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A Manual for the Use of Students in Egyptology. By Edward Yorke McCauley, U. S. N.

(Read before the American Philosophical Society, July, 1881.)

Preface

In the following "Manual", compiled from the authorities within my reach, will be found much information which, after the first elementary Knowledge has been acquired, is essential to progress in the study of Egyptology.

No attempt, that I am aware of, has been hitherto made to bring together within the compass of one volume, and in its present fullness, the results of the learned labors of Egyptologists eminent in this department. To obtain these results, requires an extensive and expensive library and many days of patient labor and research.

In a department of Knowledge where our metes and bounds are constantly widening it would be presumptuous to assume that the lists, I have given, of Gods, of symbols, Names of Countries &c comprise all that are Known or that may be found in hieroglyphic texts: Those, in fact, alone are given which are of daily occurrence.

The student will observe, in my List of Ideographs, that, not content with giving the main idea only, of which any single example is the exponent, as is generally the case, I give a list of the terms which start from the parent ideograph: By this amplification, which is far from complete, a conception may be formed of the general value or tenor of the ideograph.

It must be borne in mind that I have not undertaken to give any general outline of Hieroglyphics during the thousands of years covered by Egyptian history, in which, what may have been correct at one period may be changed at another; Wherefore, although errors undoubtedly occur in the following pages (Errare est, &c), haste in imputing them is to be deprecated.

It gives me pleasure to acknowledge the constant aid and encouragement which I have received from J. P. Lesley L.L.D. and also the untiring courtesy extended to me by Mr. Lloyd P. Smith and his assistant Mr. B. Samuel at the Ridgeway Library.

Philadelphia — Edward Yorke McCauley

1st Nov: 1881. — U. S. Navy

ALPHABET.

Value	Meaning	Value	Meaning	Value	Meaning	Value	Meaning	Value	Meaning
a	reed tōp	ab	hide	at	thread	ab		hab	plough
apt Xu		a	arm	ap		ba		her	
a	paddle	at		aah	moon	ba	bull	heq	crook
ak se	goose	ax xu		a		ba	ram	hu	
am ham		ax abh		an		b	hawk	hu	
ab	column	at kt		dat		b	heron	ha	
ab		au		ash	lizard	b	basket of fruit	ha ten ha	
ai	come	ab ub		ap		fi	worm		
ab ub		ab		ir ar		f		hu	
am	tree	ab		a		f		hu	tusk
am	cross	ab		an		Ga la		han	vase
ap tep	head	ab		a		hu		hut	onion
ap	horns	a		amx		hi		htp	table
ap	"	aa xaa	calf	a		ha		her	
as	noble	au xau		a		ha		han	vase
as	"	a	eagle	ahn hen		ha		ht	
as	"	aa		a		ha		ht	
as	"	hab ab	bee	bu	leg	ha		hut	
as	papyrus	anx		ba	furnace	hm		ha	
a hu	post	an un		ba xax		hm		hes	
an	mast	ar at tem	strip of stuff	bu xa		hm		hp	
an	"	an un	hare	ber	pyramid	hm		her	

ALPHABET.

	her	road		k	bundle		ma	hole		ma			net	hammer
	her	tomb door		ka fot			ma	weight		ma	thumb		net nem	
	hsi	throne		ka	stool		ma	pen		men			an hun	
	h			les kes	chisel		ma			mer	drill		netr	axe
	h			kar	fight		ma	sickle		met	bird leg		n	
	ap h	hans		kem			meh	thread		mu nu	water		n	
	h			kem			men	basket		na	crown		n	
	h			ka			mer	pool		na	"		n	
	h			ka	hair		mer	"		nu	jar		n	
	heb			xem kem			meh	nest		nu stk			nt	
	heb			ka mes			mes	flowers		nub	gold rag		n	
	h			keb			mut	vulture		net	beads		nem	
	i			kep			mer	hoe		neb	bowl		n	
	i			k			maq	key		nub			n	
	i			k	wig		meh	sail		nen			n	
	ai			k	"		m	jasper		ntr	guitar		n	
	ui			k	cynocef.		m			neh			nu uu	
	ari			k	asp		ma			t rehi			nu	
	i			k	snake		nas	tongue		nem			pa	
	i	jackal		ma	owl		men	vase		nem			pu	shutter
	k			am ma			ma			lam nen	stick		pu	
	q, k	knee		ma	cubit		meh			n nex	shoot		per	house

ALPHABET.


p
per paddle
pst bow
hr pet sky
paut eye-ball
peh
peh
ru lu pu
pek
paut
reti
res balance post
resh plant
ar
r
r
r
r
r
r
r
r lotus leaf
r knife
r quiver
sa lap
sa
su
sat
sep
sen tat
su chair back
lēs bolt
se
su meadow
su shoot
Juat seb
sud
s
seb ring
su egg
sem spade
sen shen
s shes
sper lip
serk
sut cow ear
sut
se goose
sat
sen lioness
sep shep
s sh
ser
ser
ser
sn shen
sn shen
sen lēsr lāmu
sex
seb flute
sa woof
sep
sa roof
sep
n sep
sep
sek
saw
sat
sat
s
lū club
ta land
ta
lā "
ta
ta
lū isle
tut hand
ti thread
t muller
teb dress
shem lēm
lēb
lēm sledge
lēn ka. u
lēr bundle of sticks
lēr bundle of sticks
lēr
lēs tet
xer
ga ta
lēsr
lā
ga lā
lēr
ta boat
tat pallette
tat
tat give
lū awl
t shoot
t
lēs chisel
t
t bread basket
lū
lū
t boat net

ALPHABET.

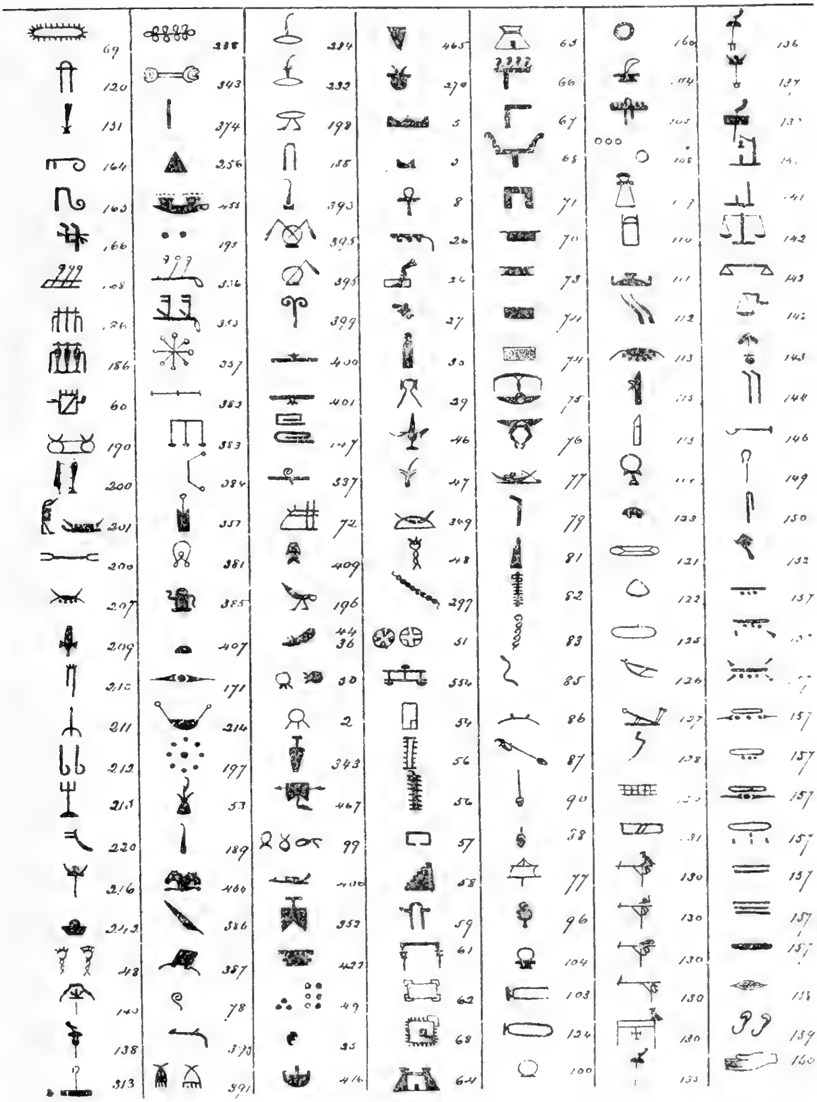
tau	
lōp	calf's muzzle
lēr	
lēn	
lāh	
let	finger
ua	pullet
ur	sparrow
w	thread
ua	..
uat	lotus sceptre
ua	
uah	
ua	
uah	
uah	
usef	
ut	
usr	
ur	
uat	

ut	
uh	
sh	pool
shen	ring
shetū	
shep	
sha	sun rising
sha	..
shu	feather
sha	field
shent	vases
shent	..
shes	sled
χa	mace
χa	sturgeon
χa	lotus leaf
χaf	
χi	seive
χem	
χen	
χepr	
χa	

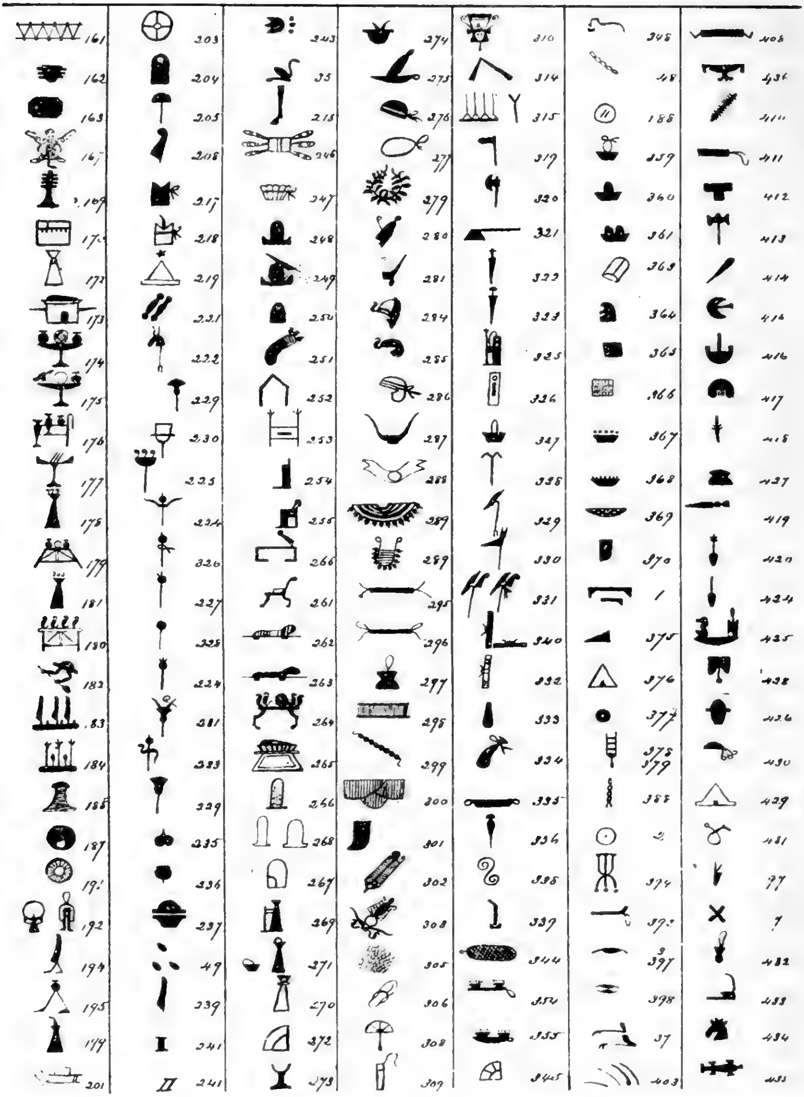
χem	
χ	fig
χa	stool
χ	

Index of determinatives, &c.

INDEX OF NONDESCRIPTS.



INDEX OF NONDESCRIPTS.



INDEX OF NONDESCRIPTS.

IDEOGRAPHS AND DETERMINATIVES.

	pet	sky, heaven	1
	aχu	suspend	
	aχt	"	
	hai	ceiling	
	χ'	elevation	
	har	over, above	
	heri	chief	
	har	half heaven course of the sun	
	hati	twist, distort	
	haiu	obstruct	
	shema	storm rain	
	ubkth		
	stahn		
	ahap		
	χena	to turn away	
	apti	loss injury	
	tehen		
	aχχ	night	
	uχa	darkness	
	χarh	"	
	aχrh	night	
	kk	obscurity	
	ashmu	darkness	
	ra	the sun	2
	atn	solar disk	
	hru	day	
	sht	to light	
	ubn	to shine	
	pst	to gleam	
	renpa	year	
	han	day	
	sef	yesterday	
	har	sunset	
	hoh	night	
	heb	festival	
	stt	sunbeam	
	het	sun's rays	
	"	daylight	
	ubn	illuminate	
	mau	gleam	
	ui	brilliancy	
	auti	bright, clear	
	hai	light	
	an	a beam	
	χu	light	
	saau	abode of stars	
		subdivision of celestial world	
	"	gate	
	hut	celestial sun	
	"	good demon	
	aχa	horizon	
	sbχχ	solar dwelling	
	aχut	solar mountain	
			
	apu		
	ra		
		lunar time	3
	a	moon	
	aah	moon	
	abt	month	
	tna	fortnight	
	χat	phase, eclipse	
	sba	star	4
	tuau	"	
	seb	adore, gate, soul	
	abt	month	
	tna	fortnight	
	hru	hour	
	hep	hour	
	"	constellation	
	apt	swan	
	ab	star	
	annut	the Gods	

IDEOGRAPHS AND DETERMINATIVES.

	set	a hill	5
	setu	foreign lands	
	meru	isle	
	mer mu mau ab sa, su shr slāfu	sea, waters water " thirst, pure drink " refine, melt	6
	am	amid- of Egypt	7
	ideograph of verbs in general, & of cross action, as "getting up and shutting the door," "judging" &c sesialu apt	arrived to judge	8
	anχ χetama s'anχ	crux ansata life, shut to nourish, feed, subsist.	8
	anχ uta snab. an invocation Life! health! strength		
	neser	of fire, flame, steam flame	9
	per-neser	the house of flame, the Eastern horizon	
	aχm beksu	extinguished something eaten	
	har hati hrt aχ shaka	peaceful heart, intention peaceful lively, gay	
	mat	granite	
	snf tχr muau χt χp χn	blood " water	

	srut (rut)	dig, engrave, plant grow, germinate
	akana	goblet
	arp	wine
	Kek han buka ua sft hrhu mrhu hanni anhu	drink vase conserve, balsam to wash pitch, cedar-oil to anoint to wax tribute
	art ashr ashbu ruχa aχm reχ	milk inflame consume brazier extinguish brazier
	tet mrh hati Haknu anta abr stbi	oil wax extract, essence drug perfume ambergris perfume
	tet hati mrhu	oil essence, extract wax
	hes amurt nemkam	jug a liquid a liquid
	han	Majesty, purity
	Kabh hes	liquids, refreshments to vex, enrage
	Hkka	liquids, refreshments

IDEOGRAPHS AND DETERMINATIVES.

	nu han	jar, ampulla 9 cont. vase
	tos	a liquid, liquid measure
	nehat pes	vapor to cook
	nemmut	a liquid
	xum	God Chumnis
	hesu	praise
	shent	dwelling in, living in
		
	aln	a substance
	kab	a liquid tarn
	nams	a liquid
	peka	a gap
	stm	stibium
	hemka	jasper
	asu amnu at afu	servant, satellite 10 captain laborer, follower, compan. spirit, light
	asi	noble
	matui anti amuth apa as as apr a	troops, mercenaries men of the gate a title ancestor noble, great statue bow maker I, me, my, myself

	of action a fot anan hekna hek amtu ap aptu apt aau at annu ash ak abh hanp ha ham kuter ker kar mat mahaut	of mind and mouth I, me, my, myself to disquiet, to fail to murmur, to be, being to discourse, to supplicate to charm, magic caste, rank move acquaint, judge suck extend oppose howl cry, plaint ruler wish, favor to spy, a deserter hailer hunt - to roar to order silence fault reverence homage, obey
		Living persons
	ari	to guard, to keep. companion
	hems bka hft kabu besht nini at	of peaceful action to sit to prostrate to squat miserable to revolt, to rebel quiet, rest labor produce.
	suax sbau	to adore to glorify
	mx msh	archer Soldier
	xeb abu heknu ha ux	of dance to sport to dance to welcome, to address Oh! Hail. to turn
	kat	to build, to labor
	tuau	variant of a star

IDEOGRAPHS AND DETERMINATIVES.

	xabu	stupid *10 cont.*
	sbau xeft	a convict - impious enemy
	nub nekhi.	to gild to work in gold
	ha aau	to rejoice to adore, praise, exalt
	hanna tehh	suppliant rejoice
	ha em	heh, a trillion years illimitably, for ever
	hes	to sing
	amn	to hide
	sxai	a scribe
	fa	to bear, to carry
	Shur or sur	to drink
	ab an	pure, priest scribe "
	Kebeh	libation
	Slem	a judge
	neham	to save

	nat	to knead
	beshta tuhu	weak prisoner
	beshta tuhu	weak prisoner
	pesh tut apa kis ases	statue " ancestor noble to please, acquaint, fill
	han hanti han han	turn back returner command
	patu rexitu resu mehtu	people intelligent beings people of S Egypt " " N. "
	ax axu	spirit manes
	mahahuit akiu amem mer tut	courtiers' family inferior beholders Superintendents of five
	Set Sti Bar satx māa ai	Typhon " Baal Sadok ass
		of names of females and Goddesses.
		of parturition
	men mena rer xem	to bring up to suckle. a wet nurse to dandle " " to put to sleep
	slesi " ap	to drag along supine "

IDEOGRAPHS AND DETERMINATIVES.

	xtb xr:shr sfx hefu nehbi bukti hetmi reitai xest	of overthrow overthrow smite lay waste growl to humble malefactor obscure rebel, culpable enemies, the impious
	seb	profane
	xebti tut kars	transformation image / Sha accuse mummy / aru ceremony ka a form of embalmming
	aut xat kars hes ab ax	matter a body embalm obedient form, type, image dead, spirit, type
	xtb	tumble
	pet	heavens, the sky
	nebkt	to wash gold to swim
	hi ufa xem kat	of construction strike 12 chastise build, construct " "
	hi ufa ten amentu betsh betnu	strike chastise bruise hide lazy, slow, injure malefactor
	aau ska	joy, acclamation exalt, praise
	ka	bearer, wearer (of diadem)
	ka	to bear, support, extend Ra who extends the heavens.

	nini kebeh	sprinkle libation
	sems	older, prince, preferred, adopted
	kes	to beg, beseech
	uxs	create, mould
		
	sbau	praise, glorification
	xet ba	invert topsy-turvy
	nmm	pygmy
	amu hak	conceal, envellop captive
	neter-han	high priest
	annu	to look back
	satem ab ash	listen hear, listen cry, plaint
	tenh	to bind, of Asiatic captive

IDEOGRAPHS AND DETERMINATIVES.

		Negro captive 12
		chief
	maan	cattle guard
	xixi	to whip
	ta seb	to offer sacrifice " drink
	maan	cattle feeder, driver
	ma	
	ash pherr	cry, plaint
	aba	to play a game
	kebeh	libation
	neham	rejoice
	maxt bak ax ahalū anan hti	powerful servant mow babble, want hoe strike
	set	spill. pour out
	uah kebeh	pour out, to feed libation
	atn	to beat, to pound
		

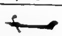
	xa	to measure corn
	hes texen	to sing to play the harp
	teb xeteb	to subdue " "
	tut	statue
	bu kes	& metal (with ▨ a stone) subdue, overcome, vanquish
	herri	Quadrigga
	tut	a statue
	shr	to terrify
	hur	elder

IDEOGRAPHS AND DETERMINATIVES.

Sign	Word	Meaning
	slā	prisoner, convey
	ur	elder
	aht or ahit	afsistant priestēss
	hems	to sit
	xen ru xer xart mpa enxu maharu se xrut sfi ap apt amlēn	baby of youth nursling child offspring to grow to nurse youth, hero, Soldier son child • move acquaint, judge caste, rank
	atn	to build, form, create
	atn	to build, form, fashion
	xpr xprla api	scarab 14 earth, world fly
	ment	bier of embalming 15
	menat nent xat str kar	repose, death bier, couch a body to lay out to embalm
	menau	sleep, death
	apu ap api thni hā tāta	head of the head 16 equal forehead face head

Sign	Word	Meaning	
	api ta api ru api ret api	upon earth 16 palate, edge of life dedication forthwith	
	her	on, upon, face.	
	ru	mouth	
	slēm an	stibium 17 appear, show.	
	ka an nhas res xtr	to spy adorn raise up suspend content	hestoux, glare aba, to pierce atn nu, sleep axt, splendor
	ari rimi axn	eye weep shut the eye, wink	
	atnt	build, form, sleep	
	ar artu ar ar ab ab	author works produced by to make passage frontage	
	armaa	to see	
	rimi rem akb	tears weep lament	
	an	precinct	
	an	appear, show	
	abh ba kaka hu	tooth 18 pay to chew, gobble up food	

IDEOGRAPHS AND DETERMINATIVES.

		of land, working the earth and of angular objects.
	ta	tooth, earth, to swallow
	hiu	means, taste, perception
	henbt	fountain
	apt	corner
	axt	horizon 19
	ab	clear
	abehu	tooth
	nu	cultivate
	tat	give, send 20
	Kab	arm
	Kabi	a pair of arms
	Kan	breast
	hept	unite
	ank	embrace
	aka	divide
	apt	rib
	tani	to encircle
	habtu	to hold together
		of power
	akhut	prepare
	ax	light, honor, suspend
	aau	reproach
	auaa	steal, take
	aa	knit
	aua	captain
	aufu	chastise
	auf	"
	auau	" length
	au	
	auai	kidnap, gainsay, catch
		of peaceful action
	Kuhu	shoulder
	Xi, Xu	to rule, protect, screen a fan
	xu	to rule
	xu	to rule

	ser	brush, reserve, private, effect, oblique, sacred, involved.
		
	ser	distribute, chosen, holy, venerable
		(all of this type seem to have the same value)
	ser	arrange
	meha	leave
	xu	rule
		of painting
	Kar	to fight
	Kat	to contend, to kill
	ma	directly, presently
	mna	to nurse 21
	snkau or shkau	} to suckle
 ka		labyrinth 22
	Kar	to rob, entrap, hasten secret, harass, ravish
	Her	to hold, possess 24
	uuh	to entice
	Kru	garrison
	Sati	the feet
	apu	guide, police
 tu pat ret men uar	Sn	Knee
	ret	foot
	xent	approach
	uar	leg
	bu	"
	ar	acre
	around	"
	suten	lie down
	hama	terrible, roar
	apt	guide, lead, propose
	peter	ent ta - to kneel

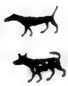
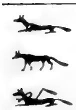
IDEOGRAPHS AND DETERMINATIVES.

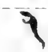
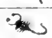
Sign	Reading	Meaning	No.
	skau tha maken bennu sati	sacrifice drunk, deprive slaughter no, not anihilate	24
	heh ail	of motion wander, search asleep, apace	
	sna xesef hem annu	turn away stop, not go stay rise, hold	
	masi	(ameni) brought, conduct, "les apports", cargo, merchandise	
	art	of parts of the body rump	25
	lash	fleshy part	26
	shaa aau	to be born, flesh sholder	27
	ha ka ua han embah harmata	of males husband bull ass husband before, in presence foreskin	28
	sa kan	of the body side binds, strands	29
	ab abu	a game of chess Numidian goat	30
	asui	testes	31
	htar desm mi	horse mare cattle	32

Sign	Reading	Meaning
	samsam	horse
	aua ka aka	bull of cattle fat
	ah aua maht kau	cow white antelope cow
	abhers aua hnhr husu ab	calf steer calf thirst
	satf ba	thigh cow
	sha fenti sesn rex xenn sen	nostril } of breathing nose } dwelling breathe joy sleep breathe
	reru xau apha	boar sow hog
	ab kamer apt bes teb xener ab hati leher	of quadrupeds elephant camel Thebes, hippopotamus askin sandal casque apiece of linen, pied bellows leather
	ba	goat, soul
	serr	Egyptian sheep
		wild goat
	karx xahsi	gazelle "
	ar at	antellope "
		
	sehak ska sahu	ancestor to collect a crowd race, family, ancestors

IDEOGRAPHS AND DETERMINATIVES.

32 contd

	set na	an ass " "
	uhar	dog
	Xau	cat
	tesm	tom-cat
	maaft	lynx
		rat
		gerboa rat
	aani	ape priest
	hati	worship
	Kant	rage
		
	Seb ansh	jackal, crafty, cunning. magus wolf, dog
	maau	lion
	Sen	lioness, turn back

	ab	elephant
	hunx	a wolf
	sa	a fox, a son, an order of priests
		rhinoceros
	apt	hippopotamus
		giraffe
		gryphon
		sphynx
	emsuh atu axem ati	crocodile " extinguish lay out
	sati	connection, beam
an un 	anx an	hare being, existence
	apsh	tortoise
	hek	frog, numerous
	ashu	tadpole, many, numerous, million
		innumerable, more than 10.000
	fnti	blind worm
	axu or ashu	lizard, numerous, to supply, to give breath to.
	serk	scorpion

IDEOGRAPHS AND DETERMINATIVES.

	hem or sānhem	Locust or grasshopper	32 cont.
Kal	het xeb hab	bee wasp King of Wr L Egypt	
	af	fly	
		mantis	
	shft tenlu xeft xex beb ahit am	ram, to fashion to rise up, pride, revolt demon, liar the throat the gullet the windpipe to eat	33
	slā	to conduct	
shef	shft tenlu xeft seshi hefau	ram, to fashion to rise up, pride demon, liar place in writing desolation	
	ah	flesh	
		thirsty	
		dorcas goat	
	pehti apehpeh	vigilant gigantic	
	henbet	subject, servant	
	hfu tenlu xept hefa em hefau	disturb, hunt rise up, pride thigh seize on the contrary	35

	solem alu	(a cow's ear) listen, heard penetrate, regulate	36
	besu tehan	pass elevate, promote	37
	palū	mortals	
	mut	die	
	kaf enkaf tuh tuh ta or tam ant	carry bear off steal claw	
	xpsh	a thigh . of fame	38
		a span measure	39
	repat	lord	40
se sa ak	se xpr sinn xenn kai	son, daughter scarab destroy sleep title	
	tai	half	
	bau	souls	
	ta	seize grasp	
	ru terp sent	duck kind of duck to prove, fear, terror, timid	
	hat	beginning	
	abhubah bah abahu	bird on corn heap inundation, to swill, harvest fill, inundate, supply, to gorge	
	pai tennu ser maten hem	to fly to move kind of goose facilitate create, produce	

IDEOGRAPHS AND DETERMINATIVES.

	ur	of evil sparrow (40 cont.)
	uls	little
	an	deficient, vain
	ak	starve, hurt
	ban	unclean
	bekai	wastē, void, cease
	bek	cease, depress
	but	abominable
	fennu	filthy, dirty
	fekti	evade
	kekar	starve, famish
	han	envy, malice
	han nui	conspire
	hesm	suffocatē
	haiu	destroy
	hat	fear
	het	oppress
	hut	afflict
	xen	little
	xepen	"
	ker	false
	emsah	mislay
	mas	hatē
	mahau	officers' family
	mayara	desolatē
	anbu	thorn
 ha	xen kam tennu	agitatē, diligent; tell, fearful to move
	rex	pure, spirit, dream
	ba an aba	soul, spirit be pass through, opposite
	am amma shem tam	give find strangle, bind wicked, match
	hma	to fish
	Mut atmu	mother food of the dead
	tefau	teal or small duck
	tef	fragrance
	sek ba s'baat setet	to be idle (snared bird) " " " " to tremble

	akam asham	wrapped up eagle or falcon
	ast	to frighten, to protect
	tesher	an adjutant, red
 x	kem	to find of seeking
		
		
		
	ba	soul.
	sex	nest, waterplace, to fill
	seshi	nest, marsh, nets
	rex	pure, soul, dream
	rex	pure, Soul, dream
	rex rexilu	pure, spirit, wise intelligent, reasoning beings
	ut neh	belonging to drag, agitatē
		
	anti	the "perfume of Anti"
	ha	predecessor
	ba	soul.

IDEOGRAPHS AND DETERMINATIVES.

	apt	duck 41
		
	nrau Kan	tō vanquish number, numerous
	tenh pai ap axm tēma axu axai axex xu	wing of flying 42 to fly to mount to soar to swoop to rise, to fly to fly " " wing or plume
	rm bat abut hutēr an bes	ray of fishes 43 abominable a kind of fish " " " a perch to bring over.
	anru	galē
	xept	thigh
	shept xa	shame body
	ru mehn fnti refref	snake 44 asp worm, viper
	apap app sba betsh axex atāne nak	elevatē Apophis wicked abomination dragon fantastic, shame Nak, the great Devourer
	xefti	enemy, accuser
	hatū	fore head.

	of names of Goddesses ura mashau mehaun apt art	 uraeus uncertain serpent head eye
	of names of trees ash	 sycamore 45. ash acacia cedar
	shaua	of wood persea (wood) tree 46
	ti hti petēr renpa xer	a shoot, time 47 horse to shew to increase, grow, plants youthful.
	su suten	he, it, they King
 as	axm amu herri arp ushm hu mpa bet mahu han menht mash	to grow of plants 48 a flower " " vine maize corn datēs corn, barley crown of flowers field fodder, clover
	aatru sem aak menht	food (lotus) reeds fodder clover, fodder
	herer	a flower
		
	su boti hut	wheat whitē barley, wheat

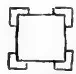
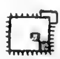
IDEOGRAPHS AND DETERMINATIVES.

		delicious 48 con.d
	ih	nosegay
	aar	a vine
	benr	dates, palm tree, delight
	ash	acacia, cedar
	"	a kind of nosegay
		lotus emblem of L.E.
	xa	to rejoice
	asx	to reap
		delicious
		(lotus leaves)
		(a pod or two leaves)

	xa	a title
	rasha	joy
	rsh	joy
		a material of stone
	mna or men	to pound, pace, go round
	asha	a laburnam
	arr rnpa ba	grapes 49 dates bronze
	ret	a turnip, boat
	anem ant anti	pearl, jasper 50 kind of unguent, yellow perfume
 nu merr	Kar merr nut	horizon of cities 57 a cake a city
	ta ba hebni markabuta ner usr Kar ati maxa xa aaut aat-Karuta aft at asr akara absi aaut aker ams benben betau hata han hakr makaeta ari ash naxt xet	stick 52 bough, wood ebony chariot paddle " " a bolt lintel balance wood, stick, sceptre pike a sledge, a chariot abode, couch kind of wood tamarind wine bolt part of a boat a boat viper hold a stick palm branch holes for ropes a mat, a bed a stick applied to festivals a grove lintel acacia, cedar power afterwards

IDEOGRAPHS AND DETERMINATIVES.

	tā	a stick	53
	tā	a club	
	ha	abode	54
	neter ha	temple	
	maten her sher ar	path, road, way, path road to approach to guide to go up to teach	55
	annu ha	hour time o'day	
	sebti anbu ab anb maten	wall wall of enclosure, rampart cornice a path	56
	xem xem	to bruise, to crush	
	maktām	a tower	
	per	of house & its parts a house	57
	per hut	treasure house	
	ha	house	
	ruper	temple	
	ha nub	house of Gold, or Hall of Gold. i.e. Hall of death	

	arr xent ab ha makfh an	steps, to mount, a hall. an approach a flower " " a stand, a frame, stocks ascend	58
	xetā hri hati	a tomb (tomb door) to fear afraid	59
	ha	a palace, a house	60
	hait	ceiling	61
	ha ah rehi	palace house garden	62
	usex	Hall of the two Truths	63
		Pylon	64
		Propylon	65
	sebxt	gate	66
	ar han an arru neh arrut	hall to bend, relations a hall " to form, to execute to struggle, to oppose	67
	mer	a circuit, an enclosure	68
	anbu	wall of enclosure, encloses names of prisoners enclosed	69
	an un an un sex matbet	a door, a hatch cover a door to open " " shut a boat's hatch	70

IDEOGRAPHS AND DETERMINATIVES.

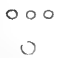
Sign	Transliteration	Meaning	No.
	serχ	door, pylon	71
	sχet sχeb	fowler, weaver, artisan join, slab	72
	mua hu iuma atr merult mer atru atu aχm hiuu hau	water ocean sea river lake basin, lake river, distance river, measure bank, wave inundate territory	73
mer	meri en	beloved of -	
	of stone & minerals auuaia teb ka abkat	 stone, pebble brick a (brick floor) a drachm	74
	heb	festival, panegyric	75
	heb hut	festival good dæmon	
	heb	festival	
	heb	festival	
	heb	triumph	76
	ba uua usχ mna mshn suak maat ta χen χef kau fenti	boat " hold barge deck cabin hatches to go by boat to place a boat to stop, to anchor to stay	77
	neshm	bulwark	
	usi sunti χesef hunti	boat to detain to stop a boat, to anchor	

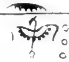
Sign	Transliteration	Meaning
	sti sebkt ha	cabin " stop
	sesn sesrt ses nef tepak tekai fa	sail air breathe breath, air, wind snow to sail to carry
	ta χesef	to sail to stop
	sti sebkt	cabin "
	χet	to navigate
		archaic form of boat
	χesef	to stop a boat
	uaa ba	a big boat
	ua en Ra	boat of the Sun
	ua en Neter	boat of a God
		barge of Amen
		barge of χons
		barge of Mut
		barge of Socaris
	sekket	barge of Ra
		barge of Socaris
	us ati	a boat a satellite

IDEOGRAPHS AND DETERMINATIVES.

Sign	Word	Meaning	No.
u	nuh hati senh sent atnu	a cord towline bind found to build, to form.	78
	urn	stern	79
Ka	Kam sba ta	to create wicked fowling stick	80
	heplū	poop-deck	81
	xa en	the wood of the mast	82
	atukar	rigging	83
	belā	blocks	84
	nefri	halyards	85
	bast	rowlocks	86
	hems	rudder	87
	hpi	paddle-blade	88
	matbet	hatch cover	89
xer hap nxt	usr hept	oar paddle	90
	xepsh xerleb	a sword, to smite to prostrate	91
	pest pet pext peti	yellow paint to shoot to extend black race, Ethiops, Lybians	92
	atnt pest peti ph	repulse strength bow in Naph	93
	sasr sati sti ser	arrow shoot arrow arrow-head	95
	Kaut menx Kat menx	fabricate, build, construct fabricate, work, labor create, form, an artisan's laborer's, soldiers or other tools.	96
	Kat hen hu serka Kas Kers ab bena	inscription phallus to carve to embalm a coffin ivory work palm branches	97
	Hen	a title	
	hui	a mace	
	us	a saw	98
si	srha art sefex xer ark ar anth ant shem anx hebs henx mer Kras sesht hap haa am xeft	a roll, a papyrus a package, a bag to tie to fall down binding, clothes clothes nosegay list each, every strap, dress clothes, reckon, account a girdle bind embalm a slip to hide to be naked cloak, clothes	99
	ant xetma senna sena	a ring to shut to enclose to turn away	100
	sesh	a ring, a handle	
	at sep xi	a circle times the "ego", person,	101

IDEOGRAPHS AND DETERMINATIVES.

	sha sna matiu	(a seal ring) to encase to turn away, knee repose, quiet, dead, precept	102
	pesh pexxa pxa pxat	(half cartouche) to seperate divisions rod lioness	103
	menat xet	seal seal, shut	104
	heha hebs henx hap aft af huth at	(basket and cord) of clothing naked to clothe a girdle conceal cartonnage cup table cloth a kind of linen	106
	xat has hebs abu bet sta hu hes naha ashahu bat betennu fenka neh hi hekar arar	of foul things mummy embalm wrap, reckon, account Elephantia bad, evil, abominable to conduct filthy " foul, copros ashes food, rations malefactor to evacuate foul impurity hunger, starve seed	107
	ant xesbet kam shebet xesbet-ma	of metals, colors, gems, perfume yellow blue - artificial lapis lazule jasper porcelain lapis lazule	108
	han kara	of boxes a box sarcophagus, shrine	109
	xem kars	a box, a shrine embalmment, funeral	110
	teb kars aa	(box lid) a box a coffin bier	111

	an ab kabati kerati	horned pure horns two horns	112
 	nub	of gold gold	113
		enamel	
	mahr henher	mirror "	114
	sba merh as	a flute " " beast, servant, mole, sepulchre, chamber, tomb, idleness, fault, leisure	115
ma	ma	cubit	116
	xa boti	to measure corn barley	119
	tnat hept stebexen	half- pint of measure	120
	ak tĭ Kufni xa boti hept hes shenef	bread fragrance " food corn, barley solid food	121
	nehar tā	a kind of bread a heap	122
	tesr	a plate, a liquid, cream or cheese	123
 shn	ren sen idau	a name to bind, an orbit a pendant	124
 an	Pet Het Barnu aw	Nubia upper Egypt Barnea to return	125

IDEOGRAPHS AND DETERMINATIVES.

Sign	Word	Meaning	No.
mer	mer hab χebua ba bamt	to love, beloved plough (to plough) to hoe a hoe to glide	126
hab	hab χebua habnt her ska amer	a plough to plough [illegible] ebony to harrow to plough a storehouse	127
	asex arti	a sickle, to reap buttock	128
	hesep or tät'a	a nome	129
	sersh aat hi	a standard a standard a place to draw	130
sh	uax pekau	a marsh a shape	131
	shiu	standards	135
	as apiu or abiu	work, skill to lay foundation	136
		lunar standard	137
	uxt	power	138
			139

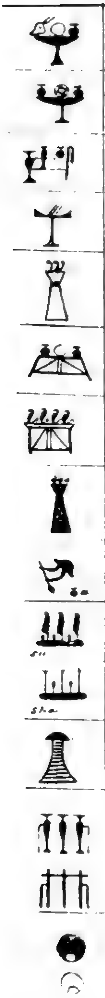
Sign	Word	Meaning	No.
		inverted horns seven horns blank writing material mistress of writing name of a goddess	140
	tes uts res enhas emhas res ulā	to (balance post) transport to carry, to go out to suspend to excite to ~~lay~~ arouse to watch to try, examine, suspend	141
	maha	balance scale	142
	sexex	to balance, adjust	143
	tā tam tkai	a finger to bear to adhere	144
	sex mātr	to examine of foreign land of foreign people	145
	tā tka pett	(a hook) to bear away to adhere ready	146
	ulen habi teb	(folded band of metal) consecration a fold, redoubled	147
ten or tet	atbu utn men mena ten tebenben ser	wells ingot, weight go round to pound to circulate ben " " s'elancer	148

IDEOGRAPHS AND DETERMINATIVES.

