125); Yorkshire Geological and Polytechnic Society, Halifax, Eng. (125); Royal Statistical, Society of Arts, London, Eng. (125); Zoölogical Society of London (122–125); William Crooks, Sir Richard Owen, London, Eng. (125); Sir Henry W. Acland, Oxford, Eng. (125); Society of Antiquaries of London (125); Royal Dublin Society (125); Prof. W. P. Wilson, Philadelphia (125); Col. Garrick Mallery, Washington, D. C. (125).

Accessions to the Library were received from the Linnæan Society of New South Wales, Sydney; New Zealand Institute, Wellington; Serge Nikitin, St. Petersburg; K. K. Universitäts Sternwarte, Prag; Gesellschaft für Anthropologie, Ethnologie, etc., Berlin; G. vom Rath, Bonn; Silesian Botanical Exchange Society, Planegg; K. Nordiske Oldskrift Selskab, Copenhagen; Biblioteca Nazionale Vittorio Emanuele, Rome; Société de Géographie, Paris; Meteorological Council, Cobden Club, London; American Academy of Arts and

Sciences, Boston; H. W. Conn, Middleton, Conn.; New York Academy of Sciences; Irish Benevolent Union of the United States, Rev. Charles G. Ames, Dr. Frazer, Martin I. J. Griffin, Philadelphia; Johns Hopkins University, Baltimore; University of California, Sacramento.

Pursuant to appointment, Mr. Philip C. Garrett read an obituary notice of the late Pliny Earle Chase, LL.D., a Vice-President of the Society.

This being the stated meeting for the balloting for candidates for membership, an election was held and the following persons were declared to have been duly elected members of the Society:

No. 2145. Prof. Guisèppe Menenghini, Pisà, Italy.

No. 2146. Prof. Edgar F. Smith, Springfield, Ohio.

A paper was presented, through Vice-President Ruschenberger, for the Proceedings, by Alfred B. Taylor, on "Octonary Numeration and its Application to a System of Weights and Measures."

Prof. Cope made some remarks on the "Phylogeny and Classification of the Artiodactyla;" after which Dr. J. Cheston Morris spoke of the remarkable resemblance between Devonshire sheep and goats; that both ewes and bucks had horns, and like the goat they had more than one period of reproduction in the year; that they seemed to be something between sheep and goats.

The President reported that he had received and paid over to the Treasurer the sum of $131.80, being the interest on the Michaux legacy, due October 1, 1887.

On motion of Prof. Snyder, the President was authorized to appoint a committee of three members to inquire into the scientific value of the newly invented language, *Volapük*, and to report thereon to the Society. [The President subsequently appointed Messrs. D. G. Brinton, Henry Phillips, Jr., and Monroe B. Snyder as the Committee.]

And the Society was adjourned by the President.

Stated Meeting, November 4, 1887.

Present, 16 members.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows:

Letters of envoy from the Meteorological office, London; New York Academy of Medicine; New York State Library.

Letters of acknowledgment from the K. K. Sternwarte in Prag (124); Anthropologische Gesellschaft, Berlin (125); Dr. Paul Albrecht, Hamburg (125); Société d'Émulation, Abbeville (125); Société de Borda, Dax (125); Professor Geikie, Edinburg (125); New York Academy of Medicine (96–125); Franklin Institute (Laws and Regulations), Mr. Charles Bullock, Philadelphia (125); Kansas Academy of Science, Topeka (125).

A photograph for the Society's Album was received from Sir Lowthian Bell, Bart., Newcastle-on-Tyne.

Accessions to the Library were received from the K. K. Geologische Reichsanstalt, K. K. Zoologisch-botanische Gesellschaft, Wien; Gesellschaft für Erdkunde, Berlin; Naturwissenschaft Gesellschaft "Isis" in Dresden; Naturforschende Gesellschaft, Emden; Naturforschende Gesellschaft, Freiburg, i. B.; Oberhessische Gesellschaft für Natur- und Heilkunde, Geissen; Oberlausitzische Gesellschaft der Wissenschaften, Görlitz; Physikalisch-Oekonomische Gesellschaft, Königsberg; Société Historique Littéraire, Artistique et Scientifique du Cher; University Library, Cambridge, Eng.; Canadian Institute, Toronto; Museum of Comparative Zoölogy, Cambridge, Mass.; Boston Society of Natural History; Academy of Medicine, State Library, Mr. Theodore Sutro, New York; Geological Survey of New Jersey, Trenton; Mercantile Library, Dr. C. M. Cresson, Mr. Henry Phillips, Jr., Philadelphia; Historical Society of Delaware, Wilmington; Society of Natural History, Cincinnati; University of California, Berkeley.

The deaths of the following members were announced:

Gustav Kirchhoff, Berlin, October 17, 1887, æt. 63.

Thomas M. Walter, Ph.D., LL.D., Philadelphia, October 30, 1887, æt. 83.

Alfred Mordecai, Philadelphia, October 23, 1887, æt. 84.

And on motion, the President was authorized to appoint suitable persons to prepare the usual obituary notices of Messrs. Walter and Mordecai. [Subsequently the President appointed Dr. Hays for Major Mordecai and Dr. Rothrock for Dr. Randolph.]

Dr. Brinton read a paper on the "so-called" *Alaguilac* language of Guatemala.

Prof. Cope made an oral communication on the mechanical causes of the structure of teeth in certain mammalia groups.

New nomination 1171 was read.

The Society authorized the President, Secretary and Treasurer to receipt for the legacy of $2000 from the estate of Henry Seybert, deceased, now ready to be paid over.

The Committee on the Purchase of the Humboldt Portrait reported progress.

An invitation to attend the lecture on "Rapid Transit in Cities," by Prof. Haupt, at the Franklin Institute, on Friday, November 11, 1887, was given to the Society.

And the Society was adjourned by the President.

Stated Meeting November 18, 1887.

Present, 31 members.

President FRALEY in the Chair.

Messrs. W. F. Norris and G. DeBenneville Keim took their seats.

Correspondence was submitted as follows: A letter from Prof. Edgar F. Smith, of Springfield, Ohio, accepting membership.

A circular from the New York Academy of Sciences, asking contributions to a memorial monument to John James Audubon, to be erected in the city of New York.

Letters from the Geographische Gesellschaft, Munich, and also one from the Colorado Scientific Society, of Denver, requesting exchanges, which requests, on motion, were granted.

Letters of envoy from the Royal Statistical Society and Meteorological Office, London.

Letters of acknowledgment from the Royal Society of New South Wales (123); K. K. Central-Anstalt für Meteorologie und Erdmagnetismus, Wien (125); Naturforschende Gesellschaft, Emden (125); Prof. Adolph Bastian (125), and Meteorologisches Institut, Berlin (117–125, etc.); Prof. G. vom Rath, Bonn (125); Naturwissenschaftlicher Verein zu Bremen (125); K. Sternwarte, Munich (125); Société Historique Littérataire, etc., du Cher (125); Société Geologique de France, Victor Duruy and Prof. Abel Hovelacque, Paris (125); Mr. L. A. Scott, Philadelphia (125 and all previous numbers).

Accessions to the Library were reported from the Geographische Gesellschaft in München; Prof. Henri de Saussure, Genève; Prof. G. Sergi, Rome; R. Academia de la Historia, Madrid; Meteorological Council, R. Statistical Society, Sir Lowthian Bell, London; Historical Society, Commission of the State Reservation at Niagara, Buffalo; Prof. J. S. Newberry and publishers of "The Cosmopolitan," New York; Publishers of "The Medical and Surgical Reporter," and Mr. Henry Phillips, Jr., Philadelphia; Bureau of Education, Washington, D. C.; Washburn College, Kansas State Society, Topeka; Colorado Scientific Society, Denver; Observatorio Astronomico Nacional de Tacubaya, Mexico; República Argentina, America del Sud-Buenos Aires.

A photograph of Prof. F. Max Müller, of Oxford, was presented by himself for the Album of the Society.

An obituary notice of the late Isaac Lea, LL.D., by Prof. Joseph Leidy, was read.

The Proceedings of the Officers and Council were submitted, and the Clerk of the Council transmitted the Report of the

Special Committee appointed by the Society on May 20, 1887, to examine into the merits of a communication for the Magellanic Premium, signed "*Magellan*," upon "The Physical Phenomena of Harbor Entrances; Their Causes and Remedies; Defects of present Methods of Improvement," and with the same the statement that the Council approved of the recommendation that the Magellanic Premium should be awarded therefor.

A paper entitled "Notes on the Ethnology of British Columbia," by Dr. F. Boas, was presented through the Secretaries.

Dr. Brinton read a paper on "An Ancient Human Footprint from Nicaragua," of which he exhibited a specimen, and in the discussion that ensued Prof. Heilprin stated that in his opinion the deposit in which it occurred was not of the Eocene period, but was Post-pliocene.

Prof. E. F. Smith (Springfield, Ohio) presented (through the Secretaries) a paper on "Electrolysis of Lead Solutions."

Pending nomination No. 1171 and new nomination No. 1172 were read.

Prof. Edwin J. Houston made the following oral communications:

On a Non-Magnetizable Watch.

C. A. Paillard, of Geneva, Switzerland, after some fourteen years' experimentation, has succeeded in producing a watch that is entirely destitute of any magnetizable material.

The rapid growth of electric lighting and electric railways renders the magnetization of watches a matter of frequent occurrence, and the injury to the accuracy of time-pieces occasioned by inadvertently entering the magnetic field of the dynamo-electric machines, or motors producing the current, is well known.

Heretofore a magnetic shield, consisting essentially of an iron-encasing box, has been employed to protect the works of the watch against the influence of an external magnetic field. Such shields are, for the greater part, clumsy and heavy.

Mr. Paillard's invention effects the protection of the watch in a much more thorough manner, and does so without rendering it any heavier.

It will be seen that the problem Mr. Paillard set himself to solve, was to produce an alloy or metallic substance that possesses the following properties, viz :

1st. It must be non-magnetic.

2d. It must resist rusting and oxidation.

3d. It must be permanently elastic.

These properties he has obtained in an alloy of palladium.

By the combination of two alloys containing different quantities of palladium, Mr. Paillard has succeeded in obtaining accurate compensation for changes of temperature in the balance wheels of his watches.

On the Gramophone.

Mr. Emil Berliner, of Washington, D. C., has recently made improvements in the speaking phonograph that, it would seem, will probably bring this instrument into every-day commercial use. These inventions are of such a character as, possibly, to a great extent, to render phonography, or short-hand reporting, one of the lost arts.

There have been two causes for the failure of Mr. Edison's phonograph to come into extensive use. These are briefly :

1st. The perishable nature of the phonogram record, which, being made on a sheet of tin-foil, was capable of reproducing the original sound a limited number of times only.

2d. The inability of the phonograph, as originally constructed, to correctly reproduce the sounds spoken into it. The pitch or tone was correctly reproduced, provided the point attached to the diaphragm of the receiving instrument was moved over the phonogram-record at the same velocity that it had while in the receiving instrument. The quality of the tone, on the preservation of which the ability to distinguish the speaker's voice depends, could not, however, be obtained to the extent a practical instrument demands. This arises not only from the fact that the original instrument failed to correctly impress on the phonogram-record the relative intensities of the over-tones, on which the quality depends, but also on the fact that the receiving instrument was unable, from the relative positions these impressions bore to the surface of the phonogram-record, to always correctly reproduee them.

These difficulties Mr. Berliner has, to a very great extent, overcome in an instrument called by him the gramophone.

The direction in which these improvements have been made is mainly in the manner in which the receiving diaphragm of the instrument is caused to leave an impression of its movements on the phonogram-record. In the Berliner instrument, unlike the original Edison instrument, the to-and-fro movements of the diaphragm are received by the plate in a direction parallel to its surface, and not in a direction at right angles thereto. By this change the movements are recoided as a sinuous line of even depth, instead of a sinuous line of varying depths.

It results from this difference that the resistance offered by the plate to the free movements of the transmitting diaphragm is reduced to a minimum, thus permitting much greater accuracy of the record received. At the same time the point attached to the receiving diaphragm has a positive motion in both directions, and can thus more correctly reproduce the characteristic quality of the spoken words.

In any phonogram record made in a direction at right angles to the record surface, the fact that the resistance to impression does not increase in the same proportion as the depth of the impression will prevent the record from agreeing closely with the original tones. Loud tones must therefore fail to impress their characteristic quality on the phonogram-record, as correctly as more feeble tones.

Mr. Berliner prepares his receiving surface as follows : A plate of glass is covered with a layer of printers' ink, and then held in the smoky flame of a coal oil lamp and covered with a uniform layer of soot. On the surface thus prepared the stylus or point attached to the transmitting diaphragm, makes its record of a uniform depth. It then only remains to fix the record so obtained. This is accomplished by the simple expedient of flowing the plate with any ordinary quick drying varnish. From this plate the sound can be directly reproduced, or a copy of it can be made on any desired metal.

There are three ways in which the reproduction may be made, viz :

1st. By the simple process of mechanical engraving.

2d. By chemical deposition.

3d. By photo-engraving.

This latter process is preferred by the inventor, the chromo-gelatine process being generally adopted.

The Committee on the Michaux Legacy presented a report, accompanied by the following resolution, which was, on motion, adopted:

"*Resolved,* That the sum of $200 be expended under the supervision of the Michaux Committee, for the expenses of lectures of Prof. Rothrock, to be delivered in the Chapel of the University of Pennsylvania."

The committee appointed October 21, 1887, to examine into the scientific value of the newly invented language, Volapük, and to report thereon, presented its report, which, after discussion, was, on motion of Mr. Winsor, made the special order for the next meeting of the Society, and the Secretaries were requested to have it printed and distributed among the resident members for inspection.

And the Society was adjourned by the President.

Notes on the Ethnology of British Columbia. By Dr. F. Boas.

(Read before the American Philosophical Society, November 18, 1887.)

Note.—The Indian words are spelled according to the system used by the Bureau of Ethnology : q is the German ch in Bach ; c is the English sh.

In the following remarks I intend to give a brief summary of the results of my journey in British Columbia. The principal purpose of my researches was to study the distribution of the native tribes, their ethnological character, and their languages. I arrived in Victoria in September, 1886, and spent most of my time among the natives of the east coast of Vancouver island and of the mainland opposite ; but in the course of my journeys I came in contact with several individuals of the Tlingit, Tsimpshian, and Bilqula tribes, and I studied particularly the language of the last, of which I had obtained a slight knowledge from a number of men who were brought by Captain A. Jacobsen to Berlin. Among the linguistic results of my journey the most interesting are the discovery of three unknown dialects of the Salish stock and the establishment of the fact that the Bilqula, who are of Salish lineage, must have lived at one time with other Salish tribes near the sea.

Though the culture of these tribes seems very uniform, closer inquiry shows that they may be divided into four groups—the northern one comprising the Tlingit, Haida, and Tsimpshian ; the central comprising the Kwakiutl and Bilqula ; the southern comprising the different tribes of the Coast Salish ; and the tribes of the west coast of Vancouver island. All these tribes are divided into gentes ; but, while among the northern tribes, the child belongs to the gens of the mother, among the southern ones it belongs to that of the father. The arts, industries, folk-lore, and other ethnological phenomena of these groups are also different, and the groups have evidently influenced one another.

I shall first show some of these differences by considering the folk-lore of a few of these tribes.

The principal legend of the Tlingit is the well-known raven myth. It is not necessary to dwell upon this myth, as it is known by the reports of many travelers. Vemianow, who lived for a long time among the Tlingit, considers the raven as their supreme deity. It appears from the myths which I collected that besides the raven the eagle is of great importance. One of the legends tells how the raven obtained the fresh water from a mighty chief called Kanuk. This Kanuk is identical with the eagle. Traces of the raven legend are found among all tribes as far south as Komoks. The Kwakiutl consider the raven the creator of the sun, moon, and stars.

The raven legend is not found among the Salish tribes ; their supreme deity is the sun, who is called by the Skqómic the great wandering chief, and a great number of myths refer to him. Among the northern tribes of this group and among the Kwakiutl the identity of the sun and the deity is not so clear; they call the latter Kants'oump (that is, "our father"), or Ata ("the one above"), or Kíkamē ("the chief"). His son, Kanikila, descended from heaven to the earth, and was born again of a woman. When he was grown up, he traveled all over the world, transforming men into animals, and making friends with many chiefs. The same legend is known to the Salish and the West Vancouver tribes. The Komoks call the deity Kumsnootl (that is, "our elder brother"); the Kauitcin, Qäls; the West Vancouver tribes, Alis. He is their culture-hero. In the southern part of Vancouver island it is said that he gave men the fire. The Kwakiutl say that he created the salmon, and gave the law of the winter dance.