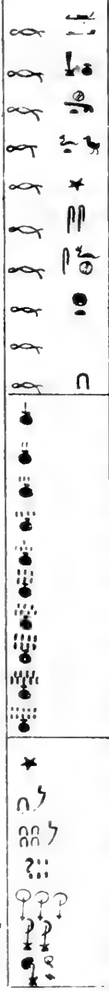
Sign	Sound	Meaning	No.
	heq. au naxb	acrook rule, a crook a ruler a title, to inscribe	149
s.	Snab	back of a chair & health	150
	uga	strength	151
	max au max hema	a key, ripe, blest blest is, mature is hemp	152
	tā	the earth, the land	157
	tā		
		Egypt, the land of the winged Sun.	
		id:	
	tāi	the two regions, Upper & Lower Egypt	
	tāu	countries	
	hesp	district	
	nu	isles	
er	ruem her	mouth (door of the head	158
		ears	159
	hfa hep	fist, seize by force hand, fist	160
	set	palm measure	
	shept shep	hand take	

Sign	Sound	Meaning	No.
	aa it	dew paint, to figure	
	set	palm measure	
			161
	pest "	back spine	162
			163
at	at tat hetta atti at	substance type, drop, tear type " "	164
	atēn	captive	165
	sah ru	gate	166
		leopard's skin	167
shep	xep shep	to receive to take, hold, seize	168
tat	emblem of stability tat shent apt arit tattu	stability, follow, palette impart bottom establish	169
			170
xem	shem xem	bolt, shrine Ithyphallic God	171
	xaui ax	altar "	172
	s	shrine, ark	173

IDEOGRAPHS AND DETERMINATIVES.

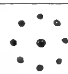
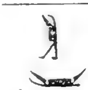


	χaiu	shrine	174
	hethu	altar, table of offerings	175
	χaui	altar	176
	χaa	altar	177
	χaiu	altar	178
	χaui	altar	179
	χau	altar	180
	aχa arit	censer staircase, hall	181
	(breast, arms and paddle) tent is placed		182
	asha sem	field clover	183
	sha	a field	184
	χersa	a truss of hay	185
	shenti	living in, dwelling in	186
	Paut	divine assembly of the Gods Synod of the Gods	187



			188
		Ordinals	
	meh-ua	first	
	meh-sen	second	
	meh-χem	third	
	meh-ftua	fourth	
	meh-seb	fifth	
	meh-ses	sixth	
	meh-sefχ	seventh	
	meh-paut	eighth	
	meh-psit	ninth	
	meh-met	tenth	
	or		
	meh-ua	first	
	meh-sen	second	
	mehχem	third	
	mehftua	fourth	
	meh-seb	fifth	
	meh-ses	sixth	
	mes-sefχ	seventh	
	meh-paut	eighth	
	meh-psit	ninth	
	meh-met	tenth	
	seb	five	
	met-psit,	19	
	hme-psit	49	
	tut seb	25	
	ashu	thousands, or very many	
	"	numerous (oxen & geese)	
	"	" (honors)	

IDEOGRAPHS AND DETERMINATIVES.

Sign	Word	Meaning	No.
	sep ud sepsen sepxem sepfluа	once twice thrice four times	188 cont.
	sessennu	thousandth	
	ua ment, met, u	thousands	
	hu	tens thousands	
	ashu	hundreds thousand	
		millions	
	mpa	billions	
		all time, forever	
	teta	everlasting, zero, infinity	
	api " "	first " "	
	ki	second	
	ia	(a stick or club)	189
	tex	a weight, a supply of liquid	190
	sesha	a shekel	191
	tat	(a buckle)	192
	armat	(two eyeballs) to see	193
	ai	to go	194
	aa annu	to bring tribute tribute	195
 sam	sam "	to direct, pass, traverse a statue	196
	apsh	hall, float circular, to encircle	197
	perai	to go out	198
	hes kapa	to sing to fumigate	199
	ab asteb shua ma abu ab ab	a kind of wine a seat or throne right, proper pure, clean feast	200
 shes	shes	to serve, a fellow, a servant	201
	beta ba bu	gift (a sledge & stone) reward bestow, symbol of the product of riches	202
	mer	a chest, box, ring,	203
	akm	(a shield)	204

IDEOGRAPHS AND DETERMINATIVES.

Sign	Transliteration	Meaning	No.
	neft sirui	fan, flabellum a fan	205
	at	hear, words	206
	at rami	fish	207
	shuam apma shu	feather, with, at dream exempt	208
	xem sept	prevail lighten	209
	aab	pass, oppose	210
	ab kam	material	211
	artū	buttock	212
	ānta at	hour of the day minute	213
	apr	equip	214
	atn	create, reckon	215
			216
	hen	a packet	217
	hen	"	
	benben	cap, tip, roof	219
 hi	hi	to drag	220
	het ti	soles of the foot	221
	hankk kaf	throat, charge desolate	222
	hankk	throat, charge	223
ht 	hut	silver	224
ht 	hut	a mace	
ht 	hutu	onions	225
hut 	hut	white	226
	amo	hold a stick	227
hut 	hut	onion	228
		sceptre of Lower Egypt	229
	usef	fiat, decree, station	230
	sxem	germ	
	aau } aaiu } aat	labor, work, honor, glory, title artisan, dignity	231
	sutenresh	King of Upper Egypt	232
nat 	nema nat	to force to turn back to make grow	233

IDEOGRAPHS AND DETERMINATIVES.

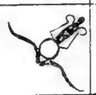
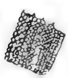
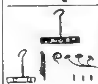
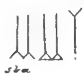
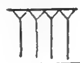
	li anhaler nap	in lēra time lark grain	234
	lāb	a fig	235
		(a pomegranite)	236
	han ar	a box grapes	237
 su		vertebra	238
a 	atā	day	239
	hanna henbi	a well territory	240
	serh ssau	drain floor	241
	mer	2nd class cities, and water stations	
	ashr	slice	242
	ba ba herni	captive, prostrate, to conduct iron salt	243
	em kefau	on the contrary	244
	em nem ushem	again, repeat to renew	245
	χem	hemp	246
	hma	flax	247
	snut	granary	248
	nam	block, place of execution	249

	boti	corn (heap)	250
	hut	onions (bundle of)	251
		pylon, gate	252
	kara	a chest	253
	ast hes kat hesb	a throne, a place " " a throne, a seat " "	254
as 	tēn ast aset hsir	a seat a place, situation Isis Goddess Osiris God.	255
	sebt	dog star, Sothis	256
	teχen tshen teχen	Obelisk " sχai engraved Obelisk	257
	lotus bud capital column		258
	lily lotus capital column		259
	lily lotus capital column		
	doum palm capital column		
	nuter	temple	260
	kani	chair	261
	hes ka kat	sofa " throne, seat	262

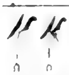
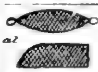
IDEOGRAPHS AND DETERMINATIVES.

Sign	Transliteration	Meaning	No.
	uts	palanquin	263
		(a seat)	264
		(a chapel)	265
	an anru	total, account a stone	266
	kar hell	a furnace " "	267
	hai	a tablet	268
	t..b	a shrine	269
		fill, inundate	270
	neph	a potter's stand, to mould	271
	apt	a manger, Thebes	272
	hurs huti uts	a pillow " "	273
	xar	load	274
	arrt	crown with asps	275
	mahu	chaplet, crown	276
		crown, circlet	278
		crown of flowers	279
	het	crown of upper Egypt	280
			281
			282
	teχh	crown of lower Egypt	283
	χepersh	helmet	284
	nams	a wig	285
	nams	a wig	286
	abeb baba	horns, extremities, to tip	287
	tes tesu	the tie of the crown to raise, elevate	288
	ub useχ	a collar " "	289
	χasχ	a collar	290
	shena	a collar	291
	χaχ	a collar	292
	annua	to tie up, plain	293
	useχ	a collar	294
	men	a bracelet, an anklet	295
	men	a bracelet, an anklet	296

IDEOGRAPHS AND DETERMINATIVES.

	ulā	a pectōral platē	297
	maka	a metāllic annlet	298
	ash	a string of beads, Acacia or cedar gum	299
	shent	an apron	300
	sha	armor	301
	shua sem	a plume a feather	302
	atef	the Crown of Osiris and of Gods of lower world	303
	atef	Crown of Horus	304
		chain armor	305
	teb tebti teb teb	sandal two sandals sandals	306
	χaibt	a fan, repose	307
	ser	a fly flap	308
	tehs	a shoe latchet	309
	sersh	a sistrum player an assistant priestess	310
	sersh	a sistrum to play the sistrum	311
	sersh	sistrum	312
		occurs in Louvre papyrus as " — au" an ingredient in an ointment for the memory	313
	χeχ peχa	a whip to whip	314
	sba atā menχ	a prop utensils "	315
		(a stick)	316
	kannu tema	hemp stands linen cloth	317
	tahen	crystals	318
	aka aku }	a battle axe	319
	neter	a god	
	neter han	a high priest, prophet	
	χetni	a battle axe	320
	sneχt	a woodman's axe	321

IDEOGRAPHS AND DETERMINATIVES.

	baasu	a dagger 322
	χaa	a dagger, a chief, above, first 323
	hurr	a chariot 324
	sχai	to write, a scribe, painting 325
		scribes' pallet 326
	teχ	a weigt, appointed 327
 ma	ma χena	a reed pen 328 to shut, to seperate, a concubine
	tër	in quantity of food, fruit.
 tam	tam sert sem	scepter 329 a liquid, cream or butter gold
	user	power, victory, riches 330
	uabt	The West 331
	shaa tës per tait	book 332 tied up roll house of books, Library
		(a polisher) shadow(?) 333
	ab arf	food, cook 334 bag, pouch, purse
		in overseer of the ... 335
	sat	336
 sta	stä sat satu	a ball of thread, to tow, to spin, to lead, to convey. to lead 337 a corde (a reel & cord)
		to reel cord & twine 338
		a spindle 339 to establish to prepare name of a metal
 as	ab abu aχ apr χetu het	a papyrus roll. oppose 340 form light equip things letter
	teruu	a roll of papyrus 341
		a chisel 342
		(linen bands) 343
 at	aat	a closed net 344
at 	aat	a net 345
at 	aat	an expanded net 346

IDEOGRAPHS AND DETERMINATIVES.

Sign	Phonetic	Meaning	No.
at	hat aat	chaos a net	347
	setp	to judge, to select, to approve	348
uuha	tua uuha	to return, retake, escape fisherman (boat & net)	349
			350
	ab an hentu	in dumb an animal Heliopolis arms, tools, utensils Is much elongated in the T. as reliefs; Is probably one of the masts raised in honor of the Gods	351
			352
		(incense burner)	353
	att mata	enclose, delect whip	354
	sahu sab	received constellation of Orion	355
	ssah	Orion, assemble, perambulate, a journey	356
	nena		357
	sep	times	358
	stem	stibium	359
	at	bread	360
		a basketful of cakes	361
		(of extent, width, space	362
		a cake	363
	nebst	date cake	364
	Kabi	honey comb, a quarter of an aroura of land	365
	pu "	a shutter a mat	366
	bsn } nebs } rub axu hebn bat er sah	dates to germinate censer honey, conserve, fruit barley since to collect	367
			368
	neb Neb er ter	Lord Lord of all, universal God	369
	ba	iron, cloud (a crucible)	370
		archaic form of crucible	371
	aten Kar	tank, rank curve	372
		(an emblem of Suphis)	373
	u	one, line, edge	374
	sens	food, a ragout	375
	ta art	to give, termination of present participle	376
	neter sle	incense	377
			378

IDEOGRAPHS AND DETERMINATIVES.

	pet ha	a bowcease to remain	379
	ssah	a journey	380
	sent sennt	foundation to found	381
	tatan	proper, peculiar (from tata, prince, minister, chief) (abbreviation of 129.)	382
			383
			384
	nemt	gallows, block	385
	shat aspen asex hebt hent hesb heska mati ma	cut slab mow cast out cut, rub destroy, desolation cut cut, hard, thick cut	386
	au	joy, magnanimity	387
	ma net	sep continued	388
			389
nas	nas ax nasr "	tongue adore superintendent a chief	390
apr	apr	to equip	391
	an	a whelstone, to order to dispose	392
	amen tensamen hemi	}	393
	betsh	lazy, slow, revolt	394
Tem	temt	total	395
	het	half	396
	hat	heart	397
	sept septi	lip banks, shores	398
	hem	female	399
Hetep	hetep	a table, peace, offerings, food, goods.	400
	tet	dish	401
	ast	a rope	402
	nnush nnushem nashem	rib kidney liver, loin	403
	smat	daub the eyebrow, stibium, half month	404
	sept	shore, lip, margin	405
	ua Kama	sole, only, one lake	406
2	Het	small (a muller)	407
	Hen	of ivory carving	408
	Kar	tail	409

IDEOGRAPHS AND DETERMINATIVES.

Sign label	Reading	Meaning	No.
sem	sem mati pen	of things divided, such as, straw, bristles, fodder &c back neck back, spine	410
	smenx	work, utensils	411
	ru rti sata	door gate a festival	412
net	net	knead, address, save, help, afflict, punish, hail! homage, praise to, glory to	413
	mena	to sharpen, to cut	414
	pebu sexa	a leather cutter to make	415
	uah	crown, buckle	416
	pesm per	a cake a kind of cake	417
	ru	a spike	418
	sxa ker	to embellish	419
	nefer	good, youth, merit, beauty, worth, to ornament	420
	sotem	to hear	421
	utau	pectoral plate	422
	tens uteb	part of a net, a stretcher to stretch	423
	xaka	to shave	424
	urx ashab	a clepsydra } ? " "	425

Sign label	Reading	Meaning	No.
	sxet	to squeeze, to make bread	426
	sha shen	to rise (sun rising) a cake, kind of food	427
			428
	ber ber	a pyramid	429
	hankti sen kam amen akeb rut	mane, down — ideogram a lock, a curl — of wrong black — " grief wool — " evil grief — " of torment posterity	430
ret	ret rut	race (a sling) engrave	431
		(counterpoise for collar)	432
			433
			434
			435
	nub	gold	436
			437
			438

IDEOGRAPHS AND DETERMINATIVES.

Sign	Transliteration	Meaning	No.
			439
			440
			441
	nemb		442
	ba	of mines and quarries / a basket	443
hem	hems / hemet	to sit / a wife, woman	444
ab	ab / aba / neka	purification / against, contrary / a gap	445
ma	ma	a cubit, a forearm's length / just, true	446
am		capstone over gate	447
Hq.			448
xen	xen	(a swamp or morass) / a swamp, morass	449
	xabes	a beard	450
	sek	a battle axe	451
	sek	to seize	452
		a suspended vase	453
shes	shes	to serve	454

Sign	Transliteration	Meaning	No.
	menti	the two mountain chains bordering the Valley of the Nile	455
	sah	constellation of Orion	456
	sep ua / sep sen / sep xemt	once / twice / thrice (indicates that the preceeding word must be repeated)	457
		follows ha-nub, 'House of Gold' an euphuism used by the Egyptians to avoid the mention of Death. / is probably a variant of the same	458
			459
			460
	per xentu	harem, house of concubines	461
		ruins / ruins	462
		head of an enemy, an Asiatic	463
	ba	bronze	464
	bulau	a piece of wood of the sacred boat.	465
			466
	set	to impregnate, to shoot arrows, to throw bread on the ground, to pour libations	467

IDEOGRAPHS AND DETERMINATIVES.

		468
		469
		One of the Cabiri 470
	bâ	the soul 471
	neferu	graces, merits, beauties, excellencies 472
		a symbol of Osiris 473
		a fingers' breadth, $\frac{1}{4}$ of a hand's breadth $\frac{1}{24}$ of a cubit, $\frac{1}{28}$ of a royal cubit 474
		two fingers breadth
		three fingers breadth
		a hand's breadth 475
		five fingers breadth
		six fingers breadth
		seven fingers breadth
		eight fingers breadth
		a span 476
	au	a cubit, 24 fingers brdth

SYMBOLS

	Xat nmat	Kings chamberlain
	neter nefer	good god
	neter ba	holy soul
	neter hat annu	horoscope
	suten neter meri	King god-beloved a priest
	neter suten han	the god his majesty a priest
		a priest
		a priest
		high priest of Amen
		title of a priest of Neith
		Priestess of Ptah
		a female musician, a priestess
		sculptors
	shes	servants, or some kind of priests followers.
	sheshu	servants

		priest of Anubis
		a scribe
	ab	Priesthood, purity
		liturgies
		prayer
	sba en Ra anet en Ra	Praises to Ra!
		prayer
	tat neb	gift to a god
		offerings to the temple
		fear
		offering of oxen & geese
		Vases of the temple, things dedicated
	hetepu	things dedicated
	Heknu	holy water, magic water
		sacrifices

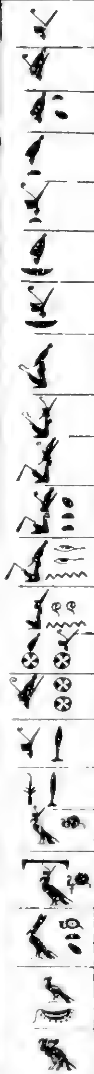
SYMBOLS

Symbol	Transliteration	Meaning
		sacrifices
		meat offering
		offering of lotus flowers
		offering of pomegranite
		offering of olive oil
		id
		sacred loaves, consecrated cakes
	neter hau	temples
	Kar neter	hades
		"
		"
		"
		house of the Gods
		scribe of the temple
		palace, Kings' house
		Kings house, temple
		house of gold, hall of death
		seat or place of the lord
		sanctuaries of Thebes
		Temple
		"
		"
		seats, places, temples

Symbol	Transliteration	Meaning
		temple
		temples
		"
		"
		"
		"
		a shrine or portable temple
		a shrine, a temple
		a great house, a temple
		" " " " "
		a temple, a libation house
		" " " " "
		temple of Ptah
		" " "
		" " "
		temple in the city of Ptkah or Memphis
		temple of Ra in the city of the sun, Heliopolis, Thebe
		a temple
		a temple

SYMBOLS

sulen ha	palace of the King
ha-ur	house of Maa, Truth Great house of the Gods
mi amen	Rameses, Memnonium
	the Memnonium
sekbet	a walled court
	a walled court
	temple services
	"
	"
	"
	"
	offerings, purification
	" "
	" "
	sacrifices,
	sacrifices, gifts for
	King of U.E.



rex	King of L.E.
pshent	King of U. & L.E.
	Queen of U.E.
	Queen of U.E.
	Queen of L.E.
	the lord the King of U.E.
	the lord the King of L.E.
	King Ruler of U.E.
	King Ruler of L.E.
	King governor of U. & L.E.
	the queen of U. & L.E.
	the King of the land; the two eyes represent the portals of the Nile.
	King of L.E.
	King of U. & L.E.
	King of U. & L.E.
	His Majesty
	his Majesty the King
	his Majesty the King
	heavenly King
	the queen
	King
	King & queen

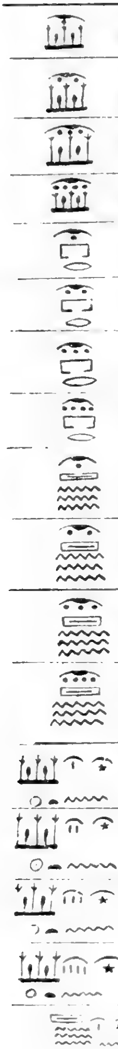
SYMBOLS

	se Ra	son of Ra
	set Ra	daughter of Ra
	sutenχabt	King of the two regions
	Suten resħu	King of L.E.
		offerings
		illustrious
		servant, one of the four orders of priests
		"
		"
		"
		"
	neb	lord
	nebt ħa	the lady of the house.
	neb ħa	the master of the house
	neb reshu	lord of L.E.
	neb meħt	lord of U.E.

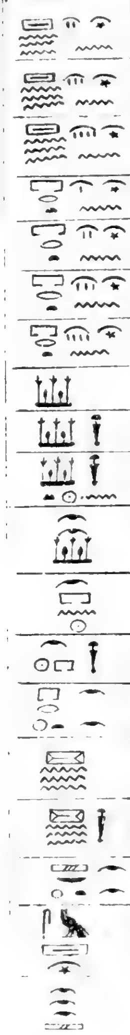
	neb ru u	Lord of battles, conqueror
	neb χepesh	Lord of the sword
	nebχam	Lord of Egypt
	Shent Kau	Ruler of the countries
	neb tau	Lord of lands
	nebχeperi	Lord of the two Egypts
	neb tai	queen of the two countries
	nebttai	queen of the two countries
	neb t Ka tai	lady of the throne of the two countrys
	neb sha	lord of the field
	neb Abt	lord of U.E. or Thebes
	nu reshu nu meħt	Land of the South, U.E. Land of the North, L.E.
	reshu mehlū	North & South Egypt
	aah	the moon
	aahu	months, in describing a persons age
	aah	id:
		monthly
		a fortnight or half month
		id " " . "
	uak	a week

SYMBOLS

Calendar



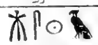
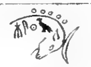
Symbol	Name	Meaning
	thoth	season of vegetation the month of
	paophi	" " "
	athyr	" " "
	choac	" " "
	tybi	harvest months
	mechir	month of
	phamenoth	" "
	pharmuthi	" "
	pachon	season of the rise of the Nile
	payini	the month of
	epiphi	" " "
	mesore	" " "
	thoth	flowering months
	paophi	the month of
	athor	" " "
	choak	" " "
	pachons	season of the rise of the Nile



Symbol	Name	Meaning
	paoni	the month of
	epep	" " "
	mesore	" " "
	tobi	harvest months
	mechir	the month of
	phamenoph	" "
	pharmuthi	" "
		season of vegetation, or first third of the civil year
	thoth	the month of
	thoth	" " "
	paophi	" " "
	tobi	" " "
	tobi	" " "
	mechir	" " "
		season of inundation
	pachon	the month of
	paoni	" " "
	paoni	" " "
	epep	" " "

SYMBOLS.

	epep	month of
	mesore	"
	hru	a day " "
		first day
	annu	hour
	annut	the appointed hour
	"	" " "
	"	" " "
		planets or wandering stars
	hru	evening star
	sba Kark	star of night
		star of night
		star of night
		star of night

		Zodiac
		star of darkness
		star of darkness
		star of light
		star of light
		star of light
		Aries
		Taurus, the birth or rising of Taurus
		Taurus
		Taurus
		Taurus
		Orion
		Gemini
		Gemini
		Gemini
		Gemini
		Sothis
		the heliacal rising of the Dog Star

SYMBOLS.

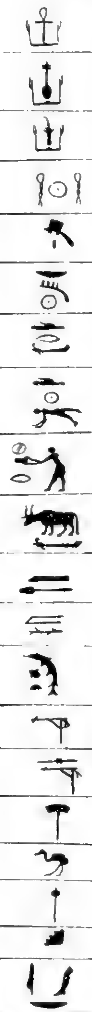
		Leo
		Libra
		Libra
	serk	Scorpio
		boat of Ra
		aquarius
		chief, or first
		chief, or last
		master of the house
		id " " "
		chief of the temple
		id " " "
		chief of the great house
		chief of the temples
		chief scribe
		chief priest
		chief of the learned men
		chief
		captain of soldiers

		water processions
		bridge
		the two doors of heaven
		the two doors of the Nile
		the keeper of the two doors
		door keeper
		door keeper
		door keeper
		guardian of the door
		jewels
		treasures
		treasures
	semkat	silver
	mesu-kat	silver
		mines
		mines
		mines
		mines
		money
		debt

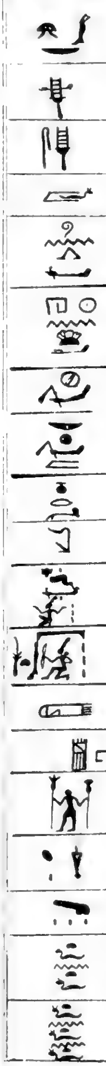
SYMBOLS.

Symbol	Transliteration	Meaning
		treasury
		paid, remitted
		money
		id:
		id:
		id:
		id
		money, to pay, to sell.
		money, gifts to the temple
		money, gifts to the temple
		chariot
		belonging to - of
		masters
		mistress
		master
		master of the land
		id: " " "
		belonging to the temple, a title of Neith
		righteous
		blessed
	maχt	blessed
		id:
		id:
		conqueror
		Lord of the years
		id: " " "
		victories
		savior, defender, avenger, punisher
		defender
		hero
		hero
		friendship
	seχt en	approved, chosen by
	meri en	beloved of -
	mer	beloved of -
		seen, shewn, "so that it may be seen that it is lawful."
		seen, shewn
		proclamation
		id
		honor
		honor
		gave victory

SYMBOLS.

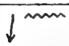


	gives life
	give blessing
	give royalty
	everlasting, eternal immortality
maχt	blessing
maχt neb }	all blessed
	conqueror
	id:
	slave
Kanaχt	powerful Bull.
maχeru	justified, justifier
	justified
χat	deceased
	raised
	righteous
	grey, spotted
teshr	red
	white
χam	black
	wore – "the vestment"



	to clothe
ha	to set up an obelisk. to load a ship
s'ha	to cause to be set up
perei	going out
un	to bear patiently
hru en sha }	accession day
	regulator or steersman to make, to fashion
	regulating the rites
	perform
	archaic form of man squatting
	lord of the enemies
	soldiers
	archer
	castle
	king of U. & L. Egypt
	eldest son
	progenitors, ancestors
ales en ales	Grandfather
	great grand father

SYMBOLS.

	mut	mother
	mat	mother
	alĕf mut }	alĕf mut
	hent	wife
	shent	sistĕr, Kinswoman.
	shen	brother, Kinsman.
		id "
	shent	sistĕr
	shent	mut aunt
	shent en	alĕf set neice
	set shent en	mut cousin
		a filthy man, (hog)

GRAMMAR.

Articles

Pa	the, masculine
Pai	the, "
ta	the, feminine
tai	the, "
na	the, plural
nai	the, "
	Demonstrative pronouns
pui	this, these, masc:
pfi	this "
tui	this, these fem:
tfi	this "
pen	this, these, masc: } both
ten	this, these, fem: } numbers
mennu	that, these
enen	those, that; precede the noun, the others follow it.
pu	This, these, & serves frequently like a substantive verb to connect subject and predicate. "Tfe-a pu seb" "my father the same is Seb"
	Personal pronouns
anuk	I,
nuk	I,
entuk	thou, masc:
entut	thou, fem:

Pronoun

entuf	he
entus	she
entuset	she
entuten	you
entusen	they
entu	they
	Pronoun suffixes
a	I,
a	I,
k	thou, masc:
t	thou, fem:
f	he
s	she
set	she
nu	we
ten	you
sen	they
set	they
u	they
un	they

These suffixes have no independent existence as words: When affixed to nouns they have the force of posessive pronouns; affixed to verbs they become personal pronouns as: *"Pteha-a ru-a" Open I mouth my I open my mouth

GRAMMAR.

Pronoun	
anuk	I
anuk	I
anuk	I, King or God
nuk	I
nuk	I
nuk	I
nuk	I
nuk	I King or God.
nuk	I
nuk	I
nuk	I
nuk	I feminine
nuk	I " " "
entēk	thou masc:
net	thou fem:
entēf	he
su	he (see independent pro:s)
entēs	she
nen	we
anen	anen
entuten	ye
entuten	ye
entēn	ye
entsen	they

Pronoun	
entēsen	they
entēsen	they
sen	they
a	I, me, mine
a	I, me, mine
a	I, me, mine, King or God
a	I, me, mine
a	I, me, mine
kua	I, me, mine
ua	I, me, mine
k	thou, thine
t	thou, thine fem:
k	thou, thine
t	thou, thine fem:
t	thou, thine fem
f	he, him, his
u	he, him, his
su	he, him, his
su	he, him, his.
s	she, her
set	she, her
seset	she, her
s	she, her
set	she, her
set	she, her
seset	she, her
n	we, our, common gender
nu	we, our, " "
nen	we, our " "
n	we, our " "

GRAMMAR

	Pronoun	
	lĕn	he, him, his
	lĕn	he, him, his
	lĕn	he, him, his
	lĕn	he, him, his
	lĕn	he, him, his
	u	they, them, their
	sen	they, them, their
	sen	they, them, their
	set	they, them, their
	sen	They, them, their
	sen	They, them, their
	set	They, them, their
	s	They, them, their
		Independent pronouns
	ŭu	is used as the French "on" and when applied as a base to the Suffixes produces a Series of independent pronouns – as
	tua	I
	tuk	thou
	tuef	he
	set	an independent suffix
	su	he, an independent personal pronoun
		Possessive pro:s
	pa-a	my. masc: sing:
	pai-a	my " "

	Pronoun	
	pai-a	my. masc: sing:
	pai-a	my, " " God, King
	pui-a	my, " "
	na-a	my, masc: plural
	nai-a	my, " "
	nai-a	my, " " God, King
	na	my, " "
or		
	pa-na	our, com: gen. sing:
	pai-na	our " " "
	nai-na	our " " " plural
	pa-k	thy, thine, masc: sing:
	pai-k	thy, thine, " "
	pai-k	thy, thine, " "
	pui-k	thy, thine, " "
	pui-k	thy, thine, " "
	na-k	thy, thine, masc: plur:
	nai-k	thy, thine, " "
	nai-k	thy, thine, " "
	nai-k	thy, thine, " "
	nai-k	thy, thine " "
	pa-t	thy, thine, fem: Sing:
	pai-t	thy thine " "

GRAMMAR.

Pronouns

	pait	thy, thine, fem: sing:
	pai-t	" " " "
	na-t	thy, thine, fem: plu:
	nait	" " " "
	nai-t	" " " "
	patn	your, masc: sing:
	patn	" " "
	patn	" " "
	paitn	" " "
	natn	your, masc: plu:
	natn	" " "
	naitn	" " "
	naitn	" " "
	paf	his, sing:
	paif	" "
	paf	" "
	paif	" "
	paif	" "
	naf	his, plu:
	naif	" "
	naif	" "
	naif	" "

Pronouns

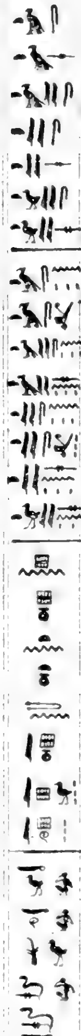
	pas	her, sing:
	pas	" "
	pais	" "
	pais	" "
	pais	" "
	nas	her, plu:
	nas	" "
	nais	" "
	nais	" "
	nais	" "
	pasn	their, com: gen: sing
	paisn	" " " "
	paiu	" " " "
	paisn	" " " "
	paisnu	" " " "
	paisn	" " " "
	nasn	their com: gen: plu:
	nasn	" " " "
	naisn	" " " "
	naisn	" " " "
	naisn	" " " "
	naisn	" " " "
	tā-a	my, masc:
	tāi-a	" "
	tāi-a	" "
	tui-a	" "

GRAMMAR.

Pronoun

ṫā	thy, fem
ṫai	" "
ṫai	" "
ṫan	our, com: gen:
ṫain	" " "
ṫain	" " "
ṫak	thy, your, masc:
ṫaik	" " "
ṫāik	" " "
ṫat	thy, your, fem:
ṫāt	" " "
ṫait	" " "
ṫait	" " "
ṫāit	" " "
ṫait	" " "
ṫātn	our, com: gen: plu:
ṫatn	" " " "
ṫaitn	" " " "
ṫaitn	" " " "
ṫaitn	" " " "
ṫaf	his
ṫaif	"
ṫaif	"
ṫaif	"

Pronoun



ṫās	her, fem:
ṫās	" "
ṫais	" "
ṫāis	" "
ṫais	" "
ṫuis	" "
ṫuis	" "
ṫāsn	their, com: gen:
ṫāsn	" " "
ṫaisn	" " "
ṫāisn	" " "
ṫaisn	" " "
ṫāisn	" " "
ṫaisn	" " "
ṫaisn	" " "
pen	determinative pronouns the, this, masc:
pen	" " "
ten	the, this, fem:
ten	" " "
ten	" " "
apen	these, com: gen:
apu	" " "
apu	" " "
Kua	reflective pronouns 1st person
Ku-a	" "
su	3rd person
tes-a	I myself
tes-ek	thou thyself

GRAMMAR.

Pronouns

	lès ef	he himself
	lèses	she herself
	lèsen	they themselves
	ha	with pronoun affixed has the reflective form of "self"
	ua neb	everyone, one all.
	ua neb	id
	ki	another, the antithesis of the above
	Pua	the one
	Ki Ketta	the other
	nu	those, the, so, thus
	nim	who
	ax	who what, when alone is an affirmative
	tènnu	each, how
	su	a person
	neb	all, every, each
	men	a certain man
	men	a certain woman
		Relative pronouns
	en	who, which
	ent	" "
	enti	" "
	a	prefixed to a word has the sense of a rel: pron:

Adverbs

	nen	no, not, negation
	en	has sometimes the value of a negation
	nent	negation
	nent	neg: when the verb is plural.
	nen pu	never
	nen sep	no time
	nen	combined with adjective forms Greek A privative
	nehau	some few
	ben	no, none
	bennu	" "
	bennu	" "
	sen	" "
	bu	" "
	bu	" "
	am nen	do not ("look on rats")
	tèm	is used for not
	tèm	" " " "
	ia	yes, affirmative
	ia ax	wherefore, so
	ma	as, like
	ma	" "
	maa	like, as it were

GRAMMAR.

Adverbs

Hieroglyph	Transliteration	Meaning
	xer	like, similitude
	hert	up, above
	haru	besides
	haru	"
	haru	"
	put api	at first
	hru neb	daily
	men	"
	emen	"
	sep	a time, with numerals, once, twice, thrice &c
	heh en	sep. indefinite number of times
	telā	for ever
	em nehem	again, a second time, renew
	em nehem	" " "
	em mau	also, anew
	em mat	" "
	em maut	" "
	ma ut	tut likewise
	ma ut	tut "
	em ter	when, on account
	ha	behind

Adverbs

Hieroglyph	Transliteration	Meaning
	quob	(arm), a second time, literally at second hand.
	kar	where (after verb), only
	shaa	(rise) until, from
	adverbs are formed by prefixing these heiroglyphs to prepositions and nouns, as	
	em hru	besides in addition to
	em hert	above
	em hert	"
	em telā	for ever
	em χat	before, after, when
	em nefer	fortunately
	em ra	indeed, verily
	em hru	besides in addition to
	em hru	" " " "
	en χat	after, near
	affixed to certain proposition form adverbs, as	
	er hert	to the above
	er hat	at first firstly
	er pehui	at the end, lastly
	ersa	behind, after
	er ma	at the place of
	er heh	constantly, for ever
	er telā	for ever

GRAMMAR.

Adverbs

	er maat	likewise
	er akar	excessively
	er aa ur	the greatest, through the whole, altogather, through
	er xa	very much
	er ter	entire
		form other adverbs by union with prepositions and nouns
	en hert	to the above, up
	" "	" " " "
	en tela	for ever
	her enti	because, above
	her enti	ama as much as in me--
	xar enti	therefore
	er enti	that, which, when, inasmuch as, It generally begins sentences and follows the verb, Tut, to say
	ma enti	as if, in the same manner
	ter enti	when
	pen enti	where
	pa enti	where
	her nnu	so, in the same manner
	embah	before

Prepositions

	ast	then
	xeft	when
	ma	where
	en	to, of, from, by, or
	en	" " " " "
	en ka	to
	am	in, from, for, as, amid
	em	" " " " "
	ma	" " " " "
	er	to, towards, for, to be, from, than
	her	so as to, on, of, from, on account
	her	" " " " "
	en her	before
	her ga	on, on top
	xeft	facing
	hat	in
	kar	under, to, course of a day
	hna	with, by, and,
	her	and (conjunc:)
	er her	with, together, towards
	xer	to, for to,
	sher	" " "
	am	to, in
	am	" "
	em tu	before
	em ha	"
	er ha	"

Prepositions, conjunctions	
Karha	before time
Karpeh	behind
em sa	"
em sa	"
em teb	instead
na	instead of, like, as
er ma	to, besides, then, with
ex su	after
en su	"
nas	about
an	by, with, from, according to
an	by
ar	because, to, towards when.
ermen	until, unto
	conjunctions, are often omitted
ka	and
her	"
her	"
her	and, (these are of subsequent to Ptolemaic time)
hna	and
hna	"
repu	or else, nor, or, either
em repu	or, nor
mak	for, because

conjuctions, interjections	
as	lo! behold, then, whilst
ast	" " " "
astu	" " " "
ast	" " " "
astu	" " " "
ask	" " " "
set	" " " "
ter	after, while, then
xeft	when
an	for, by, of
ax	how much
ax tera	what now
er ax	how much, to how great an extent
ia ax	let it be, therefore
puti	what? how?
xer	for, but,
ker	now, but
ka	" "
ki tet	otherwise said
her maxt	but after, but when
ki tet	otherwise said
em	inasmuch as
	Interjections
a	Oh!
a	Oh!

GRAMMAR.

interjections, verb

Hieroglyph	Transliteration	Meaning
	a	oh!
	a	oh!
	a	oh!
	hai	oh!
	haii	oh!
	ka	oh!
	ka	oh!
	an	is — Verb "to be"
	pu	it is
	pu	" "
	ar	is, (frequently precedes "pu": "ar" is often placed at commencement of sentences)
	aru	plural conju: of "to be"
	au	to be, to exist, is
	mau	signifies similitude of condition
	au-a	I am, I was
	au-k	Thou art, Thou wast, masc
	aut	thou wert, Thou wast, fem
	auf	he is, he was
	aus	she is, she was
	au nu	we are, we were
	auten	ye are, ye were
	ausen	they are, they were
	or ausen	" " " "
	or ausen	" " " "

Verb

Hieroglyph	Transliteration	Meaning
	au entu	having been
	au tu	" "
	au tu	" "
	tu tu	it is
	ann ef	he is
		placed between the root and the nominative case forms the imperfect
	an an her	I was, I was about
	an an her	" " " " "
	an an ut	are passive forms of preceeding one
	an an ut	(are passive forms of preceeding one)
		the Verb is connected with its subject, either immediately or through the particle "n" or "an"

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	Shenu	Esneh	7
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	suten tai	King of the two regions	16
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	suten re	" "	
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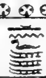		Lower country	26
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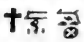	xamu nasi	Egyptians	33
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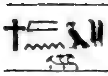
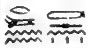
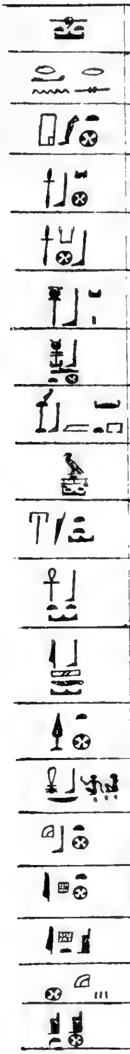
	xamu	"	
	xamu	" "	
	xamu	"	
	xam	Egypt	
	xamu	Egypts	
	xamut	Egypt	
	xamenai	the two Egypts	
	xam	Egypt	
	xami	the two Egypts	

	xanv	Egypt	37 cont.
	Kamu	Egypt	
	Xamu	Egypt	
		"	
		"	
		W. Egypt, land of winged Sun	
		W. Egypt	
		Egypt	
		"	
		"	
		W. Egypt, land of 'ls	
		L. Egypt	
		L. Egypt	
		" "	
		" "	
		" "	
		" "	

GEOGRAPHIC.



		L. Egypt	37 cont.
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		Thebes	
	Abt	Thebes	
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	Abt	Thebes	
	Abt	Thebes	
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		Thebes	
		Thebes	
	Abt	Thebes	
	Abshek	Thebes	
	am	Thebes, "the graceful"	
		Thebans	
	Apt	sanctuary of Thebes	
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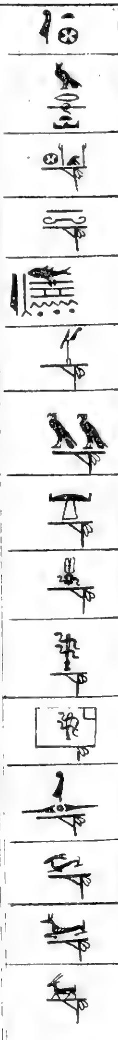
	Apt	Thebes	
	Apt	Thebes	
		Thebes Sanctuaries	



	Shu, or Ma	Thebes the city of (Truth) Amen.	
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		Speos city, or maybe Artemideos	52

GEOGRAPHIC.

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	Menefer	Memphis	

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		"	
		"	
		"	
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GEOGRAPHIC.

Hieroglyph	Name	Place	No.
	San	Janis	76
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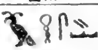
	sebax	Crocodilopolis	78
		Jentyra, Denderah	79
	Sesau	Sais city	80
	Sas	" "	
	Sas	" "	
	Sas	Sais	
	shenti Sais	Living in Sais, or Ruler of Sais	
		Hermopolis or Oshmoonayn	81
		" "	
		Esné city	82
	Pant	Arabia	83
	Anxem		84
	Jut	Ethiopia	85

Hieroglyph	Name	Place	No.
		Ethiophia	85
		Ethiopia	
	Jat	Ethiopia	
	Jut	Ethiopia	
		"	
		"	
		a city of Ethiopia taken by Amunoph III.	
		Ethiopia	
		Ethiopia	
		A Southern City taken by Amunoph III.	86
		a city in which Thoth was worshiped	87
	Baru	Philæ	88
	Rebu	Arabia	89
	Rebu	Arabia	

GEOGRAPHIC.

	Ashuash	a part of Arabia	89
	Serkar	may be Scythians, whom Pliny calls Attacori or Joccari	90
	Jukeri	Joccari, Scythians	91
		a people living south of Egypt, conquered by Rameses III	92
	Nahsi	Negroland	93
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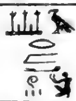
	Haru	"	
	Sharmau	Some part of Arabia conquered by the Egyptians	
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	Smehu	one of four races which are usually named together	98
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GEOGRAPHIC

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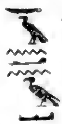
	Temeh	Dsamahu	149		Kanana	Canaan	167
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THE NOMES OF EGYPT.

Nome		Greek name	Chief city		region	Deity
	Jouf	Antæopolitēs		Per Har nub	U.E.	Horus
	Jat	Aphroditopolis		Tebti	U.E.	Hathor
	Amef peh	"		Kes	U.E.	Hathor
	Kat	"		T	U.E.	Hathor
	Res Har	Apollinopolis magna		Tebt, Edfoo	U.E.	Horus
		(Arabia)		Per tat Har	L.E.	Horus, Subt & Sexet
	Ampeh	Arsinoitēs		Crocodilopolis Sebek neter	L.E.	Sebek
	Kaxam	Athribitēs		Hatahert ab	L.E.	Har & Xouit
	Enxent	Bubastitēs		(Abousir) Per Bast	L.E.	Basht
		Busiritēs		Per H'siri n	L.E.	
		Cabasitēs				Horus
	Aa	Coptitēs		Coptos	U.E	Jum or Khem
	Shu Anub	Cynopolitēs		Hem het saka (vulgar)	U.E	Anubis
	Jam	Diopolitēs		Abt (Thebes	U.E.	Amon
		Diospolitēs		Xebeh / Ab } Elephantine	U.E.	
	Sati resh	Gynæcopolitēs Menelaitēs Racotis?				Amon

NOMES

Nomes		Greek name	Chief City		Region	Deity
	Hek Net	Heliopolites		An or Per Ra	L.E.	Ious-aa-s Bull Mnevis Tum & Ra
	Am Shent	Heracleopolites		Xenensu	U.E.	Har Shefi
	Uabt			Hermonthis An Munt	U.E.	Muntu
	An	Hermopolites		Sesun		Thoth
				Heroopolis Taru	L.E.	
		Hypselites		Sha s'hetep	U.E.	Num
				Nexeb	U.E.	Num Ra Nexeb
		Leontopolites				
	Xepsh	Latopolites		Latopolis Sen, Esneh		Pasht Har ur
		(Lybia is part of)				
	Amef Shent	Lycopolites		Ut, Lycopolis	U.E.	Anubis
				Saut, Siout	"	"
		Mareotes				
	Xa	Mendesius (part of)		Mendes Per ba neb tat	L.E.	Munt, Mando Bi neb tat
		Menelaites		Canopus	L.E.	Amen, Sebek and Horus in succession
		Ombites, (Ombos, Tokens)		Elephantine Ombos		Xnoum
		Onouphites		Sent nefer	L.E.	Sebek Ra
		Oxyrinchites		Mert, afterwards Per Matah	U.E. "	
	Xem	Panopolites		Apu	U.E.	Xenu
		Pharbaetites		Hebes	L.E.	Horus Isis

NOMES

Nomes		Greek name	Chief City		Region	Deity
	ua Shent Abt	Phthemphu		Tuk and	L. E.	Tum and Hathor
				Per Atum	"	"
	Ampeh	Phtheneotes		Semet	L. E.	Wati
				Per Wat	"	"
				P'ta en Wat	"	"
	Xenes	Prosopites		Sexem	L. E.	Horus
	Sa Uat	Saïtes		Sas	L. E.	Neith
		Sethroites	may have been formed with a portion of the Nome of Xent-abt		L. E.	
	Shutei	Tentyrites		Dendera Ta neter	U. E.	Horus and Hathor
		Thinites		Teni	U. E.	Anhur
	Set Ka	Xoites		Xesuu	L. E.	Amen

Index to the names of Gods &c.

GODS. ETC.

	Ra	the SunGod, Helios 1
	Ra	
	Ra	
	Ra	
	ura	Ra with Uræus,
	Ra	
	api Ra	
	api Ra	
	Ra	
	axut	Ra on the horizon, the young Horus
	hut	celestial Ra
	Ra	feminine Ra
	Ra anx	Life giving Ra
	Ra	
	Ra	
	Ra ma	Ra Truth
	Ra anx	the Life giving Sun
	Ra	

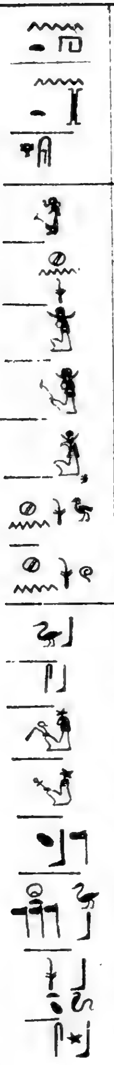
	Ra	governing Sun
	Sri en Ra	Suns' eye
	Ra	Originator, Life
	Ra	(Horus) Ra
	Ra	
	Ra	
	Atn	a solar God, 2
	Atn	The Solar disk
	Atn	" " "
	Amen	the God of Thebes, the hidden God, the unknown God 3
	Amen	
	Amen	often the first character of "Amen meri Rameses.
	Amen Ra	Amen who is Ra
	Amen Ra	
	Men Ra	Amen Ra
	Amen Ra	

GODS. ETC.

	Ra	first syllable in Rameses in many cartouches
	Amen	Ammon 4
	Amen	"
	Amen	"
	Amen	"
	Amen	"
	Amen	"
	Amen	"
	Amen	"
	Atēn Ra	Sun's disk, the Lord Ra
	Aben Ra	" " " "
	Uben Ra	Light of the Sun
	Auben Ra	" " " "
	Nef chnubis χnuph	Jupiter Ammon chnubis of Elephantina chnoumis, Kneph 6

	Nef Knuph	
	originally used to represent Nef, latterly as letter B	
	Nefu	Nef re
	Nef	" "
	Afi	" "
	Afi	" "
	Amen Nef	" "
	Net khem	Neith, Minerva 6
	Net	Neith
	Net	"
	Net Aset	Neith and Isis
	Net	Neith
	Net	Neith queen of the East Divine mother, Lady of Sais
	Net	Neith
	Net	Neith, masculine
	Net	Neith, Goddess of S. Egypt
	Net	Neith
	Net	"
	Nu	Abyssus. Mother of Gods, Queen of heaven (is not Net)
	Nu	

GODS, ETC.



	Neth	Neith
	Net	"
	her neter ha.	a title of Neith "over the temple"
	χons	Khons, Chons, one of the Trinity with Ammen and Maut.
	χonsu	χons, Hercules 7
	χons	Khons Lunus
	χons aa	Great χons
	χons	χons Lunus
	χons	χons
	χonsu	"
	Seb	Saturn, father of the Gods. the seventh day was Sebs, whence the Jews obtained th name Sabbath 8
	Seb	
	Seb	Saturn
	Seb	"
	Seb	"
	seb paut	neteru seb and the divine assembly of Gods
	Seb	Seb, feminine
	Seb	Saturn

	Sebak	God of Ethiopia probably Seb. Many Kings of Ethiopia were named Sebak-hetep. Crocodile god
	Sebak	
	Sebak	
	Sebak	
	Sebak Ra	Sebak the Sun-god
	Sebak Ra	" " " "
	Sebak	Khem, Sum the Creator, the phallic god, has the left hand concealed; Amsi, Min
	χem	
	χem	Khem
	Ham	"
	Amen Ra	mut-ef- Amon-χem the husband of his mother. The Mneris, the bull of Heliopolis
	χem	the ▲ has, evidently, a gutturalsound
	χem	Khem
	χem	Khem Lord of Tanis
	χem	The bull, the husband
	Aχ-pet	the bearer of the heavens

GODS. ETC.

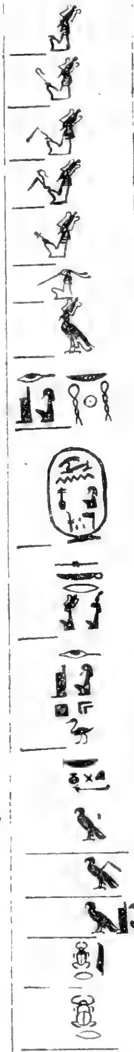
	Amon Ra Xem Ka Mut-ef	Amen sun god creating, the (bull) husband of his mother. A Trinity or a Unity with the attributes of a trinity
	xem	Khem
	xemaah	Khem-Sunus
	Har xem	Khem-Horus
	xeb	Khem
	Amon Xeb	Amen-Khem
	Aset	Isis
	Aset	"
	H'set	"
	Aset	"
	Iset	"
	Sat	"
	Sit	"
	Sat	"

	set	Isis
	sat	"
	asit	"
	asit	"
	aset	"
	"	"
	"	"
	"	"
	mut-neter	Goddess mother
	mut-neter	"
	mut anx	Life giving mother
		determinative of Isis
	Hekatu	Isis-Hekat
	Hekat	" "
	Heku	" "
	Hek	Wife of Chnumis
	Sexet or Pasht	Lion head Goddess; beloved of Ptah. Goddess of Bubastis: is probably Nepthys

12

GODS. ETC.

Pasht	Pasht or Basht, Lady of Bubastis, Latona
Pasht	" "
Pasht	" "
H'siri	Osiris 12
H'siri	"
Asir	"
Hśir-neter	Osiris god
Hśir-suten	Osiris King
Hsir Ra neter	Osiris Sun God (used since Ptolemies)
Hśiri	Osiris
Hśiri	"
Hśiri	"
User	Victorious
User qab	the Victorious arm
User-u	of victories
Hśiri	Osiris



H'siri	Osiris
Hśiri	"
Hsiri	"
Hśiri	"
H'siri	"
Bennu	"
H'siri	"
Hśiri neb heh	Osiris Lord of eternity
Annefer	the good King of Gods 13
Seker Hśiri	Sochar-Osiris Socharis
Hsiri-apis	Osiris-apis, Serapis
Neb Nak	Lord of the great serpent Nak
Har	There were three Horus, Horus, son of Isis, Horus, the new Sun Horus, (Scarab) Creator.
Har	with whip of Osiris 14
Har se	Set Horus son of Isis
Hera (Xepera)	Horus Creator
Her (Xeper)	" "

GODS ETC.

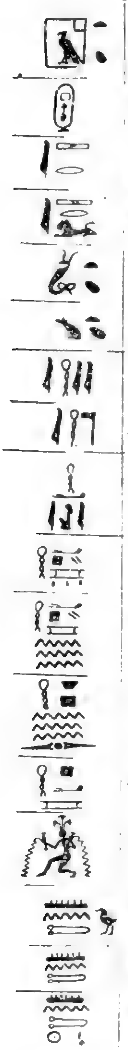
(Har)	
Xem Xepera (Horus)	Khem-Horus the Creator
Ra er Xeper	Aroeris
Ra eper	Sun creator
Ra User Har	the Sun Victorius Horus
Har em axu	Horus of two horizons: Rising & setting Suns
Amen Ra Har,	Amen Ra Horus
Ra	the Sun Horus
Ra er pet-i	Sun of the upper & lower worlds, or celestial hemispheres
axut-i	Horus of the two horizons
Ra tā-i	Sun of the two regions
Har	Horus with Amen's distinguishing feathers
Har	Horus
Har	Horus, eldest son of Amen
Har ur	Great Horus
Har se Hsi	Horus son of Isis
Har hur	Haroeris
Har hur	"

Har hur	Haroeris
Har se Hsi	Horus son of Isis
Har	
Neb en meht	Lord of the North (Egypt), Lower Egypt.
Net	the defender, the punisher, avenge
Net	"
Net nefer	the good Defender (of his father)
Net	the defender (Horus)
Anep	Anubis 15°
Anep	"
Anepu	"
Anepu	"
Apu	Anubis the judge
Api	" " "
Apterа	Anubis guide of roads
"	" " "
"	" " "
Anup	Anubis
Anup hetep	

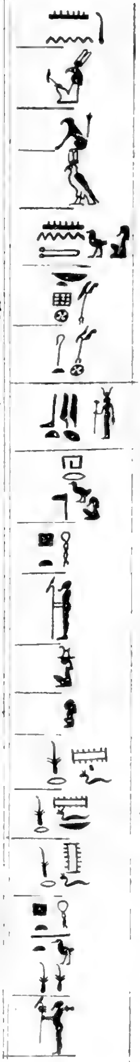
GODS. ETC.

	Anub	Anubis		Nebtha	Nebthys
	Nubti	"		Nebt ha	"
	Nubti	"		Neteri Shent	Nepthys Sister Goddess
	Anub	"			Providence 17
	Anup	Anubis, Judge of Amenti, of the Dead.			The Good Genius. The "uta"
	Anup	Anubis Lord of Thebes		Tet	Thoth. Mercury, Lord of letters, Thrice Great God, Lord of Scribes, Lord of Oshmoonayn.
	Anup	Anubis-first sign of Oimenephtha's name		Tet	Thoth 19
	Anup	Anubis		Tet	"
		Anubis the Avenging Judge. (a tiger's skin on a pole)		Teti	"
	Apiera	Guide of the sun's Orbit		Tet	"
	nub	Anubis		Telfi	"
	heri ef	a title of Anubis, "belonging to the offerings"		Sas	"
	Amu	a title of Anubis "Devourer of the food of the Dead"		Teti	"
	Nebt tai	Nepthys, Lady of the two regions 16		Teti	"
	Nebt	Nepthys		Teti aah	Thoth Lunus
	Nebt ha	Nepthys		Tet Ma	Thoth-Truth
		a trinity of Isis, Osiris and Nepthys		Neb sxai	Lord of writing
		a trinity of Isis, Horus and Nepthys		Athor	Athor, Hathor 20 Venus, Goddess of Love and Beauty. With a cow's head she represents Taaha mother of Ra

GODS. ETC.

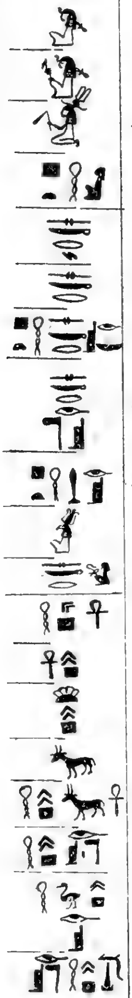


Ather	Athor, Hathor
Ather	" "
Asher	" "
Asheru	" "
Urt	Athor "
Heq	Goddess with mouse head probably Athor; worshiped at Athribis
Ahi	Name of a god who was called the son of Athor; may be Xons who was son of Athor and Amen-Ra 21
Ah	
Hai	a Goddess 22
Hapi mu	Nilus, Apis + nu water 23
Hapi mu	Nilus
Hap mu	"
Hap mu	"
Hapi mri	Nilus concealer of waters
Ment	Mando, Munt 24
Ment	"
Ment Ra	Mando Sun God

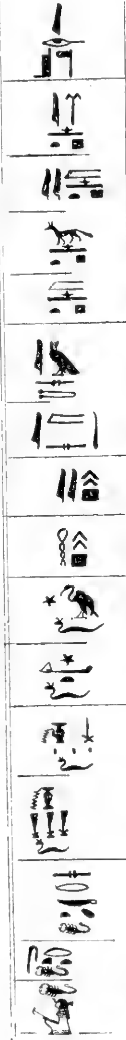


Mant	Mando, Munt
Mant	"
Mant Ra	"
Mant Ra	Mandoulis
Mantu	Mando
Neb Uta or Neb hesep	Mando Lord of the Western Nomes
Hek Uat	Mando Ruler of Thebes
Bai	Goddess of the year 25
Hru neter	God of day 26
Ptah	Pthah, God of Memphis; Vulcan 27
Ptah	Pthah
Ptah	"
Ptah	Pthah pigmy, Vulcan
Suten er	Menofre, King of Memphis
Suten er	Menofre neb, Pthah King of all Memphis
Suten er	Menofre Pthah King of Memphis
Ptah tu	suteni Ethiopian form of Pthah the King
Ptah	Pthah Hephaistes

GODS, ETC.



	Ptah	Pthah
	Ptah	"
	Ptah tatan	Pthah the Chief
	Ptah	Pthah
	Sekeri	Socharis a title of Osiris, from the hill of Sokara where he was worshiped
	Seker	Socharis 28
	Ptah Seker H'siri	Pthah-Socharis-Osiris
	Seker H'siri	Socharis Osiris
	Ptah han H'siri	Pthah the Majesty Osiris
	Seker	Socharis
	Seker	"
	Hpi	Apis the bull: the crux ansata distinguishes it from Apis the God
	Hpi	Apis 29
	Shapi	"
	Hepi	"
	Hepi	"
	Hepi H'siri	Osiris-apis or Serapis
	Hepi Apis	Osiris-apis or Serapis
	Hsiri Hepi Neter nas	Serapis the Chief God



	A-H'siri	Serapis (a' is probably an abbreviation of Apis
	Amhetep	Amothetep 30
	Imhetep	Imothetep
	Amhetep	Amothetep
	Amhetep	Amothetep, called a daughter of Ra
	Amset	First Genius of Amenti, one of the four Gods of the Dead. He made the mummy case. human headed God. 31
	Amset	
	Ipi	One of the four Gods of the Dead. with a Jackals head. 32
	Hepi	second minor God of the Dead 33
	Semutef	Third minor God of the Dead; He swathed the body. With a Jackals head 34
	Sutef	the same the cutter of the body.
	Snuf	Fourth minor God of the Dead. 35
	Snuf shentu ef	
	Serk	Isis, probably, in one of her characters Serk, Selk, Selchis. 36
	Serk	" "
	Serk	" "

GODS, ETC.

Mer	Goddess Meroe. Upper Egypt was called Meroe. 37
Tape	Goddess of the City, i.e. Thebes 38
Tafen	Goddess of the City "Hanes" "Tapehanes" Daphnae 39
Nehema	Goddess. 40
Ament	The nether world, the abode of the Dead - Hades, Hell; The goddes Amenta 41
Amunt	Hades the Southern semicircle of the Sun's apparent course.
Amunta	Hades
Amenti	Goddess Amenta
Ament	Hades
Ament	land of Amenti
Neb Ament	Lord of Amenti, Osiris
Neb Ament	" "
Apt Amenti	a name given to three Goddesses.
Shent Amenti	Dwelling of Amenti
Shent Amenta	" "
Hehes	a leopard head God. 42

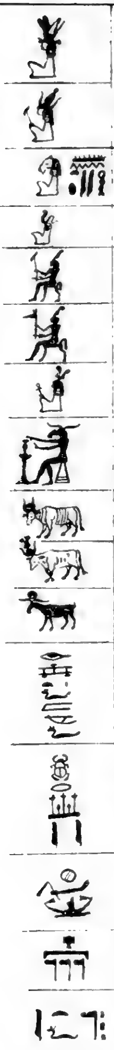
Mau	Truth, son of Neith 43
Mau	Truth, son of Horus Ra
Ma	Goddess Truth
Maa	" "
Ma	" "
Ioh	a goddess with a cow's head 44
Aht	Ioh
Aht	Ioh
At suten	Ioh
sot	Ioh, (hearkening God)
Mes Ra ta neb	Born of Ra, Lord of earth. (Cerberus) the Hippopotamus before Osiris 45
Sheput	Typhon, the god or goddess of evil, Hermaphrodite Boar's head and feet 46
Urt	Immortal applied to gods Goddesses and Kings 47
Urt neteru	immortal gods as opposed to deified mortals
urt neteru	immortal gods
urt neteru	" "
anx sbau	Living Stars, Living Gods
	Demon, Liar 48
app Nak	Apophis the Great Swallower 49

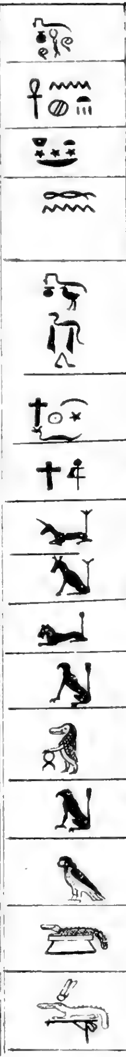
GODS, ETC.

	Nu pet	Horus the dew of heaven	50
	Atat		51
	Ahi	son of Athor	52
			53
	Ahi	an assistant pries-tess	54
	Athor	Hathor, Athor	55
	Ma	Goddess of Truth	56
	User Ma	Victorious Truth	57
	Mut	Buto	58
	χu	Ruling Goddess	59
	Apt	Hippopotamus Goddess with head of human hair	60
	P'neb ta	the Lord of the earth, Horus	61
	Iri en Har	the eye of Horus	62
	χeper	God Creator	63

	Mau	Light God	64
	Nefer Atum	the Good Atum	65
	Atum	Atmu	66
		ape-head god	67
	Hepi	Hapi	68
	Num	Lord of Satti, Num	69
	Num suten χenn	Num lord of some part of Abyssinia	70
	Num Ra	Num Sun-god	71
	Num Ra	" " "	72
	Set	Set, the Ruler, devil or god.	73
	χeper	Creator	74
	Athor	Venus, Hathor	75
	Ma	Truth	76
	Anka	Anucis	77
	Nu pet	firmament goddess	
	Jatann	Chief Goddess	
	Pti	Phut, Lybia personified	
	Mut	Mouth	

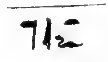
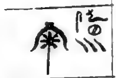
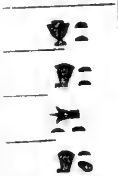
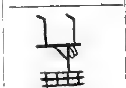
GODS. ETC.



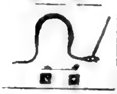
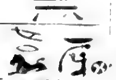


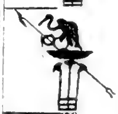
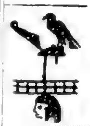
Name	Meaning	No.
Ather	Athor, Hathor, Venus	82
Sti	Satō, Juno	83
Menhi	Menhi great Lady of Xentā	84
Ura	Goddess Uræus	85
Ma	Truth, masculine	86
User-Ma	Victorious Truth "	87
Mati	The two Truths	88
Tum	Atum or Supi, the Creator	89
Hepi	Apis	90
Paka	Bull of Socharis	91
Num Ra	Num, sun god	92
Artef-em meri ef	Aurora	93
Xeper em shai	Creator of the two fields	94
Xu	Steersman of the Sun's barge	95
Her neteru	Over the Gods, chief of the gods	96
Atef neteru	Father of the Gods Osiris + Pthah are often so called.	97
Nuh	Serpent of wickedness; eternal	98
Anxtu	a good serpent, fem:	99
Nebt neteru	Mistress of the Gods	100
Mehen Mehent	The name of the serpent forming the canopy over the boat of Ra a goddess	101
Nuti	The serpent of wickedness, borne by nine men who have conquered it; Eternal	102
aah(x)ames	Monthly guardian	103
Api-amu	Avenging Judge	104
Set	Typhon	105
Set	"	
Pext	Goddess Pext	106
Bar	Baal	107
Tahur	Thoueris	108
Munt Ra	Gryphon with hawk head.	109
Ba	the Soul	110
Sebek	Suchis	111
Sebek-Ra	Suchis Helios	112

GODS. ETC.

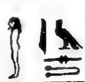
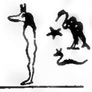
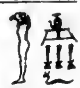
		Heavenly Goddess 113
	Net	Neith goddess of L. E. 114
	Serennu	Goddess of W. E. 115
	Rannu	Mistress of the supplies of the Gods. 116
	Ti	Fire breathing serpent of Hades 117
	Xu	Ruling God 118
	Neter Atef	Divine Father 119
	Bes	Bacchus, God of jollity, also of death 120
	Sefex or Saf	Goddess of Knowledge Special Goddess of libraries. a fem. Thoth 121
	Sati	Satis 122
	Sati	"
	Sati	"
	Sati aa	neb pet, Satis great Mistress of heaven
	Sati	Satis, Great Goddess
	Sebt	Sothis Great Goddess
	Ptah	Pthah as stability 123
	Ka	Frog head father of the fathers of the Gods: a form of Pthah
	Pasht Basht	forms of the name of Pasht or Basht Salona. 124
	Mut Uati	Mother of the two Urei
	Net	Neith 125
	Nebt ur mut neter neb, Neith, great mother of Gods all.	
	Net	Neith
	Ra	the life giving, power-giving Sun, Creating Sun 126
	Har em axu	Harmachis
	Nubt	Nubti 127

GODS. ETC.

	Nubti neb ta	Nubti Lord of the earth 127
	Apap	Apophis 128
	Apap	Apophis speared by Horus
	Shu se Ra	Shu Son of Ra 129 Hercules
	Ranni neter	Shu, two named God-minister
	Pa neb tai	The Lord of the two regions, Horus 130
	Ta sent nefer	Ta the good sister, Nepthys 131
	Nefer Atum	The good Tum 132
	Nefer Atum	The good Tum Protector of the two regions
	Nefer-Atum χu tai	Good Atum Ruler of the two regions
	Meru neb Abt	Meru Lord of Thebes 133

	Urhek	Hecate, a form of Isis 134
	Seneb	Seneb of Eilethya 135 Giver of Life & health
	Uati or Seneb	The Genius of the two regions 136
	Wati	The Genius of S.E.
	Seneb or Nishem	Lady of Eilethya
	Seneb or Nishem	" "
	Wat	Lady of heaven
	Wata	Lady of Tepep re
	Hap-hap	Nilus 137
	Renpi or Rpi	The year 138
	Heh	Snake head Goddess Creator of visible beings 139
	Nebt hetep	The Lady of Peace 140

GODS. ETC.

	Wnnu	the hour 141
	Amset	The four Genii of the lower regions, they had charge of – – The stomach and large intestines 142
	Hapi	the small intestines
	Tuatmutef	the lungs & heart
	Kabhsenuf	liver and gall bladder. were placed in vases, called "canopus" made in the shape of these deities
	Supt	Sapti, Sucht, Sothis, Dog star 143
	Net	Mistress of Heaven; stands on a dog. 144
	Ranpu	Mars 145
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On the Origin and Drainage of the Basins of the Great Lakes. By J. S. Newberry.

(Read before the American Philosophical Society, November 4, 1881.)

Having lived for half my life on the shores of Lake Erie, and beginning my geological studies there at an early age, the mode of formation of this water basin naturally became a subject of observation and thought with me. Subsequently, I for ten years owned a country place on one of the islands near the west end of the lake, and during the summer residence of my family there I had a more satisfactory opportunity for the study of the structure of these islands than can be enjoyed by any one now, since some of the most striking cliffs and rock surfaces have been quarried away or covered with buildings.

The interest which I acquired in the subject also led me to visit and examine with some care the whole chain of lakes, and to follow this line of drainage from Duluth, Lake Superior, to its present outlet at the mouth of the St. Lawrence, and its ancient one at New York.

The results of the observations thus made were communicated to the public in "*Notes on the Surface Geology of the Basin of the Great Lakes*" (Boston Natural Historical Society, 1862); "*Geological Survey of Ohio, Report of Progress for 1869;*" "*The Surface Geology of the Basin of the Great Lakes and the Valley of the Mississippi*" (Lyceum of Natural Historical Society, New York, 1869); "*The Surface Geology of Ohio*" (Report of Geological Survey of Ohio, Vol. ii, 1874); "*The Geological History of New York Island and Harbor*" (Popular Science Monthly, 1878).

In the progress of these investigations, I discovered what had not before attracted attention, that (1), at one time the eastern and middle portions of the continent stood considerably higher above the ocean than at the present time; (2), that an extensive system of drainage lines which once traversed the continent had been subsequently more or less filled up and obliterated, generally by the drift of the Ice period; (3), that our modern rivers had often deserted their ancient valleys altogether, and flowed sometimes hundreds of feet above their former beds ; and (4), that glaciers had once occupied the basins of our great lakes, moving in the lines of their major axes.*

These facts formed the basis of the history of the formation of our lake basins which I then reported.

This history may be briefly epitomized as follows :—

1st. In the Tertiary age a great river traversed and drained the basin of the lakes, rising in the highlands north of Lake Superior, and terminating in the Atlantic ocean eighty miles south and east of New York.

2d. In the advent and decline of the Ice period, local glaciers descending from the Canadian highlands and following the lines of lowest level, scooped out expansions of the river valleys forming the basins of the present lakes.

3d. These basins were connected by cañons which cut the rock barriers separating them, and through which flowed their surplus waters.

4th. At the culmination of the Ice period a general ice sheet filled and overflowed the lake basin, choking up the river valleys with boulder clay, and obliterating the details of local topography.

5th. After the retreat of the glaciers the great river which drained the lake basin, finding its old channel obstructed, chose for itself a new route. Following the line of lowest levels it left its former trough buried under the Grand Sable, to cross a spur of the Canadian highlands at Sault St. Marie, again it crossed a point extending northward from the Alleghany highlands at Niagara, and, finally, its Mohawk channel being obstructed it chose a new route by the Thousand Islands and Lachine Rapids to the Gulf of St. Lawrence.

A large number of facts sustaining these conclusions are given in the papers to which reference has been made, but a repetition of that which has been so fully stated would be superfluous here.

In tracing the course of the ancient river which drained the lake basin, I ventured to predict that a buried channel would be found connecting the basins of Lake Erie and Lake Ontario, "somewhere between Long Point and the western end of Lake Ontario."

This channel Prof. J. W. Spencer, of King's College, Windsor, N. S., claims to have discovered ; and in a paper published in the last issue of the Proceedings of the American Philosophical Society, he maps and describes it, locating it where I had predicted its discovery, although he says it is a

*The first suggestion of the existence of these ancient buried channels was given by the borings for oil in the valley of the Cuyahoga at Cleveland, where I then resided, and in the valleys of other tributaries to the Lake system or the Ohio. Every stream bed in that section was at that time probed for petroleum, and in most cases the rock bottoms of the valleys were only reached after penetrating a considerable mass of clay beneath the present stream. At Cleveland the rock bottom of the old valley is two hundred feet below the bottom of the river, and the lake basin into which it flows, though silted up to within sixty feet of the surface of the water, was once excavated to a still greater depth than the river trough.

channel "of which there was no clue or even suggestion until working up the origin of the Dundas valley." Prof. Spencer also does much more than describe this buried channel in the paper referred to, for he there discusses at length the origin of the lake basins, and reaches conclusions which are in some respects at variance with those previously published by myself.

The points of difference between us are briefly these; I had claimed the existence of an ancient river flowing from Lake Superior through the lake basin and down the Mohawk valley into the trough of the Hudson, and thence to the ocean by New York. The valley of this stream, locally expanded into boat-shaped basins by glacial action, according to my view, formed the basins of the great lakes.

Prof. Spencer denies that glaciers have played any part in the formation of the lake basins, and more sweepingly that ice has any excavating power. He also rejects the theory that the outlet of the lake basin was by the Mohawk valley, saying, "the Mohawk course will not answer as the Geological Survey of Pennsylvania has shown, for at Little Falls, Herkimer Co., the Mohawk flows over metamorphic rocks."

Meeting the last objection first, I venture to say that the Geological Survey of Pennsylvania has not shown that the outlet of the lake basin through the Mohawk valley "wont do." The fact that the present Mohawk river flows over rocks at Little Falls is no new discovery, as it could hardly escape the observation of any traveler over the New York Central Railroad, but there is ample room in the adjacent country, where heavy beds of drift cover the rock, for the continuation of the old, deeply-cut Mohawk valley. In the country about Little Falls, not only is there room for such a channel, but the facts necessitate its existence. The rocky barriers over which the Niagara and St. Mary's flow are equally conclusive evidence against a continuous buried channel connecting the great lakes,—in which we both believe.

In regard to the agency of glaciers in excavating the lake basins I think no one who will carefully observe the facts, will hesitate to ascribe to them an important function. It is true that Prof. Whitney denies that ice has ever excavated a lake basin, and Prof. Spencer echoes and endorses the statement; but it is also true that Prof. Ramsay, Director of the Geological Survey of England, claims that *all* lake basins have been excavated by ice, and Prof. J. Le Conte whose range of observation has been extensive, attributes the origin of Lake Tahoe and other lakes in the Sierra to this cause. They have also supported their views of the power of ice as an erosive agent, not simply by the authority of their names, but by an imposing array of facts. In such circumstances those who deny any excavating power to glaciers can hardly expect their curt dismissal of the ice theory to be accepted without some sort of evidence beside their personal assertion. It has happened to me to have opportunities of studying the effect of glaciers ancient and modern in many countries, and I am compelled to say that the statements that ice has no erosive power, and has made no impression on topography except by the accumulation of morainic material, and also that ice has had no agency in the excavating of the lake basins, are alike disproved by my own observations. Any one who has visited the present termini of the Alpine glaciers cannot fail to have remarked the *roches moutonnées* and the broadly excavated troughs, the work of the glaciers when they had greater reach. He will also have noticed that these glacial troughs, under and beyond the present glaciers, are furrowed by deep and narrow channels, the work of the streams flowing from the melting ice. Here we obtain conclusive evidence that ice *has* erosive power, and have, on a small scale, typical examples of the kinds of erosion wrought by ice and water. The higher portions of the Sierra Nevada, and the whole summit of the Cascade mountains bear such indisputable evidence of the erosive action of ice that it is incomprehensible that any one should have seen this record and deny its validity. On the Cascade mountains there are thousands of square miles over which the rocks are planed down, grooved and furrowed, where the rough and ragged summits are reduced to *roches moutonnées* and enough material has been removed by ice to fill all the water-cut channels of the continent. In the Report of the Geological Survey of Ohio I have described in detail the evidence of the action of ice in forming the basin of Lake Erie. No one can visit the group of islands off Sandusky without being convinced that they are carved by ice out of the solid rock. Their sides and surfaces are everywhere glaciated, and areas of acres in extent planed down to the smoothness of a house floor. The corals and other fossils which fill the limestone are here cut across as smoothly as it could be done by hand ; and as I have elsewhere shown, the direction of the furrows and the trails left behind chert masses in the limestone, prove that the ice moved in the line of the major axis of Lake Erie, and from the north-east toward the south-west. Similar facts both in regard to rock striation and the transport of material have been observed about Lake Ontario, Lake Huron, Lake Michigan and Lake Superior.

The manner in which ice accomplishes the erosion effected by it, is no mystery, as any one who has seen a glacier has seen the agent in action. The soft ice simply becomes a great emery wheel. Rocks, gravel and sand are frozen into its under surface or are spread beneath it and pressed down upon its bed with the enormous weight of the moving mass ; the result is a grinding that nothing can resist. The ground up material is "till" or boulder clay, sand, gravel and boulders, and this residue, perhaps insignificant in quantity compared with the amount produced, covers literally hundreds of thousands of square miles on this continent alone. How, in the face of these facts, can any one say, ice has no erosive power? Prof. Spencer misunderstands and misrepresents me when he imputes to me any vacillation of opinion or any uncertainty in regard to the agencies which have excavated the lake basins. From the first I have recognized the existence of an ancient river draining the lake basins at a low level, and was by many years the first to indicate the existence of such a stream, but

I have never for an instant doubted that the erosive action of this river was supplemented and modified by local glaciers. It is quite beyond the reach of fluvial erosion,—of which in the cañons of the Colorado, I have studied the best examples extant,—to form basins like those of our great lakes; and while it gives me pleasure to find in Prof. Spencer's discovery a confirmation of the prediction made years ago, and to give him credit for the sagacity and industry which marks his investigations, I cannot but feel that before attempting to write a general history of the Lake basins, it would have been well to have gone in person over all the ground under discussion.

Discussion.

Mr. Lesley remarked that in all controversies over the Glacial hypothesis, as it used to be called, the Glacial theory as it has now well established itself to be, a vast number of observed facts are accepted on all hands as part of the actual human knowledge. No one now thinks of disputing the former extension of existing glaciers; nor the former existence of sheets of ice over large areas of the earth's surface, where nothing like a glacier is now noticeable even at the close of the severest winters; nor the meaning of the scratches and grooves, clays and gravels, moraines and kames, pot holes, ponds, terraces, sand dams, reversed drainage, and whatever else are the characteristic marks and vestiges of the agency of the ice which once covered such areas. All geologists who have studied existing glaciers in the Alps, for instance, or who have acquainted themselves with their character and action through good descriptions of them, take precisely the same view of the circumstances.

What geologists are not yet agreed upon is not whether moving ice once covered now fertile districts, but the precise limits of these glaciated districts; not that all moving ice moves rocks, but precisely in what manner the rocks move with, on, in or under the ice; not that glaciers deposit heterogenous materials, but precisely what part water, melted ice, plays in the drama, and how one can best distinguish its work from that done by the ice itself, unmelted, in and of itself; not whether there has been an age of ice, but whether there were not two or more, and whether human beings began to live in an earlier, in a medial, or in a later age; and above all, not whether the surface of glaciated regions was modified by the long or short, single or repeated passage of ice over them, but precisely to what extent this modification went.

In a word, the Glacial Theory, perfectly well defined and accepted by all in the clear light of long continued, thorough and consistent investigation, is still surrounded by a penumbra of Glacial Hypotheses, about which very enthusiastic and dogmatic geologists are disposed to debate with a great deal of personal warmth, as if their personal reputation for genuine scientific ability was involved. The fact is, some of the questions thus presented are so difficult of any precise definition that we must wait long for their answers.

The most difficult of all these questions has naturally excited the most strenuous discussion :—the excavatory power of ice.

Every geologist knows that an uncertain amount of erosion must be explained by ancient ice movements ; for, the eroding action of glaciers may be studied in Alpine valleys as it is now going on. But some think this erosion to be so insignificant as to be justly compared to the sandpaper smoothing-off of a roughly-planed board ; while others please their imaginations with its incredible force and magnitude, and describe it as ploughing out Alpine valleys, and excavating American lakes. Recent works on the Glacial Age might be quoted to show that conjectures of all grades between these two extremes are accepted by their geological authors—vague postulates, or general propositions, taken for granted, without being subjected to any mathematical analysis—as a groundwork for the consideration and description of old and new local facts.

It is needless to say that no personal sentiment on the subject can have a scientific value. For my own part, I entertain a lively persuasion in favor of the sandpaper end of the series of hypotheses ; but I can assign no higher value to this persuasion, or personal opinion, nor do I think it can any more efficiently secure scientific results, than an impulse towards the opposite, or lake excavating prejudice. It is after all merely a prejudice, but a prejudice in favor of the preponderance of a multitude of facts which bear upon the subject under discussion ; facts which I think have never yet been placed in the strongest light ; facts of topography, especially abundant in regions near to but outside of glaciated regions.