These two traditions—the raven legend and the legend of the sun and the son of the deity—are mixed in numerous tribes, particularly among the Kwakiutl. The Bilqula, on the other hand, have both these legends, but a third one in addition. They say that four men—Yulátimot, Masmasalániq, Matlapálitsek, Matlapéeqoek—descended from heaven after the raven had liberated the sun. Then the tradition goes on: And Yulátimot thought, "Oh, might Masmasalániq carve men out of cedar!" and Masmasalániq carved men; and Yulátimot thought, "Oh, might Masmasalániq make a canoe!" and Masmasalániq made a canoe, etc. Yulátimot gives Masmasalániq his thoughts, and Masmasalániq accomplishes them. Thus these two spirits created men and gave them their arts. It is remarkable, however, that by some individuals Yulátimot is described as the raven himself, and he is represented in this way in masks, paintings, and carvings.

From these few remarks it will appear that the mythology of each tribe can only be understood by studying it in connection with that of his neighbors.

Certain mythological ideas, however, are common to all tribes of the north-west coast. The myth of the creation of the world is very uniform among all tribes. The northern group say that in the beginning it was dark until the Raven liberated the sun. The southern tribes say that there was a sun from the beginning, but that daylight was kept in a box by the chief of the sun, and that it was liberated by the Raven. After it had become light, the earth, trees, fire, and water were made. It is remarkable that all these were obtained from some chief who retained them for his own use. Nothing was created. Thus the earth was prepared for man, who descended in the shape of birds from heaven. When they arrived on the earth, the birds threw off their skins and became men. These became the ancestors of the gentes, and each of them received a certain tract of land when the great transformer, Kanikila, met him. Subdivisions of the gentes derive their origin from one of the descendants of these first men. It is told, that in olden times certain men descended into the sea, or went up the mountains, where they met with some kind of spirit, who gave them his emblems. Thus they became the ancestors of subgentes.

Before Kanikila's arrival, animals had the shape of men ; but even after they were transformed they were able to appear in the shape of men by taking off their blankets. The northern tribes who do not know the great transformer, say that men were transformed into animals at the time of the great flood.

All tribes consider the sky a solid vault, which can be reached in the far west. After having crawled through a hole in the sky, another land is found, with forests, mountains, ponds, and lakes, in which the Sun and many other spirits live. There is another very remarkable way of reaching this land. The man who intends to go there takes his bow and shoots one arrow into the sky ; then he shoots another one, which sticks in the lower end of the first one ; and so he goes on shooting until a chain is formed reaching from heaven to earth. I believe that this tradition belonged originally to the tribes of the Salish stock. The Okanagan myth told by Gatschet in Globus, 1887, Vol. 52, No. 9, belongs to this group of legends. It is told in a great number of modifications among the tribes of Vancouver island and the neighboring coast. One of the most important of these is : How the Mink, the son of the Sun, visited his father. This tradition is told by the Kwakiutl and Bilqula. Mink made a chain of arrows reaching to the sky, and climbed up. When he arrived in heaven he found his father, an old man, sitting near the fire. The father was glad to see him, and asked him to carry the sun in his stead. Mink complied with this request, and next morning his father gave him his nose ornament, the sun, and said to him, "Do not go too fast, and don't stoop down, else you will burn the earth." Mink promised to obey, and ascended slowly his path ; but when it was near noon, clouds obstructed his way. He got impatient, and wanted to see what was going on, on the earth. He began to jump and to run and stoop down ; then the earth began to burn, the rocks to crack, and the ocean to boil. When Mink's father saw that his son disobeyed his orders, he pursued him, tore him to pieces, and cast him into the ocean. There he was found by two women.

Another interesting tradition is told by the Komoks, which in some respects resembles a well-known myth of the Tlingit. In olden times the gum was a blind man. He used to go out fishing during the night, and early in the morning his wife called him back. One day, however, she slept too long, and when she came down to the shore the sun was high up in the sky. She called her husband, but before he could return he had melted. His sons wanted to revenge his death, and made a chain of arrows reaching from heaven to earth. They climbed up and killed the Sun with their arrows. Then the elder brother asked the younger one, "What do you intend to do?" He said, "I will become the moon ;" the elder one said, "And I will become the sun."

Another remarkable tradition is told by the same tribe. The son of the Sun ascended a chain of arrows into heaven, and married Tlaiq's daughter. Tlaiq tried to kill his son-in-law, but did not succeed in his attempts. The latter, in revenge, killed Tlaiq. I consider the last-mentioned traditions of great importance, as both evidently refer to the killing of the old sun and the origin of the new one.

Visits to the Sun, or to the deity which lives in heaven, are frequent in the folk-lore of all these tribes. The Kwakiutl, for instance, tell of a chief's son who ascended to heaven and married the deity's daughter. Their son was the Raven.

The fact that the same mythical beings are known to a great number of tribes shows that the folk-lore and myths of the tribes of the north-west coast have spread from one tribe to another. The raven legend seems to have belonged to the Tlingit and their neighbors, but traces of it are found far south. On the other hand, the sun legend seems to have originated with tribes of Salish lineage; but parts of this tradition are at the present time told by their northern neighbors, and faint traces are even found among the Tsimpshian and the Tlingit.

A number of spirits occur in the folk-lore of most of the tribes of Northwest America. One of these is the Tsonokoa, who is evidently a mythical form of the grizzly bear. She is a woman living on high mountains, or, in some instances, in heaven. She visits the villages in order to steal fish, which she puts into a basket that she carries on her back. One tradition says that a man wounded and pursued her. At last he arrived at her house in heaven. He was called in in order to cure her, and did so by extricating the arrows, which none of her companions were able to see. In reward she gave him her daughter, the water of life, and the fire of death, and on his return he became a mighty chief. Another spirit, which is known from Komoks to Bilqula, is Komokoa, a water-spirit, the father of the seals. Many legends tell of men who visited him, or of his visits to villages where he married a woman and became the ancestor of certain gentes. The Sisiutl, a double-headed snake, is known to all tribes from Puget Sound and Cape Flattery to the northern tribes of the Kwakiutl. It is the emblem of many gentes, and its most remarkable quality is that it can assume the shape of any fish or snake.

I have to say a few words about the dances, particularly the cannibal dances, of these tribes. The legend ascribes the origin of the latter to a spirit, Baqbakualanusiuaē. This being lived in the forest. Once a man came to visit him, and when the spirit was about to devour him, he made his escape, Baqbakualanusiuaē pursuing him. When the spirit had almost reached him, he threw a stone behind him, which was transformed into a large mountain. The pursuer had to go all around it, but again he approached. Then he poured out a little fish-oil which he chanced to carry. It was transformed into a lake. Again the spirit approached, and now he threw down his comb, which was transformed into a forest of young trees. He reached his house, and locked the door. When the spirit arrived, he gave him a vessel filled with dog's blood, and said, "Come in. This is my son's blood. You may eat him." But when the spirit accepted the invitation, he threw him into a pit, which he filled with fire, and thus killed him. His ashes were transformed into mosquitoes.

Besides this spirit, the crane, and the so-called "Hámaa," can become the genii of the cannibals. The right to become cannibal is hereditary in certain gentes, but every individual has to acquire it by being initiated. For this purpose he goes into the woods, where he lives for three or four months. After this time, he approaches the village, whistling and singing; then the people know that he has become a cannibal (Hámats'a). The next morning they go into the woods in order to fetch him back. They sit down in a square and sing four new songs which are composed for the occasion. The first song has a slow movement, the second is in a five-part measure, while the third and fourth have a quick movement. As soon as these are sung, the new Hâmats'a makes his appearance. He is surrounded by ten men, who carry rattles, and is accompanied by them to the village. All those partaking in the ceremony wear head-rings and neck-rings made of hemlock branches. Four nights the new Hámats'a dances in the house of his father. On the fourth night he suddenly leaves the house, and after a short time returns, carrying a corpse. As soon as the old cannibals see this, they rush forward and cut the corpse to pieces, which they devour. This custom is principally practiced among all tribes of Kwakiutl lineage; but it is also found among the Bilqula and Komoks, who have evidently adopted it from the Kwakiutl. Similar customs prevail among the Tsimpshian. G. M. Dawson says that they have four different systems of rites of religious character, which he calls Simhalait, Mihla, Noohlem, and Hoppop. The third of these are dog-eaters, while the last are the cannibals.

According to my inquiries, this refers to the following tradition: A man went out hunting. After some time he saw a white bear, and pursued it until it disappeared in a mountain. The hunter followed him, and saw that it was transformed into a man, who led him through his house, which stood in the interior of the mountain. There he saw four groups of men, and what they were doing. The first were the Mēítla, the second were the Nootlam ("dog-eaters"), the third were the Wihalait ("the cannibals"), and the fourth were the Semhalaidet. Four days the man staid in the house. Then he returned; but when he came to his village, he found that he had staid in the mountain four years. The bear had told him to do as he had seen the men in the mountain doing. Since that time the Tsimpshian eat dogs and bite men. There are no reports that cannibal ceremonies exist among the Haida and Tlingit.

The masks which all these tribes use in their dances represent spirits or some of the heroes of their legends. Most of the winter dances are pantomimical performances of their traditions. At the great feasts other masks are used, which refer to the tradition of the gens of the man who gives the feast. The use of masks is most extensive among the northern tribes. The variety of masks of the Haida, Tlingit, Tsimpshian, and Kwakiutl, is wonderful, but the more southern tribes have only a very limited number. Among the Nanaimo their use is the privilege of certain gentes. The Lkungen of Victoria use only very few masks, which they destroy by fire as soon as a death occurs in their tribe.

Besides the dances and the use of masks, other customs are common to all tribes of the north-west coast. One of the principal of these is the use of copper-plates. These have frequently been described as being used instead of money, but this is not the case. They are manufactured from copper found on the upper Yukon, and given as presents by one tribe to another. The Indians value a copper-plate the more, the more frequently it has been given as a present. Every single plate has its name and its own house, and is fed regularly. No woman is allowed to enter its house. Almost every tribe has a tradition referring to their origin. Some say that a man who visited the moon received it from the man in the moon. Others say that a chief living far into the ocean gave it to a man who came to visit him, etc. Similar legends refer to the Haliotis shells which are used for ear and nose ornaments and bracelets.

The so-called Potlatch is a feast celebrated by all these tribes. A chief invites all his neighbors, sometimes to the number of a thousand and more, to his house, and presents every one with blankets, skins, and nowadays even with money. The Salish tribes have a kind of scaffold in front of their house, which is used at these festivals. The chief and two of his slaves are standing on it, and distributing the blankets among the guests. Small festivals of this kind are celebrated very frequently. An Indian who has been unsuccessful in hunting, and feels ashamed on this account or for any other reason, gives such a festival to restore his honor.

In the beginning of these feasts four songs are sung, and four different kinds of dishes are served. Then one of the guests stands up and praises the liberality of the host, who, in his turn, replies, praising the deeds of his ancestors. In this speech he frequently uses a mask representing one of his ancestors.

I mentioned above that the social institutions of the northern group and those of their southern neighbors are different; therefore their mortuary customs and marriage ceremonies are also different. The northern tribes burn the corpses of all men except medicine-men. These are buried near the shore, and the corpse of the son is always deposited on top of the corpse of his father. It seems that some of the Kwakiutl tribes used to burn their dead; but by far the greater number of tribes of this stock either hung up the dead in boxes in top of trees, the lower branches of which were removed, or deposited these boxes in burial-grounds set apart for this purpose. Chiefs are buried in a separate place. Food of all kinds is burned for the dead on the shore.

I shall describe their mourning ceremonies as illustrative of those in use of most of the coast tribes. The mourning lasts for a whole year. For four days the mourner is not allowed to move. On the last of these days all the inhabitants of the village have to take a bath. On the same day some water is warmed and dripped on the head of the mourner. For the next twelve days he is allowed to move a little, but he must not walk. Nobody is allowed to speak to him, and they believe that whosoever disobeys this command will be punished by the death of one of his relatives.

He is fed twice a day by an old woman, at low water, with salmon caught in the preceding year. At the end of the first month he deposits his clothing in the woods, and then he is allowed to sit in a corner of the house, but must not speak to the other people. A separate door is cut, as he is not allowed to use the house door. Before he leaves the house for the first time, he must approach the door three times and return without going out. Then he is allowed to leave the house. After four months he may speak to other people. After ten months his hair is cut short, and the end of the year is the end of the mourning period. After the death of a chief, his son gives a great festival, in which he takes the office and name of his father. At first, four mourning songs are sung, which have a slow movement, and then the son of the chief stands up, holding the copper-plate in his hand and saying, "Don't mourn any more. I will be chief. I take the name of my father."

The marriage ceremonies of the Kwakiutl tribes are very remarkable. The dowry of the bride consists of bracelets made of beaver toes, copper-plates, so called "button-blankets," and the Gyíserstal. The latter is a board, the front of which is set with sea-otter teeth. It is intended to represent the human lower jaw; and the meaning is, that the bride will have to speak or be silent, as her husband may desire. Before and after the marriage, the son-in-law gives many presents to his wife's father. If the woman intends to return to her parents, her father must repay all he has received from his son-in-law. This is done frequently, in order to give an opportunity to the father-in-law to show his liberality and wealth. As soon as he has paid the husband, the latter repurchases his wife. The use of the Gyíserstal is very limited. I found it only among the Kwakiutl proper and Nimkish.

I do not intend to describe the houses, the hunting and fishing, and industries of all these tribes, neither will I attempt to discuss the character of the art products of the different groups. I have endeavored to show in my remarks that the culture of the Northwest American tribes, which to the superficial observer seems so uniform, originates from many different sources, and that only a thorough knowledge of the languages, folk-lore, and customs of these tribes and their neighbors will enable us to trace at least part of their obscure history.

Electrolysis of Lead Solutions. Determination of Boric Acid. Dihalogen Derivatives of Salicylic Acid. Barite. By Edgar F. Smith.

(Read before the American Philosophical Society, Nov. 18th, 1887.)

The following is a report of work prosecuted in the laboratory of Wittenberg College, Springfield, Ohio, during the past year, partly by myself and partly by students under my supervision:

I. Electrolysis of Lead Solutions.

Lead is one of the metals which has given analysts considerable trouble to estimate electrolytically; consequently, many suggestions have been offered, as to the best course to pursue in determining it in this manner. In this note I purpose giving some results obtained by using an alkaline solution of lead containing a phosphate. Employing a lead solution with an unknown quantity of lead, I took from it, 5 c.c., to which I added an excess of disodium phosphate, dissolving the precipitate formed in sodium hydroxide, then subjected the liquid to the action of a current derived from three small Grove cells, for a period of two hours, after which the action was interrupted; the deposit of metallic lead was washed with water, alcohol and ether, then carefully dried and weighed. In this manner I obtained .0105 grs. Pb. A second experiment conducted under like conditions gave a similar result. With 10 c.c. of the lead solution the following amounts of lead were obtained:

1. .0210 grams Pb.	3. .0213 grams Pb.
2. .0215 " "	4. .0210 " "

The same current strength was used in all these determinations, but the time varied from two to four hours. In all instances, the precipitated metal showed a regular, compact appearance.

I analyzed another lead solution of unknown strength, using, as before, sodium phosphate and hydroxide, and obtained:

.0225 grams } Pb.
.0217 " }

The current was from three small Grove cells. Time, 3½ hours.

Subsequently, I dissolved 8.7315 grams of lead nitrate in 250 c.c. water, and treated as follows:

1. One c.c. of the solution was precipitated by sodium phosphate, the precipitate dissolved in sodium hydroxide and the solution exposed to the action of a current from two Grove cells for two hours. In this way I obtained a lead deposit equal to .0215 grams Pb. The metal, after being washed with water, was dried in a current of hydrogen. This seemed necessary and was done in the following determinations:

2. Same as in 1; obtained .0220 grams Pb.

3. Same as in 1; obtained .0213 grams Pb.

4. Same as in 1; obtained .0220 grams Pb.

The theoretical amount of lead in the electrolyzed solution was .0219 grams.

These experiments indicate that the metal can be deposited in good form from an alkaline phosphate solution, but to insure satisfactory results, great care must be exercised in the drying, as the moist metal oxidizes readily.

II. Experiments in the Determination of Boric Acid. By E. B. Knerr.

It was observed that a considerable quantity of uranium nitrate could be added to a borax solution containing potassium ferrocyanide before the characteristic red-brown precipitate of uranium ferrocyanide appeared. This suggested the possibility of obtaining a quantitative method for the estimation of boric acid. I, therefore, dissolved 4.18 grams of uranium nitrate in one litre of water, and 1.16 grs. of well-crystallized borax in 250 c.c. water. The uranium solution was then placed in a burette and carefully added to definite portions of the borax solution until a drop of the mixture, added by means of a thin glass rod, to a drop of a concentrated potassium ferrocyanide solution, on a porcelain plate, gave a reddish-brown color. The first distinct coloration was regarded as the final reaction. The following results were obtained:

1.	5 c.c. of the	borax	solution	required	8.8	c.c.	uranium nitrate.
2.	"	"	"	"	8.9	"	"
3.	"	"	"	"	8.8	"	"
4.	"	"	"	"	8.8	"	"
5.	"	"	"	"	8.8	"	"
6.	"	"	"	"	8.8	"	"
7.	"	"	"	"	8.8	"	"
8.	"	"	"	"	8.8	"	"
9.	"	"	"	"	8.8	"	"
10.	10 c.c.	"	"	"	17.7	"	"
11.	"	"	"	"	17.6	"	"

A second uranium nitrate solution, containing 8.6267 grams nitrate in 500 c.c. of water, was standardized as above with a borax solution (containing .9051 grams borax in 250 c.c. water). The results were as follows:

1.	5 c.c. borax	solution	required	1.35	c.c.	uranium nitrate.
2.	"	"	"	"	"	"
3.	"	"	"	"	"	"
4.	"	"	"	"	"	"
5.	"	"	"	"	"	"

From this we discover that 1 c.c. of uranium solution equaled .004917 grams B_2O_3.