There are two principal lines of investigation, it seems to me, which may lead us to a hopeful elucidation of the question of *how much of our topography has been effected by ice.*

1. We may take up one feature of topography after another, and by a process of exclusion, narrow down the field of ice-action until what is left shall remain reasonably certain to be due to ice alone ; and

2. We may study, directly and mathematically, by number, weight, bulk and velocity, the work actually done by an existing glacier, and infer by strict comparison the possible limits of ice-work over any given glaciated region.

Thus, to take the last first, let us ask what is the potential of eroding energy in the case of a glacier?

Pure ice, of course, has no scratching power. The facility with which it moulds itself upon surfaces, is shown, in an astonishing manner, by grooves on the underside of a moving glacier, produced by large stones lying quite loose upon the bed-rock, and prevented from slipping forward with the ice by some slightly obstructive irregularity of the bed-rock surface. The common notion is that all such stones are necessarily embedded by the ice and used as scratchers, or eroding tools. But at least some of them are not so taken up by the ice, which slips smoothly over them, retaining as a groove the shape of their cross section, for many yards after passing their position.

The number of stones thus inoperative at the base of a glacier is one of the factors in the equation of erosion.

That ice uses sand, gravel and boulder débris to scratch its rock bed is not doubted by any one. The abrupt termination of striæ, deepening and widening to their abrupt termination, was one of the earliest observed facts, and was explained on the old diluvial theory, and the iceberg theory, by the arrest and rotation of the block which served as a graving tool, fixed in the ice, or by the breaking off of the point of the tool.

The chapters of James Hall's Report of the Geology of the Western District of New York, published in 1844, which describe the Drift and Glaciation of that District suffice to show how carefully these phenomena were studied fifty years ago. Dr. Newberry and other ultra-erosionists would do well to note what Hall says (on page 331) in evidence of the comparatively slight force necessary for producing the grooves and polished surfaces, the overturning of bed plates, and transport of fragments, from which such exaggerated theoretical consequences are deduced.

In those really admirable chapters may be found the earliest hints of the now accepted activity of subglacial water, loaded with débris, in doing much of the work wrongly ascribed to ice.

The actual erosive power of rock-set ice must certainly be susceptible of an approximately accurate mathematical calculation,

Its differential is : *one stone*, held by the ice against the bed-rock with a certain pressure—the stone of a certain hardness (a)—the bed-rock of a certain hardness (b)—the ice-grasp of the stone, of a certain plasticity (c) —the maximum pressure exerted by the weight of the ice, up to the point-crushing degree (d).

It is evidently wrong to make the total weight of the column of ice above the tool a measure of the engraving. Were the ice piled to the height of miles, its graving power would be no greater than that of a column of ice weighing just enough to crush the point of the tool. All the declamation in books respecting the enormous erosive force of a sheet of ice several thousand feet thick pressing down upon and moving over sandstone, limestone and shale strata is simply wasted. A thousand miles thickness of pure ice moving over a bed of clay, would erode it no more than a thousand miles of water would. If it held stones, they would be simply embedded in the clay and left behind. If they moved over any kind of solid rock, they would simply be reduced to fine sand or mud, and act as a *lubricating medium*, protecting the bed-plate surface from erosion.

Every glacier must slip to a greater or less extent upon a lubricated surface, consisting principally of muddy water, or watery mud. The thicker the glacier the more of this lubricant it will have beneath it. The law of increase of temperature descending from the surface must act in ice as in rock. Where the bare rock surface of the earth has a mean temperature of 32°, the temperature at 1000 feet down stands at, say, 52°. Were a glacier 3000 feet deep to remain for a century immovable over a region the normal mean air temperature of which is

32°,—while it would waste slowly at its surface by spontaneous evaporation, and more rapidly at its surface by solar heat—it would waste at its base also by the upward transmission of earth heat. But this waste would be represented by so much water, which under an immovable glacier would form a lake. Under a movable glacier it helps to form a river, and the river which issues at the terminal surface moraine brings out the evidences of the lubricant, as "mountain meal."

Every glacier must be made cavernous by its river, and along the caverns produced by the river and its branches are collected and deposited or rolled forward all the stones in the glacier while those upon its surface (or melted out to its surface, by the upper waste), ride down to its lower end.

The much larger part of the erosive action of a glacier must therefore be of the nature of river erosion ; while a certain percentage of it may be of the nature of engraving. But if so, then our knowledge of river erosion must direct us in the investigation of glacial erosion.

River erosion is local and interrupted. Parts of a river bed are filling up, while reefs and barriers are being cut away. So, under a glacier, the loci of erosion must be few and of limited extent. Behind these the rolled glacial débris are covering and protecting the bed rock instead of eroding it. Our kames show therefore not only that Glaciers are feeble eroders, but that they are great depositors and protectors of the earth surface.

We may go one step further, and show how in the age of ice the usual erosion of our topography was almost stopped and forbidden by the ice.

For, the topography of the earth's surface is evidently due to rain, softening the surface—to rills, removing the softened surface—to brooks, sweeping the collections made by rills, down through the brook-vales and ravines which they have made,—until the process of erosion is reduced to a minimum where river deposits commence. Rivers never erode, except at rock barriers—or, in rainless regions, where they saw strait down, using their whole débris.

Now, in the ice age, the ice-covering protected the whole country from rain, rill and brook erosion, and the process of topographical modification of the earth's surface ceased, and was not resumed until the close of that age. What erosion took place, must have been exclusively confined to the lines of subglacial rivers and their branches, along the subglacial caverns. In a continental ice-flow crevasses were impossible, except along a few lines of escarpment.

The rain, therefore, in the ice age must have constituted a great riseau of superglacial drainage incapable of eroding the subglacial topography ; in fact removed from it hundreds and even one or two thousand feet from it vertically. If the Canadian ice had a surface slope southward, towards Pennsylvania and Ohio, or south-westward up Lake Erie and across Illinois, then mighty rivers, heading in the Laurentian mountains and the Adirondacks, must have flowed for a long time over the upper surface of the ice sheet, southward and south-westward into the Mississippi valley—without affecting the previously constituted topography beneath the ice—of which previously constituted topography the Lake Basins were an essential part and grand feature.

Meanwhile, a totally different system of drainage was carrying on its work of transportation beneath the ice sheet, in an opposite direction, northward (from Pennsylvania and Ohio) and eastward, through the lake basins. But this lower or sub-ice river system, deprived of *direct* alimentation from rain, must have been inferior in volume and power to the upper or surface-ice river system; although it may have received here and there through the ice sheet considerable accessions of surface rain water.

I do not wish to discuss here the line of Prof. Spencer's great river, nor the claim of Prof. Newberry to the discovery, years ago, of its debouchement, via the Mohawk and Hudson valleys, into the ocean at New York, except to remark that Prof. Newberry does not seem to appreciate Prof. Spencer's chief difficulty. It is not that the rocks appear at Little Falls; but that his Ontario river ran in a bed more than 780 feet beneath the present level of the lake, and therefore more than 900 feet below Little Falls, and the demonstration of a buried, concealed, old river channel nearly 1000 feet deep anywhere alongside of the Little Falls exposure seems a rather hopeless task. But worse than that; the Mohawk valley east of Little Falls, is barred by rock ranges 300 or 400 feet high, through which the Mohawk cuts a cañon, where its bed is at least 900 feet above the old river bed in the lake.*

I wish to confine my remarks to the feeble erosive power of the Canadian ice-sheet, as a particularly inefficient kind of glacier, and to the probable possibility of a mathematical demonstration of the feeble erosive power of any glacier, even in the most favorable circumstances.

Taking one stone graving-tool as the differential of *means*;—the engraving quality of that stone tool (under the conditions (a), (b), (c), (d) above stated) as the differential of *power*;—and the destruction of bed-rock by that stone-tool during its life as a tool, as the differential of *effect produced, i. e.* of erosion,—then,—to obtain a transcendental maximum, we must multiply one stone-tool (in area) by the total width and total length of the ice bottom; *i. e.* we must stud the whole bottom of the glacier with tools; keep them all at work, each one for the whole length of time of its descent from the upper to the lower end of the glacier;—replace those that are lost or spoiled by fresh ones;—and repeat the operation during the entire life of the glacier.

It is evident that this transcendental maximum if it could be calculated, would be of little value, in as much as it would almost infinitely exceed the actual practical erosive power of any given glacier.

But it would be the best starting point for a reasonable discussion of the erosive power of glaciers; and it seems to me, that if the calculation were

*See my notes to Dr. Spencer's appendix, at the end of White's Report of Progress, 2d. Geol, Sur. of Pa., Q. 4, 1881, p. 403.

made, it would have the effect of putting a stop to much of that vague babble about the "immense" "enormous" "amazing" influence of the ice age in sculpturing the surface of our planet, which has in some respects demoralized our science.

Had the age of ice commenced in Laurentian days or even in Permian times and lasted until now, we should certainly be compelled to ascribe most of our topography to the action of ice. But as the ice age was late and comparatively short, we must consider its effect upon our topography not only local but slight.

The second line of argument, therefore, is a very simple one. We should enquire first, what are the main features, the characteristic elements of our topography; and secondly, whether those be essentially the same in the glaciated and in the nonglaciated regions. If we find them to be identically the same in both regions, then, it follows, as a matter of course, that they cannot be ascribed to ice.

This line of argument I have taken numerous occasions, in past years, to follow out, and I have shown that the great lake basins of the north are in all (but one respect) topographically like the great valleys of the south and therefore *not* excavated by ice. The one item of exception is, that they have been more or less filled with the débris of the ice sheet, and afterwards with water dammed in behind glacial deposits. So far from the glacier having excavated them, it has simply buried them.

The argument pursued on this grand scale, repeats itself on a small scale now that the Terminal Moraine has been traced across the mountains and valleys of New Jersey and Pennsylvania. If the glacier covered the top of the Kittatinny mountain, for example, along its whole course from the Hudson to the Delaware, and for some miles west of the Delaware, and did *not* cover it anywhere along its whole course through Pennsylvania, Maryland and Virginia (and these facts are now demonstrated)—and if, notwithstanding, the mountain in its north-eastern prolongation is precisely the same as in its south-western prolongation—it follows without argument that it existed in its present form before the ice age, and was merely a little *sandpapered* by the ice during the ice age.

What is true of the Kittatinny, is true of the (Catskill) Pocono mountain plateau behind it, and of the Orwigsburg or Delaware river (Upper Silurian and Devonian) valley which separates the two ranges. Across this broad valley (the analogue of Lake Erie) the Terminal moraine runs west of Stroudsburg. The topography of the valley east of the moraine precisely resembles the topography of the valley west of the moraine, only that it is covered with drift material and marked with scratches. Of course the valley existed before the ice age, and the glacier merely polished its surfaces and *protected parts of it from subsequent erosion;* just as the glacier *protected lake Erie from erosion,* while it scratched the islands of which Prof. Newberry speaks, and all the hard outcrops, around it, as described by James Hall in New York, by Carll, White and others in Pennsylvaina, and by Dr. Newberry in Ohio.

And so of each valley and each mountain successively as one follows the terminal moraine north-westward, across the gorge of the Lehigh, across Hellkitchen mountain, across Conyngham valley, across the Nescopee mountain, across the Susquehanna above Berwick, across the Schickshinny mountain, near its west end, across the Muncy hills, across the Alleghany mountain north-east of Williamsport, across the Loyalsock ravine, and the Cañon of Lycoming creek, the plateau of Potter county, to its great angle north of Olean and Salamanca in New York.

Along this whole line, the topography to the east (under the ice) is precisely the same as the topography to the west (where ice has never been) and the only distinction observable is this: that west of the great moraine there is no drift and no lakes; east of the moraine the whole surface is sheeted with drift and spotted with ponds;—and all the scratches point south-south-westward, the ice evidently having moved from the Adirondacks.

From Salamanca the Terminal moraine has been traced by Mr. Lewis and Mr. Wright as a nearly straight ridge of trash, south-westward, across Western Pennsylvania to the Ohio line (near Darlington) 13 miles north of the Ohio river; the scratches all pointing S. S. E. and S. as if coming square across Lake Erie and ascending the highlands to the south of it. Nowhere along this line has it affected the topography; it has merely deposited drift, and choked the ancient valleys so as to reverse the drainage. Mr. Carll has pointed out the noses of hill-spurs which he thinks were sharpened by the ice; but even this slight modification of the pre-existing topography, occurs at places lying outside or to the south of the terminal moraine, and we must therefore find some other explanation for it.

It seems unreasonable in the highest degree therefore to speak of the glacial erosion of Lake Erie and Lake Ontario, when it is evident that the ice sheet was perfectly incompetent to erode the countries which it invaded, and left them everywhere precisely in the topographical condition in which it found them; merely scratching their rock exposures, incumbering and embarassing somewhat their lines of drainage, spreading a slight sheet of drift material over them, and tearing a few blocks out of the looser outcrops and depositing these blocks after a short transit; often on higher levels, and sometimes on much higher levels; for Mr. Lewis has found Helderburg blocks carried completely to the top of the Kittatinny mountain.

An Obituary Notice of William E. DuBois. By Robert Patterson.

(*Read before the American Philosophical Society, November 18, 1881.*)

William Ewing DuBois was born at Doylestown, Pennsylvania, December 15, 1810. Through his father, Rev. Uriah DuBois, he was descended from Louis DuBois, a French Huguenot of honorable extraction, who emigrated to America in 1660, seeking freedom of religious worship, and, in connection with others of his countrymen, formed the settlement of New Paltz, Ulster county, New York. Through his mother, Martha Patterson, daughter of Professor Robert Patterson, of the University of Pennsylvania, he inherited the Scotch-Irish element which has exerted so marked an influence in the development of our country.

The father of Mr. DuBois was a Presbyterian clergyman, in charge of churches in and near Doylestown, and was Principal of the Union Academy at that place, a classical school then and afterwards of high reputation. He was greatly respected, both as preacher and teacher. His death, at a comparatively early age, left a large family, in narrow circumstances, to be provided for. The kindness of friends, but above all the energy and devotion of the widowed mother, lightened the weight of this calamity. The subject of our notice was, at this time, but eleven years of age. His education, already begun at the academy under his father, was continued there under his successor, Rev. Samuel Aaron, and for a short time at the once noted school of John Gummere, Burlington, N. J.

The bright and studious mind of Mr. DuBois gathered every advantage from his opportunities, and although his early education did not extend beyond the schools named, he was well furnished in the classics and mathematics and in English literature. While yet a boy he developed a freedom and capacity as a writer quite remarkable ; was a frequent contributor of articles to the county papers, and aided in conducting one of them.

His oldest brother was an eminent member of the bar, and it seemed fitting that Mr. DuBois should, under his guidance, adopt the law as his profession. He accordingly pursued the usual course, in the meantime aiding to support himself by literary work and conveyancing, and was admitted to practice in September, 1832. But it was not permitted him to prove whether he could attain reputation in that line. His course was arrested by a fatal obstacle. Always somewhat delicate in constitution, he was at this time attacked by a bronchial disorder, which adhered to him through life. It so far affected his voice as to unfit him for the legal profession, or any other requiring him publicly to address his fellow-men. To all human apprehension this was a calamity that dashed every hope of eminence, at least in any intellectual field. But as we now stand at the end of his career and review the steps by which he gained distinction, we rather persuade ourselves that it was a providence constraining him to a course of life in which every higher quality of his mind and character had full play, while the physical affection, if it caused to himself some suffering, in no degree hindered his success. For since a change of profession had become necessary, he accepted an appointment in the Mint at Philadelphia, and thus began the life-work by which his reputation was established and made firm.

Mr. DuBois entered the Mint in September, 1833, and was first employed in the office of the Director, Dr. Moore. In 1835, at the request of the Assayer, Mr. Jacob R. Eckfeldt, he was transferred to a more congenial position in the Assay Department. Here he continued for the remainder of his life. In 1836 he was appointed Assistant Assayer. In September, 1872, he succeeded Mr. Eckfeldt, as Assayer, and remained at the head of the department until his death, July 14, 1881, thus completing nearly forty-eight years of Mint service.

For the special branch of metallurgy in which Mr. DuBois thus engaged, we see that his previous training had not prepared him ; but doubtless he had been marked as having the intelligence, the carefulness and the concentration of mind required for this work, and he had in Mr. Eckfeldt, as instructor, a thorough master of the art. It is certain that Mr. DuBois early took rank as an accomplished assayer, and long before his death had reached the head of his profession.

I have referred to the association of Mr. Eckfeldt and Mr. DuBois, and it is fitting, before I proceed farther, to allude to the singular partnership in the labors of these two. The close intimacy made needful by their official relations, developed into warm friendship. The tie was made closer by the marriage of Mr. DuBois, in 1840, to Susanna Eckfeldt, the sister of his chief. I shall have to speak of published works and scientific communications appearing under the names of Eckfeldt and DuBois. Although it was understood that Mr. DuBois was the sole literary author, yet no separate claim of authorship was made by either. Whatever of reputation was earned, each was contented that it might be shared by the other, and jealousy never for a moment weakened a union that bound them for life.

A variety of circumstances gave importance to the Assay Department of the Mint during the service of Mr. DuBois. Most of these he has himself, in rapid summary, and with engaging style, set before us in his obituary notice of Mr. Eckfeldt read before this Society. Considering how intimately he was associated with his chief in the labors of that time, the details thus given were in large part auto-biographical, and I shall briefly recall them as appropriate to this obituary notice.

In the year 1834, a change took place in the ratio of gold to silver in the standard of U. S. coins, the effect of which was to bring large deposits of gold to the Mint. The coinage previously had been chiefly of silver. The more equal supply of the precious metals gave active employment in the assay of each of them, and was of course most valuable as an experience to Mr. DuBois, who about this time became connected with the Assay Department.

In 1837, on a revision of the Mint laws and standards brought about by

Dr. Robt. M. Patterson, then Director, a reform was effected in the method of reporting assays, the millesimal system taking the place of the time-honored but cumbrous method of carats and grains. About this time, also, the older plan of assaying silver was abandoned, the humid assay being substituted, and largely worked under the direct supervision of Mr. DuBois.

About 1838, Branch Mints were organized in the States of Louisiana, Georgia and North Carolina. The labors and responsibilities of the Philadelphia assay department were increased by this development, partly from the necessity of instructing assayers for the new branches, and partly in testing the correctness of the assays made there.

In 1848, the great discovery of gold in California was made known. This brought a tremendous pressure on every department of the Mint, and not the least on the Assayers. The gold coinage was in three years raised from a little over three million dollars to more than sixty-two millions. The assays were often counted by hundreds in a day. But whatever the pressure in the office, accuracy ruled, and the correctness of the assays was never impeached.

In 1853, a change was effected in the law for providing subordinate silver coins. This brought about, for some years succeeding, an unprecedented coinage of that metal, and still further increased the labors of the Assay Department.

Shortly after, a minor coinage, in part of nickel, was established, and the assay of that metal became a part of the routine of the deparment. The determination of nickel alloys was not well laid down in the books, and the assay was troublesome, but all difficulties were overcome, and a practical method introduced. A bronze coinage afterwards followed, calling for further assay processes.

Finally, and after Mr. DuBois became principal Assayer, in 1872, followed the heavy coinages of gold as a consequence of the Resumption Act, and of silver under the Silver Act of 1878. These, while they brought heavy labor and responsibility on the Assay Department, involved nothing new in the methods, and only served to test the accuracy and system of the office while placed in his charge.

This review points to the occasions, connecting Mr. DuBois most directly with the Mint by his official action. But he was not content with the performance of routine duty. More than once he has quoted as a rule of action a saying of Paley, that "a life without employment is a life not worth living." He was, indeed, never idle. We might infer that the harassing labors of an Assayer would prove sufficiently absorbing. Yet not long after he entered the Assay Department, Mr. DuBois found, or made, the time for engaging in other tasks.

One of these was the foundation of the Cabinet of Coins which now adorns the Mint. This was commenced in 1838. A small annual appropriation was procured from Congress for this purpose, and the work of collection committed entirely to Mr. DuBois. He brought to it all the enthusiasm which animates most numismatists, sobered, however, by good judgment. His expenditures were always judicious. Some of the best of the specimens were culled from the Mint deposits for the bullion value merely of the pieces. After the collection had taken good shape, and been well classified, he wrote and published in 1846, a description of it, under the title "Pledges of History," &c. The title thus selected intimated his opinion as to the real value of such collections. He thought that a coin should be prized for its historical teaching, or artistic merit, and discouraged the rage to possess a piece simply because of its rarity. Mr. DuBois acted as Curator of the Cabinet until his death. It falls short of many other collections in numbers, but is so well selected and arranged that it holds high rank in the estimation of good judges. The study of numismatology thus begun in his youth he continued to the last, and was ranked as among the chief masters of the science in our country. He added to it a special study of counterfeits, in the detection of which he became an expert, and was able to give much valuable information to the public.

Another important labor undertaken by Mr. DuBois (in connection with Mr. Eckfeldt) was the preparation and publication, in 1842, of a "Manual of the Gold and Silver Coins of all nations, struck within the past century." This was a work of very great labor, and, from its expense, of some risk also, to the authors. It is admirably arranged, the information clear, and it embraced every subject of interest at that date as to coins, bullion, counterfeits, &c. Subsequently, in 1850 and 1851, supplements were published covering later topics, made prominent in consequence of the California gold discoveries.

Apart from the above more ambitious works, the occasional writings of Mr. DuBois were numerous, and continued up to the year of his death. His papers on Numismatics were frequent and always attractive, his last appearance in print being in April of this year, in an article on "The Coinage of the Popes." To the "American Philosophical Society" of which he was elected a member in 1844, he made various communications, on behalf of Mr. Eckfeldt and himself, mostly on topics suggested by experiences in the Assay Department. Among the most curious was one on "The Natural Dissemination of Gold," by which we were astonished to learn that this precious metal is found in appreciable quantity in the clays underlying our city.

In 1869, he wrote, for the Banker's Magazine, "Propositions for a Revised System of Weights, and a Restoration of the Silver Currency." The development of his views on these subjects is a model of clear exposition, and the conclusions reached were such as might be expected from a mind aiming to attain practical results rather than to impose visionary theories. The time may yet come when these views, in whole or in part, will be embodied in legislation.

I refer, with some hesitation, to other writings of Mr. DuBois, since they were privately printed, and carefully reserved from the public eye. These were Genealogical Records of his father's and mother's families. It has been well said by Daniel Webster, that "men who are regardless of their ancestors and of their posterity are apt to be regardless of themselves. Our ancestors belong to us by affectionate retrospect ; our descendants by affectionate anticipation." Some such sentiment must have encouraged Mr. DuBois in the labor involved in the preparation of these Records. They were written with perfect good taste and truthfulness, and set a good example in a branch of literature then novel, but in these latter days not uncommon.

I have now traced the principal occasions bringing Mr. DuBois before his fellow-men, but cannot bring this notice to a close without referring to some other particulars, bearing upon his character as an officer and a man.

From the beginning he was highly esteemed at the Mint. It was his ambition to acquire a knowledge of every branch of the service, and with his capacity and opportunities this end was attained. He early became the trusted friend and counsellor of his colleagues, and was able to serve them in many ways, perhaps most of all with his ready pen. As time passed, and forty-eight years of experience was given to him, he was recognized by all as the Nestor of the Mint service.

And here I pause to draw a lesson, from the example of Mr. DuBois's life, as to the value of a properly organized civil service. In the department with which he was connected, political tests were never obtruded, and permanence of tenure followed on merit. On no other basis could his services have been claimed or retained. They would have been transferred to a private sphere, probably to his pecuniary gain, certainly to the public loss. Under a more rational policy, he was content to give to the Government the devotion of a life-time. Proud of the service in which he was engaged, he sought to fix it at a high standard. If he lent it reputation by his labors and varied talents, he felt that this was for himself a sufficient reward. And he sought further to elevate the service through the new men brought into it, giving to their instruction an intelligence and patience which they gratefully remember. But if he spared not himself, and gave freely of his time, his talents, and his experience, he was nevertheless sparing for the Government, cautious in public expenditure, scrutinizing the smallest details, and never permitting an extravagance.

We have seen that Mr. DuBois appeared on many occasions as an author. It is to be regretted that these were not more frequent, for his style had singular merit. Whatever was the matter treated, he attracted and held you to the end. There was a certain quaintness, a vein of humor, which cropped out in the most unexpected way, and all the more charming from the contrast with the otherwise dry theme under discussion.

In personal appearance Mr. DuBois was tall and spare, showing marks of the delicate health to which he was subject from early manhood. His features were regular, his eyes dark and brilliant, his countenance habitually grave, but easily lighted to kindly expression in the intercourse with friends. He was deterred by the vocal difficulty, of which I have spoken, from seeking society, but he enjoyed it when it came in his way, was a good listener, observant, and with a keen sense for the humorous side of things. He was very accessible, and ever ready to lend aid from the stores of his knowledge, but in particular did he delight to instruct and bring forward his younger friends.

I am happy to close this notice by speaking of the deep religious faith of this dear friend. Before reaching manhood, he consecrated his life to the service of God, through Christ, and never afterwards wavered in his trust. His belief was to him a source of perennial joy, and he did not fail in the duty of trying to bring others to share in the faith which was the life of his life. No stress of labor, no ordinary worldly interests, checked the spiritual meditations of this earnest man. Since his death there have come to light, before kept secret from his own family, volumes covering a period of nearly fifty years, embodying mainly his religious thoughts, and laying bare his soul. I confess that it is with a certain awe that I have read these utterances, voiced as it were from the grave. Here the whole man is seen, and the completeness of his character made clear.

Mr. DuBois was able to fulfill his official duties until within a few months of his death. He was fully conscious of his approaching end, preserving his intelligence to the last, and the faith which had comforted him in this life supported him at its close. He left surviving him a widow, two sons, and one daughter, who have in the memory of his well-spent life a blessed inheritance.

Note on the Laramie Group in the vicinity of Raton, New Mexico. By John J. Stevenson, Professor of Geology in the University of the City of New York.

(Read before the American Philosophical Society, December 2, 1881.)

Raton, New Mexico, is an important station on the Atchison, Topeka and Santa Fé Railroad, at about five miles south from the Colorado line. It stands on the Canadian plain immediately south from the basalt-capped Raton plateau (the Chicorica mesa of Hayden's map of Colorado), and at the foot of the Laramie bluff, which forms the western boundary of the plain. The cañon of Willow creek, followed by the railroad from the Colorado line, opens at little more than a mile north from Raton. Dillon's cañon and that of the Upper Canadian open together at barely two miles south-west from the station, while petty cañons notch the face of the bluff at irregular intervals.

The lower beds of the Laramie group are fairly well shown at many places along the bluff as well as near the mouths of the larger cañons. During 1881, the Atchison, Topeka and Santa Fé Railroad Company made extensive examinations of the *Dillon coal bed, coal bed A* of the writer's generalized section, which exhibit the structure of the bed far better than did the natural exposures described in the writer's report on his explorations of 1878.* : The measurements made at the company's openings are given here as supplementing the observations detailed in that volume.

The *Dillon* is the lowest persistent *coal bed* found in the Trinidad coal-field, and is separated from the *Halymenites sandstone*, by but five to ten feet of shale. An opening on Coal cañon, tributary to that of the Upper Canadian, shows the following section:

1.	*Coal*	0′ 3 ″ to 8″	
2.	Shale	3′ to 4′ 0 ″	
3.	*Coal*	0′ 8 ″	
4.	Shale	0′ 1 ″	
5.	*Coal*	0′ 6 ″	
6.	Shale	0′ 1 ″	
7.	*Coal*	0′ 7½″	
8.	*Coal* and sandy clay	0′ 4½″	5′ 1″ (Nos. 3–14)
9.	*Coal*	0′ 6 ″	
10.	Shale	0′ ¼ ″ to 4″	
11.	*Coal*	1′ 3 ″	
12.	Shale	0′ 1 ″ to 4″	
13.	*Coal*	0′ 10 ″	
14.	Bony *coal*	0′ 4 ″	

No. 3 sometimes falls to 4 inches. Like No. 5, it contains some good coal, but with it is not a little bony stuff, and the whole is strongly pyritous. Nos. 4, 6 and 12 are hard pyritous clays. Nos. 8 and 10 are sandy, sometimes becoming hard sandstone. Nos. 7 and 9 are fairly good coal, but contain binders and diagonal streaks of sandstone, which make them utterly worthless. Nos. 11 and 14 are bony stuff, but No. 13 is excellent coal.

This opening is evidently on the upper division of the bed. The lower division is not exposed. Another opening was run in the Canadian cañon, where entries had been driven in both divisions of the bed. The lower division has five benches, all of which yield coal with much ash. No new features were seen in the upper division. The clay overlying the bed here is full of leaf impressions.

A section was obtained in Dillon's cañon at a deserted opening, just below Dillon's ranch. This is described in the writer's report† upon this region, but the measurements are repeated here to show the general structure of the bed. The section is:

Upper division		4′ 4″
Carbonaceous shale	0′ 4″	
Coal	2′ 10″	
Shale	0′ 4″	
Coal	0′ 10″	

* U. S. Geographical Survey, west of the 100th Meridian, Vol. iii. Supplement. Now passing through the press.

† Loc. cit. p. 275.

Clay shale, drab		2′ 8″
Lower division		4′ 7″
Coal	0′ 10″	
Parting	– –	
Coal	0′ 8″	
Parting	– –	
Coal	1′ 7″	
Clay	1′ 0″	
Coal	0′ 6″	

The outcrop coal is not altogether promising in appearance, and has a decidedly slaty structure. Some of it was tried on a locomotive, but it burned much like rotten wood. Prospecting entries were driven into the sound coal at a little way below the old opening. The quality improved rapidly as the entries advanced, and a locomotive test of the sound coal proved as satisfactory as that of the crop coal had proved unsatisfactory. Extensive mining operations were begun here in June of 1881.

Many prospecting pits were digged north from Dillon's cañon along the bluff fronting on the plain, but none of these reached sound coal.

Fulbrite & Company made an opening in the *Dillon coal bed*, at, say, a mile and a half north-west from Raton. They mined only the upper division, which has the following structure:

1. *Coal*	0′ 11″	4′ $1\frac{1}{2}$″
2. Sandstone	0′ $0\frac{1}{4}$″	
3. *Coal*	1′ 1″	
4. Parting	0′ $0\frac{1}{4}$″	
5. *Coal*	0′ 8″	
6. Parting	0′ $0\frac{1}{16}$″	
7. *Coal*	1′ 5″	

The coal of Nos. 1, 3 and 5 is compact, though in part of slaty structure, and is an excellent fuel. The ash is bulky but powdery. No. 7 breaks much like cannel, and in appearance is fully equal to some of the Pennsylvania cannels which are thought to be good marketable coals. It gives a long quick flame, and yields a bulky, powdery ash. This bench is sometimes parted near the middle. The lower division of the bed is not well exposed, but as nearly as can be determined, its thickness is 30 inches near the mouth of this pit.

An opening near the mouth of Willow creek cañon showed:

1. *Coal*	0′ 11″	3′ $7\frac{1}{2}$″
2. Parting	– –	
3. *Coal*	0′ 10″	
4. Parting	– –	
5. *Coal*	0′ $7\frac{1}{2}$″	
6. Parting	– –	
7. *Coal*	0′ 6″	
8. Parting	– –	
9. *Coal*	0′ 9″	

This also is on the upper division, and the features are very similar to those observed at the Fulbrite opening. At the time of examination, the entry had been driven 79 feet, but sound coal had not been reached as the hillside is very badly slipped. Another opening was run at a little distance further up the cañon. There the lower division is insignificant, and an entry had been driven nearly 60 feet in the upper division, which showed :

1. *Coal*	0′ 6″ to 8″	2′ 11″ to 3′ 7″
2. Sandstone parting	0′ 1″ to 2″	
3. *Coal*	0′ 7″	
4. Clay and sandstone	0′ 1″ to 2″	
5. *Coal*	0′ 8″	
6. Bony *coal*	0′ 2″ to 3″	
7. *Coal*	0′ 5″	
8. Bony *coal*	0′ 1″ to 2″	
9. *Coal*	0′ 4″ to 6″	

The quality of the coal varies materially in the several benches. It all burns readily, and yields a powdery ash. No. 7 and 9 are liked for use as domestic fuel. At another opening further up the cañon, the lower division is worthless, and the mining was done on the upper division, which shows :

1. *Coal*	0′ 6½″	2′ 11½″
2. Parting	– —	
3. *Coal*	0′ 6″	
4. Parting	– —	
5. *Coal*	0′ 6 ″	
6. Parting	– —	
7. *Coal*	0′ 8 ″	
8. Parting	– —	
9. *Coal*	0′ 9 ″	

Unlike the other pits, this shows no good coal, and the whole bed is more or less bony. The last opening examined is at nearly two miles from Raton, and very near the last exposure of the bed in this cañon. No exposure of the rocks, either above or below the bed, was found, but the structure at this opening is so different from that observed at the other pits, that there is no room for doubting that this is the lower division. The section is :

1. *Coal*	0′ 4½″	3′ to 2′ 10½″
2. Shale	0′ 2½″ to 4″	
3. *Coal*	1′ 3 ″ to 9″	
4. Shale	0′ 5 ″ to 8″	
5. *Coal*	0′ 9 ″	

No. 1 burns well, but is very bony, and the ash consists of angular fragments. No. 3 leaves a powdery ash, but it is pyritous. Nos. 2 and 4 vary at its expense. No. 5 is merely a coaly shale. The roof is irregular, and rolls or horsebacks cut out much of the bed.

The coal from the *Dillon bed* is far from being such as is obtained from the standard beds of the Appalachian field, but it is fully equal to that from many beds, which is used as domestic fuel over large areas of our country. That from the openings in Dillon's cañon, from Fulbrite's opening and from one opening in Willow's creek cañon is a good domestic fuel, superior indeed to that from the *Waynesburg coal bed* in Southwest Pennsylvania, which is an important source of supply for an extensive area. The ash does not exceed 15 per cent., barely one-half more than the amount contained in much of the Connellsville coke. This bed will become important to the region along the Atchison, Topeka and Santa Fé Railroad, which is cut off from the *Trinidad bed* at Trinidad, by the difficult grade between Trinidad and Raton pass.

Another bed, probably *coal bed H* of the writer's generalized section, has been mined to some extent near the head of Willow creek cañon. The bed was opened somewhat more than a year ago by Mr. Pettigrew, who hauled the coal to Raton. The section at the Pettigrew opening is :

1. *Coal*	1′ 0″	5′ 10″.
2. Shale	1′ 0″	
3. *Coal*	2′ 2″	
4. Sandy shale	0′ 1½″	
5. *Coal*	0′ 10″ to 8″	
6. Sandy shale	0′ 1″	
7. *Coal*	0′ 8″	

No. 1 is slaty, and streaks of coal occur in No. 2. The coal from No. 3 is clearly the best found within several miles of Raton. It leaves a somewhat bulky ash and contains some pyrites, but it is a strong fuel, and admirable for steaming, as has been proved by tests on locomotives, where it worked better than the Trinidad coal does. It is preferred also for domestic purposes. The coal from No. 5 is but little inferior to that from No. 3, and the two benches were mined. No. 7 yields a coal which is hardly equal to that of the other two benches. The bed is somewhat twisted in this mine. A sudden dip was found at a short distance from the mouth of the pit, which continues for somewhat more than ten yards, beyond which the miners did not follow it.

The railroad company has opened an extensive mine at a little way further down the cañon. The measurements there are almost exactly the same as in the Pettigrew opening.

On a New Substance resembling Dopplerite from a Peat Bog at Scranton. By Henry Carvill Lewis, Professor of Mineralogy in the Academy of Natural Sciences of Philadelphia.

(Read before the American Philosophical Society, December 2, 1881.)

In the course of an excavation for a new court-house at Scranton, Pa., made last July, a very interesting substance was discovered, specimens of which were sent to the writer at that time for investigation. The excavation cut through a peat bog, and it was at the bottom of this bog, some 25 feet from the surface of the ground, that the substance here referred to was found.

It appears that formerly there had been a lake or swamp at this place, which with the extension of the town had been filled up. Below eight feet of cinder and other rubbish there is a bed of peat 10–12 feet in thickness. The peat is said to be a good fuel after drying. Beneath the peat is a deposit of "swamp muck" or carbonaceous mud, which dries to a hard compact gray mass, burning with difficulty. In this "muck" are numerous plant remains and occasional seeds.

The whole deposit rests upon glacial till or "hardpan," and is therefore of post-glacial origin.

Scranton is in the glaciated portion of the State, and the peat bog found here is one of the many which owe their origin to glacial causes. These peat bogs have been formed, for the most part, in former swamps or lakes caused by the damming up of streams by ridges of drift deposited at the time of the melting of the glacier.

Near the bottom of the Scranton peat bog are irregular veins filled with a black jelly-like substance, elastic to the touch. The veins of this substance, which are confined to the muck above described, vary in width from a mere stain to between two and three inches, and make all angles with the horizon, being frequently nearly perpendicular.

The substance, as thus found, has the following properties: When first taken from the ground it is jelly-like in consistency, breaking with a conchoidal fracture, and having a hardness of less than 1. Immediately on exposure to the air it becomes tougher and more elastic, resembling India rubber. It may be preserved in this condition if kept in alcohol. The substance is black by reflected light. When a thin slice cut by a knife is examined under the microscope it appears brownish-red by transmitted light, and is nearly homogeneous in character.

Occasional seeds occur in this substance as well as in the surrounding peaty matter. In general appearance they resemble the seeds of certain Cyperaceæ. Under the microscope their surface is seen to be curiously marked with irregular wavy outlines. Professor J. T. Rothrock has been kind enough to make some sections of these seeds and reports concerning them that they have the characters of spores of one of the higher cryptogams, probably *Marsilia*. He states that Marsilia is a bog plant which is found during later geological time, and that the general shape and size of its fruit corresponds with that of the specimens under examination. The outer coat is made up of outwardly pointing prismatic columns, the extremities of which gives the peculiar wavy appearance seen on the surface of these *peat seeds*. Yet since the interior bag and its contents can be reduced neither to an embryo nor to the interior structure of the Marsilia, it is not possible to assign these seeds definitely to that species. No other recognizable organisms have been noticed in the substance here described.

The black jelly is tasteless and odorless. If placed in the flame of a Bunsen burner before drying, it burns slowly and without flame. It is almost insoluble in water, alcohol or ether, but is almost completely dissolved in caustic potash; and from the dark-brown solution thus formed may be precipitated in reddish-brown flocculent masses by the addition of an acid.

After exposure to the air until completely dry, the substance becomes brittle, and nearly as hard as coal. In this condition it resembles jet or some of the varieties of lignite, and might readily be mistaken for those substances. It acquires a hardness of 2.5, and has the brilliant resinous lustre, and conchoidal fracture of true coal.

It has a specific gravity of 1.032. It is jet black in the mass, but in powder is dark-brown. It now burns with a clear yellow flame. Soaking in water will not soften it appreciably. In the closed tube it gives off water, and abundance of brown oil and empyreumatic vapors. The latter are in the form of a white smoke which can be lighted at the end of the tube.

In solubility it is like the undried substance. Hot alcohol dissolves a small portion, and forms a pale yellow solution. On treatment with caustic potash it dissolves completely, with the exception of an extremely slight residue of impurities. It will dissolve even in the cold. This test serves to distinguish the dried substance from brown coal or lignite, which are but partially soluble in alkalies.

A very slight trace of ammonia is given off on heating with caustic potash. By dissolving in a standard solution of alkali and titrating with standard acid, it is found that the substance has an acid reaction. It is therefore either an organic acid or a mixture of such acids.

The physical characters of this substance are closely allied to *Dopplerite*, but its chemical composition, as will be seen from its analysis, prove it to be an undescribed substance.