To test the accuracy of the method, I dissolved 1.1762 grams freshly crystallized borax in 250 c.c. of water, and titrated portions of it with the above standardized uranium solution:

1.	10 c.c. of borax	solution	required	4.0	c.c.	uranium solution.
2.	"	"	"	3.5	"	"
3.	"	"	"	3.4	"	"
4.	"	"	"	3.5	"	"
5.	"	"	"	"	"	"
6.	"	"	"	"	"	"
7.	"	"	"	"	"	"

Taking 10 c.c. of the borax solution as equivalent to 3.5 c.c. of the uranium solution, we have the 250 c.c. of the borax solution equal to 85 c.c. of the uranium solution ; but the 85 c.c. represent 85 × .004917 grms. B_2O_3 = .43023 grms. B_2O_3 or 36.57%. The theoretical amount of boric acid in 1.1767 grms. borax is .43114 grs. B_2O_3 or 36.64%.

Free acid very materially affects the results. Extremes of dilution also influenced the same to a certain degree.

I next endeavored to ascertain how ferric salts would act upon borax. At first, potassium ferrocyanide was employed as an indicator, but was later rejected. On substituting potassium sulphocyanide for it, a few drops of the same were placed in the vessel containing the borax. The first decided "blush" which came over the solution was counted as the end of the reaction. I standardized a definite amount of ferric ammonium sulphate with a definite quantity of borax, finding that one c.c. of the iron solution was equivalent to .004479 grams B_2O_3. I then dissolved 1.2651 grms. of borax in 250 c.c. of water, and titrated a number of portions with the standardized iron solution. The results were 36.73% B_2O_3, instead of 36.64% by theory.

Upon standardizing a new quantity of iron salt, instead of adding the sulphocyanide solution directly to the borax solution, a few drops of it were placed upon a porcelain plate, and as the end reaction was approached, portions of the liquid were brought in contact with the sulphocyanide by means of a glass rod. In this way the following numbers were obtained :

1.	10 c.c.	borax solution	required	1.05	c.c.	iron solution.
2.	" "	"	"	"	"	"
3.	5 c.c.	"	"	0.5	"	"
4.	10 "	"	"	"	"	"
5.	5 "	"	"	0.5	"	"
6.	10 "	"	"	1.05	"	"
7.	" "	"	"	"	"	"
8.	20 "	"	"	2.10	"	"
9.	" "	"	"	"	"	"
10.	40 "	"	"	4.20	"	"

Thus, I found that one c.c. of the iron solution was equal to .00967 grms. B_2O_3.

The following tests were then made with the iron solution :

1. 2.2741 grms. borax were dissolved in 250 c.c. of water, and portions of it titrated :

10 c.c.	borax	required	3.40	c.c.	iron solution.
" "	"	"	"	"	"
" "	"	"	"	"	"
20 "	"	"	"	"	"

This gave 36.14% B_2O_3 ; theory 36.64%.

2. Six determinations were made with a solution containing 2.1490 grms. borax in 250 c.c. water.

Found 36.40% B_2O_3, instead of 36.64%.

3. With a solution containing .0865 grms. of borax, I obtained 36.89% B_2O_3.
4. .0254 grms. borax, dissolved in water and titrated, showed 36.46% B_2O_3, instead of 36.64%.
5. .0104 grms. borax gave 37.50% B_2O_3.
6. .0198 grms. borax, titrated as before, gave 36.35% B_2O_3.

A number of determinations showed that sodium salicylate can also be advantageously employed as an indicator.

For rapid work, where approximate results are sufficient, the foregoing methods will no doubt be of service. Free acids should always be avoided.

I have also experimented with tungstic and molybdic acids in the same manner, and while the results are very promising, I prefer reserving an account of the same until the details have been fully worked out.

III. Dihalogen Derivatives of Salicylic Acid. By W. S. Hoskinson.

In the *American Chemical Journal*, Vol. viii, No. 2, Smith and Knerr described metachloriodosalicylic acid and its derivatives. Pursuing a somewhat similar line of research, I prepared a brom chlor-acid, and an iodo-brom-salicylic acid, as well as derivatives of the same. Below I give a brief description of these new compounds.

Brom-chlor-salicylic Acid.

C_6H_2 OH BrCl COOH.

To obtain this acid I used a definite quantity of metachlorsalicylic acid (m.p. 172° C.), and dissolved the same in alcohol. To this solution was gradually added a corresponding, equivalent amount of bromine; the flask in which the reaction was performed was kept cool. When the entire quantity of bromine was added, the alcoholic solution was evaporated to dryness upon a water bath. The residue was boiled with water and barium carbonate, the liquid filtered and allowed to cool. The barium salt separated in bushy needles. Its solubility in water is about 1 : 100. The sodium salt was prepared from the barium salt, and from it the acid was liberated by hydrochloric acid. The free acid forms small, white needles, nearly insoluble in boiling water, but soluble in alcohol. In its pure state it melts constantly at 229° C.

The *barium salt* [(C_6H_2 OH BrCl CO$)_2$ Ba + $4H_2O$] forms long bushy needles, soluble with difficulty in boiling water. An analysis of it gave 10.02% H_2O and 21.20% Ba. The formula given requires 10.14% H_2O and 21.48% Ba.

The *sodium salt* (C_6H_2 OH BrCl COONa + $1\frac{1}{2}$ H_2O) appears in beautiful bunches of white needles, which are very soluble in water. An analysis showed 9.09% H_2O and 8.25% Na; theory requires 9.89% H_2O and 8.40% Na.

The *calcium salt* is anhydrous. Its analysis gave 7.42% Ca, while theory requires 7.39%.

The *zinc salt* forms small crystals, much like fish-eggs. It dissolves with difficulty in hot water. When analyzed it gave 13.91% H_2O and 12.24% Zn; the theoretical figures are 14.06% H_2O (5 molecules), and 11.94% Zn.

The *magnesium salt* does not crystallize well. It is not readily soluble, even in hot water. It contains six molecules of water of crystallization. Upon analysis I obtained 17.19% H_2O and 5.33% Mg. The calculated percentages of water and magnesium are 17.03% and 4.79%.

The *cadmium salt* forms beautiful crystals.

The *silver salt* was obtained as a white precipitate insoluble in water. I employed it in preparing the methyl and ethyl esters.

Methyl Ester (C_6H_2 OH BrCl CO OCH_3). This was obtained by the action of methyl iodide upon the silver brom-chlor-salicylate. It forms beautiful needles, dissolving with difficulty in both alcohol and ether. It melts at 126–127° C. This ester was burned with lead chromate, and gave good results. The *ethyl ester*, also prepared, was not further studied.

The free brom-chlor acid was burned with lead chromate. The result showed 33.07% carbon and .96% H. Theory requires 33.46% C and 1.53% H.

Iodo-brom-salicylic Acid.

C_6H_2 OH IBr COOH.

Metabrom-salicylic acid was first prepared, and then iodated by the method of Weselsky. Little heat was evolved in the reaction; sometimes this was added by means of the water-bath. When the reaction was complete the alcoholic solution was removed to an evaporating dish and run down to dryness. The residue was boiled with water and barium carbonate; from the hot filtrate the barium salt crystallized out, but it was immediately converted into the sodium salt, from which I set the acid free. The latter forms small, beautiful needles, dissolving with difficulty in hot alcoholic water. It melts at 208–209° C. A combustion of the pure acid gave 24.17% carbon and 1.30% H, instead of 24.48% C and 1.17% H.

The *barium salt* contains three molecules of water. It forms branched, purple-tinted needles. An analysis gave 6.48% H_2O and 15.55% Ba, instead of 6.27% H_2O and 15.65% Ba, as required by theory.