Mr. John M. Stinson, of the Second Geological Survey of Pennsylvania, has, at the request of the writer, kindly made the following analysis. The substance was carefully separated from the surrounding earthy material, and dried at 212° F. before analysis. Carbon and hydrogen were determined in duplicate, the two determinations closely agreeing:

Carbon	28.989
Hydrogen	5.172
Nitrogen	2.456
Oxygen	56.983
Ash	6.400
	100.

Approximate analysis of the dry separated material gave :

Volatile matter	72.190
Fixed carbon	21.410
Ash	6.400
	100.

Subtracting the amount of ash from the first analysis, we have :

C	30.971
H	5.526
O + N	63.503
	100.

From this we may deduce the empirical formula $C_{10}H_{22}O_{16}$. This formula would yield the calculated composition :

C	30.15
H	5.53
O + N	64.32
	100.

In giving the above formula, it is by no means assumed that it represents a simple mineral substance. It is merely a convenient expression of its composition. It is probable that the substance here described is a complex organic acid containing water. The nitrogen may possibly exist as ammonia. The small amount of carbon and the excess of hydrogen distinguish this substance from other organic acids. By the subtraction of NH_4O, and one or more parts of H_2O from the formula, it may be more closely allied to some of the organic acids which form Humic acid, the formula of which is so variously given by different authors. The determination of the true formula of the acid here analyzed, can only be determined after the formation of an organic salt with lead or silver. The absence of any exact knowledge concerning the composition of the organic acids existing in humus, as recently shown by Julien,* renders it difficult to express definitely the chemical relations of the substance under discussion.

The relation which it bears to its nearest ally, Dopplerite, may best be seen after a review of the facts as yet gathered about that curious mineral.

The mineral known by that name, and generally regarded as allied to Humic acid, was first found in a peat-bog near Aussee, Austria, at a depth of 6 to 8 feet below the surface. It was a black gelatinous substance, known by the peat-cutters as "*Moder-substanz*," which after exposure to the air became at first elastic and afterwards brittle, assuming the lustre of coal. Döppler drew attention to this substance in a paper entitled "On a re-

* Proc. A. A. A. S., 1876 p. 311.

markable gelatinous substance discovered in Austria," read before the Vienna Academy in 1849,* and stated that it was nearly insoluble in water, alcohol and ether, but almost entirely dissolved by caustic potash.

Having been referred to Haidinger and Schrötter for further examination, it was fully described and named by them a week later. Schrötter † found its composition to be (after drying at 212° F.):

C	48.06	or without ash	
H	4.93	C	51.63
O	40.07	H	5.34
N	1.03	O + N	43.03
Ash	5.86		

Haidinger named the substance and described its physical properties. He stated the observation of Löwe that it burned without flame, and that of Ettinghausen that it contained recognizable vegatable organisms.

In 1858, Gümbel‡ announced that a substance very similar to Dopplerite occurred in a peat-bed near Berchtesgaden, Bavaria. Like the substance from Scranton, a black jelly-like substance was found as irregular and sometimes nearly vertical veins of varying, but slight thickness, in the lower part of the peat. It was known as Peat-Pitch-Coal. It was very slightly soluble in alcohol, giving it a pale yellow color, but was almost completely soluble in alkali. Unlike the original Dopplerite, it burned with a yellow flame. Gümbel indicated the chemical changes which converted wood into peat, and showed that Dopplerite had the same composition as peat, and was in fact a truly homogeneous peat.

In 1863, Dopplerite was discovered in a peat-bog at Obburg, Switzerland, and was described by Kauffmann, who in an important paper§ showed that it had the same physical properties and chemical composition as the Dopplerite of Aussee.

It occurred in a black peat at a depth of 12 to 14 feet, in layers sometimes a foot in thickness. Except in burning without flame, its physical properties were nearly identical with the Scranton substance. The air-dried Dopplerite lost 19.7 per cent. of water at a heat of 110° C., and according to Muhlberg had the following composition:

C	52.2
H	5.9
O + N	35.7
Ash	5.2
	100.

By dissolving in caustic potash, precipitating by acid, and then analyzing the dried precipitate, a similar composition was obtained. Kauffmann

*Sitzunsb. d. k. Acad. d. Wiss. Wien, 1849, Vol. i, p. 239.
† Loc. cit. p. 286.
‡ Neues Jahr., f. Min., 1858, p. 278.
§ Jahr., d. k. k. Geol. Reich, Wien. 1865, Vol. xv, p. 283.

concludes that Dopplerite consists of one or more of the humous acids, and shows that the portion of peat soluble in alkali is identical with Dopplerite, and that compact peat contains minute black particles of Dopplerite. Peat is therefore a mixture of Dopplerite with partially decomposed plant remains; while Dopplerite itself may be regarded as a homogeneous peat in which all organisms have been decomposed. He shows that in different peats the proportion of Dopplerite, or part soluble in alkali, increases with the age of the peat, while the contrary is the case with mineral coal. Thus while in a recent peat but 25–30 per cent. was soluble, in an old compact peat, the proportion was 77 per cent. On the other hand, the solubility of coal, decreases with its age, as shown in the following table, where the figures represent the degree of solubility in alkali:

(Dopplerite)	(100)
"Slate coal," a woody lignite, Diluvial	75
Brown coal	42
"Pitch coal," Upper Miocene	10
" Lower "	5
Bituminous coal, Eocene	2.3
" " Carboniferous	trace.
Anthracite	0

He concludes that in the formation of coal from peat, the first step of the process is the formation of Dopplerite, and the second the gradual transformation of the latter into a material less soluble in alkali, and richer in carbon.

Several other European localities for Dopplerite have more recently been discovered.

A substance resembling Dopplerite in the peat of Hägnetswyll, St. Gall, Switzerland, mentioned by Deicke,* burns with flame, and is regarded by Kenngott as having characters more nearly approaching those of Pyropissite or Melanchyme. It possibly is more analogous to the substance from Scranton.

Dopplerite has not as yet been discovered in America. While the substance described in the present paper more nearly resembles Dopplerite than any other known mineral, it differs, as already shown, both in composition and in its behavior when burning.

A distinguishing feature of the Scranton mineral is its very low percentage of carbon. Dopplerite has almost the precise composition of peat, and peat, as is well known, contains more carbon than is contained in wood. Yet the Scranton mineral contains even less carbon than is contained in wood.† The empirical formula of the Scranton mineral gives

* Neues Jahr. f. Nim., 1858, p. 663.

† The composition of peat is about:

C	H	O + N	Ash.
61	6	33	= 100

The average composition of wood is:

C	H	O + N	Ash.
49.6	6.1	43.1	1.2 = 100

v. Coal, its History and Uses. Thorpe, etc., p. 165.

a larger amount of hydrogen than is expressed in the formulas of any similar substance.*

The first printed notice of this substance was given by Mr. T. Cooper.† A week later Mr. C. A. Ashburner, contributed to the same Journal the following analysis made by Mr. J. M. Stinson:

Water at 212°	66.758
Volatile matter	9.826
Fixed carbon	4.012
Ash	19.404
	100.

Mr. Stinson informs the writer that this analysis was made upon a sample consisting of a mixture of peat, muck, and the jelly-like substance, and that as no attempt was made to separate the latter, the analysis is not of scientific value.

Special interest is attached to the substance here described as being perhaps an intermediate product between peat and coal. While the quaternary lignites illustrate the transformation of wood with coal, this substance illustrates a similar change from peat. As by the investigations of Kauffman, it was shown that the formation of Dopplerite preceded that of any of the varieties of coal, so in the present case we have perhaps a yet earlier stage.

The characters of the Scranton mineral entitle it to a distinctive place among the hydrocarbons of natural origin. It has been the custom among mineralogists to regard these substances, as mineral species. In view, however, of the objection to adding new mineral species whose distinctive characters are made prominent only by analysis, the writer believes that it would be more advisable to combine those already described under generic names, and to regard the minerals included in such genera as varieties.

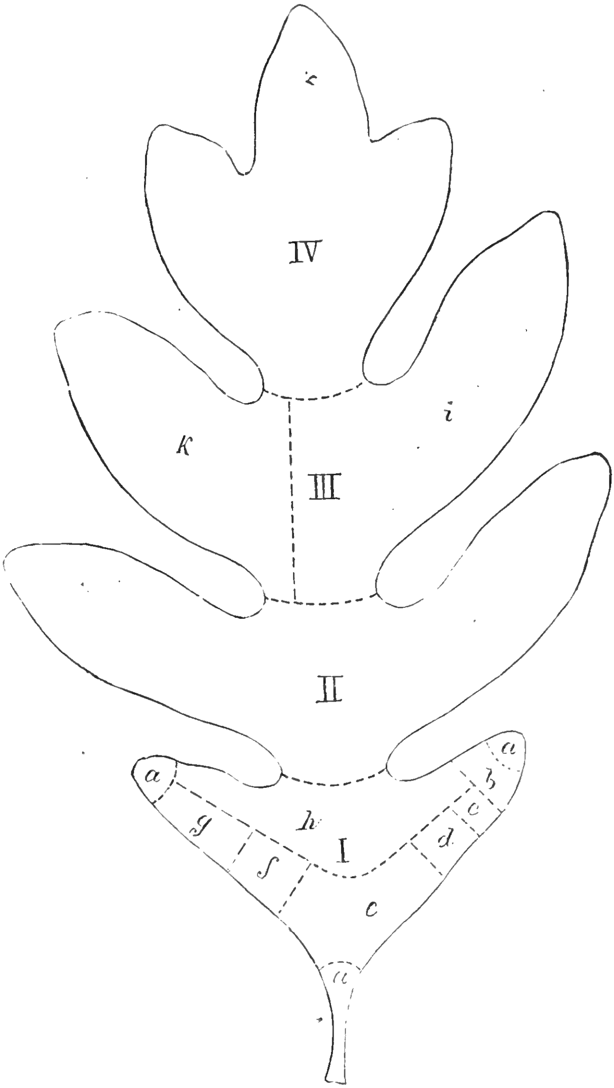
In the present case we have to do with a black jelly-like substance derived from vegetable decomposition, which with a different composition and with somewhat different physical properties has been found in similar geological conditions in several parts of Europe. It is therefore suggested that all of these substances be combined under one generic name. The name "*Phytocollite*" (φυτόν, κόλλα) signifying "plant-jelly," would include all jelly-like substances formed by the decomposition of plant matter. Dopplerite would then be regarded as one of its varieties, the mineral described by Diecke would be another, and the mineral from Scranton yet another.

* The formula of Dopplerite has been given as:

C_{40}	H_{25}	O_{25}	(Gmelin);
C_{16}	H_{10}	O_{10}	(Descloiseaux);
C_{10}	H_6	O_5	(Dana).

† Engineering and Mining Journal, Aug. 13, 1881.

PLAN OF ROCKERY



ON THE CAMPUS OF THE UNIVERSITY OF PENNSYLVANIA.

Rockery at the University of Pennsylvania, built in 1881. By Eli K. Price.

(*Read before the American Philosophical Society, Dec. 16, 1881.*)

The form of the White Oak leaf is used and the rocks so placed, that every one may be seen. They are arranged according to the places where they were found, to show how nature has disposed of them.

SECTION I.—The large upright black stones at the three corners (*a*) came from the tunnel on Thirtieth Street, near Master, 40 feet below the curb, 50 to 60 below the gravel hill.

The quarried stones (*b*) are from the quarry of Price & Moore, next westward of the Woodlands Cemetery; those next east (*c*) from the quarry of Samuel C. Bunting, Junior, south of Walnut, west of Forty-fourth Street; those farther east (*d*) from William P. Supplee's quarry east of Fifty-third Street, southward of Girard Avenue; those marked (*f*) from McKinley's quarry on Rittenhouse Street, near the Wissahickon; and all the other quarried stones in this section (*e* and *g*) are from grounds of Eli K. Price, on both sides of Twenty-ninth and Thirtieth Streets and of Master and Jefferson Streets; and the residue of this section is covered by transported rubbed rocks from the gravel hills of the same and adjoining grounds, at an elevation of about 100 feet.

SECTION II is wholly covered by white and light-colored rocks, transported and polished, from grounds of George S. Harris, J. Clothier, L. Dolby and others, on south side of Market Street, from Forty-eighth to Forty-ninth Streets, a space of 480 feet by 246 feet, from a sand and gravel hill of a height of about 100 feet above tide. The large white rocks at the ends of this section lay near together, and show that when transported they came as one rock.

SECTION III.—Letter *i* are stones from the south side of Chestnut Street, extending from Forty-seventh to Forty-eighth Streets, from a gravel and sandy elevation of about 70 feet above tide, from the grounds of the Byvam heirs and others.

SECTION III.—Letter *k* are stones from both sides of Forty-fifth Street and of Spruce Street, from grounds of Albert S. Letchworth and others. The elevations were about 90 feet above tide.

SECTION IV is wholly covered by stones from the City Almshouse grounds, westward of Thirty-seventh Street, and both sides of Spruce and Thirty-eighth Streets, from gravel about 85 feet above tide.*

* These elevations are based upon the following *curb heights*, which are about ten feet lower than the gravel banks had been:

PHILADELPHIA, December 8th, 1881.

Dear Sir:—The following are the elevations of the *curb* corners above tide, asked for in your note of 7th inst.:—Jefferson and Twenty-eighth, 96.57 feet; south side of Market and Forty-ninth, 88 feet; south side of Chestnut and Forty-seventh, 64.74 feet; north side of Spruce and Thirty-eighth, 76 feet, and south side ditto, 75.50 feet; Spruce and Forty-fifth streets, 83.50; Tunnel, Thirtieth and Master streets, 40.70 to bottom.

Yours, &c.,

SAMUEL L. SMEDLEY, Chief Engineer and Surveyor.

TO ELI K. PRICE.

For the taking of the above stones I had, as far as known, the permission of the owners or their representatives, and for them the University of Pennsylvania and citizens owe thanks to the City of Philadelphia, to William Baldwin, Chief Commissioner of Highways, George S. Harris, Dr. Twaddell, J. Clothier, L. Dolby, Samuel C. Bunting, Jr., Albert S. Letchworth and others, who gave them these valuable objects of curiosity and science without charge. The hunting, hauling and building them into a Rockery has been my occupation, with men and carts taken from my quarry for one day or more of the week, from the beginning of June to the end of December, 1881. The purpose of gathering these rocks has been for their preservation, and convenience of study by professors and students, and all interested in the important questions to which they give rise.

What do these rocks say to us here to-day? Plainly they show the minerals they contain. But we go back from these to the period of primary rocks, to the granites and other igneous rocks, whose melting and moving power was fire, and whose disintegrations furnished the material for the stratified rocks deposited by later pervading waters; and these also again, becoming disintegrated by frost, heat and water, also became modifying and different sources for their last granular depositions in strata. We have here from the quarries gneissic rocks, the first strata of the secondary formation; and we have the transported rocks, also deposited by water, consisting of materials that have undergone many changes of stratification and re-stratification as well as of attrition.

In the study of these rocks we pass from a time when no life was on this globe into periods since the beginning, spoken of in the first verse of Genesis, wherein all life has been created; and therein perceive the methods of the Creator in the structure of this globe.

The transported rocks demand special explanation. We ask to know what are their compositions? What their names? Where were they in the regular order of the geological stratification? Where geographically? How were they torn from their places? How transported to where found round our University? How polished? How lifted upon the hills? Had we really a great "continental glacier" to bring them here? Was the world made, peopled, civilized for the repetition of the disaster of the "Great Glacier"?

These are some of the questions for the mineralogists and geologists, in and out of the University, to answer: it is hoped that they may long incite to interesting and useful study. The objects are the oldest, but the questions are of new presentation.

Charles E. Hall, of our State Geological Survey, began to observe some of these rocks in 1875, and has partially answered the above questions, according to his observations and convictions at that time. (See Proceedings Amer. Philos. Soc., No. 95, Nov. 1875, p. 633.) He followed Agassiz, Lyell, Geikie, Croll, Dana and Newcomb in placing the south line of the great continental glacier at and below the 40th degree of north latitude, and naturally inferred that it was the cause of the deposit here of these transported rocks.

In 1878 Professor Cook published his "Report on the Geology of the State of New Jersey," and placed the glacial drift northward, on a line from a point of the Raritan river (lat. 40° 30′), thence N. W. to Denville (near the 41°), thence westward and south-westward to Belvidere on the Delaware (lat. 40° 50′).

In 1881 Professor Henry Carvill Lewis, also of the Second Geological Survey of Pennsylvania, has traced the southern line of the glacial drift through this State for a distance of about 400 miles. He informs me, in advance of publication, that this line, which is marked by a terminal moraine, starts at a point opposite Belvidere, and passes in a north-west direction over the Kittatinny and Pocono mountains, and across the Lehigh and Susquehanna rivers into Lycoming county, where it ascends the Alleghany Mountains, and continues thence in a nearly straight line into Cattaraugus County, N. Y. (lat. 42° 15′). It there curves south-westward and, re-entering Pennsylvania in Warren County, passes south-west through Venango, Butler and Lawrence Counties, until in Beaver County (lat. 40° 50′) it crosses the Ohio State Line.

In his "Essay on the Antiquity and Origin of the Trenton Gravels," Mr. Lewis states his belief as to "the Terminal Moraine" which he had explored, which "winds over hills and across valleys in such a manner that by no other known agency than a great glacier could it have been produced," p. 17. This is the product, he says, of the last glacial epoch. There is some evidence that in an earlier period a glacier advanced south of that limit. To the north "the great glacier has left undoubted traces, in the universal covering of unstratified boulder clay or *till*, in the smoothed and grooved rocks, the transported boulders, &c." "There are many facts which indicate that the ice, even close to its lower terminus, had a thickness of over 1000 feet, which increased northward," pp. 18, 19.

Mr. Lewis also speaks of a post-glacial flood, "at a time when the river [Delaware] was larger than at present," as a "conclusion warranted by many facts, and as a cause of the deposit of the Trenton gravels," p. 19, &c.; and "that the boulders upon its surface were dropped from ice-cakes is, however, probable," p. 23.

Did, then, these transported rocks come here by glacial action? If so, at a first or second glacial epoch? By a great glacier or by floated ice? Were they *lifted* upon the hills by ice or water? Or was the earth sunk when they were brought, and the rocks afterwards lifted by the rising of the earth's surface? Professor Lewis gives to these transported rocks a transporting cause common to the Philadelphia red gravel and our brick clay, at "an epoch of submergence as indicated by the elevation of their deposit;" and that "it is probable that this clay may be assigned to a period when the land stood 150 feet or more below its present level, and when the cold waters from the melting glacier bore ice-rafts which dropped their boulders," pp. 4, 5, 6, 7.

It seems apparent that the supposed ice-sheets or glaciers have been greatly magnified by the first-named glacialists, both in their thickness and extent, by reason of their taking the earth as a stable land-mark, whereas it is less stable than the ocean. Great rocks have been taken for boulders, though in *situ*, because they have been abraided by floating ice-sheets and the rocks they have borne; rocks supposed to have been transported and *upheaved* by glaciers, have been floated *downwards* by ice rafts or icebergs, and afterwards have been lifted by the rising oscillation of the earth; and mountain sides are supposed to have been scored by great glaciers 6000 or more feet thick, yet the scorings may have been made much lower, and afterwards have been carried upwards to such height by the rising mountains. It seems not to be sober philosophy to seek abnormal causes when the ordinary laws of nature may afford the sufficing explanation. A sufficient cause is enough. The mountain tops have been higher and colder, and been since lowered by erosions; their oscillations have been upwards and downwards; the valleys have been raised by the *debris* of the mountains, and have risen and fallen with the rocks beneath them; and how frequent are these alternations, and for what beneficent purpose, may be seen in every seam of coal in the carboniferous regions; for each was grown on a plain in the open air, and had the light and heat of the sun, and then sank below the waters, that these might deposit the particles to make the protecting covering rocks for the unknown centuries that followed, when again all were corrugated and lifted to bring them into human reach for man's uses, in ages when skillful enough to win and apply the coals, the products of the soil, water, air and sun, and the life that God gave to the plants at a remote and momentous era of creation.

It becomes us not to unreasonably impeach the goodness of the Creator. It seems, from all we know, not likely that He would destine the fairest portion of this earth, where man has best developed his civilization, to destruction by ice. The physical sciences, as well as those of morality and religion, furnish the proof that there is a limitation of forces that conserve nature, and afford us the foundation of a scientific faith that man's best home on earth is an abiding one for the race. Yet must science observe all facts and heed all reasonable reasons; and doing so mankind, it is believed, will gain reassurance that they are held in safety by a Creator who forever conserves His works.

The Vagus Nerve in the Domestic Cat (Felis domestica).
By T. B. Stowell, A.M., Ph.D.

(Read before the American Philosophical Society, July 15, 1881.)

The idea of using the cat as the basis of anatomical study is by no means a recent one. Straus-Durckheim's "Anatomie du Chat," Dr. B. G. Wilder's "Anatomical Uses of the Cat," and other papers published by the same author since 1877, and Mivart's recent work on "The Cat," present the general thought with more or less directness. I am not aware, however, that any one has made a study of the nerves of the cat in their detailed distribution. Having compared the vagus nerve in man, cat, dog, horse, ox, sheep, rabbit and frog, I am satisfied that the cat (*Felis domestica*) presents advantages over all others as a basis for comparative study. I accordingly submit the accompanying figures and text to aid students who may be disposed to investigate Comparative Neurology.

The cat, dog, and rabbit were injected with plaster, as recommended by Prof. Simon H. Gage, of Cornell University, in a paper published in The American Naturalist, vol. xii, p. 717. The figures are semi-diagrammatic; they were originally drawn to a scale, natural size; for the purpose of giving prominence to certain relations, to ramuli and anastomotic filaments, such modifications have been made as seemed necessary; where a nerve trunk is continuous, with no distinctive characters, it is shortened, e.g., the gastro-cardiac portions of the vagus (Fig. 9). The figure of the stomach is reduced one-half (Fig. 13). For the sake of simplicity no attempt has been made to reproduce plexuses or the terminal ramification of filaments.

The nomenclature used is largely that advocated by Dr. B. G. Wilder, before the American Association for the Advancement of Science, at Boston, 1880, in a paper entitled "A Partial Revision of the Nomenclature of the Brain," and in a more detailed communication published in Science, March 19, and 26, 1881, entitled "A partial Revision of Anatomical Nomenclature, with especial reference to that of the Brain." The simplicity and perspicuity of the nomenclature commend it alike to the lecture-room and the laboratory.

[In cases where it was thought that any possible doubt might arise from using the new terminology, the new words are followed by their anthropotomical equivalents.]

The vagus nerve (N. vagus; N, pneumogastricus; Pars vaga; Par vagum; N. ambulatorius; N. sympathicus medius; Eighth pair, pneumogastric branch, Willis; Tenth pair, Sömmering and Vicq-d'Azyr) presents the following marked characters, viz:—

General Characters: N. vagus has the most extensive distribution and the longest course of the cranial nerves; in its cephalic region principal rami are derived from ganglia; it forms by its frequent and complex anastomoses with N. sympathicus numerous plexuses, hence presents involved physiological and pathological complications; its terminal filaments supply the muscular substance and the mucous membranes of organs ; its development in relation with the development of, notably, the heart and adjacent blood-vessels, and the stomach, renders its distribution somewhat asymmetrical, necessitating special anatomical study of its dextral and sinistral relations, and giving corresponding and distinctive physiological and pathological characters ; the relation of this nerve to organic life, to the automatic and the reflex phenomena of respiration, and to the so-called "inhibitory phenomena" gives importance to its study.

Special anatomical characters: N. vagus and its rami are distributed to the most important viscera, at least to viscera most intimately related to the functions of organic life, e. g., *digestive*—pharynx, œsophagus, stomach, liver, pancreas, intestines ; *circulatory*—heart, pulmonary arteries, pulmonary veins, systemic arteries and veins in the region of the heart ; *respiratory*—larynx, trachea, bronchi, substance of lung.

Special physiological characters: N. vagus is a sensory-motor nerve, having both sensitive and motor fibres ; it controls, regulates or modifies the movements and the secretory functions of the organs to which it is distributed, and upon it depend the sensory phenomena which characterize the respective organs.

DESCRIPTION : Origin and cervical portion—N. vagus in the cat (*Felis domestica*) takes its superficial origin from two regions of the medulla : by 12–14 filaments from the ventral border of corpus restiforme and the depression line between cp. restiforme and the portion of medulla next laterad (Fig. 3, 4),* in a line caudad of (posterior to) the origin-filaments of N. glosso-pharyngeus (ninth pair of cranial nerves), (Fig. 2, 4), from which nerve it is sometimes separated by a small arterial twig of A. cerebellosa inferior ; and by 4–6 filaments immediately ventrad in the slight depression line ventrad of oliva and cephalad of the origin-filaments of the spinal portion of N. accessorius (Fig. 2. L). The dorsal filaments form a somewhat curved line of superficial origin, measuring 3–4 mm. in caudo-cephalic direction, and presenting its convexity dorsad (Fig. 2. X) ; the cephalic filaments are most ventral and leave the medulla oblongata just caudad of A. cerebellosa inferior—a considerable branch of A. basilaris at right angles with the main trunk and

* There is some difficulty in establishing satisfactorily the homologies of the medulla. There are reasons for regarding the third nerve tract from the dorsimeson as the homologue of corpus olivarium : this is manifestly not the cp. olivarium of Foster as given in his "Practical Physiology ;" it should be noticed that the cephalic origin-filaments of N. accessorius become apparent in this depression line, while the caudal origin-filaments appear along the depression line ventrad of this tract. The elliptical area (Fig. 1, 3) laterad of ventripyramis (anterior pyramid) and the one still dorso-lateral have relations upon which homologies might be based, giving each one the name oliva (corpus olivarium). It is not proper in this connection to discuss homologies. I have made this allusion in apology for the indefiniteness of description of the origin-line of N. vagus. Whatever homologies may be established and names assigned, the figures (Fig. 3, 4) designate the relation.

given off 4–6 mm. cephalad of union of AA. vertebrales. These filaments unite about 1 mm. peripherad of their superficial origin into six or seven ramuli, which lie ventrad of plexus choroideus lateralis (Fig. 2, Pl. Ch.), and blend in foramen jugulare to form a single flattened nerve trunk, N. vagus. In the **passage through the foramen** 6 mm. peripherad of its origin, N. vagus is enclosed in common with N. accessorius (XI) in a sheath formed by a tubular prolongation of the dura mater and the arachnoid membrane, where it is also joined by N. glosso-pharyngeus (IX); but the sheath of the united NN. vagus (X) and accessorius (XI) may be readily dissected from that of N. glosso-pharyngeus (IX), which lies ectad and cephalad. Centrad of its foramen of exit—Foramen jugulare, (Foramen lacerum-posterius, Lacerum foramen posterius)—and 3–4 mm. peripherad of medulla oblongata, N. vagus presents a ganglionic enlargement, **ganglion jugulare,** ganglion of the root. This ganglion is hemispherical in form, of a grayish color, and measures nearly 2 mm. in diameter; it has relations with NN. facialis, glosso-pharyngeus, accessorius and sympathicus (Fig. 5, J).

At G. jugulare, N. vagus is connected by a single twig with the adjacent petrous ganglion of N. glosso-pharyngeus (IX) the "ganglion of Andersch" (Fig. 5, Pe.); by a considerable trunk with N. accessorius (Fig. 6, *10*); by ramus auricularis (Fig. 5, *2*), with N. facialis (VII), from which ramus, a slender ramulus penetrates the petrous bone and joins a branch of N. facialis; a portion of the ramus continues across N. facialis to the cochlea (Fig. 5, *5*), a filament from the auricular branch connects with a ganglionic plexus of N. sympathicus, entad of the gangliform plexus of N. vagus.

Plexus gangliformis. The 5 mm. of N. vagus immediately caudad of G. jugulare is involved in a somewhat intricate net-work, which seems to be allied to plexus gangliformis (Fig. 6., Px. gang.); the apposed trunks of NN. glosso-pharyngeus (IX), vagus (X), accessorius (XI) and hypoglossus (XII), are embraced by interlacing filaments of N. sympathicus, with which nerve they sustain more or less intimate relations, through anastomotic filaments; N. glosso-pharyngeus is ectal in this group, and, together with its root-ganglion—G. Ehrenritteri, which lies upon the ectal surface of G. jugulare, but which does not seem to sustain anatomical relations with it—may be dissected from the ental trunk; NN. vagus and accessorius are most intimately related—their separation involving the rupture of interlacing fibre—and apparently constitute a single trunk; entad of this united trunk is N. hypoglossus. At the caudal border of this plexus N. accessorius is directed dorsad to be distributed to the muscles of the neck, and N. hypoglossus assumes ectal relations, crossing the ectal surface of N. vagus nearly at right angles, and takes its course ventrad, to the muscles of the tongue. As N. hypoglossus crosses N. vagus, it detaches a filament to G. inferius (Fig. 5, *13*). This region marks the origins of two other rami with whose terminal filaments N. vagus sustains intimate relations, NN. thyro-hyoideus and descendens noni.

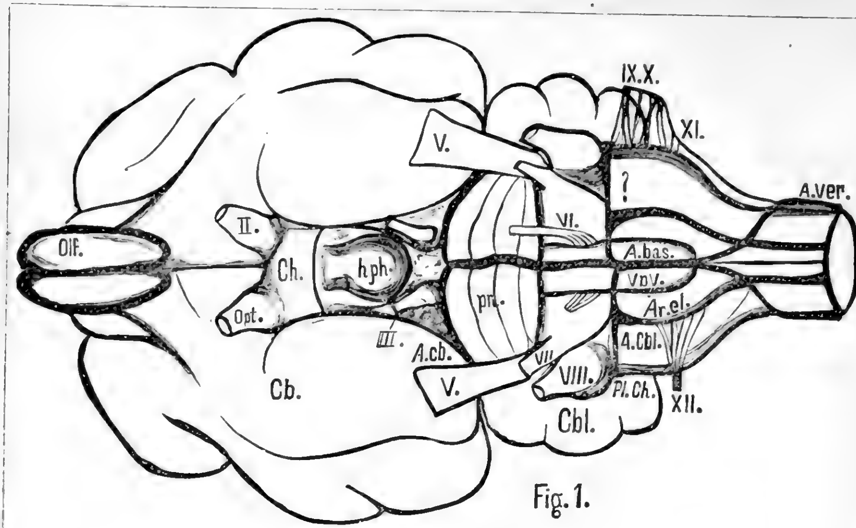


Fig. 1.

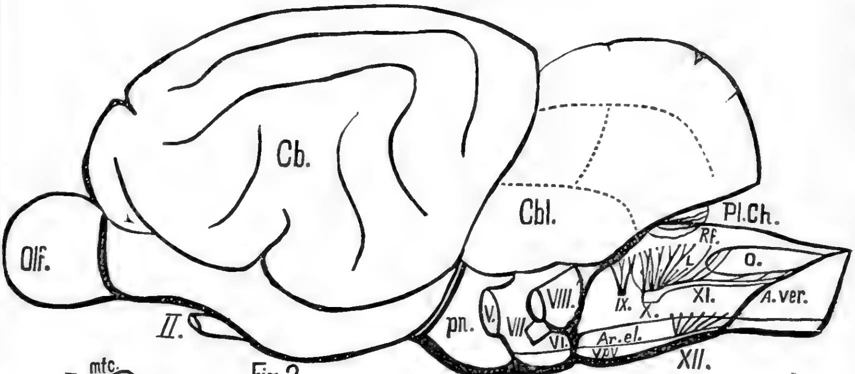


Fig. 2.

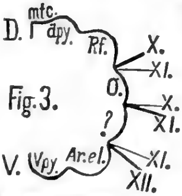


Fig. 3.

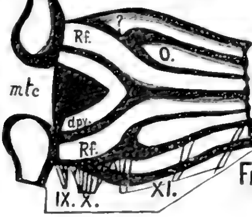


Fig. 4.

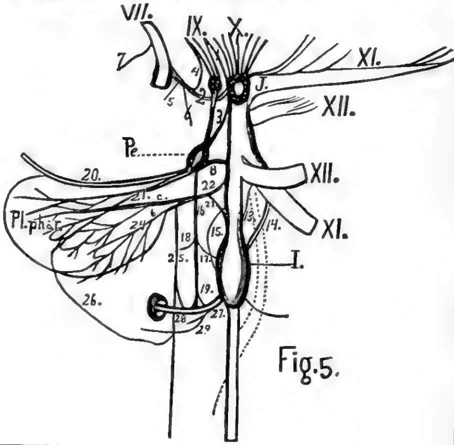


Fig. 5.

15 mm. caudad of G. jugulare and dorsad of the origin of A. carotidea interna, N. vagus receives a second ganglionic enlargement, **ganglion inferius,** ganglion of the trunk (Fig. 5, I.). This ganglion has a fusiform outline 5–8 mm. in caudo-cephalic diameter and 2 mm. in dorso-ventral; it is of a pinkish color; is located ectad of (superficial to) and dorso-caudad of the closely-apposed superior cervical ganglion of N. sympathicus, to which it is very intimately related through anastomotic filaments; its cephalic extremity is apposed to the middle of the superior cervical ganglion. G. inferius does not embrace or involve the main trunk of N. accessorius; it is however joined at its dorso-cephalic border by a large ramus given off from N. accessorius just peripherad of Px. gangliformis (Fig. 5, *14*); it is the superficial origin of a large ramus of N. vagus, viz., N. laryngeus superior; it communicates with N. glosso-pharyngeus (IX) (Fig. 5, *17*), N. accessorius (XI) (Fig. 5, *14*), N. hypoglossus (XII) (Fig. 5, *13*), with the spinal nerves NN. vertebrales, in the loop which connects the first and second cervical nerves, and with N. sympathicus (entad of Px. gangliformis).

In the cervical region N. vagus continues caudad from G. inferius associated with N. sympathicus in the sheath of A. carotidea primitiva. In the cephalic 20 mm. the trunk lies dorso-laterad of A. carotidea externa and A. carotidea primitiva, being concealed within the arterial sheath by the artery and by V. jugularis interna. As the nerve approaches A. occipitalis (?)* it lies laterad of A. carotidea primitiva and crosses the venter of A. occipitalis (?) at its origin; it resumes its dorso-lateral relation 5–8 mm. caudad of A. occipitalis (?) until it enters the thorax. The trunk of N. vagus in its cervical region caudad of G. inferius gives off several ramuli which anastomose with ramuli of N. sympathicus to constitute a more or less dense plexus around the trachea and œsophagus; this is especially marked in the caudal portion of the cervical region. The distinctive courses of the sinistral and the dextral nerves in the thorax require separate descriptions.

The principal rami of the cervical portion of N. vagus are Rm. auricularis, N. pharyngeus, and N. laryngeus superior.

Rm. auricularis, is a large anastomotic branch and has its superficial origin in the dorso-ental border of G. jugulare; its course is curved dorso-laterad and cephalad, and it enters the periotic bone, follows a groove along the dorso-caudal border of the tympanic bulla, traverses the petrous portion of the bone and enters aqueductus Fallopii at a point 2 mm. centrad of the origin of chorda tympani; a portion of Rm. auricularis continues to the opening where it meets the dorsal branch of N. facialis, to be distributed to the ear. A considerable fasciculus crosses N. facialis and may be traced to the cochlea (Fig. 5, *5*). 2 mm. peripherad of its origin Rm. auricularis receives a considerable twig from N. glosso-pharyngeus (IX), and about

* This artery, 25 mm. caudad of foramen of exit and dorsad, or 1–3 mm. dorso-cephalad of A. thyreoidea superior, seems to be allied to A. princeps cervicis. There are some objections to this homology, but the measurements given in the text identify it beyond question.

the same distance, still peripherad, an anastomotic filament from N. sympathicus (Fig. 5, *6*).

N. pharyngeus, the pharyngeal branch, takes its superficial origin from the ventro-ental surface of N. vagus just caudad of the united trunks of NN. vagus and accessorius, 7 mm. caudad of G. jugulare and entad of the point where N. hypoglossus (XII) lies ectad of N. vagus; its origin is, therefore, involved in Px. gangliformis. A considerable accession is traceable through the plexus to the accessory branch of N. accessorius. Its course is ventrad, parallel with N. glosso-pharyngeus (IX), and only 2–3 mm. caudad of that nerve; it lies ectad of A. carotidea interna, and entad of V. jugularis interna and A. carotidea externa; just peripherad of its origin it gives a twig caudad to the trunk, which may be traced to G. inferius (Fig. 5, *23*). Opposite A. carotidea interna it divides into two rami (Fig. 5, *22*, a, b), from which filaments are given to A. carotidea interna and to the adjacent V. jugularis interna. From the *cephalic ramus* anastomotic filaments join N. glosso-pharyngeus (IX) to form a plexus, from which filaments are distributed to the cephalic border of MM. pharyngis constrictor medius, and pharyngis constrictor superior; others anastomose with filaments of N. sympathicus and form the pharyngeal plexus (Fig. 5), other filaments join N. hypoglossus (XII) in this plexus. The *caudal ramus* has its general course caudad; 5 mm. peripherad of its origin, it subdivides into two ramuli, which may be designated, in view of their distribution, as the pharyngeal (Fig. 5–*24*), and the œsophageal (Fig. 5, *25*); the *pharyngeal ramulus* is directed meso-dorsad and forms a loose network with the terminal filaments of the pharyngeal ramuli of N. glosso-pharyngeus (IX)—Px. pharyngeus. The *œsophageal ramulus* gives filaments to MM. pharyngis constrictor medius and pharyngis constrictor inferior. 10–12 mm. caudad of the filaments to the muscles of the pharynx a considerable twig joins the cephalic ramus of N. laryngeus superior and receives an anastomotic filament from the caudal ramus of the same nerve. The œsophageal ramulus continues along the dorsum of the œsophagus caudad as far as the caudal third of the cervical portion, interlacing in the plexus around that viscus.*

N. laryngeus superior, the superior laryngeal branch, is considerably larger than N. pharyngeus; it takes its superficial origin from the ventral border of the middle region of G. inferius; its course is immediately ventrad—occasionally it is directed caudad apposed to the main trunk and ectad of N. sympathicus, 8–10 mm., at which point it turns ventrad—and passes entad of A. carotidea primitiva, where it bifurcates into a cephalic, ental, ramus, *N. laryngeus internus* (Fig. 5, 7, *28*) and a caudal, ectal, ramus, *N. laryngeus externus* (Fig. 7, *29*).

N. laryngeus internus is much larger than N. laryngeus externus; it accompanies A. laryngea superior, and with the artery perforates the hyo-thyroid membrane at the ventro-caudal border of the cephalic cornu

* It sometimes occurs that the caudal ramus is detached caudad of the cephalic ramus of N. pharyngeus; in this case it constitutes a second pharyngeal nerve; this arrangement does not change its distribution.

of Ctl. thyroidea—A. laryngea superior is given off from A. carotidea externa, just caudad of the origin of A. carotidea interna; its course is, therefore, at right angles with A. carotidea externa,

N. laryngeus externus lies ectad of the larynx; it sends a pharyngeal ramulus cephalad and entad of A. laryngea superior (Fig. 7, *30*), which is distributed to M. constrictor pharyngis inferior, anastomoses with the œsophageal ramus of N. pharyngeus (Fig. 7, *31*), gives terminal filaments to Px. pharyngeus and the pharyngeal mucous membrane; filaments of this ramulus anastomose with N. crico-thyroideus and unite in plexiform relation with N. sympathicus around A. thyroidea superior; a twig of this pharyngeal ramulus detached just dorsad of the hyo-thyroid foramen, passes ventro-caudad to terminate in M. crico-thyroideus. This ramus sends a laryngeal ramulus ventro-caudad which lies entad of M. sterno-thyroideus, to which a few filaments are distributed, and is apposed to A. laryngea inferior, which artery it accompanies to the cricoid membrane as far as the ventrimeson (Fig. 7, *32*); from this ramulus filaments are given to M. crico-thyroideus. A caudal ramulus is also detached whose course is dorsad of M. sterno-thyroideus and parallel with its dorsal border to Cp. thyroideum (Fig. 7, *33*); it gives filaments to M. crico-thyroideus and anastomotic filaments to N. descendens noni, which it joins opposite the origin of A. thyroidea superior.

N. laryngeus internus enters the hyo-thyroid foramen and divides into a cephalic and a caudal offset: the *cephalic offset* (Fig. 7, *34*) accompanies the ental portion of A. laryngea superior, pierces M. thyro-arytænoideus to which numerous filaments are distributed, takes its cephalic course obliquely toward the ventrimeson and perforates the thyro-hyoid membrane 2 mm. laterad of the meson. Terminal filaments of this offset supply the epiglottis (Fig. 7, *36*), the arytæno-epiglottidean folds (Id. *37*), the laryngeal glands (Id. *35*), and the mucous membrane of the larynx (Id. *35*, a). A twig given from the cephalic offset, 2 mm. peripherad of the foramen, passes entad of the apposed artery (A. laryngea superior entalis) and joins the caudal offset 2 mm. cephalad of the caudal border of Ctl. thyroidea (Fig. 7 and 8, *39*).

The *caudal offset* lies closely apposed to the ental surface of Ctl. thyroidea (Fig. 7 and 8, *38*); its first twig is sent dorso-caudad and terminates upon M. crico-arytænoideus lateralis, M. arytænoideus and M. constrictor pharyngis inferior (Fig. 8, *40*); anastomotic filaments join in plexiform relation with its dextral homologue and with the pharyngeal and œsophageal plexuses. The principal portion of the caudal offset at its union with the twig from the cephalic offset gives off radiating filaments upon the ectal surface of the arytænoid muscles which constitute a multiple palmate plexus (Fig. 8, *41*.); a twig passes dorsad of the articular facet of Ctl. cricoidea and joins N. laryngeus inferior (Fig. 8. *42*). Near the union of the twig and the offset, entad of cephalic border of Ctl. cricoidea several filaments penetrate M. crico-arytænoideus and are distributed upon the mucous membrane of the larynx.

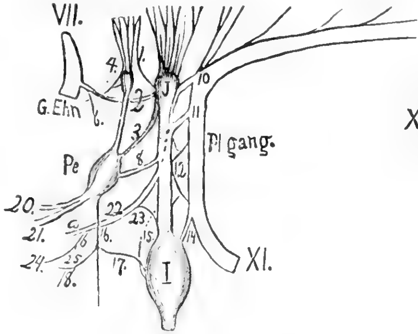


Fig. 6.

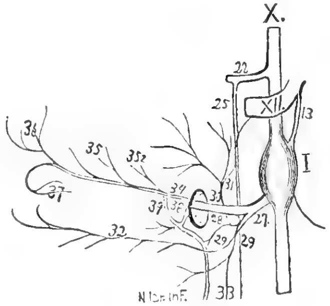


Fig. 7.

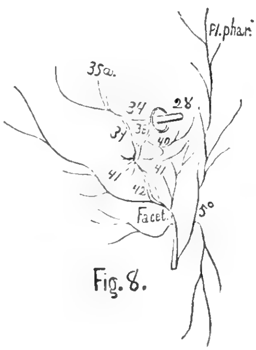


Fig. 8.

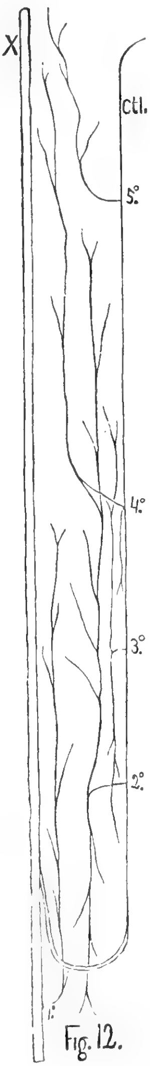


Fig. 12.

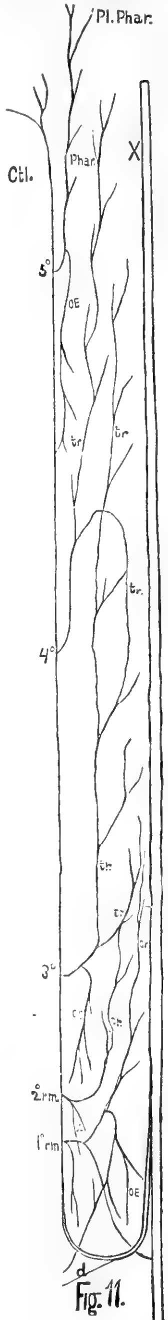


Fig. 11.

Thoracic division of N. vagus sinister: The main trunk of N. vagus sinister enters the thorax dorsad of V. innominata sinistra at the union of V. subclavia and V. jugularis externa, meso-dorsad of V. vertebralis and laterad of A. carotidea primitiva sinistra. In the thorax cephalad of the arch of A. aorta the nerve lies between AA. carotidea and subclavia meso-dorsad of A. sternalis until it reaches a point 10–15 mm. cephalad of A. aorta, at which point it rests upon the ventral surface of A. subclavia and crosses the arch ventro-laterad of the origin of A. subclavia. Opposite the origin of A. sternalis the nerve is crossed by N. phrenicus and lies dorso-laterad of this nerve in the area between the two arteries aforenamed.

As N. vagus enters the thorax, two fasciculi from the middle and caudal areas respectively of the middle cervical ganglion of N. sympathicus, G. thyreoideum, connect N. vagus with N. sympathicus; these commissural fasciculi are about 3 mm. apart. Between a point opposite A. sternalis and the arch of A. aorta the trunk of N. vagus sustains intimate relations with N. sympathicus, N. cardiacus magnus and N. cardiacus minor through numerous anastomotic filaments which constitute a plexiform network around the arteries, trachea and œsophagus in this region of the thorax—AA. subclaviæ, carotideæ primitivæ and innominata. Opposite the caudal border of the arch of A. aorta a considerable fasciculus from the main trunk about 5 mm. in length joins N. laryngeus inferior. 7 mm. peripherad of this fasciculus, where N. largyneus inferior bends around the arch of A. aorta, a ramulus is given off whose interlacings with rami from NN. vagus and sympathicus constitute a plexiform network which is related with the cardiac plexus. In its course caudad of arch of A. aorta, N. vagus passes dorsad of the root of the left lung.

Pulmonary Rami: Between a point opposite the cephalic border of A. pulmonaris and 15 mm. caudad, N. vagus gives several ramuli meso-ventrad to anastomose with terminal filaments of N. cardiacus minor and N. laryngeus inferior in the formotion of the ectal (superficial) cardiac and the ventral (anterior) pulmonary plexuses. From the same region of the main trunk filaments are directed meso-dorsad, which interlace in a dense network with filaments of offsets detached from the main trunk of the area above named, and with terminal filaments of N. cardiacus minor, and other filaments from N. sympathicus to form on the ventral aspect of the trachea just cephalad of its bifurcation, a large plexus, the ental cardiac—*Px. profundus magnus*—from which filaments ramify upon the bronchi and have intimate relations with the plexiform network which is formed by filaments from the offsets named and accessory offsets from thoracic ganglia of N. sympathicus around the bronchi,—dorsal pulmonary plexus. Offsets from this plexus may be traced along the air tubes into the substance of the several lobes and upon the broncho-pulmonary mucous membrane of the sinistral lung. The ramuli which form the dorsal pulmonary plexus are noticeably larger than those given to the ventral plexus.

Œsophageal Rami: Cephalad and caudad of the pulmonary rami numerous filaments are directed dorsad, by whose anastomoses and union with N. sympathicus is formed the œsophageal plexus which embraces the entire length of the thoracic œsophagus. Caudad of the ramuli given to the pulmonary plexus, 15–20 mm. caudad of the caudal border of the arch of A. aorta, N. vagus sinister divides into sinistral or lateral and dextral or mesal rami (Fig. 9, *46*) which lie respectively upon the sinistral dorsum and venter of the adjacent œsophagus. The *lateral ramus* trends dorso-caudad, and 50–60 mm. peripherad of its origin it unites with the lateral ramus of N. vagus dexter in a median line upon the dorsum of the œsophagus, to constitute a single dorsal trunk for about 25 mm. (Fig. 9, *47*). Numerous anastomotic filaments from the two rami of N. vagus sinister and the rami of N. vagus dexter interlace in the œsophageal plexus from which filaments are given to the muscular tissue and mucous membrane of the œsophagus. The united dorsal trunk perforates the diaphragm and enters the abdomen as the *gastric nerve*.

The *mesal ramus* of N. vagus sinister trends ventro-caudad, and 20–25 mm. peripherad of its origin is joined by its dextral homologue (Fig. 9, *48*), and these two mesal rami constitute a united ventral trunk which lies in the caudal mediastinum upon the venter of the œsophagus and perforating the diaphragm near the meson, lies on the venter of the cardia (Fig. *13*). A slight twig connects the two mesal rami 2 mm. peripherad of their origins. From the thoracic portion of the ventral trunk anastomotic filaments are given to its homologue in the formation of the œsophageal plexus.

The thoracic portion of N. vagus dexter lies ventrad of A. subclavia and mesad of A. sternalis; at the caudal border of A. subclavia it bends slightly dorsad to pass mesad of V. vertebralis at its junction with V. innominata, it continues laterad of the trachea, entad of V. azygos and dorsad of the root of the right lung. As the main trunk enters the thorax it sustains intimate relations through anastomotic twigs with N. cardiacus magnus, N. cardiacus minor and the inferior cervical ganglion of N.-sympathicus (Fig. 10). 15 mm. caudad of A. subclavia a considerable ramus is directed meso-caudad and accompanies a large ramus detached entad of V. azygos; these cardiac rami pass meso-ventrad around the base of the right pulmonary artery and to the right auricle (Px. cardiacus ectalis). Three or four ramuli are given off between A. subclavia and V. azygos whose ramifications interlace the plexus of the trachea and œsophagus. From the 12–14 mm. of the trunk dorsad of the lung, numerous filaments are directed mesad and ventrad to join the pulmonary plexus (Fig. 9). Caudad of this point and opposite the bifurcation of its sinistral homologue the dextral nerve bifurcates into lateral and mesal rami (Fig. 9, *49*); caudad of the bifurcation the lateral ramus trends dorso-caudad until it joins its sinistral homologue already described. The mesal ramus gives recurrent ramuli cephalad to the dextral border of the pulmonary plexus. Several other anastomotic filaments are detached from the ramus between the root of the lung and the union with its fellow which terminate in the œsophageal plexus (Fig. 9).

NN. laryngei inferiores, recurrent or inferior branches of N. vagus, tracheal recurrents, have the following *general characters in common,* viz.: their general cephalic direction; their disposition along the dorso-lateral border of the trachea; the anastomotic character of their ramuli; the distribution of the terminal filaments; the sensory function of the fibre. *Distinctive characters:* their origin; their length; their disposition in the thorax; the relative number of anastomotic filaments; the number of tracheo-œsophageal ramuli.

Special description: *N. laryngeus inferior sinister,* the sinistral recurrent nerve, branches from the mesal aspect of the main trunk of N. vagus, 1–3 mm. cephalad of the arch of A. aorta (Fig. 9, 45); * its course is caudad, apposed to the mesal side of the main trunk as far as the root of A. subclavia sinistra where the main trunk crosses the arch of A. aorta. Upon the ventral aspect of the arch of A. aorta, N. laryngeus inferior separates from the main trunk upon the mesal side, and twisting around the concave aspect of the arch about 1 mm. sinistrad of the obliterated "ductus arteriosus," it trends meso-dorsad, and returns cephalad along the dorso-lateral border of the trachea, between the trachea and the œsophagus, as a "recurrent nerve" (Fig. 9, *50*). At the caudal border of the larynx N. laryngeus detaches several ectal filaments to M. crico-thyroideus (Fig. 8), passes ental of a caudal twig of A. thyroidea superior, bends dorsad around the articular facet of Ctl. cricoidea (Fig. 8) and enters the larynx as an ental nerve. A slender anastomotic twig passes ectad of the arterial twig named and may be traced dorsad of the nerve trunk until it joins a corresponding twig from the caudal division of N. laryngeus superior (Fig. 7, *29*, a). Pharyngeal ramuli from the ental nerve are distributed to M. constrictor pharyngis inferior; other dorsal filaments supply M. arytænoideus posterior and M. arytænoideus; ventral filaments supply MM. crico-arytænoideus lateralis and thyro-arytænoideus, while terminal filaments reach the sub-glottic mucous membrane. Upon the ectal surfaces of MM. crico-arytænoideus posterior and crico-arytænoideus lateralis a multiple palmate plexus is formed by anastomotic filaments of NN. laryngeus superior and laryngeus inferior (Fig. 8, *41*).

N. laryngeus inferior dexter is detached from the main trunk of N. vagus, 12 mm. cephalad of the origin of A. subclavia, where the main trunk is disposed upon the ventral aspect of A. subclavia (Fig. 10); N. laryngeus dexter is immediately directed caudad over the venter of the artery, is reflected around the caudal aspect, and assumes a meso-dorsal direction to the dextral side of the trachea, and is disposed like its sinistral homologue, with the exception of having fewer anastomotic filaments. Peripherad of the origin of N. laryngeus inferior dexter, dorsad of A. subclavia, ramuli are given to the deep cardiac and the posterior pulmonary plexuses; another ramulus cephalad joins its sinistral fellow, a third, the thoracic cardiac, is directed caudad by the side of the main trunk of N. vagus dexter, and terminates in the dextral bronchial plexus. As N.

* An occasional origin is 8–10 mm. cephalad of cephalic border of arch of A. aorta.

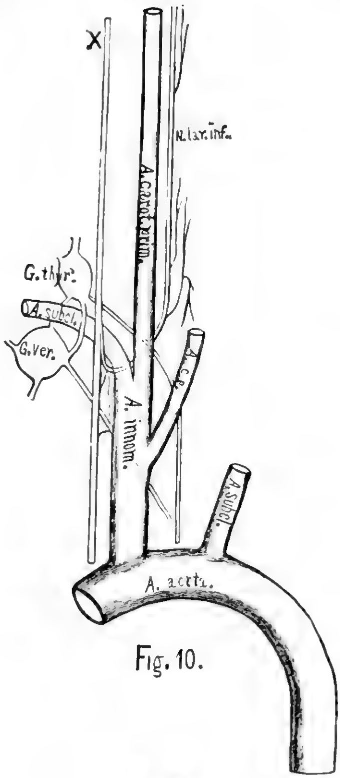


Fig. 10.

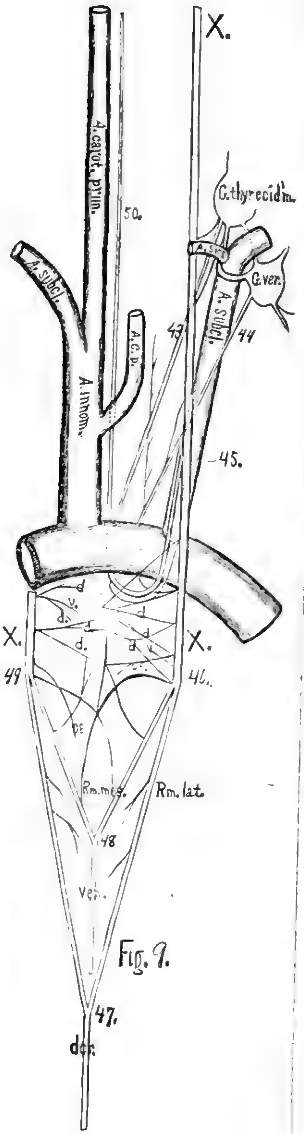


Fig. 9.

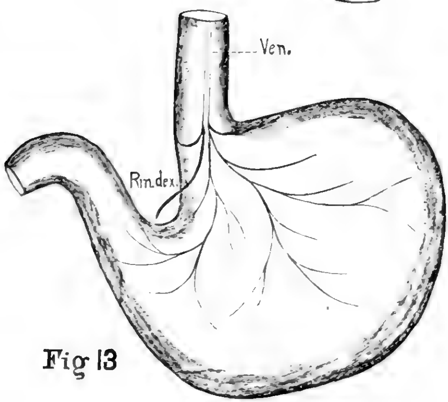


Fig 13

laryngeus inferior dexter bends around A. subclavia, just dorsad of A. sternalis, a branch is given off caudad, which, 10–12 mm. from its origin, joins N. cardiacus minor (Fig. 10), and these apposed trunks are joined 5 mm. peripherad by N. cardiacus magnus dexter, and the trunk thus constituted passes dorsad of V. cava descendens and A. innominata to the dorso-caudal border of the arch of A. aorta, where it terminates in Px. magnus profundus, from which filaments proceed to the ventral and dorsal coronary and the pulmonary plexuses.

Tracheo-œsophageal ramuli of N. laryngeus inferior (Fig. 11, 12). *General characters:* these ramuli of the sinistral and dextral nerves have in common the following characters—their origin; general direction; numerous terminal filaments; the plexiform relation of these filaments; their mode of entering larynx; their distribution upon its mucous membrane; distribution of the dorsal filaments to œsophagus. *Distinctive characters:* the smaller number of ramuli from the dextral side than from the sinistral; the homologue of the first sinistral nerve is always found as a ramulus from the main trunk caudad of the origin of N. laryngeus inferior dexter (Fig. 12); the terminal filaments of the dextral side are less numerous than those of the corresponding nerves of the sinistral side.* *Special description:* opposite the cephalic border of the arch of A. aorta the first tracheal ramulus is detached (Fig. 11, 1°rm.); a considerable offset is directed caudad from the origin to Px. magnus profundus; 2 mm. peripherad of origin an anastomotic filament joins N. vagus 8 mm. caudad of origin of N. laryngeus inferior; 6 mm. peripherad of origin the ramulus bifurcates, the longer division is distributed upon the dorsum of the trachea 30 mm. cephalad of the arch of A. aorta; the shorter or caudal division sends filaments to Px. cardiacus ventralis, to Px. magnus profundus and to the bronchioli.

Five mm. cephalad of the first ramulus a second is given to the venter and the sides of the trachea over that portion corresponding to the distribution of the cephalic division of the first ramus upon the dorsum.

Ten mm. cephalad of the second ramulus and nearly opposite the origin of A. sternalis, the longest ramulus is detached; this divides into three offsets, the caudal is distributed to the venter of the œsophagus, the median to the sides of the trachea, the cephalic lies just laterad of the ventrimeson and gives two considerable fasciculi, whose terminal filaments supply the walls of the trachea; the terminal filaments of the ramulus are traceable nearly to Ctl. cricoidea.

Opposite the sixth cervical vertebra the fourth ramulus is detached, whose filaments anastomose with the preceding ramulus, and supply the dorsum of the trachea and venter of adjacent œsophagus along the entire cervical region from the thorax to the larynx.

The fifth tracheal ramulus takes its origin 10mm. caudad of Ctl. cricoidea

* The double ramuli sometimes occur with separate origins; this apparent increase of ramuli may be regarded as a modification and not a violation of the plan. In the special description the details of measurements of a single specimen are given.

(Fig. 8 and 11, 5○). This ramulus is largely if not exclusively œsophageal and joins in Px. pharyngeus; the caudal or recurrent portion is reflected caudad upon the œsophagus.

Gastric nerves: Caudad of the diaphragm the **dorsal gastric nerve** splits into several terminal ramuli, the longest of which terminates in ganglion semi-lunare of the great solar plexus, *Px. solaris;* near the cardia numerous filaments are distributed to the cardia; offsets supply the lesser curvature of the stomach, the plexus around A. coronaria ventriculi, and the dorsal surface of the stomach; ramuli may be traced to the plexus around A. hepatica (Px. hepaticus), A. splenica (Px. splenicus), A. mesenterica superior (Px. mesaraïcus). At the cardia, terminal filaments of the **ventral trunk** are distributed to the lesser curvature of the stomach, a few join terminal filaments of the dorsal trunk (Fig. 13), and others still may be traced to the great solar plexus, from which ramuli enter the gastro-hepatic omentum and join the hepatic plexus. This anastomosis of the dorsal and ventral trunks in the solar plexus constitutes the "memorable loop of Wrisberg."

SUMMARY.

A. Anatomical. 1. Origin—12–14 filaments along a line ventrolaterad of Cp. restiforme, and by 4–6 filaments ventrad of oliva.

2. **Foramen of exit**—foramen lacerum posterius.

3. **Ganglia**—G. jugulare, in the proximal end of foramen of exit—G. inferius, 15mm. peripherad.

4. **Relations of ganglia**—G. jugulare, with NN. facialis (VII), glosso-pharyngeus (IX), accessorius (XI), sympathicus; G. inferius, with NN. glosso-pharyngeus (IX), accessorius (XI), hypoglossus (XII), pharyngeus, laryngeus superior, sympathicus.

5. **Px. gangliformis**—the 5 mm. of trunk peripherad of G. jugulare; it is formed by accessory portion of N. accessorius, anastomotic filaments between NN. vagus and accessorius, filaments to N. pharyngeus, and N. sympathicus.

6. **Principal rami**—respective origins and general distribution: Rm. auricularis, G. jugulare to N. facialis; N. pharyngeus, Px. gangliformis to Px. pharyngeus and œsophagæus; N. laryngeus superior, G. inferius to larynx; N. laryngeus inferior, N. vagus near arch of A. aorta to trachea and œsophagus; Rm. cardiaci, trunk of N. vagus proximad of base of heart to Px. cardiaci; Rm. pulmonares, trunk of N. vagus proximad of root of lungs to Px. pulmonares; anastomotic filaments to N. sympathicus.

7. **Bifurcation**—dorso-laterad from roots of lungs into lateral and mesal rami.

8. **Formation of nerve trunks**—dorsal trunk by union of lateral rami = dorsal gastric nerve (N. gastricus dorsalis)—ventral trunk by union of mesal rami = ventral gastric nerve (N. gastricus ventralis).

9. **Termination**—ganglia semi-lunaria of Px. solaris in loop of Wrisberg.

B. Physiological—sensibility of mucous membrane of pharynx, larynx, trachea, bronchi, bronchioli—motion of pharynx, larynx; reflex movements of broncho-pulmonary passages, œsophagus and stomach—action upon secretions, e. g., gastric juice, biliary products, etc.*—indirect influence upon phenomena of respiration and of "inhibition."

Explanation of the Numbers and Abbreviations used in the Figures.

A. bas., A. basilaris; A. cb., A. cerebralis posterior; A. cbl., A. cerebellosa inferior; A. ver., Arteria vertebralis; Ar. el., area elliptica (possibly related to olivary body); ?, elongated, pyriform area lateral from Ar. el., whose homology is not determined; Cb., cerebrum; Cbl., cerebellum; Ch., chiasma; dpy., dorsipyramis (posterior pyramid); Ehr., G. Ehrenritteri; hph., hypophysis; I., G. inferius; J., G. jugulare; mtc., metacœlia (fourth ventricle); O., oliva, corpus olivarium (?); olf., lobus olfactorius; opt., N. opticus; Pe., G. petrosum; Px. ch., plexus choroideus lateralis; Px. phar., plexus pharyngeus; Pn., Pons Varolii; Rf., corpus restiforme; Vpy., ventripyramis (anterior pyramid); II., N. opticus; III., N. motor oculi; V., NN. trigemini; VI., N. abducens; VII., N. facialis; VIII., N. auditorius, Portio mollis; IX., N. glosso-pharyngeus; X., N. vagus; XI., N. accessorius; XII., N. hypoglossus: 1, accessory filament from N. glosso-pharyngeus; 2, Rm. auricularis; 3, anastomotic twig from J. to Pe.; 4, filament from origin line of IX. to 2; 5, ramulus from 2 to cochlea; 6, anastomotic twig to N. sympathicus; 7, chorda tympani; 8, anastomotic twig from Pe. to X.; 10, Rm. accessorius from XI.; 11, second accession from XI.; 12, anastomotic filaments between X. and XI.; 13, filament from XII. to I.; 14, Rm. from XI. to I.; 15, superior cervical ganglion of N. sympathicus; 16, pharyngeal ramus from IX. at Pe.; 17, anastomotic filament from 16 to I.; 18, anastomotic filament from 16 to Px. phar.; 19, filament from 16 to N. laryngeus superior; 20, cephalic ramus of IX.; 21, caudal ramus of IX.; 22, N. pharyngeus: 22 a, cephalic ramus; 22 b, caudal ramus; 23, filament from 22 to I.; 24, pharyngeal ramus of 22 b; 25, œsophageal ramus of 22 b; 26, filament from 25 to 22 a; 27, N. laryngeus superior; 28, cephalic = ental ramus: 29, caudal = ectal ramus; a, twig to 50; 30, pharyngeal ramus of 29: 31, filament from 30 to 25; 32, Rm. of 29 to Mb. crico-thyroidea; 33, to Cp. thyroideum, a, to descendens noni; 34, cephalic offset of 28; 35, filaments to interior of larynx; 36, to epiglottis; 37, to arytæno-epiglottidean folds; 38, caudal offset of 28; 39, twig from 34 to 38; 40, twig from 38 to M. arytænoideus, etc.; 41, palmate plexus; 42, ramus to 50; 43, N. cardiacus magnus sinister; 44, N. cardiacus minor; 45, origin of 50; 46, division of N. vagus sinister; 47, union of lateral rami; 48, union of mesal rami; 49, division of N. vagus dexter; 50, N. laryngeus inferior.

*The extent to which secretions and excretions may be referred directly to N. vagus is questionable.

Description of the figures.

Fig. 1.—General view of venter of brain ; special reference to venter of medulla, area post pontilis, showing relations of lines of origin-filaments of NN. glosso-pharyngeus, vagus, and hypoglossus ; also ectal relations, ventripyramis (vpy.), area elliptica (ar. el.), and the lateral tract (?).

Fig. 2.—View of sinistral surface of brain, special reference to curved line of origin-filaments of N. vagus and to origin line (L) ventrad, and their relations ; the cephalic filaments of N. accessorius (XI) are in the depression line ventral from Rf., while the caudal filaments have their origin in the depression line lateral from O.

Fig. 3.—Diagram to show the origin of N. vagus ventro-lateral to Rf. ; also that N. accessorius (XI) has its cephalic filaments from the same depression line, and its caudal filaments from the depression line ventro-lateral to O ; N. hypoglossus (XII) is dorso-lateral to ar. el.

Fig. 4.—Dorsal aspect of metencephalon (medulla) showing origins of NN. IX, X, XI ; metacœlia (mtc.), dorsipyramis (dpy.), corpus restiforme (Rf.), oliva (O), and the lateral tract (?).

Fig. 5.—To show relations of origin-filaments ; of Rm. auricularis ; of G. jugulare ; of G. petrosum ; of G. inferius. G. Ehrenritteri is removed from its normal relation which is ectal to G. jugulare, and is placed cephalad to expose the parts. N. XII, is reflected dorsad to expose origin of N. pharyngeus and anastomotic ramus from Pe. The dotted lines represent NN. hyo-thyroideus and descendens noni. Px. phar. = pharyngeal plexus.

Fig. 6. is Fig. 5, dissected to show Rm. accessorius given to J., and the second accession to the trunk peripheral to J. ; N. XII, is omitted as are the anastomotic filaments of Px. gangliformis ; the dotted line shows the direction of the filaments from N. XI, to N. pharyngeus.

Fig. 7.—N. laryngeus superior ; origin ; division ; distribution of ental or cephalic and ectal or caudal rami ; anastomotic relation between pharyngeal ramulus of the ectal ramus and the œsophageal ramus of N. pharyngeus.

Fig. 8.—N. laryngeus inferior. To show the laryngeal relations of N. laryngeus inferior ; entad of Ctl. thyroideus ; the palmate plexus ; the anastomotic filaments of NN. laryngeus superior and laryngeus inferior ; the pharyngeal ramus of N. laryngeus inferior (5○).

Fig. 9.—N. laryngeus inferior sinister. To show its origin ; relations with A. aorta and adjacent plexus ; relations of N. vagus with N. sympathicus ; division of N. vagus dorso-caudad of root of lungs ; the relations of the lateral and the mesal rami ; the dorsal and the ventral pulmonary plexus ; the formation and the relations of the dorsal and the ventral nerve trunks.

Fig. 10.—N. laryngeus inferior dexter. To show its origin ; its relations with A. subclavia ; relations of N. vagus with N. sympathicus.

Fig. 11 and 12.—Tracheo-œsophageal ramuli of N. laryngeus inferior sinister and dexter respectively.

Fig 13.—Distribution and relations of the ventral gastric nerve and the ramus which terminates in the dextral G. semilunare of Px. solaris.

Contributions to the History of the Vertebrata of the Lower Eocene of Wyoming and New Mexico, made during 1881. By E. D. Cope.

(Read before the American Philosophical Society, Dec. 16, 1881.)

I. The Fauna of the Wasatch Beds of the Basin of the Big Horn River.

The basin of the Big Horn river contains the most northern area of the deposits of the Wasatch or Suessonian epoch known. In order to ascertain whether the fauna it contains differs in any way from that I discovered in the corresponding beds of New Mexico in 1874, I sent, during the past season, an expedition, under the direction of J. L. Wortman, already known from his successful exploration of the Wind River basin in 1880. The present paper gives a review of the results of the season's work, prefaced by an account of the geology furnished by Mr. Wortman. The species herein described are being engraved for the fourth volume of Dr. Hayden's report of the United States Geological Survey of the Territories, now passing through the press.

1. *The Geology of the Big-Horn Basin, by Jacob L. Wortman.*

As early as 1859 Dr. Hayden described in detail the Tertiary sediment occupying the upper drainage basin of the Big-Horn river, which he determined as belonging to the lower Eocene formation, and applied the name Wind River group, from its being exposed along the Wind river, a name given to the upper portion of the Big-Horn. From an extensive collection of vertebrate fossils made by the writer at this horizon, during the summer of last year, Prof. E. D. Cope, for whom the collection was made, has, in a bulletin, U. S. Geol. Surv. Terrs., F. V. Hayden, Vol. vi, No. 1, 1881, confirmed this determination, and discussed at length the faunal relations they bear both to the Bridger and Wasatch beds respectively. The conclusions reached are, that this series is intermediate to a certain degree, containing genera hitherto regarded as peculiar to each. This upper basin covers quite an extensive area, and is bounded upon every side by lofty mountains. The Owl Creek mountains, which afforded a barrier to the waters of this Eocène lake on the north, has subsequently been cleft by the Big-Horn, leaving a deep and rough cañon, through which it now flows in its course north to the Yellowstone. After passing the Owl Creek mountains it emerges into a second or lower basin, commonly called the Big-Horn basin proper. This one covers a much larger area than the upper, and like it is walled in by mountain ranges, and filled with a mass of sedimentary rock which is also referable to the lower Eocene series.

During the summer of the present year the writer has been engaged in further exploration of this interesting region, which resulted in the collection of a large number of extinct vertebrates, obtained exclusively from the lower Eocene horizon of the Big-Horn, and which have all been submitted to Prof. Cope, at whose instance the party was organized and equipped.

Dr. Hayden has made the observation that upon the eastern slope of the Wind River mountains all the corresponding strata are visible from the Silurian to the Cretaceous; this is also true of the northern slope of the Owl Creek mountains, while the southern side does not exhibit such continuity of structure. Upon entering the basin from the south, the older formations are seen to extend towards its centre for a distance of ten miles, inclining at an angle of 30° to the north, while the level of the Tertiary has been little or not at all disturbed since its deposition. That this basin contained a separate and isolated body of water, limited by its present boundaries, which were outlined about the beginning of the Wasatch epoch, there is every reason to believe. A section made by the Big-Horn at the southern extremity shows the Tertiary to rest unconformably upon a thick mass of buff colored sandstone, rather coarse in texture, somewhat laminated, and towards the bottom interspersed with thin layers of impure lignite varying from six inches to one foot in thickness. This sandstone most probably belongs to the Laramie series, but in the absence of fossils the determination is by no means satisfactory.

The Eocene sediment covers a large part of the basin, and cannot be less than 4000 feet in vertical depth. This mass, once continuous over a large area, has since been carved and weathered into many fantastic and remarkable forms, presenting at once a bold and striking appearance, a characteristic feature of the western Tertiary bad lands.

Beginning at the southern limit at a point opposite the mouth of Meyers creek, on the east side of the river, a series of low bad land bluffs, facing to the west and gradually becoming higher as they proceed, describe a gentle curve to the north, terminating at the river's edge 30 miles below. The character of the country between the river and these bluffs is a barren sage brush plain, while back of the bluffs a high mesa occupies the country for many miles. On the west side, numerous rivers, creeks, and their tributaries, putting down from the Sierra Shoshone range, have excavated the mass in every direction, leaving bold escarpments, high bad land buttes, elevated tables, with innumerable gulches and ravines. Country of this character stretches far away to the northern limit, near the Big Horn gap, presenting that desolate and sombre appearance, so often met with in bad land regions.

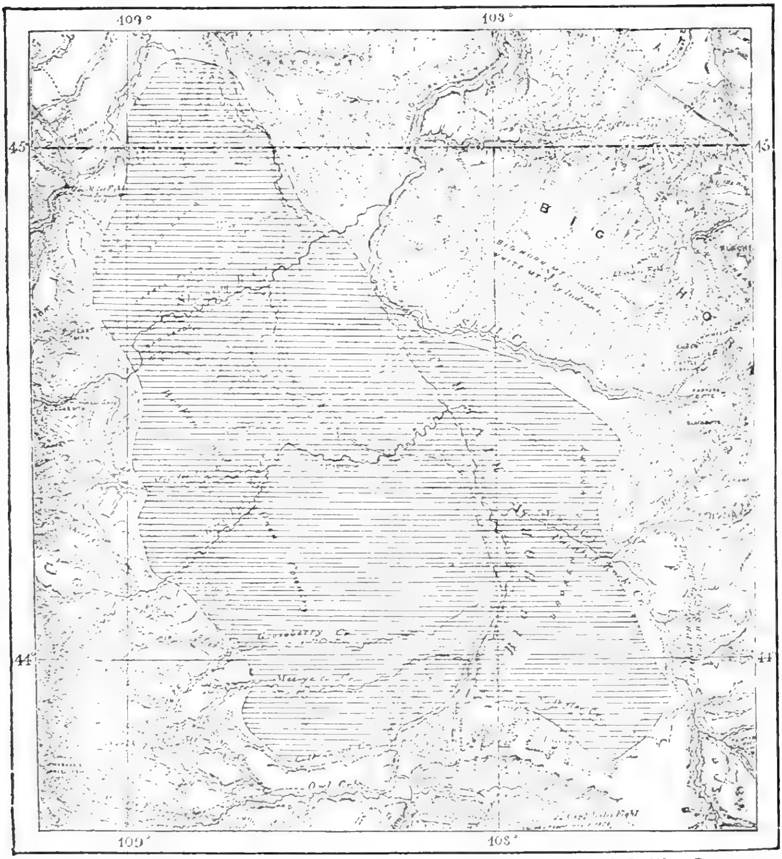
Its composition may be described as consisting of various colored clays alternating with layers of brown and blue sandstone, although that evenness of stratification by which a single layer of either, in one part, could be identified in another, does not exist. Those exposures, for example, on the east side of the Big-Horn are highly arenaceous, the clay and sand existing in almost equal proportions, while in the exposures along the Grey Bull river, and in the vicinity of Coryphodon butte, the quantity of sand is greatly diminished, and is found in separate layers. The preponderance of the red clay is a marked feature, and has called forth the remark from Dr. Hayden, relative to the sediment of the upper basin, "that they remind one of the Jura Trias red beds." This remark is forcibly illustrated by the character of the sediment found in the south-western part of the basin, near the head of Gooseberry creek, where the exposures consist largely of thick strata of the red clay, which gradually thin out to the north and east, blending with the pink, blue, and buff colors. In the northern part of the basin, and along Stinking river, the sediment consists almost exclusively of a pale yellow sandstone of a bluish tinge, from which few fossils were obtained.

The clays contain much lime in the form of small limestone nodules of a rusty brown appearance, in which the fossils are often found, having a thin and intensely hard layer of ferrous oxide investing them externally. In the red the fossils are always scarce and fragmentary, and when found are usually such parts as would, under the most favorable circumstances, be preserved. The blue seems to be the more productive, and to have offered better conditions for their preservation ; but, owing to the fact that lime forms the petrifying base, and being less able to withstand the heavy pressure than many other materials, the fossils from both the red and the blue are, as a general rule, greatly distorted and crushed. This fragmentary occurrence of fossils in the fine-grained clay, I am inclined to believe, is due, not to a scattering of the bones by currents, but rather to imperfect and unfavorable conditions for their preservation. That entire skulls and skeletons were deposited, where now nothing but the teeth remain, I am well satisfied from the circumstance that both superior and inferior series are not unfrequently found in proper position without a trace of ramus or cranium. In the sandstones, however, the fossils are in a magnificent state of preservation, but their extreme scarcity in this material gives the collector many long and fruitless searches. Two skeletons which have proven of considerable interest were all of any consequence that were obtained from the sandstones.

The general stratigraphical appearance, as well as the scattered and fragmentary condition of the fossils, together with the community of a large number of genera, refer it to the Wasatch epoch, but a full discussion of this point belongs properly to the paleontologist. A thorough elucidation will be found in Prof. Cope's paper on the fossils.

The exploration of this region is most arduous and difficult. The great scarcity of water in these bad land wastes, makes it very inconvenient, and renders it necessary to carry a water supply a distance of often 20 miles or more. Even when water does exist it is so strong with alkali as to be scarcely fit for use. Many of the streams coming down from the mountains dry up as soon as the snow has melted from the low foot hills in early spring, leaving large tracts entirely destitute of water, which frequently abound in fossiliferous exposures, and which it is the object of the explorer to examine. The broken and mountainous character of the country forbids the use of wagons to such an extent that pack animals are indispensable.

The accompanying map is intended to illustrate the exact position, as well as the extent of country covered by the Wasatch sediment at this point. Its topography is taken from a map made by Capt. J. Russell, Third Cavalry, U. S. A. (and published by the War Department), during a reconnoissance of that region in the summer of 1880, and to whom, as well as Dr. W. H. Corbusier, Col. J. W. Mason, and other officers stationed at Fort Washakie, I wish to express my deep sense of obligation for their very kind and courteous treatment.



Map of the Big-Horn Basin, reduced from the Map of the U. S. War Department.

2. *Synopsis of the Fauna.*

PISCES.

Clastes sp. ; not abundant.

Pappichthys sp. Vertebræ ; not very common.

REPTILIA.

CROCODILUS sp. Allied to the *C. chamensis* and *C. heterodon*, but not represented by sufficiently well preserved specimens to permit of determination. There are numerous molariform teeth in the posterior parts of jaws, and the crowns of the longer teeth are grooved. Not uncommon.

EMYS sp. Rare; one specimen of 220 mm. in length, of the type of *E. wyomingensis*, but not sufficiently well preserved for determination.

As the Eocene forms of this order are of unusual interest, I give an analysis of the extinct genera of the Cryptodire division of tortoises which have been found in North America up to the present time.

In the check-list of the North American *Batrachia* and *Reptilia*,* I enumerated nine families of this division of the *Testudinata*, three of which are extinct. Subsequently another extinct family, the Baënidæ, was added. I now define all of these families.

I. Plastron not articulated to the carapace, but presenting to it more or less open digitations. *Dactylosterna*.

Phalanges of anterior limb without condyles, and covered by a common integument; eight pairs of costal bones.................. *Cheloniidæ*.

Phalanges of anterior limb without condyles; nine or more costal bones, *Propleuridæ*.