The *sodium salt* contains one molecule of water. It forms nodules, consisting of silky needles, very soluble in water. When analyzed it yielded 5.20% H_2O and 6.08% Na; theory requires 4.70% H_2O and 6.30% Na.

The *calcium salt* resembles the barium salt in form; it is possibly somewhat more soluble in hot water. It contains four molecules of water. Its analysis gave 8.04% H_2O and 5.65% Ca, instead of the theoretical 8.01% H_2O and 5.53% Ca.

The *cadmium salt* forms beautiful needles, readily soluble in water. Its analysis showed 8.21% H_2O and 14.13% Cd, instead of 8.29% H_2O and 14.19% Cd.

The *zinc salt* consists of indistinct needles, readily soluble in water. Its analysis showed the presence of five molecules of water, and 10.51% Zn.

The *methyl ester* crystallizes in beautiful needles, which melt at 104–105° C. By its combustion I obtained 26.23% C and 2.15% H. Its formula requires 26.86% C and 1.68% H.

The study of other mixed dihalogen derivatives of salicylic acid is being carried forward in this laboratory, the results of which will be published later.

IV. Barite from Ludlow Falls, Miami County, Ohio.
By Charles H. Ehrenfeld.

This mineral was found in the summer of 1886, the chief interest in connection with it being that it is the first time barite has been found in this locality. It is white, semi-transparent and massive, and it occurs in the Niagara limestone, associated with small crystals of pyrite, the surface of which is brown owing to oxidation. The average of four sp. gr. determinations of the barite is 4.48.

An analysis showed the following composition :

$BaSO_4$	91.10%
$SrSO_4$	7.63 "
$CaSO_4$	.98 "
Total	99.71%

Chemical Laboratory of Wittenberg College,
Springfield, Ohio, Nov. 8, 1887.

Stated Meeting, December 2, 1887.

Present, 34 members.

President, Mr. Fraley, in the Chair.

Dr. Morton W. Easton was presented to the Chair and took his seat.

Correspondence was submitted as follows: Letters acknowledging receipt of diploma from Messrs. R. N. Toppan, Cambridge, Mass.; William John Potts, Camden, New Jersey; Charles A. Oliver and Henry Reed, Philadelphia.

A letter of envoy from Das K. Württ. Statistische Landesamt (Stuttgart).

Letters acknowledging the receipt of the Proceedings, No. 125, from: Bibliothèque Impériale Publique, Library of the Academy of Sciences, Comité Geologique de la Russie, Observatoire Physique Central, Prof. Serge Nikitin, St. Petersburg; K. Bibliothek, K. Geologische Landesanstalt and Bergakademie, Berlin; Verein für Thüringische Geschichte und Alterthumskunde, Jena; Publishers of "Natur-Forscher," Tübingen, Würtemberg; Prof. Remi Siméon, Paris; Amer. Statistical Association, Boston; Akademie der Wissenschaften, Wien; Dr. Hugo von Meltzel, Hungary; Messrs. Friedländer & Sons, Berlin; K. Sächsischer Alterthums Verein, Dresden; Verein für Thüringische Geschichte und Alterthumskunde, Jena; Deutsche Gesell. für Anthrop., etc., München; K. Würtembergisches Statistisches Landesamt, Stuttgart; Nassauischer Verein für Naturkunde, Wiesbaden; Institut R. Grand Ducal de Luxembourg; Soc. R. Malacologique de Belgique, Acad. R. des Sciences, etc., Bruxelles; Instituto y Observatoire de Marina de San Fernando, Madrid; Publishers of "Nature," London; Museum of Comparative Zoölogy, Cambridge, Mass.; Vassar Brothers' Institute, Poughkeepsie; Messrs. Wm. M. Meigs, Henry Phillips, Jr., Richard Vaux, Philada.; Johns Hopkins University, Baltimore; U. S. Commissioner of Fish and Fisheries, Bureau of Navigation, U. S. Department of Agriculture, Washington; University of California.

A letter was read from Professor Rothrock, enclosing tickets for his Free Michaux Forestry lectures under the auspices of the American Philosophical Society and the Pennsylvania Forestry Association, at the University of Pennsylvania.

Circulars were read as follows: From Prof. Antonio Favardi, of Milan, Italy, announcing the preparation of a new edition of the works of Galileo. From the "Record Society," Pensarn, Abergele, North Wales, in reference to its publication of original documents relating to Lancashire and Cheshire. From the publishers of "The American Geologist," announcing the issue of a new journal under that title.

Prof. Daniel Kirkwood (Bloomington, Indiana) presented, through the Secretaries, a communication, entitled, "Note on the possible existence of Fireballs and Meteorites in the Stream of Bielids."

The Report of the Committee on *Volapük* was read, after which a discussion upon the subject-matter of the Report ensued, participated in by the members, and ultimately, on motion of Mr. McKean, the whole subject was recommitted.

The Report of the Treasurer was presented and referred to the Finance Committee, and the Society was adjourned by the President.

Note on the Possible Existence of Fireballs and Meteorites in the Stream of Bielids. By Daniel Kirkwood.

(Read before the American Philosophical Society, December 2d, 1887.)

A revision of my paper on this subject, read September 2d, 1887, suggests the following modifications :

1. Before 1832, the earth passed the comet's node early in December. The first eight meteors of the list should therefore be rejected.

2. In Greg's Catalogue the circumstances which indicate the radiant are not generally given ; the probability that the meteors belong in part to the stream of Bielids must be judged by a comparison of their relative numbers with the mean number during a specified time. In the thirty years from 1831 to 1860, the list gives seven hundred and twenty-one fireballs and meteorites, or six for any three days of the year taken at random. The number for November 28–30 is twelve, or twice the average. Of these, one is the meteorite which fell during the shower of Bielids on November 27th, 1885 ; one is the conformable fireball of November 28th, 1850, the date of a well-marked shower of shooting stars ; three (1839, 1848, and 1850, Nov. 30) are non-conformable ; and the directions of the remaining seven are unknown, at least to the writer. Mr. Greg calls attention to November 27–30 as an aerolitic epoch coincident with one of shooting stars.

3. The attempt in my paper of September 2d, to trace a period approximately equal to that of Biela's comet was probably premature.

Ancient Human Footprint on Tufa, from Nicaragua.

On an Ancient Human Footprint from Nicaragua.

By D. G. Brinton, M.D.

(*Read before the American Philosophical Society, Nov. 18th*, 1887.)

The discovery of human footprints in volcanic rocks near the shore of Lake Managua, Nicaragua, under circumstances which seemed to assign them a remote antiquity, has been announced for several years.* We owe thanks especially to Dr. Earl Flint, of Rivas, Nicaragua, for information about this discovery, and for sending several specimens to the United States. Four of these are in the Peabody Museum of Archæology, Cambridge, and recently, I have myself received one from Dr. Flint, together with several letters describing the locality. The possession of this material has induced me to present, along with its description, a general review of the subject.

The surface of the Republic of Nicaragua presents in nearly all parts the signs of enormous volcanic activity. It is broken by a complex series of mountain ranges whose sides are scored with vast lava streams. Frequent earthquakes attest the continued energy of the subterranean forces and prepare us for incidents of elevation and subsidence on an uncommon scale.

The great lakes of Nicaragua and Managua are divided by a low plain through which flows the river Tipitapa connecting these sheets of water. South of this lowland rises a mesa or tableland 400 or 500 feet above the level of the lakes, and upon this stand the volcanic cones of Mombacho (4588 feet) and Masaya (2972 feet). Beyond these, the land still rising, reaches its height in the Sierras de Managua, presenting the craters of the extinct volcanoes of Tizcapa, Nezcapa (Nehapa), and Asososco: and further to the north-west, immediately upon the shores of the Lake Managua, the still smoking peaks of Chiltepec (2800 feet) and Momotombo (6121 feet).

The last named (Momotombo) was active in 1852, and Masaya in 1858 and 1872, while Mombacho, though quiet, so far as we know, since the conquest, according to tradition, destroyed an important town just before that epoch, and its sides still reveal signs

* The following are the principal references: Letter of Dr. Flint, dated Jan. 7, 1884, in the *American Antiquarian*, March, 1884; *17th Report of the Peabody Museum* for 1884, page 356; *18th Report* of the same, 1885, page 414; *Proceedings of the American Antiquarian Society*, 1884, p. 92. Letter of Dr. Flint in *American Antiquarian*, May, 1885.

of terrific outbursts at no distant date. In the eruption of March, 1872, Masaya vomited a lava stream two miles in width.*

I quote these facts to show the volcanic character of the country and the powerful agencies at work there.

For our present purpose, we have to confine our attention to the extinct volcano of Tizcapa. Like its neighbors, the cones of Nezcapa and Asososco, it has long since burnt out its fires, and all three have changed their flaming craters into deep and still lakes, encircled by precipitous walls of congealed masses. Tizcapa is about two and a-half miles from the shore of Lake Managua, and in ancient times its molten streams found their way into the waters of the lake. Its eruptions were irregular, and evidently long periods of quiescence intervened between those of violent action, periods extended enough to allow the earlier tufa beds and lava streams to become covered with vegetation, the relics of which we find imbedded beneath later overflows. How much time this would require is a vital question in deciding the age of the footprints. These are found on the surface of the *first* or lowest tufa bed, which itself rests upon a bed of yellow sand.

Before proceeding to a discussion of the antiquity we may fairly assign to the relic, I shall insert Dr. Flint's description of the locality, and add a vertical section of the cutting in the quarry on the lake shore, in which the footprints are found. Both of these he has kindly sent me in a recent letter.

"The Cordilleras east of Lake Nicaragua are a continuous succession of low mountains, spread out and gradually diminishing to the depression, where the outlet of Lake Nicaragua passes seaward by the San Juan river. In past ages the spur west of the lakes Nicaragua and Managua (formerly part of an ocean inlet) was the theatre of volcanic action seldom exceeded; and its latent fires, out of the axial line, at Ometepetec and Momotombo, still smoke. These magnificent cones may continue to burn for ages, until they disappear, like their neighbors, leaving like them, an abyss to mark their location.

"Zapatero has its deep lake, whose surface is but slightly above the waters of the one surrounding it; north-west and near Granada, we look down from the edge of the old crater on a

* See Pablo Levy, *Notas sobre la Republica de Nicaragua*, pp. 83, 84 (Paris, 1873), and A. Schiffman, *Una Idea sobre la Geolojia de Nicaragua*, p. 125 (Managua, 1873).

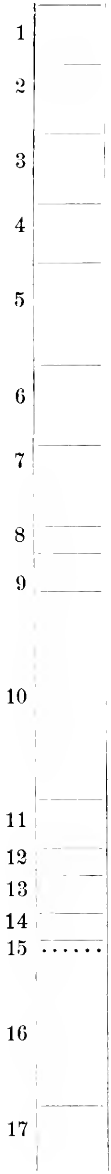
placid lake, whose four square miles of water are seldom stirred by the wind, and whose depth has not yet been fathomed. When were the fires of this immense crater extinguished?

"Lake Masaya far exceeds that of Apoyo; as we descend the deep ravines cut through the tufas to its margin, we see the work of centuries carrying back this detritus to refill the abyss, and no perceptible diminution is noted. Passing on, we find the lakes Nehapa, Asososco, and Tizcapa, under similar conditions; the latter near Managua, furnished the material forming the tufas on which the footprints occur.

"These lakes at the time of the Spanish occupation, now nearly four centuries, presented nearly the same aspect as they do now; their rock-bound shores were covered with inscriptions, of which no tradition could be obtained of the tribes then occupying this region. The country was clothed with impenetrable forest that had sprung up on these arid wastes of tufa. We dig below this fertile soil, and after removing five well-marked beds of tufa, including a lower one of pure ash, we encounter a deposit of clay, a soil of other times, accumulated under circumstances familiar to that now on the surface. It also had its plants and trees. Among the former we see long liriaceous leaves impressed on the friable deposit. We ask, is this the soil of the first inhabitants? Before deciding, we dig below, through four more deposits, with other accumulations in the seams, of pumice and volcanic sand. We reach a thin friable tufa, nearly black, about two inches thick; removing it, we find a heavy deposit of tufa lying on yellow sand. This is the last in the series; on its upper surface we find innumerable footprints of a people who had passed over it, at different times, when in a plastic state. Some sank deep in the mass, while others left superficial impressions. Now and then, a stray leaf of that horizon was trodden into the imprints; others are on the friable under-surface; they seem to differ from those above under the ash."

Dr. Flint sends me a vertical section of the quarry from which the present specimen was taken. The location is about 300 feet from the shore and close to the town of Managua. At that point the overlying strata present a thickness of twenty-one feet beneath the surface soil, the most of the mass being compact tufa, similar in general appearance to the block bearing the imprint.

Vertical section, 21 feet in depth, of a Quarry on Lake Managua, showing strata overlying human footprints.



1. Surface soil, about 18 inches.
2. Compact tufa, 20 inches, separated from No. 3, by a sand seam.
3. Compact tufa, 20 inches, separated from No. 4 by a sand seam.
4. Compact tufa, 17 inches, separated from No. 5 by a sand seam.
5. Compact building tufa, 28 inches, resting on a seam of black sand.
6. Solid, dark-blue ash, 14 inches.
7. Hard clay, 12 or more inches, its surface presenting numerous leaves (impressions, fossils), and remains of the mastodon.
8. Pumice, about two inches, unequally distributed.
9. Sand drift, supporting the clay.
10. Compact building tufa, 47 inches, separated from No. 11 by a sand seam.
11. Compact tufa, 5 to 7 inches.
12. Black sand, 1 inch.
13. Dark, friable tufa, 2 inches.
14. Volcanic sand, containing fossil leaves, 1 inch.
15. The dotted line ...... shows the horizon of the footprints impressed upon number
16. Compact building tufa, 47 inches.
17. Yellow sand, believed to be Eocene (?) of undetermined thickness, containing numerous small shells.

Beginning with the lowest stratum, the yellow sand, the only clue offered to ascertain its age, believed by Dr. Flint to be Eocene, is the shells which it offers in abundance, but apparently only of one species. They are small and well preserved. Dr. Flint transmitted a number of them for examination to Prof. Newcombe, of Cornell University, who considered them a new species, and has called them provisionally *Pyrula nicaraguensis*, and adds that the genus is represented in North America by but one other species, *P. nevadensis* Stearn.

I submitted a number of them to my colleague at the Academy of Natural Sciences, Prof. Angelo Heilprin, who writes me:—"I should not like to pronounce positively upon the age of the deposit represented by the Nicaraguan shells, as by themselves they scarcely give direct evidence. But I should incline to the opinion that the deposit in question is more nearly Post-pliocene than Eocene, the specimens having a decidedly new look, and lacking the Eocene tertiary characters."

Dr. Flint sent to the Peabody Museum a number of leaves from the deposit marked 14 on the section; and I have recently inquired of the authorities of the Museum whether their age and character have been determined. They reply, that these characters have not yet been made out.

The hard clay deposit, No. 7 of the plan, increases in thickness in other localities to ten or twelve feet. It is considered by Dr. Flint to represent a period of repose of many centuries, and on its surface, bones of the mastodon have been found at other points along the lake. It is the only deposit in the section which seems to demand considerable time; and even here, the question will suggest itself whether a submergence of the lake shore for a few centuries or less might not be sufficient to produce this deposit. The presence of the mastodon bones is no evidence of great antiquity. That huge herbivore lived in tropical America almost in historic times. A complete skeleton of one was found not long since in an *artificial* salt pond, constructed by the Indians, near Concordia, Colombia. The pond, with its bottom of paved stones together with the animal, had been entombed by a sudden landslide.*

* See R. B. White, "Notes on the Aboriginal Races of the Northwestern Provinces of South America," in the *Journal of the Anthropological Institute of Great Britain*, February, 1884, p. 244.

The deposit of ashes, No. 6 on the section, is held by Dr. Flint to mark a period of volcanic energy of wide extent and important consequences in modifying the physical geography of the region. It led to the elevation of the coast range and the separation of Lake Nicaragua, previously a bay of the ocean, from the sea. Dr. Flint's expressions are:

"West of Jinotepe a well was sunk one hundred and nineteen varas in search of water; there this ash deposit is fifteen feet thick, at least twenty miles from the nearest crater.

"We see many proofs, that the cataclysm enclosing Lake Nicaragua (formerly salt water) was at the time of this ash eruption; while the tufas, *previously ejected*, pushed over the sea inlet at Tipitapa, enclosing that of Managua; they were not broken up by the cataclysm, nor those at the quarry, and all on the northern slope; nor the slip of coast north and south of San Rafael."

Passing to a study of the tracks themselves, they are described by Dr. Flint as quite numerous and passing in both directions, that is, to and from the lake shore, from which the average distance of those found is about 300 feet. The maximum stride was 18 inches, and the longest foot measured 10 inches.