Phalanges of anterior limb with condyles; digits inclosed in distinct integuments; eight costal bones; sternal elements united by digitations and inclosing fontanelles; caudal vertebræ procoelous... *Trionychidæ*.

Phalanges of anterior limbs with condyles; digits distinct; eight costal bones; sternal elements united by suture and inclosing no fontanelles; caudal vertebræ opisthocoelous.......................... *Chelydridæ*.

II. Plastron uniting with the costal bones of the carapace, by denticulate suture, and by ascending axillary and inguinal buttresses. (Feet ambulatory.) *Clidosterna*.

A. Intersternal bones present.

No intergular scuta.................................... *Pleurosternidæ*.†

Intergular scuta; caudal vertebræ opisthocoelous.............. *Baënidæ*.

AA. No intersternal bones.

a. Intergular scuta.

A mesosternal bone.. *Adocidæ*.

aa. No intergular scuta.

A mesosternal bone; three series of phalanges................ *Emydidæ*.

No mesosternal bone; three series of phalanges............ *Cinosternidæ*.

A mesosternal bone; two series of phalanges................ *Testudinidæ*.

* Bulletin U. S. National Museum, No. 1, 1875. p. 16.

† There are two genera of this family, neither of them yet found in America; *Pleurosternum* Ow., with smooth shell, and *Helochelys* Myer, with sculptured shell.

III. Plastron uniting with the marginal bones of the carapace by straight contact only. (Feet ambulatory.) *Lysosterna.*

No intersternal bone nor intergular scutum ; a mesosternal bone and three series of phalanges.................................*Cistudinidæ.*

The extinct species of the *Cryptodira* of this continent belong to eight of the above families. I give diagnoses of the genera to which they are referred. Names of existing genera are in Roman type.

CHELONIIDÆ.

Postabdominal bones distinct from each other...........Chelonia Brong.

Postabdominal bones united with each other by suture..*Puppigerus* Cope.

PROPLEURIDÆ Cope.*

Transactions of American Philosophical Society, xiv., 1870, p. 235.

Ten costal bones ; first two marginals united with carapace by suture ; shell smooth, flattened............................*Osteopygis* Cope.

Nine costal bones ; first two marginals united to carapace by suture ; shell sculptured (a high dorsal keel).... ....*Peritresius* Cope.

Nine costal bones ; one marginal united with carapace by suture ; second by costal gomphosis ; shell not keeled nor sculptured .... *Propleura* Cope.

?Nine costal bones ; first united with carapace by suture ; second without costal gomphosis ; shell not sculptured...........*Catapleura* Cope.

?Nine costal bones ; marginals all free ; shell not sculptured........... *Lytoloma* Cope.

TRIONYCHIDÆ.

a. Surface of bones smooth.

Postabdominal suture digitate ....*Axestus* Cope.

aa. Surface of bones sculptured.

β. Sutures of plastron digitate.

A dermal flap protecting posterior legs below ; marginal bones........... Emyda Gray.

A dermal flap ; no marginal bones................Cyclanosteus Peters.

No dermal flap nor marginal bones ; muzzle much abbreviated.......... Chitra Gray.

No dermal flap nor marginal bones ; muzzle elongate....Trionyx Geoffr.

ββ. Suture for postabdominal coarsely serrate.

Postabdominal recurved in front......................*Plastomenus* Cope.

CHELYDRIDÆ.

a. Bridges of plastron wide ; ?caudal vertebræ.

One row of marginal scuta ; six pairs of scuta of the plastron.......... *Idiochelys* Myr.

* *Palæochelys novemcostatus* Geoffr., belongs to this family, but not *Palæochelys* Myr.

One row of marginal scuta ; scuta of plastron? not distinct.............. *Hydropelta* * Myr.

aa. Bridges of plastron very narrow.

β. Carapace smooth, not sculptured.

Two rows of marginal scuta ; five pairs of scuta of the plastron........... Macrochelys Gray.

One row of marginals ; five pairs on plastron............Chelydra Schw.

One row of marginals ; four pairs of scuta on plastron....Claudius Cope.

ββ. Carapace sculptured.

One row of marginal scuta..... ....*Anostira* Leidy.

BAËNIDÆ.

Cope, Annual Report U. S. Geol. Surv. Terrs., 1872 (1873), p. 621.

Supramarginal scuta (Rütimeyer) ; no interhumerals.....*Platychelys* Myr.

No supramarginals nor interhumeral scuta...... ....*Baëna* Leidy.

No supramarginals ; interhumeral scuta present ......*Polythorax* † Cope.

ADOCIDÆ.

Cope, Proceedings American Philosophical Society, 1870, p. 559.

a. Vertebral bones and scuta normal.

One intergular scutum entirely separating the gulars ......*Adocus* Cope.

Either two intergulars, or the gulars meeting behind intergular.......... *Amphiemys* Cope.

aa. Vertebral bones wedge-shaped, widening upwards ; vertebral scuta not wider than the bones.

Elements of carpace early coössified................*Homorhophus* Cope.

EMYDIDÆ.

a. No scutal sutures.

Surface sculptured..................................*Apholidemys* Pom.

aa. Scuta including intermarginals and two anals.

Lobes of sternum narrow..........................Dermatemys Gray.

Lobes of sternum wide....... ....*Agomphus* Cope.

aaa. Scuta ; two anals, no intermarginals.

Surfaces of carapace sculptured ; plastron fixed......*Compsemys* Leidy.

Surfaces of carapace smooth ; plastron fixed ; recent *Emydidæ* and the genus...Emys Brong.‡

Posterior lobe of plastron movable ; surface smooth....*Ptychogaster* Pom.

Anterior and posterior lobes of plastron movable ; surface smooth........ *Dithyrosternum* Pict. et Humb.

aaaa. Scuta ; one anal, no intermarginals.

Carapace smooth ....*Stylemys* Leidy.

* *Eurysternum* Wagn. (*Palæomedusa* et *Acichelys* Myr. (fide Rütimeyer) is nearly allied to *Hydropelta*.)

† Possibly one of the *Adocidæ ;* see Proceed. Acad. Phila., Oct., 1876.

‡ Gray has distinguished several good genera among existing species on cranial characters.

TESTUDINIDÆ.

a. Two anal scuta.

Ten abdominal scuta....... ....*Hadrianus* Cope.

aa. One anal scutum.

Lower jaw with two cutting edges....................Xerobates Agass.
Lower jaw with one cutting edge.......................Testudo Linn.

RODENTIA.

PLESIARCTOMYS BUCCATUS Cope.

Two mandibular rami.

PLESIARCTOMYS DELICATIOR Leidy.

Mandibles of six individuals, some of them accompanied by bones of the skeleton.

BUNOTHERIA.

TÆNIODONTA.

Additional material gives the following results with regard to the affinities of this sub-order. There are three allied groups represented by the genera *Esthonyx, Tillotherium* and *Calamodon* of the American Eocenes, which are equally unlike each other. *Esthonyx,* as I long since showed, is related to the existing *Erinaceus;* very nearly indeed, if the dentition alone is considered. Its anterior incisor teeth are unusually developed, and have, as in *Erinaceus,* long roots. One pair at least in the lower jaw has enamel on the external face only, and enjoys a considerable period of growth. The genus *Tillotherium* is (fide Marsh) quite near to *Esthonyx.* Its molars and premolars are identical in character with those of that genus, the only important difference being found in the incisors. Here, one pair above, and one pair below, are faced with enamel in front only, and grow from persistent pulps as in the *Rodentia.* This character has been included by Marsh in those he ascribes to his "order" of *Tillodontia,* but as he includes *Esthonyx* in that order,* which does not possess the character, it is not very clear on what the supposed order reposes. The rodent character of the incisors is the only one that I know of which distinguishes *Tillotherium* from the *Inesctivora.* I have on this account retained the *Tillodonta* as a sub-order, and referred *Esthonyx* to the *Insectivora.*

The *Tæniodonta* agree with the *Tillodonta* in the possession of a pair of inferior incisors of rodent character, but it adds several remarkable peculiarities. Chief among these is the character of the inferior canines. In the *Tillodonta* they are either wanting, as in *Erinaceus,* according to the Cuvierian diagnosis, or they are insignificant. In *Calamodon* they are of large size, and though not as long-rooted as the second incisors, grow from presistent pulps. They have two enamel faces, the anterior and the posterior, the former like the corresponding face of the rodent incisors.

* Report of U. S. G. Survey 40th Parallel, by Clarance King; Vol. i, p. 377.

The function of the adult crown is that of a grinding tooth. This character distinguishes *Calamodon* as a form as different from *Tillotherium*, as the latter is from *Esthonyx*. There are, however, other characters. The external incisors, wanting in *Tillotherium*, are here largely developed, and though not growing from persistent pulps have but one, an external band-like enamel face. Their function is also that of grinders.

The fact that the rodent teeth in the lower jaw are the second incisors, renders it probable that those of the *Tillodonta* hold the same position in the jaw. This is to be anticipated from the arrangement in *Esthonyx*, where the second inferior incisors are much larger than the first and third. The superior dentition of the *Tæniodonta* is yet unknown.

CALAMODON SIMPLEX Cope.

Report Vertebrate Foss., New Mexico, U. S. Geog. Surv. W. of 100th Mer. 1874, p. 5. Report of do. Capt. G. M. Wheeler, IV, ii, p. 166.

A nearly complete mandible of this species was found by Mr. Wortman, besides a series of unworn molar and canine teeth of a second individual, and fragments of some others. These furnish the correct dental formula as far as they go, as follows: I. 3; C. 1; M. 5. It appears that I correctly referred the long rodent teeth to the lower incisior series, but that the truncate two banded teeth so characteristic of the sub-order, are canines and not incisors, and that they belong to the lower as well as probably to the upper jaw.

The characters of the incisors are very peculiar. The first are small with short subcylindric crowns, and conic roots. The second incisors have been described; as in *C. arcamœnus* they have a horizontal shoulder posterior to the base of the cutting portion. The third incisors increase in diameter upwards, and have a triangular section. The largest side of the triangle is interior, and the shortest the posterior, and neither possess any enamel. The anterior or enamel faced side is slightly convex. The grinding face is transverse and is in the plane of the corresponding face of the canine. The long diameter of the crown of the canine is at right angles to the anterior face of the third incisor, and diagonal to the long axis of the mandibular ramus. This, with the peculiarities of the other incisors, gives an irregular appearance to the anterior dentition.

The five molars are very similar in character, and even those with unworn crowns do not present any distinction into premolars and true molars. The enamel covers the summit of the crown, but on wearing, it is soon reduced to a cylindrical sheath. Further wear brings the grinding surface to the anterior and posterior surfaces which are covered with cementum instead of enamel.

INSECTIVORA.

ESTHONYX BURMEISTERI Cope.

Report Vertebrate Foss., New Mexico, 1874, p. 7. Report U. S. G. G. Surv. W. of 100th Mer. G. M. Wheeler, IV, ii, p. 156, pl. XI, fig. 26.

Two fractured crania exhibit the entire dentition of this species, and give the generic characters satisfactorily. The dental formula is, I. $\frac{2}{3}$; C. $\frac{1}{1}$; P-m. $\frac{?3}{3}$; M. $\frac{3}{3}$. The first superior incisor is large, and the crown is somewhat spoon-shaped. The second incisor is as robust as the first, but the crown is shorter. The second premolar has one external and one internal lobe, in the third (fourth) premolar these lobes are much enlarged, and the tooth is transverse. The true molars have two external cusps, which are flattened, close together, and well within the margin of the base of the crown. There is one internal lobe and a strong posterior ledge, as in the opossums. Of the inferior incisors, the median is large and half gliriform, while the first and third are small. The inferior, like the superior canines, are large. The first and second (third) premolars have no internal lobes, but the second (third) has a heel. The fourth is more or less like the first true molar.

The specimens show that my original determinations of the incisors based on loose teeth were correct. They also show that this genus is not far removed from the more rodent-like genus *Anchippodus* of Leidy.

There are several species of the genus, which I define as follows:

I. Fourth inferior premolar like first true molar.

Larger; third superior premolar larger; fourth premolar with the external cusp bilobate..*E. acutidens.*

Medium; third superior premolar smaller; fourth premolar with external cusp simple; superior incisors wide; large inferior narrower........ *E. burmeisteri.*

Medium; superior incisors narrow; large inferior wider....*E. bisulcatus.*

II. Fourth inferior premolar with anterior V open and cutting.

Smallest; incisors unknown.................................*E. acer.*

A species of the size of *E. acer* has been named *E. spatularius,* but I cannot place it in the above key, as the premolar and incisor teeth are unknown. The section II, approximates nearer the genus *Conoryctes* than sect. I.

Mesodonta.

Hyopsodus lemoinianus, sp. nov.

This Mesodont is distinguished from the known species of the genus by its superior size, and the fully developed heel of the inferior third molar. The anterior inner cusps of the inferior molars are absolutely simple, and the same teeth have a weak external and no internal cingulum. The cusps are elevated and the enamel smooth.

The species of this genus known to me by their mandibles are four, and these differ chiefly in size. Their characters are as follows:

Length of true molars M. .0165; last molar elongate.....*H. lemoinianus.*

Length of true molars M. .0140; last molar longer than second.......... *H. paulus.*

Size as last; last molar shorter than second................*H. miticulus.*
Length of true molars M. .0115; last molar elongate.........*H. vicarius.*

H. lemoinianus and *H. miticulus* have not been found out of the localities where they were discovered, while the other two species are distributed through most of the Eocene horizons, and have been found in many localities. Of the *H. lemoinianus* Mr. Wortman found nine more or less fragmentary mandibles.

Dedicated to my friend, Dr. Victor Lemoine of Reims, well-known for his brilliant discoveries in the vertebrate paleontology of the Lower Eocene beds near that city.

HYOPSODUS PAULUS Leidy.

Thirty-eight more or less broken mandibular rami.

HYOPSODUS VICARIUS Cope.

Eleven mandibular rami. A few specimens are intermediate between this species and the last in dimensions, the inferior true molars measuring M. .0120 and .0125 in length.

PANTOLESTES CHACENSIS Cope.

Four mandibular rami. This species has the fourth premolar more robust and less trenchant than in *P. secans*, and shorter than the last true molar. In *P. secans* it is longer than the last true molar.

PANTOLESTES METSIACUS sp. nov.

A small species of the size of the *P. longicaudus*, and distinguished by several peculiarities of dentition. The two cusps composing the anterior internal lobe of the molars are quite distinct but appressed. Each one is connected with the external anterior lobe by a transverse crest as is seen in *Esthonyx*, and these enclose between them a fossa. This fossa is closed internally by the appression of the anterior inner cusps. The fourth premolar is not so large as in *P. secans*, but resembles in proportions that of *P. chacensis*. It differs from that of *P. longicaudus* in its very short heel and its large anterior basal tubercle. The latter is double, consisting of two small cusps, one within and anterior to the other. The posterior heel is distinct on both sides of the ridge that marks the median line. The posterior external lobe is V-shaped, and the posterior inner is a small cone. Between the two is a minute median tubercle. The posterior tubercles are not so elevated as in the species of *Hyopsodus*. A weak external cingulum; enamel smooth.

Measurements.	M.
Length P-m. IV, with M. I, and II; (No. 1)	.0140
" P-m. IV	.0048
" M. II	.0048

Measurements.	M.
Width M. II	.0040
Length M. III; (No. 2)	.0050
Width "	.0030
Depth ramus at P-m. IV; (No. 1)	.0060
" " M. III; (No. 2)	.0070

Portions of four mandibles preserved. No. 2 is a little smaller than No. 1, and No. 4 is a little larger than No. 1.

The species of *Pantolestes* may be distinguished as follows:

a. Fourth premolar trenchant everywhere, longer than second molar. Length of true molars M. .0150; second molar with but one anterior inner cusp....................*P. secans.*

aa. Fourth premolar with blunt heel, not longer than second molar. Length of true molars .0160; all with double cusps..........*P. chacensis.*
Length of true molars .0140; fourth premolar with minute anterior cusp, and long heel....................*P. longicaudus.*
Length of true molars .0130; fourth premolar with double anterior cusp, and short heel; molars with double cusps................*P. metsiacus.*
Length of true molars .0105; fourth premolar small, .0035, without anterior cusps, and with two ridges on heel; true molars with double anterior inner cusps....................*P. nuptus.*

PANTOLESTES NUPTUS, sp. nov.

This is the last species of the genus, and is represented by a portion of a right mandibular ramus which supports three molars from the fourth to the sixth inclusive. Besides its small size, this species is distinguished by the relatively small dimensions of the fourth premolar, which is shorter than the first true molar instead of longer, as in all the other species. The well developed basin of its heel, which is bounded by a ridge on each side, distinguishes it at once also from *P. secans,* and is more distinct than in *P. chacensis;* from the latter and *P. metsiacus* the entire absence of anterior basal lobes separates it. The well developed pair of anterior inner tubercles of the true molars shows that it cannot be an abnormal *Hyopsodus vicarius,* with which it agrees in size. The first anterior tubercle is more widely separated from the second anterior than in any of the species of the genus, and is quite as in species of *Pelycodus.* It is smaller than the second anterior inner, which equals in size the anterior outer. The heel is wide, enclosing a basin, which is bounded externally by an angular ridge. Its posterior inner angle supports a cusp, which is separated by a deep notch from the anterior inner cusp. External to it on the posterior border of the crown is a small tubercle. No basal cingula.

Measurements.		M.
Length of three molars		.010
Diameters of M. i	anteroposterior	.004
	transverse	.003
Depth of ramus at P-m. IV		.007

Basin of the Big-Horn: J. L. Wortman.

PELYCODUS ANGULATUS Cope.

The species of this genus are, in the present state of our knowledge, best distinguished by their size.

Length of true molars on base	M. .024 ;	*P. pelvidens.**
" " " "	M. .019 ;	*P. jarrovii.*
" " " "	M. .017 ;	*P. tutus.*
" " " "	M. .015 ;	*P. frugivorus.*
" " " "	M. .012 ;	*P. angulatus.*

Remains of species of this genus are very common in the Wind River bad lands; they were originally found in the Wasatch beds of New Mexico, and have not yet been announced from the Bridger formation.

The *P. angulatus*, heretofore only known from New Mexico, is represented in the Big-Horn collection by five mandibular rami, and a portion of a maxillary bone with teeth.

PELYCODUS FRUGIVORUS Cope.

Two mandibles and seven separate rami represent this Mesodont.

PELYCODUS TUTUS Cope.

Four rami display the typical length of the true molars, M. .017. Three are smaller, having the molars .016 in length, while one gives .018 for the same teeth. Other portions of the skeleton will be necessary to determine exactly the specific position of these specimens.

PROSIMIÆ.

CYNODONTOMYS LATIDENS, gen. et sp. nov.

Char. gen. Derived from mandibular rami. Dental formula I. ? 0 ; C. 1 ; P-m. 2 ; M. 3. The premolars are counted as two, on the supposition that the anterior one is two-rooted ; should it prove to be one-rooted, then the number will be three. The canines are very large and close to the symphysis, so that there do not appear to have been any incisors. The true molars have the frequently occuring three tubercles in front and a heel behind ; but the arrangement is peculiar in that the three tubercles are but little more elevated than the borders of the heel, and occupy a small part of the crown. The last molar is lost from both jaws, but the space for it is about as large as that occupied by the penultimate. The fourth premolar has but two anterior cusps, and these are more elevated than those of the true molars, and the heel is narrower. The mandibular rami are not coössified.

The dental characters of this genus resemble considerably those of *Anaptomorphus* and *Necrolemur*, but the large size of the inferior canine tooth distinguishes it from both. The double anterior cusps of the fourth premolar equally distinguish it from them.

Char. Specif. The inferior true molars are subquadrate in horizontal outline, somewhat narrowed anteriorly. The concave heel is the larger part of the crown ; it is only elevated into a low cusp at the posterior external angle. The anterior cusps are conic, and are in contact at the

* *Lipodectes pelvidens* Cope, Amer. Naturalist, Dec., 1881, p. 1019.

base. The external and posterior internal are of about the same size; the anterior inner is smaller and does not project so far inwards as the posterior. The fourth premolar has the posterior border of its heel serrate. The anterior cusps are elevated and moderately acute; the internal is a little less elevated than the external, and is separated from it by a deep notch. The alveoli for the anterior premolar are so close together, as to render it probable that they belong to but one tooth. They are placed somewhat obliquely to the long axis of the jaw. There is no diastema. The section of the base of the crown of the canine is a regular oval, the long diameter coinciding with the vertical diameter of the ramus.

The ramus is rather slender, but is shortened anteriorly. The boundaries of the masseteric fossa are well marked, the anterior ridge descending to below the middle line of the ramus. The mental foramen is large and is situated below the contact of the two premolars. The inferior edge of the ramus is rather thick.

Measurements.	M.
Length of dental series including canine	.0240
" premolars	.0062
" molars	.0114
Long diameter base canine	.0036
Diameters P-m. IV { anteroposterior	.0038
Diameters P-m. IV { transverse	.0026
" " M. II. { anteroposterior	.0042
" " M. II. { transverse	.0038
Depth of ramus at P-m. I	.0060
" " " M. III	.0068

Anaptomorphus homunculus Cope, American Naturalist, 1882, Jan. (Dec. 30th, 1881), p. 73.

The genus *Anaptomorphus* was characterized by me in 1872,* from a mandibular ramus which exhibited the alveoli of all the teeth, three of them occupied by the teeth; viz.: the P-m. iv, and the M. i and M. ii. From the specimen the inferior dental formula was ascertained to be I. 2; C. 1; P-m. 2; M. 3. The Big-Horn collection contains a nearly entire cranium of what is probably a species of the same genus. From it the superior dentition, exclusive of the incisors, is determined to be: C. 1; P-m. 2; M. 3. The premaxillary bones are mostly broken off, but a part of the alveolus of the external incisor of one side remains.

The indications are that the external incisor was a small tooth, not exceeding the canine in size; and it was situated close to the latter. The canine is also small, and its simple crown is not more prominent than those of the premolars. The latter are separated from it by a very short diastema. The long diameter of their crowns is transverse to the long axis of the

* Proceedings American Philosophical Society, 1872, p. 554. Paleontological Bulletin, No. 8, p. 1, Oct. 12, 1872.

jaw ; and each one consists of a larger external, and smaller internal cusp. The true molars are also wider than long, and support two external and only one internal cusps.

The orbits are large and are entirely enclosed behind. The frontal bone does not send inwards to the alisphenoid a lamina to separate the orbit from the temporal fossa, as is seen in *Tarsius*. There is no sagittal crest, but the temporal ridges are distinct. The occipital region protrudes beyond the foramen magnum, or at least beyond the paroccipital process, which is preserved, the condyles being lost. The otic bulla is large, extending anteriorly to the glenoid cavity. The pterygoid fossa is large, the external pterygoid ala being well developed, and extending well upon the extero-anterior side of the bulla, as in *Tarsius*. As in that genus, the foramen ovale is situated on the external side of the bulla, just above the base of the external pterygoid ala. The carotid foramen, as I suppose it to be, is situated at the apex of the bulla. The lachrymal foramen is situated anterior to, and outside of the orbit as in *Lemuridæ* generally.

The cast of the anterior part of the left cerebral hemisphere is exposed. This projects as far anteriorly as the middle of the orbits, leaving but little room for the olfactory lobes. The relations of the latter as well as of other parts of the brain will be examined at a future time. The part exposed does not display fissures, and gentle undulations represent convolutions.

The characters of this genus now known, warrant us in thinking it one of the most interesting of Eocene Mammalia. Two special characters confirm the reference to the *Lemuridæ* which its physiognomy suggests. These are, the external position of the lachrymal foramen, and the unossified symphysis mandibuli. Among *Lemuridæ*, its dental formula agrees only with the *Indrisinæ*, which have, like *Anaptomorphus*, two premolars in each jaw. But no known *Lemuridæ* possess interior lobes and cusps of all the premolars, so that in this respect, as in the number of its teeth, this genus resembles the higher monkeys, the *Simiidæ* and *Hominidæ*,* more than any existing member of the family. Of these two groups the resemblance is to the *Hominidæ* in the small size of the canine teeth. It has, however, a number of resemblances to *Tarsius* which is perhaps its nearest ally among the lemurs, although that genus has three premolars. One of these points is the anterior extension of the otic bullæ, which is extensively overrun by the external pterygoid ala. A consequence of this arrangement is the external position of the foramen ovale, just as is seen in *Tarsius*. Another point is the probably inferior position of the foramen ovale. Though this part is broken away in the cranium of *Anaptomorphus homunculus*, the paroccipital process is preserved, and has the

* In an early description of *Anaptomorphus*, Proc. Amer. Philos. Soc., 1873, the types make me say "this genus * * might be referred decidedly to the *Lemuridæ*, were it not for the unossified symphysis." It is scarcely necessary to state that *Simiidæ* should be read in place of *Lemuridæ*.

position seen in *Tarsius*, as distinguished from the *Indrisinæ*, *Lemurinæ*, *Galaginæ*, etc. In this it also resembles the true *Quadrumana*.

When we remember that the lower *Quadrumana*, the *Hapalidæ* and the *Cebidæ*, have three premolar teeth, the resemblance to the higher members of that order is more evident. The brain and its hemispheres are not at all smaller than those of the *Tarsius*, or of the typical lemurs of the present period. This is important in view of the very small brains of the flesh-eating and ungulate Mammalia of the Eocene period so far as yet known. In conclusion, there is no doubt, but that the genus *Anaptomorphus* is the most simian lemur yet discovered, and probably represents the family from which the true monkeys and men were derived. Its discovery is an important addition to our knowledge of the phylogeny of man.

Char. specif. The specimen is distorted by pressure, but its form is normally nearly round, when viewed from above or below. The extremity of the muzzle is broken away, but the alveolus of the external incisor indicates that it is short, and not prolonged as in *Tarsius spectrum.* The mandibular ramus, already described, proves the same thing. The orbits are large, but not so much so as in *Tarsius spectrum* ; their long diameter equals the width of the jaws at the last superior molar teeth inclusive. The supra-orbital borders project a little above the level of the frontal bone, which is concave between their median and anterior parts. The cranium is wide at the postorbital region, in great contrast to its form in the *Adapidæ*, resembling the *Necrolemur antiquus* Filh. in this respect. The postfrontal processes are wide at the basal portion, and flat. From their posterior border the temporal ridges take their origin. These converge posteriorly and probably unite near the lambdoidal suture, but this part of the skull is injured. The anterior lobes of the cerebral hemispheres are indicated externally by a low boss on each frontal bone.

The paroccipital process is short and wide at the base, and it is directed downwards and forwards. The alisphenoid descends so as to form a strong wall on the anterior external side of the otic bulla. This is also the case in *Tarsius spectrum*, but in the extinct species the descending ala is more robust, and has a thickened margin. On the latter the external pterygoid ala rests by smooth contact of its thickened superior edge. This ala is twice as prominent as the internal pterygoid ala. The posterior nareal opening is not wide, and its anterior border is parallel with the posterior border of the last superior molar teeth. The palate is wide, and its dental borders form a regular arcade as in man, being quite different from the form usual in monkeys and lemurs, including *Tarsius.* Perhaps the form is most like that of *Microrhynchus laniger.* The proximal parts of the malar bone are prominent, and overhang the maxillary border, as in *Tarsius.*

The *foramina ovale* and *lachrymale* are rather large. There are two infraorbital canals, lying beside each other, and issuing by two foramina externa. The external appearance justified this conclusion, but the fact was demonstrated when I accidentally broke away the anterior border of one of the orbits. This displayed the two canals filled with matrix their entire length. The anterior foramen externum is anterior to and above the posterior, and both are above the first (third) premolar tooth. The lachrymal foramen is above the space between that tooth and the canine.

The crown of the canine tooth is a cone with a very oblique base, and a convex anterior face. The base rises behind, and the posterior face has on the median line a low angular edge. The internal cone of the third (first) premolar is not so prominent as that of the second, though large. The external cusps of both premolars rise directly from the external base. They are flattened cones, with anterior and posterior cutting edges. The crowns are a little contracted at the middle, so as to be narrower than the inner lobe of the tooth, which is narrower than the external portion. Both premolars have delicate anterior, posterior and external cingula. The external cusps of the true molars rise directly from the external base, and like those of the premolars, have a regularly lenticular section. At the internal base of each one is a small intermediate tubercle, which is connected by an angular ridge with the single internal cusps. There are delicate anterior, posterior, and external cingula, but no internal. The posterior cingulum shows a trace of enlargement at its inner part, which is well marked on the second molar, but it is not as prominent as in many Creodont genera. The posterior external cusp of the last true molar is reduced in size. Taking the molars together, the first true molar is the largest, and they diminish in size both anteriorly and posteriorly. The third true molar is a little smaller than the first (third) premolar. Enamel smooth.

Measurements.		M.
Length of cranium to occipital prominence above paroccipital process, and minus premaxillary bone		.0280
Total width at posterior border of orbit, below		.0240
Length of palate from front of canine tooth		.0116
Width of palate and peunltimate molars		.0125
Length of superior molar series		.0095
" " true molars		.0060
Diameters of crown of canine	anteroposterior	.0018
	vertical	.0018
Diameters crown of P-m. iii,	anteroposterior	.0020
	transverse	.0026
Diameters crown of P-m. iv,	anteroposterior	.0020
	transverse	.0035
Diameters M. ii,	anteroposterior	.0032
	transverse	.0040
Diameters M. iii,	anteroposterior	.0016
	transverse	.0028
Diameters of orbit	anteroposterior	.0110
	vertical (? depressed)	.0078
Interorbital width (least)		.0050

The *Anaptomorphus homunculus* was nocturnal in its habits, and its food was like that of the smaller lemurs of Madagascar and the Malaysian islands. Its size is a little less than that of the *Tarsius spectrum*. The typical specimen was found by Mr. J. L. Wortman in a calcareous nodule in the Wasatch formation of the Big-Horn basin, Wyoming Territory.

Creodonta.

Shortly after the publication of my arrangement of the Creodonta in 1880*, I obtained a good deal of additional material, which enabled me to improve it in several respects. A number of genera have been added, and the characters which distinguish the *Miacidæ* and *Oxyænidæ* have been more fully brought out. The *Miacidæ* differ from all other families in having the fourth superior premolar sectorial as in the true *Carnivora*, while the true molars are tubercular. In *Oxyæna*, the fourth superior premolar displays no indication of sectorial structure, the first true molar assuming that character. In *Stypolophus* and allies, the second superior true molar is more or less sectorial, and the first true molar and even the fourth premolar in some of the genera, develop something of the same character. But there is every gradation between the triangular *Didelphys*-like, and the sub-sectorial *Pterodon*-like forms of the superior molars, in this group of genera.

The glenoid cavity of the squamosal bone presents differences in the various genera of this sub-order. In *Arctocyonidæ* (fide De Blainville), *Oxyænidæ*, and *Mesonychidæ*, it is bounded by a transverse crest anteriorly, as well as by the postglenoid posteriorly, while in the *Leptictidæ* it is plane and open anteriorly. In *Amblyctonidæ* its condition is unknown. In existing *Carnivora* this character is not very constant as a family definition; it is best marked in the *Felidæ*, and least marked in the *Canidæ*. Nevertheless there is a group of genera allied to the *Oxyænidæ*, which are very marsupial in character, which have been called the *Leptictidæ*, and which differ so far as known from *Oxyæna* in the absence of the preglenoid crest. I suspect that these forms constitute a family by themselves, and for the present, until our knowledge of them is fuller, I define it by this character. The definitions of the families will then be as follows:

I. Ankle-joint plane transversely, or nearly so.

True molars above and below, tubercular; last superior not transverse.... *Arctocyonidæ*.

Superior true molars, tubercular; last superior premolar sectorial; first inferior molar "tubercular sectorial"... ....*Miacidæ*.

Superior last molar transverse; inferior molars tubercular-sectorial or with reduced anterior cusp; no preglenoid crest...............*Leptictidæ*.

Last superior molar trenchant, transverse; first superior true molar sectorial; inferior true molars tubercular-sectorial; a preglenoid crest... *Oxyænidæ*.

*Proceedings Amer. Philos. Society, p. 76.

Last superior molar longitudinal ; inferior true molars without developed sectorial blade.................................... *Amblyctonidæ.*

II. Ankle-joint tongued and grooved, or trochlear.

Molar teeth in both jaws consisting of conic tubercles and heels ; none sectorial ; a preglenoid crest.......................... *Mesonychidæ.*

I now give the characters of the genera. All these are derived from examination of typical specimens. The opportunity of doing this I owe to the kindness of Messrs. Leidy, Gervais, Gaudry, Filhol, and Lemoine.

ARCTOCYONIDÆ.

Premolars, $\frac{4}{4}$; the first inferior one-rooted ; the last inferior well developed ; *Arctocyon* Blv.

Premolars below, 4, the first two-rooted, the last true molar much reduced ; (fide Lemoine).................................. *Hyodectes* Cope.

Premolars below, 3, first two-rooted ; true molars normal................ *Heteroborus* Cope.

MIACIDÆ.

Inferior tubercular molars two, premolars four.............. *Miacis* Cope.

Inferior tubercular molars one, premolars four.......... *Didymictis* Cope.

LEPTICTIDÆ.

I. Superior molars sub-equilateral, without cutting heel posteriorly.

a. Fourth inferior true molar like the true molars, with three anterior cusps.

β. Third superior premolar with internal cusp ; anterior cusp of inferior molars small, median.

Third premolar with one external and one internal cusps. *Mesodectes* Cope.

Third premolar with two external and one internal cusps.... *Ictops* Leidy.

ββ. Third superior premolar without internal cusps ; anterior cusps of inferior molars present.

Cusps of superior molars marginal ; two superior incisors ; *Leptictis* Leidy.

Cusps of superior molars median in position ; anterior cusp of inferior molars well developed.......................... *Peratherium* Aym.

βββ. Anterior cusps of inferior molars wanting.

Fourth inferior premolar like true molars................ *Diacodon* Cope.

aa. Fourth inferior premolar different from true molars in a simpler constitution.

Last inferior molar tubercular ; cusps of other true molars well developed; three inferior premolars.......................... *Lipodectes* Cope.

Inferior true molars alike, with anterior inner cusps little developed ; three premolars (?).................................. *Triïsodon* Cope.

Inferior true molars alike, with cusps well developed ; four premolars.... *Deltatherium* Cope.

II. One or more superior molars, with the external heel produced into a blade.

a. Molars 4—3 ; three last inferior tubercular sectorial.

Premolars robust, conic............................ *Quercitherium* Filh.
Premolars compressed ; the fourth superior with a conic cusp and heel externally.................................... *Stypolophus* Cope.
Premolars compressed ; fourth superior with a simple blade externally... *Proviverra* Rütim.

OXYÆNIDÆ.

I. Inferior molars without internal tubercles.

Molars, $\frac{4}{3}$ $\frac{3}{3}$; three sectorials in the lower jaw.............. *Pterodon* Blv.

II. Inferior molars with internal cusps.

a. Posterior heel of one or more superior molars elongate and trenchant.

Last inferior molar truly sectorial, without internal tubercle ; second, tubercular-sectorial................................ *Protopsalis* Cope.
Molars, $\frac{4}{4}$ $\frac{2}{2}$; two last inferior molars tubercular-sectorial... *Oxyæna* Cope.

AMBLYCTONIDÆ.

Fourth inferior premolar with a broad heel supporting tubercles ; an anterior and no internal tubercles................ *Amblyctonus* Cope.
Inferior molars with tubercular heel, an anterior and an internal tubercle. *Periptychus* Cope.
Dental formula below, 3, 1, 3, 3. Fourth inferior premolar with a cutting edge on the heel ; both internal and anterior tubercles............... *Palæonyctis* Blv.

MESONYCHIDÆ.

a. Inferior molars seven ;

Cones of inferior and superior molars simple.................... *Mesonyx.*
Cones of last two inferior molars with lateral cusps............. *Dissacus.*

aa. Inferior molars ? six.

Internal lobes of penultimate superior molar v-shaped..... *Sarcothraustes.*

aa. Inferior molars five.

Inferior molars with strong anterior lobe.................... *Patriofelis.**

MIACIS CANAVUS Cope.

Bulletin U. S. Geol. Survey, Terrs., 1881, p. 189. One mandible.

MIACIS BREVIROSTRIS Cope, loc. cit. p. 190.

Parts of four mandibles.

DIDYMICTIS DAWKINSIANUS Cope, l. c., p. 191.

Six mandibular rami more or less complete.

Individuals of the genus *Didymictis* are abundant in the Wasatch beds

* Of uncertain reference to this family.

of the Big-Horn, and a good many of them do not coincide well in characters with the species already described. I define them as follows, premising that with other parts of the skeleton some changes may be found to be necessary. The large *D. altidens* was not obtained by Mr. Wortman in the Big-Horn country.

I. Inferior tubercular molar oval in outline, with a heel.

Length true molars .010 ; last three premolars .0135 ; last molar narrow.. *D. dawkinsianus.*

Length true molars .016—.018 ; last three premolars .028—.030 ; last molar narrow.......................................*D. leptomylus.*

Length true molars .019—.020 ; last three premolars .036 ; last molar elongate.......................................*D. protenus.*

Length true molars .025 ; last three premolars .035 ; last molar short..... *D. altidens.*

II. Inferior tubercular molar short, subquadrate in outline.

Length true molars .011 ; depth of ramus at sectorial .010............... *D. massetericus.*

Length true molars .018 ; depth of ramus at sectorial .017....*D. curtidens.*

DIDYMICTIS LEPTOMYLUS Cope.

American Naturalist, 1880, p. 908.

The specimens which I refer at present to this species belong to two varieties, which may perhaps be specifically distinct ; but this cannot be demonstrated at present. They differ in dimensions only. Thus the true molars of the type, which comes from the Big-Horn beds, measure M. .016 in length. Five specimens from the Big-Horn basin agree in having this dimension .018. The entire inferior molar series is only a little shorter than that of the smalier variety of the *D. protenus* from New Mexico (See my report to Capt. Wheeler, plate XXXIX).

DIDYMICTUS PROTENUS Cope.

Jaws more or less complete, of six individuals, are referable to this species. They agree closely in measurements and belong to the larger variety of the species figured on plate XXXIX of the report to Capt. Wheeler.

DIDYMICTIS MASSETERICUS, sp. nov.

This species is intermediate in size between the *D. leptomylus* and the *D. dawkinsianus*, and is characterized by the peculiar form of its tubercular molar, and the deeply excavated masseteric fossa. It appears to have been a rare species, as only one mandibular ramus was found by Mr. Wortman. This is broken off in front of the fourth premolar, and supports the last true molar teeth.

The tubercular molar is subquadrate in form, and consists of three low tubercles in front, and a wide heel behind, which has an elevated posterior border. The tubercular-sectorial has a short and narrow heel. Its anterior cusps are not very acute, and the two internal are equal, and a good deal shorter than the external. The fourth premolar is relatively shorter than in any other species of the genus, and the posterior marginal lobe is a mere thickening of the edge of the heel. There is a low anterior basal tubercle. The enamel is smooth.

The ramus is compressed and not deep. The angle is prominent, and is not inflected; it does not extend so far posteriorly as the posterior border of the condyle. The inferior border of the masseteric fossa is an angular line, without abrupt excavation, but the face of the fossa descends rapidly. The anterior border of the fossa is abrupt and is formed by the usual subvertical ridge.

Measurements.	M.
Length between P-m. IV, and condyle inclusive	.0520
" of posterior three molars	.0170
" of tubercular-sectorial	.0070
Elevation of " "	.0070
Depth of ramus at sectorial	.0100

DIDYMICTIS CURTIDENS, sp. nov.