The specimen which he has sent me, and which is offered for inspection [specimen presented], is the impression of a left foot. The total length of the impression is 9½ inches, the breadth at the heel 3 inches, at the toes 4½ inches. The apparent length of the foot itself was 8 inches. The instep was high, and the great toe large, prominent and exceeding in length the second toe. This last peculiarity has been by some considered of ethnic importance.* The greatest depth of the impression is at the ball of the foot, the weight being evidently thrown forward as in vigorous walking. At this part the maximal depression below the plane of the superfices is 2 inches.

The footprints on the tufas at Managua are not the only ones discovered in that Republic by Dr. Flint. Others were seen on the southern slope of the Sierra de Managua, near the town of

* See J. Park Harrison, "On the Relative Length of the First Three Toes of the Human Foot," in the *Journal of the Anthropological Institute of Great Britain*, February, 1884. The general conclusion seems to be that a long second toe indicates a lower stage of development.

San Rafael. The character of this horizon is thus described by Dr. Flint in a letter to me:

"Collateral evidence touching man's antiquity here, not less weighty, is found in the neighborhood. The eruptions covering the south-west slope, and the disturbance caused by one, along the ocean beach, elevating the coast range, affords us indisputable evidence of Pliocene man. In descending the slope through immense ravines formed by the annual floods, we see enormous blocks of tufa, isolated by the removal of the material surrounding them, showing that they had been uplifted by some mighty force and re-embedded in the resultant débris.

"In 1875–8 and 1883, I spent over a month visiting the coast-hills to the south-west about San Rafael, seeking out the limits of the cataclysm.

"A strip of land, commencing at Bocano, extends along the coast about forty miles and widens out about San Rafael, terminating some eighteen miles above the latter place, at the base of the old primitive range. South-east of the town, a notable break in the upheaval shows that this strip was undisturbed, while the succession of hills to the east and south-east widens out and extends to the south at San Juan del Sur, and thence to Salinas bay. The force culminated against the south-west slope of the old primitive volcanoes mentioned, also shown north-west of San Rafael, where the tufa of the first eruption, on the slip of land mentioned, was unbroken, while in ravines near, the ocean sediment of the upheaval overrides it, forced over it as the rise occurred near by to the east.

"This sediment has been carried seaward by the rivers since formed. As they removed the debritus from the tufa, these were found covered with footprints of animals and man. One of these (sandal shod) was forwarded to the Peabody Museum.

"Where the rivers have cut through the old sea sediment down to the primitive rock, we see beds of shells of many species, among them enormous oysters of an oblong figure, perfect fossils, yet unnamed. They are *in situ*. Their contents resemble slaked lime. All this shows a sudden elevation. A few can be seen at the National Museum with the fossil leaves in the rock above them, similar to those on the Managua clay under the ash eruption. The latter eruption broke up the clay and elevated the coast range. On the neighboring hills innumerable shells are adherent to the fractured limestone, and south to those west of Rivas; from there the limestone dips to south-east and is only about sixty metres above the sea between San Juan and Virgin bay, while part of the Rivas plateau was undisturbed."

It will be observed that one of these footprints indicates the use of sandals or moccasins by the pedestrians of that day. None of this character have been reported from Managua. Undoubtedly a society which wears shoes cannot be assigned to the earliest stages of human culture. Many of the natives of Central America to this day never protect the feet in any manner.

In conclusion, I should say, that there can be no doubt of these being genuine human footprints. They are not of that mythical origin which the fancy of savage nations delights to imagine,* nor can there be the least doubt of their authenticity. Their antiquity remains uncertain. In regions at once tropical, fertile and volcanic, we may expect sudden upheavals and subsidences, and the ravages of the most violent outbursts are repaired by a luxuriant vegetation with surprising rapidity. My own opinion is, that there is not sufficient evidence to remove them beyond the present Post-pliocene or Quaternary period.

Stated Meeting, December 16, 1887.

Present, 27 members.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows: Letters of envoy were received from Société R. des Sciences à Upsal; Fondation de P. Teyler van der Hulst à Harlem; Società Italiana della Scienze, Torino; Lords Commissioners of the Admiralty, London; U. S. Naval Observatory, U. S. Geological Survey, Washington, D. C.

A letter from Lord Rayleigh, London, acknowledging receipt of his diploma.

A letter was read from Prof. March, Easton, Pa., in refer-

* See Dr. Richard Andree, on "Fussspuren," in his *Ethnographische Parallelen und Vergleiche*, s. 91 (Stuttgart, 1878).

ence to the lately-appointed commission to determine upon a uniform mode of spelling in public documents, etc., of the State of Pennsylvania.

The American Association for the Study of Modern Languages was invited to visit the Society's Hall during its approaching session in this city.

Letters of acknowledgment from Imperial Russian Geographical Society, St. Petersburg (125); Prof. Otto Donner, Helsingfors (125); Société R. des Sciences, Upsal (123, 124 and List of Members); Captain Richard Temple, Mandalay (125).

Letters were read from the Engineers' Club of Philadelphia, inviting the officers of the Society to be present at its Reception, December 17, 1887, the Decennial Anniversary of the Foundation of the Club;

From the Rutland County (Vermont) Historical Society, requesting Constitution, Laws, etc.;

From the Smithsonian Institution, announcing the election of Prof. Samuel P. Langley, LL.D., as Secretary;

From the Oneida County Historical Society, in reference to a celebration of the New Hartford Centennial.

A circular was read announcing the proposed issue of a new journal to be called *The American Anthropologist.*

Accessions to the library from Royal Society of Tasmania; Geological Survey of India, Calcutta; Naturforschender Verein, Riga; K. B. Akademie der Wissenschaften, München; Société R. des Sciences, Upsal; Fondation de P. Teyler van der Hulst, Harlem; Società Italiana della Scienze, Torino; Publishers of "Cosmos," Paris; Lords Commissioners of the Admiralty, London; Philosophical Society, Cambridge; Radcliffe Observatory, Oxford; Philosophical Society, Glasgow; Messrs. Henry W. and Henry V. Poor and Charles E. Sprague, New York; Mr. Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Baltimore; U. S. Geological Survey, U. S. Naval Observatory, Washington, D. C.; Prof. J. W. Mallett, University of Virginia.

The death of Dr. Middleton Goldsmith (Rutland, Vermont), on November 26, 1887, æt. 70, was announced.

This being the evening for the consideration of communications pending for the Magellanic Premium, the Society discussed the claims of one signed "Magellan" on the "Physical Phenomena of Harbor Entrances; Their Causes and Remedies; Defects of Present Methods of Improvement," and on being put to a vote it was unanimously resolved that the Society would consider the claims of the said paper.

Upon the question then recurring as to whether the said communication was worthy of the proposed premium, a vote was taken and the Society unanimously resolved that the said communication was worthy of the premium, and that the Magellanic Premium should be awarded therefor.

The sealed letter accompanying the crowned performance was then ordered to be opened, which was done by the Secretaries, and the name of the author, Prof. LEWIS M. HAUPT, of the University of Pennsylvania, was announced as the person entitled to the said premium. On motion, the President was authorized to appoint at his leisure a committee of three members to attend to all the details connected with the preparation of the medal, etc. [The President subsequently appointed Messrs. J. Sergeant Price, R. M. Bache and Henry Phillips, Jr., as such committee.]

The Secretaries presented a communication by Rev. Charles W. King, entitled "The Epitaph of M. Verrius Flaccus."

Prof. Houston exhibited a Palladium Hair Spring of a non-magnetizable watch and mentioned the experiments he had already made and was making on it.

The Finance Committee presented its Annual Report, and the appropriations for the ensuing year were passed.

The Committee on Volapük reported progress, and the report was made the special order for the next meeting.

This being the regular meeting for balloting for candidates, a ballot was gone into, and Mr. Samuel Castner, Jr., of Philadelphia, was declared duly elected a member of the Society.

And the Society was adjourned by the President.

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Stated Meetings Held.

New Members Elected.

December 17, 1886.

February 18, 1887.

May 20, 1887.

October 21, 1887.

December 16, 1887.

Decease of Members.

Papers Presented. *Page.*

Miscellaneous Business.

Erratum.

On page 204, "Pseudo-maple Mimetites" should read "Pseudo-morphic Mimetites."

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXIV. JANUARY TO JUNE, 1887. No. 125.

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☞ In order to secure prompt attention it is requested that all correspondence be addressed simply "To the Secretaries of the American Philosophical Society, 104 S. Fifth St., Philadelphia."

PUBLISHED FOR THE AMERICAN PHILOSOPHICAL SOCIETY

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EXTRACT FROM THE BY-LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

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