As in the case of the *D. massetericus* the present species is represented by a single fragmentary mandibular ramus. This supports a sectorial tooth of the size and form of that of the *D. protenus,* and is thus much larger than that of the species just named. This tooth is placed nearer to the base of the coronoid process than is seen in any other species, and only leaves space for a short tubercular tooth. This is lost from the specimen, but the alveolus shows pretty clearly its dimensions. The base of the fourth premolar remains, and it is evident that this tooth was like that of *D. protenus* in form and proportions. The base of the posterior marginal lobe is present. The ramus is deeper and larger than in the *D. massetericus.*

Measurements.	M.
Length of bases of last three molars	.0285
" " fourth premolar	.0120
" " sectorial on base	.012
Width " in front	.008
Depth of ramus at sectorial	.017

ICTOPS BICUSPIS Cope. Bull. U. S. Geolog. Surv., Terrs. 1881, p. 192.

This mammal was founded on a skull from the Wind River region. It is now represented by a mandibular ramus. The form of the fourth premolar being unknown, its reference to this species is provisional only. It may be remotely allied to *Stypolophus,* but the anterior inner cusp of the molars is small and does not reach the inner side of the crown, and the anterior external cusp is but little larger than the second anterior inner. The two cusps last named stand opposite to each other, and their apices are only separated from each other by an open notch. They, with the first anterior inner (here median), form a transverse narrow triangle. The posterior part of the crown is rather large and, though lower than the anterior part, is absolutely quite elevated above the alveolar border. Its summit presents a V externally, and there is a small posterior median angle. In the last true molar this angle is a little more prominent than in the others, and rises into a cusp. The external bases of the crowns are protuberant, but there are no cingula. Enamel smooth.

The ramus is rather compressed, and the masseteric fossa is well marked, and is bounded anteriorly by a prominent rib.

Measurements.		M.
Length of true molars		.0100
Diameters M. III	anteroposterior	.0035
	vertical	.0035
	transverse	.0030
Diameters M. I	anteroposterior	.0035
	transverse	.0028
Depth of ramus at M. II		.0070

This species is smaller in all dimensions than *I. didelphoides*, and the crowns of the molar teeth are shorter and more elevated than in that species.

DELTATHERIUM ABSAROKÆ Cope. American Naturalist, 1881, p. 669.

A small species, represented by an imperfect cranium and lower jaw with nearly complete dentition.

STYPOLOPHUS ACULEATUS Cope.

Several fragmentary mandibles nearly coincide in measurements with this species. The molars are .0240 in length, and the ramus is .0140 in depth. The only difference in the measurements is that the true molars measure .0250 in *S. aculeatus*. The latter is, however, a species of the Bridger epoch, so that further comparison will be necessary before identification is made.

STYPOLOPHUS WHITIÆ, sp. nov.

Stypolophus strenuus Cope. Bulletin U. S. Geol. Survey, VI, 192; not of Report Capt. Wheeler, vol. IV, pt. ii.

The greater part of the skeleton, with skull and dentition of this species, were brought from the Big-Horn by Mr. Wortman. A part of a mandible of a second individual was also found. The species is, however, primarily based on a specimen from the Wind river. This is represented by a right mandibular ramus which supports all the molar teeth, and displays the alveolus of the canine, and lacks all posterior to the coronoid process; also by a portion of the frontal bone, two vertebræ, fragments of scapula, humerus, ulna, radius, ilium, and tibia, and the greater part of both tarsi. They represent a species larger than the Virginian opossum, and intermediate between the *S. brevicalcaratus* and *S. strenuus* in proportions. It has not the rudimental heels of the molars of the former species, nor the robustness of the latter.

The inferior outline of the mandible is gently curved from the canine to below the last molar. The anterior border of the masseteric fossa is well marked, but not the inferior border. The ramus is compressed and deep. The canines have stout roots and narrow curved crowns. The first premolar is separated by a short space from the canine and by a longer one from the second premolar. It has either a single compressed root or two roots confluent within the alveolus. The crown is truncated obliquely behind. The second premolar is two-rooted and the crown is elevated anteriorly and depressed posteriorly. The third premolar is more symmetrical, but the heel is produced. It is narrow and keeled medially. The fourth premolar is abruptly larger than the third. Its crown is simple, except a low tubercle at the anterior base and a short trenchant heel at the posterior base. Of the three tubercular-sectorials the first is the smaller. The heels of all three are rather narrowed and elongate. Their margin is raised all round, inclosing a basin ; a notch in the external margin cuts its anterior part into a tubercle. The two internal tubercles are rather obtuse, and are considerably shorter than the external cusp.

Measurements.	M.
Length from canine to end of last molar	.060
" " " first true molar	.037
" " " second premolar	.015
" of base of fourth premolar	.009
Elevation of fourth premolar	.007
Length of base of second true molar	.007
" heel " " "	.006
Elevation of second true molar	.009
Depth of ramus at third premolar	.015
Length of superior canine	.028
" crown of superior canine with enamel	.012

A portion of the frontal bone shows weak anterior temporal ridges uniting early into a sagittal crest, which is low as far as preserved. The parietal bones overlap the frontal as far forwards as the temporal ridges. Anterior to the latter the front is concave in transverse section. Viewed from below, the spaces for the olfactory lobes are large and entirely anterior to those which received the anterior lobes of the hemispheres ; each one is about as wide as long. In the small part of the cerebral chamber wall left, there is no indication of convolutions, which would be visible in a gyrencephalous brain ; two air-chambers in front of each olfactory lobe.

The base of the transverse process of the atlas is perforated from behind to the middle of its inferior side ; from the latter opening a foramen penetrates directly into the neural canal. A posterior dorsal vertebra has the centrum longer than wide and much depressed. Its inferior face is regularly convex in section. The proximal end of the scapula shows that its inner border is much thickened, and that the spine arises abruptly and near to the glenoid cavity. There appears to have been scarcely any coracoid ; the surface adjoining it is, however, injured. The humerus lacks the proximal portion and the inner half of the condyles with the epicondyles. The deltoid crest is not very prominent, so that the shaft is rather slender. The external distal marginal crest is thin, and is continued well up on the shaft. The external part of the condyle displays no intertrochlear ridge. Olecranar and coronoid fossæ well marked. The olecranon is robust and deep, and is truncate posteriorly and below. The head of the radius is a regular transverse stout oval.

A fragment of the ilium from near the acetabulum displays a prominent "anterior inferior spine." The best preserved tarsus includes calcaneum, astragalus, cuboid, and navicular bones. The tibial face of the astragalus is strongly convex antero-posteriorly and slightly concave transversely. The head is prolonged some distance beyond the distal extremity of the calcaneum, and presents a convex internal border and a concave external one. Its long axis is parallel to that of the tibial portion, but is not in the same axis, owing to its lateral position. The external face of the trochlear portion is vertical, and is interrupted by a deep fossa behind. The internal face is very oblique, and becomes the superior face of the head. The posterior face of the trochlea is grooved with a wide and shallow groove, which just reaches the superior face, terminating on the external side. The superior face is not grooved, but is shallowly concave in transverse section. The head is a transverse oval, and is convex; it has a small facet for the cuboid on the outer side.

The heel of the calcaneum is large and expands distally, so as to be as wide as deep. The convex astragalar facet is very oblique to the long axis of the calcaneum; the sustentaculum is rather small. Below the latter is a narrow tuberosity looking downwards and forwards. On the external side, close to the cuboid facet, is a depressed crest. The cuboid facet is as deep as wide. The cuboid bone is a little longer than wide proximally, and narrows distally. It has a narrow astragaline facet and a deep fossa below proximally. The hook inclosing the groove for the tendon of the flexor muscle is prominent. The navicular is rather small, and has three inferior facets, which diminish in size outwards. It has a strong posterior knob-like process, with a narrow neck.

When the tarsal bones are in position, and the tibia stands vertically on the astralagus, the cuboid bone is turned inferiorly. This indicates that this species walked on the outer edge of the hinder foot.

Broken metapodial bones are slender and straight. The proximal end of a metacarpal does not display the interlocking lateral articulation seen in *Protopsalis*. Two phalanges are depressed in form.

Measurements.		M.
Diameters of a dorsal centrum	anteroposterior	.0145
	vertical	.0075
	transverse	.0115
Diameters of glenoid cavity scapula	anteroposterior	.0145
	transverse	.0090

Measurements.			M.
Depth of olecranon			.0110
Width of head of radius			.0110
" neck of ilium anteroposteriorly			.0120
Diameter of shaft of tibia at middle			.0085
Diameters of astragalus	anteroposterior		.0180
	greatest		
	transverse.	of trochlea	.0140
		of head	.0100
Length of head			.0070
" calcaneum			.0300
Width of calcaneum at sustentaculum			.0140
" cuboid facet			.0066
Length of cuboid			.0120
Diameters	anteroposterior	distal	.0070
		proximal	.0075
	transverse proximal		.0098
Diameters of navicular	vertical		
	transverse	with tuberosity	.0100
		without tuberosity	0070
	anteroposterior		

As already remarked, it is probable that the semigrooved trochlea of the astragalus of this species is an indication that the genus *Prototomus* must be retained as distinct from *Stypolophus*, to which the present species probably truly belongs.

The specimen described, together with the mandibular ramus of another supporting the last two molar teeth, were found in the bad lands of Wind river, Wyoming, by J. L. Wortman. Dedicated to Frances Emily White M. D., of Philadelphia.

OXYÆNA FORCIPATA Cope.

Report Vert. Foss., New Mexico, 1874, p. 12. Report Capt. G. M. Wheeler, U. S. G. G., Expl. Surv. W. of 100th Mer. IV, ii, p. 105, 1877.

This formidable animal was abundant in Northern Wyoming, during the Wasatch epoch. At least ten individuals are represented in the collection. The following are the dimensions of the mandibles of the five best preserved.

	1	2	3	4	5
Length of dental series	.103	?	.100	.100	.107
" premolar "	.042	.045	.044	.051	.054
Depth of ramus at M. III	.042	.039	.037	.042	.047

The measurement .035 for the length of the premolars given in my report to Capt. Wheeler, loc. cit., refers to the anterior three teeth, which were originally supposed to be the only premolars.

The claws of this species are moderately compressed, and they terminate abruptly and obtusely. The extremity is deeply fissured, and each of the two apices is rugose.

MESONYX OSSIFRAGUS Cope, American Naturalist, 1881, p. 1018.

Pachyæna ossifraga Cope. Report Capt. Wheeler, U. S. G. G. Surv. W. of 100th Mer. IV, ii, p. 94, 1877.

A series of specimens of this species demonstrates the following points: (1) *Pachyæna* was founded on a superior molar of *Mesonyx*, and must be suppressed. (2) *Mesonyx navajovius* Cope must be separated as a distinct genus, since the apices of the crowns of the last two molars have two cusps. I have called this genus *Dissacus* (American Naturalist, Dec., 1881). (4) It results that there are three species of *Mesonyx*: *M. ossifragus* Cope, *M. lanius* Cope, and *M. obtusidens* Cope.

M. ossifragus was the largest Creodont of the Eocene, equaling the largest grizzly bear in the size of its skull. In a cranium with lower jaw and almost complete dentition, the length to the premaxillary border from the postglenoid crest is M. .365; the largest *Ursus horribilis* in my collection gives .270 for the same length. This specimen has the dental formula I. $\frac{3}{2}$; C. $\frac{1}{1}$; P-m. $\frac{4}{4}$; M. $\frac{3}{3}$. The claws have the flattened form which I discovered in *M. lanius*, and the proximal phalanges have much the shape of those of a Perissodactyle. The astraglus has much the character of the animals of that order, and has the distal facets as I originally detected them in the *M. obtusidens*. The form of this bone is rather shorter and wider than in the latter species.

The inferior canine tooth of a large specimen has the following diameters at the base of the crown: anteroposterior .039; transverse .024.

AMBLYPODA.

PANTODONTA.

The explorations in the bad lands of the Big-Horn river yielded several species of this sub-order, all which I refer at present to the *Coryphodontidæ*. They, however, represent several genera, two of which have not been previously known. I have distinguished these (American Naturalist, Jan., 1882), in the characters of the superior molar teeth as follows:

I. Last superior molar with two interior cusps.

All the superior molars with a well marked external posterior V......... *Manteodon.*

II. Last superior molar with but one inner cusp or angle.

a. Last superior molar with posterior external cusp.

Anterior two molars with posterior external V................ *Ectacodon.*

aa. Last superior molar without external posterior cusp.

† Anterior two molars with posterior external V.

Astralagus transverse, with internal hook.................. *Coryphodon.*

Astragalus subquadrate, without internal hook.............. *Bathmodon.*

††First superior molar only with posterior external V....... *Metalophodon.*

The type of *Manteodon* is the *M. subquadratus*, which was about the size of an ox. The characters of its superior molars are more like those of Perissodactyles than are those of the other *Coryphodontidæ*. The type of *Ectacodon* is the *E. cinctus*, a species of about the dimensions of the last named. Its last superior molar is parallelogrammic, and has a cingulum all around it except on the external side.

MANTEODON SUBQUADRATUS, gen. et sp. nov.

Char. gen. These have been already pointed out in the key above given. They are a little more like those of the superior molar teeth of such *Perissodactyla* as *Limnohyus* and near allies, than those seen in the typical *Coryphodon*. The posterior transverse crest of that genus is here represented by a complete V, but the anterior lobe of that crest which represents the anterior V of the Perissodactyle, is only a lobe, as in *Coryphodon* The tooth in fact is much like the penultimate molar of the latter genus. The two internal cusps are unique in the family. The additional one is a growth of the inner extremity of the posterior cingulum, and is separated from the anterior inner cusp by a deep and wide notch. It is opposite to the posterior V, as the anterior inner cusp is opposite the anterior rudimental V. The premolar and incisor teeth are similar to those of *Coryphodon*. The skeleton is unknown.

Char. specif. These are learned from a series of teeth which were found together by Mr. Wortman free from admixture of others. They are not worn, excepting by moderate use of the animal when living.

The last superior molar is not of the oval form belonging to the species of *Coryphodon*, but is quadrate, with the internal side shorter and with rounded lateral angles. The first anterior cingulum, which represents the anterior basal cingulum of the *Lophiodontidæ*, is as elevated as in the species of *Coryphodon*. Externally it rises in a protuberance with sharp edge, which curves posteriorly and disappears on the external side of the crown. The inner extremity terminates abruptly, forming the anterior interior tubercle. The anterior external lobe is rather flat, and is not conical nor elevated above the anterior cingular lobe. It is not deeply separated from the latter, nor from the posterior V ; its edge is rough. The posterior V projects well inwards, and is rather narrow. Its posterior border extends as far outwards as the point of junction of its anterior border with the anterior external lobe, and terminates in a slight elevation of its border. The base of the crown extends external to the base of the V, and forms a strong posterior external protuberance. This causes the outline of the external base to be concave. This side of the crown has several small protuberances and rugosities. The posterior basal cingulum extends as far externally as the posterior V, and terminates internally in the posterior internal cusp. The second or basal anterior cingulum is well developed. There are no external nor internal cingula. The surface of the enamel is strongly and closely rugose where not worn.

The posterior inferior molar exhibits a transverse posterior crest, without any tubercle or ridge in the mouth of the posterior V-shaped valley. There is a strong posterior cingulum, amounting to a narrow heel. As in the case of the superior molar, the enamel where not worn is closely and strongly wrinkled. The first superior premolar is characterized by the very small development of its internal lobe, which is only a strong basal cingulum. The crown proper has a sub-triangular outline, and the external face is flat and not concave. No external cingulum; enamel wrinkled. An external incisor has a large transversely extended crown, without cingula. A low rib on the median line of the inner side. Enamel wrinkled. In this and in another incisor, the base of the crown is considerably expanded laterally.

Measurements.

		M.
Diameters of crown M. III, sup.	anteroposterior	.035
	transverse	.041
	vertical	.020
Width of M. III inferior, posteriorly		.022
Diameters P-m. I sup.	anteroposterior	.018
	transverse	.014
Diameter base crown I, II		.024
Length crown I, II		.019
Width base crown I, III		.026

ECTACODON CINCTUS, gen. et sp. nov.

Char. gen. In *Ectacodon* the last superior molar has more of the elements of a posterior external V than in *Coryphodon*, but not so much as in *Manteodon*. The posterior transverse crest, it is true, has no oblique posterior ridge joining it, to form with it more or less of a V. But the external posterior angle of the crown supports a cusp, homologous with the vertical rib found at the basal or external angles of the Vs in *Palæosyops* and allied genera, and indicating the outlines of a V which lacks its posterior side, in a manner not seen in *Coryphodon.* The penultimate and ante-penultimate superior molars are like those of the latter genus. Skeleton unknown. I have a single species of this genus.

Char. specif. Six superior molars of one skull represent this species. They belong to a large animal, one about the size of the *Manteodon subquadratus.* The last superior molar has a characteristic outline. It is not oval as in the species of *Coryphodon,* nor quadrate as in *Manteodon* sp., but sub-parallelogrammic. The transverse diameter exceeds the anteroposterior, and the anterior and posterior sides are parallel. The external outline is slightly oblique and slightly notched in the middle. The internal border is regularly rounded. The basal or second cingulum extends entirely round the tooth from the posterior external cusp, round the inner base to the anterior external base of the crown; being absent only from the external base. The first cingula both anterior and posterior are well developed as in the species of *Coryphodon,* and unite in the prominent internal angle. The posterior first cingulum joins the posterior basal cingulum at the middle of its length. The anterior first cingulum extends to the anterior external part of the crown, and then turns downwards and posteriorly and terminates at the middle of the external base. The posterior crest is not transverse, but quite oblique, sloping at an angle of 45° with the axis of the jaw. The part of the crest which represents the posterior V is a good deal larger than the part representing the anterior V, and is closely joined with it. The latter is well separated from the anterior first cingular ridge and its anterior exterior elevated portion. The enamel of this tooth is finely wrinkled, and is more readily worn smooth than in the *Manteodon subquadratus.*

The penultimate superior molar has the posterior V well developed, and its posterior basal or external angle is marked by a tubercle homologous with that which is so prominent on the last molar. The anterior V is a conic tubercle closely joined with the posterior V, and well separated from the anterior first cingular lobe. The basal cingula are well developed, but do not meet on the inner base of the crown. The first or superior cingula meet as usual in an interior angle, but there is a contraction of the anterior crest just before reaching this angle. The first true molar is smaller than the second and has the same general structure. Here, however, the anterior first cingulum is more prominent near the internal angle than the posterior. The characters of the premolars do not differ from the corresponding ones of species of *Coryphodon.* The enamel is delicately wrinkled. The first superior premolar is not preserved.

Measurements.		M.
Diameters of crown of M. III	anteroposterior	.034
	transverse	.043
	vertical	.015
Diameters M. I	anteroposterior	.028
	transverse	.033
	vertical	.012
Diameters P-m. III	anteroposterior	.023
	transverse	.030

It is probable that this species was about the size of an ox.

Coryphodon anax, sp. nov.

Mr. Wortman sends me a number of teeth of probably two individuals, which exceed in size those of any species of *Coryphodon* yet known, and differ in certain details of form from all of them. The specimens consist of incisors, premolars and molars of both jaws of one animal, and an inferior canine, which from its separate wrapping, I suppose to have been derived from a different locality.

The incisors and premolars have the form usual in species of the genus, differing only in their large size. The same may be said of the premolars. A well preserved superior true molar is probably the third. It has the form usual in the genus, but exhibits two peculiarities. The posterior transverse crest is divided more deeply than usual by a deep notch which enters it from the transverse valley. The external portion is the shorter, and exhibits the peculiarity of being connected with external part of the anterior transverse crest. It is as closely connected with this crest, as it is with the internal portion of the posterior crest. The external connection does not exist in the other species of the genus, where the two crests are separated at their outer extremities by a deep valley. The posterior basal cingulum is obsolete, while the anterior is well developed. The enamel of this tooth where not worn, is wrinkled.

The posterior part of the last inferior molar is characteristic. The posterior transverse crest is short and very oblique, its inner extremity striking the posterior margin near the middle. Here it is elevated into a cusp, which rises above the surrounding parts in a characteristic manner. There is no ledge round its posterior base, but the border expands outwards at the base of the true crest. The additional inner marginal tubercle is low and compressed as in *C. lobatus.* A second inferior true molar is normal, with well developed anterior marginal ridge. The inferior canine mentioned is of large proportions, exceeding by one-half the dimensions of the inferior canine of *C. lobatus.* Its crown is curved outwards, and has a basal alate expansion of its internal ridge.

Measurements.		M.
Diameters of last superior molar	anteroposterior	.039
	transverse	.051
Diameters of second inferior true molar	anteroposterior	.039
	transverse	.028
Length of inferior canine		.160
" crown of "		.090
Diameters of base of crown of canine	vertical	.037
	transverse	.036

This species is nearest the *C. lobatus* in some respects. The short posterior crest of the last inferior molar with its cusp-like extremity, and the absence of posterior ledge on this tooth will readily distinguish it.

Bad lands of the Big-Horn river, Wyoming.

There are six individuals of this species in the collection which are mostly represented by fine specimens, which represent the entire dentition.

Eight other species of *Coryphodon* were obtained by the Big-Horn Expedition, and the material enables me to distinguish them better than heretofore. I present the following differential synopsis of their characters:

I. The last inferior molar with three posterior cusps, the internal sometimes represented by a ridge; or the posterior inferior molars with an accessory cusp or tubercle on the inner side between the crests (*Coryphodon*, Owen):

An internal tubercle; last upper molar with the anterior cross crest and anterior external crest closely connected; size largest.......... *C. anax.*

An internal conic cusp ; posterior crest oblique ; heel very small ; size medium.. .... *C. cuspidatus.*

An internal crest ; posterior crest oblique ; heel small ; size medium..... *C. obliquus.*

An internal tubercle ; posterior crest little oblique ; heel large ; size large. *C. lobatus.*

II. Posterior inferior molars with two posterior cusps ; without internal accessory tubercle :

a. Posterior inferior molars with small or no heel :

Large ; posterior superior molar oval, with distinct straight posterior crest ; inferior molars elongate ; symphysis mandibuli produced and narrowed ; premaxillary elongate........................ *C. latipes.*

Medium ; inferior molars nearly as wide as long ; premaxillary short..... *C. latidens.*

aa. Posterior inferior molars with prominent or wide heel :

Medium ; posterior superior molar with posterior angle, and angulate posterior crest ; inferior molars elongate ; symphysis mandibuli broad and short ; premaxillary elongate ; tusk trihedral.... *C. elephantopus.*

Smaller ; premaxillary bone short ; tusk trihedral.............. *C. simus.*

Medium ; premaxillary elongate ; tusk compressed and grooved......... *C. molestus.*

Large ; last superior molar oval, with angulate posterior crest ; its anterior lobe connected with anterior cingular crest............. *C. repandus.*

III. Last inferior molar with but one posterior cusp from which a curved crest extends round the posterior border of the crown.

Superior true molars narrow ; external incisors sharply angulate on external face.. *C. curvicristis.*

IV. Posterior inferior molar unknown.

Posterior superior molar oval ; posterior crest straight ; internal crest fissured (? normally) ; a complete internal cingulum... *C. marginatus.*

CORYPHODON CUSPIDATUS Cope.

This species was found in a single individual obtained in New Mexico ; a second one was discovered by Mr. Wortman in the Wind River basin, and a third has now been brought from the Big-Horn.

CORYPHODON LATIPES Cope.

I refer seven individuals provisionally to this species. Three of these are represented only by superior teeth, etc., and in four the last inferior molar is preserved. Of the latter, three have an angle, sometimes almost a crest, descending from the posterior inner tubercle, as in *C. obliquus,* but the specimens are all of superior size to that species, some of them very much exceeding it. It is also possible that this ridge is not a constant character. This species has the dentition which I have referred to the *Bathmodon radians,* but no astragalus of the species occurs in the collection. It may be the *C. latipes,* of which the teeth have not yet been identified. I hope soon to be able to decide this question.

CORYPHODON SIMUS Cope.

A broken mandible and maxillary bone, with several teeth represent this small species in the Big-Horn collection.

CORYPHODON ELEPHANTOPUS Cope.

Portions of the dentition of both jaws, including the last molar teeth of two individuals, prove that this species inhabited Wyoming in the early Eocene period. One of the individuals, represented only by the last molars of both jaws, is a little smaller than the typical specimen of which an entire cranium is figured in Capt. Wheeler's report (4to, 1877, Pl. LI–III), while a second specimen, which includes the entire superior molar series, is a little larger than the same.

This species is characterized by the obliquity of the edge of the posterior crest of the posterior superior molar backwards away from a transverse line; and by the slope of the external side of this crest. In other words the inner half of the posterior crest nearly forms a V, like that of the penultimate molar. The posterior edge of the V is present, running outwards from the inner end of the posterior crest, which thus becomes the apex of the V. The *C. elephantopus* thus most nearly approaches the genus *Manteodon,* of all the species. To accommodate the obliquity of the crest the posterior outline of the last upper molar is strongly angulate, giving a sub-triangular outline. The heel of the last inferior molar is insignificant.

.CORYPHODON REPANDUS, sp. nov.

This large species is known from the posterior portions of the dentition of both jaws, with an entire symphysis.

The last superior molars are intermediate in outline between the regular oval of the *C. radians,* and the sub-triangular form of the *C. elephantopus.* The peculiarities of the species are seen in the posterior crest. The two lobes of which this is composed, do not form a continuous line as in *C. latipes* and *C. simus,* but form an angle with each other as in *C. anax.* The anterior lobe is compressed, and its long axis is nearly that of the jaw; the second lobe leaves it at a right-angle, but curves backwards as it extends inwards, giving a concave exteroposterior border. There is no ridge descending outwards from the inner extremity of the crest, to form a V, as in *C. elephantopus.* But the posterior basal cingulum extends to the external side of the tooth, which is not the case in any other species known to me excepting the *C. marginatus.* The anterior cusp is closely joined to the external elevation of the anterior first cingulum as in *C. anax;* a character which separates it from all other species. A strong trace of a cingulum passes round the inner base of the crown. No external cingulum. The first true molar does not differ materially from that of other species. It is considerably smaller than the last. The apex of the premaxillary bone with the second incisor and alveolus of the first, is preserved. The bone is rather short. The crown of the incisor is regularly convex externally, and is not expanded at the base. There is a strong internal cingulum.

A fragment of the lower jaw supports the last two molars. The internal angle of the last one, is unfortunately broken. The posterior crest is, however, perfectly transverse, which is not the case with the species with three posterior tubercles. The preserved part of the posterior border shows a distinct, rather narrow heel. The anterior Vs are well developed and there are no lateral cingula. The symphysis is flattened out by pressure. The inferior canine is large. It is sub-triangular at base and has an anterior basal angular projection.

Measurements.		M.
Diameters of superior M. III	transverse	.046
	longitudinal	.037
Diameters of superior M. I	transverse	.036
	longitudinal	.032
Diameters crown I. 2	vertical	.018
	transverse	.018
Diameters inferior M. III	transverse	.028
	anteroposterior	.040
	vertical in front (restored)	.024
Length of symphysis		.107
Depth of ramus at M. III		.056

The superior molars of this species might readily be taken for an undersized individual of *C. anax,* but the last inferior molar is of a different type, and refers the species to a different section of the genus.

CORYPHODON CURVICRISTIS, sp. nov.

The fragments which represent this species belong to one individual. They include a considerable part of both mandibular rami with numerous molar teeth, and most of the inferior incisors loose. Also the second superior molar, some superior premolars, the canine, and three or four incisors, two of them in place in an incomplete premaxillary bone. None of the bones of the skeleton were obtained, so far as known.

The ramus of the mandible is both robust and deep. Its inferior border does not rise posteriorly so much as in some species, as *e. g., C. latidens,* and the angle is well below the horizontal line of the dental alveoli. The dental foramen is just about in this line. The inferior premolars and molars do not differ from those of several other species, but the last molar has several peculiarities. The external cusp is the only one of the posterior pair which is present. It gives origin to two crests, both of them curved. The posterior represents the usual posterior transverse crest, but is gently convex backwards, and turns forwards on the inner side of the crown, only terminating at the external base of the anterior cross crest. The other curved crest is low, although higher than in most species, and extends to the middle of the base of the anterior cross crest. There is a distinct heel which is elevated at the middle and disappears gradually at each end, not being abruptly incurved as in *C. anax.* The anterior part of this tooth is as peculiar as the posterior. The external cusp gives origin to three crests, two of them the usual limbs of the anterior V; while a third descends to the anterior border a little exterior to its middle. It encloses a deep groove with the anterior ridge of the anterior V. This arrangement is not seen in any other species.

The inferior canine is robust, and has its anterior angle prominent, but not alate. The crowns of the inferior incisors are regularly convex exteriorly, and have no cingula. They are regularly graded in dimensions.

The superior molar preserved is probably the penultimate. Its anterior portion is broken. The posterior external V is narrower than usual for a second molar, and resembles somewhat that of the last superior molar of the *Manteodon subquadratus*. A slight contact face on the posterior cingulum shows that this tooth is not the last molar. The said cingulum extends to the external base of the V; in rising to the internal cusp it forms a sigmoid curve. The cingulum below this, on the inner base of the crown, is rudimental. The superior canine has a long and robust crown, with a triangular section to the apex. The posterior face is a little wider than the other two, which are equal. The anterior is slightly concave in cross-section, and the posterior slightly convex transversely, although concave longitudinally. There is a weak ridge nearly parallel to and near the postero-external angle, and traces of others on the postero-external face of the crown in front of this one. The antero-internal angle is swollen at the base.

The superior incisors present characteristic features. The ridge of the external face, which is weakly developed in some of the species, and is wanting in others, is here represented by a strong longitudinal angle, which extends from the base of the crown to its apex, dividing the external face into two distinct planes. This character is most marked on the external incisor, where the planes are sub-equal, and concave. On the second the anterior plane is smaller, and on the first it is a good deal smaller. These incisors have a weak internal cingulum, but no external one.

Measurements.

		M.
Length of ramus from P-M. IV inclusive		.257
" inferior true molars		.098
Diameters of M. I infer.	anteroposterior	.0275
	transverse	.020
Diameters of M. III infer.	anteroposterior	.036
	transverse	.029
Depth of ramus at M. III		.075
Diameters of M. II super.	anteroposterior	.0315
	transverse	.039
Diameters of crown of superior canine	longitudinal	.094
	anteroposterior	.022
	transverse	.034
Diameters of crown of I. iii	vertical	.022
	transverse	.024

The numerous characteristic marks, show that this species is one of the most distinct of the genus. It is also one of the largest, being second only to the *C. anax.*

Coryphodon marginatus, sp. nov.

This is one of the smaller species, having nearly the dimensions of the *C. molestus.* It is only represented by the superior canine, first inferior premolar, and last superior molar of one individual found together by Mr. Wortman. Their size, mineral condition and degree of wear, render it probable that all belong to one individual.

The superior molar is of the oval type, without posterior shoulder. The posterior crest is therefore straight, and parallel with the anterior crest. Its inner extremity does not display the least tendency to form a V, as is seen in *C. elephantopus.* Its exterior extremity is widely separated from the external prominence of the anterior crest (cingulum). The latter displays, at its inner extremity, the peculiarity of a deep fissure of the anterior side, which nearly divides the crest, and partially isolates the internal tubercle. Adjacent to the fissure its crest is tuberculate. The posterior upper cingulum descends from the inner cusp to the basal cingulum. The basal cingulum is well developed on the anterior and interior sides of the crown, and on the posterior as far as the base of the inner cusp of the posterior crest, where it gradually fades out. Enamel wrinkled.

The superior canine is remarkable for its small size. The posterior face is a little the widest, and its bounding edges are sharp, but not expanded. There are no prominent ridges of the enamel. The anterior face is moderately wide. The first inferior premolar presents no peculiarities.

Measurements.

		M.
Diameters of M. III superior	anteroposterior	.028
	transverse	.038
	vertical	.019
Diameters of P-m. I inferior	anteroposterior	.015
	transverse	.009
Diameters of C. superior	anteroposterior	.014
	transverse posterior	.018

The superior molar is but little worn, and shows that the animal was just adult. The canine is more worn than the molar.

There are several characters which mark this species as distinct from those previously known. It is the only member of the genus which has a complete internal cingulum. The fissure of the anterior crest, if normal, is peculiar to this species. The superior canine is disproportionately small.

Besides the *Coryphodons* already mentioned, a number of more or less complete skeletons were obtained, some of which can be identified by comparison with those which are accompanied by teeth, and which are enumerated in the preceding pages.

METALOPHODON TESTIS, sp. nov.

The genus *Metalophodon* was described by me in 1872.* Since that time it has remained without further illustration of importance, as no good specimens of it have been obtained by any of my expeditions up to the present year. Thy material now at hand consists of the entire superior molar series of the right side, and the superior molars of the left side, in beautiful preservation. These display the characters on which the genus was proposed, *i. e.*, the conversion of the posterior external V of the second true molar into a transverse crest similar to that of the last true molar. It follows that the first true molar is the only one which exhibits this V. It also follows that in this genus the peculiarities of the dentition of *Coryphodontidæ* are carried further than in *Coryphodon*, where two molars display the V, and one the crest; or than in *Manteodon*, where all three have a V, and none the crest. The genera then stand in the order of evolution, *Manteodon, Coryphodon, Metalophodon.*

Char. specif.—The first superior premolar has lost its crown. The other premolars do not display any marked peculiarities. The internal cusps are well developed, and are most prominent posterior to the line of the apex of the exterior crest. They connect with the posterior cingulum by a broad ledge, but do not connect with the anterior cingulum. The two cingula nearly connect round the inner base of the crown on the third premolar.

The first true molar is well worn. The base of the posterior external V can be seen, and the anterior and posterior cingula. There is no internal cingulum. The second true molar is the largest of the teeth. It is subtriangular in outline, its external side forming with the posterior, a right angle. Its general character is much like that of the Coryphodontes, but it presents the remarkable exception which constitutes the character of the genus *Metalophodon*. The posterior crest does not include a V, but is straight, and consists of the same elements as the posterior crest of the third true molars, but differently proportioned. The part representing the anterior V is a cone, much shorter than the part corresponding to the posterior V. As there is a postero-exterior angle of the crown there is an oblique surface rising to this part of the crest, which represents the external face of the V. There is also a small tubercle at the angle, where a similar one is found in the corresponding tooth of *Ectacodon cinctus.* Altogether this tooth is like the posterior molar of *Coryphodon elephantopus*, with a more prominent postero-external angle added. The anterior and posterior basal cingula are well developed, the latter being strong interiorly to the point where it sends a branch upwards to the internal cusp. There is no internal cingulum.

The last superior molar is a transverse oval, more regular than usual in the species of *Coryphodon*, since the diameters of the internal and external portions are about equal. The characters of the posterior crest differ from

*Proceedings American Philos. Soc., 1872, p. 542.

those seen in the genus named in that the internal portion is much smaller than the external, having a small conic apex, distinct from that of the exterior portion. Its postero-external face is nearly vertical, and it diverges a little posterior to parallel with the anterior crest. The latter (the first cingulum) is elevated, and is widely separated externally from the posterior crest, to whose base it descends on the external extremity of the crown. The basal cingulum is present all round the crown except at the base of the posterior crest, and externally. It is narrow on the inner extremity of the crown. It sends upwards a strong branch to the apex of the internal cusp. The enamel of all the molars is strongly wrinkled, but is worn smooth wherever rubbed.

Measurements.		M.
Length of superior molar series		.179
" premolar series		.085
Diameters P-m. II	anteroposterior	.019
	transverse	.025
Diameters M. I	anteroposterior	.029
	transverse	.032
Diameters M. II	anteroposterior	.036
	transverse	.042
Diameters M. III	anteroposterior	.0285
	transverse	.041
	vertical	.015

The *Metalophodon testis* differs from the *M. armatus*, in the more triangular form of its penultimate superior molar. Its form is quite different from that of the last molar, while in *M. armatus*, the two teeth resemble each other closely. The species are of about the same size.

The individual from which the above description is taken is rather aged.

Dinocerata.

Bathyopsis fissidens Cope.

Bulletin U. S. Geolog. Survey, Terrs., Feb. 1881, 194.

A considerable part of the dentition of the mandible of this species was found in the Big-Horn bad lands. This includes an incisor tooth, which is quite characteristic, and renders it probable that the anterior parts of the jaws differ considerably from those of other *Uintatheriidæ*. The root is sub-round. The crown resembles a good deal that of the species of *Coryphodontidæ*. It is higher than wide and has a subacute apex. One edge of the crown is convex, and the other concave. The external face is concave in both directions, and has no ridges nor cingulum. The inner face is concave longitudinally and convex transversely. The convexity is median and has a longitudinal concavity on each side of it. No internal cingulum except a trace at the base of the concave edge. The edges are obtuse even when unworn, and the enamel is obsoletely rugulose.

Measurements of incisor.

		M.
Diameters of crown	anteroposterior	.012
	transverse	.020
	vertical	.020
Diameters of root	anteroposterior	.012
	transverse	.014

This incisor is very different from the kind seen in *Loxolophodon.* Mr. Osborne has shown that genus to have these teeth with compressed two-lobed crowns, a type unknown elsewhere among *Mammalia.**

PERISSODACTYLA.

In a paper on the "homologies and origin of the molar teeth of the Mammalia Educabilia," published in March, 1874,† I ventured the generalization that the primitive types of the Ungulata would be discovered to be characterized by the possession of five-toed plantigrade feet, and tubercular teeth. No Perissodactyle or Artiodactyle mammal was known at that time to possess such feet, nor was any Perissodactyle known to possess tubercular teeth. Shortly after advancing the above hypothesis, I discovered the foot structure of *Coryphodon,* which is five-toed and plantigrade, but the teeth are not of the tubercular type. For this and allied genera, I defined a new order, the *Amblypoda.* and I have published the confident anticipation that genera would be discovered which should possess tubercular (bunodont) teeth. This prediction has not yet been realized. I now, however, record a discovery, which goes far towards satisfying the generalization first mentioned, and indicates that the realization of the prophecy respecting the *Amblypoda,* is only a question of time.

In 1873,‖ I described from teeth alone, a genus under the name of *Phenacodus,* and although a good many specimens of the dentition have come into my possession since that date, I have never been able to assign the genus its true position in the mammalian class. The teeth resemble those of suilline Ungulates, but I have never had sufficient evidence to permit its reference to that group. Allied genera recently discovered by me, have been stated to have a hog-like dentition, but that their position could not be determined until the structure of the feet shall have been ascertained.§

In his recent explorations in the Wasatch Eocene of Wyoming, Mr. J. L. Wortman was fortunate enough to discover nearly entire skeletons of *Phenacodus primævus,* and *P. vortmani,* which present all the characters essential to a full determination of the place of *Phenacodus* in the system. The unexpected result is, that this genus must be referred to the order *Perissodactyla,* and that with its allies, it must form a special division of that order corresponding in the tubercular characters of its teeth with the

* A Memoir on *Loxolophodon* and *Uintatherium.* By H. Osborne.

† Journal of the Academy of Natural Sciences, Philadelphia.

‖ Palæontological Bulletin No. 17, Oct., 1873, p. 3; also, Report G. M. Wheeler, U. S. Engineers Expl. W. 100 Mer., iv, p. 174—1877.

§ Proceedings Amer. Philos. Society, 1881, p. 495.

bunodont or suilline division of the *Artiodactyla.* In this character, however, there is a closer gradation than in the case of the *Artiodactyla,* and it would scarcely be necessary to create such a group on that character alone. But the genus differs further from the *Perissodactyla* and approaches the *Proboscidia,* in the fact that the astragalus articulates with the navicular only, and by a universally convex surface, as in the Carnivora.

The astragalus resembles that of the latter order very closely, and differs from that of *Hyracotherium* and the nearest forms among the *Perissodactyla. Phenacodus* has moreover five well developed toes on all the feet, and was probably not entirely plantigrade. The cast of the brain case shows that the cerebral hemispheres were quite small and nearly smooth, and that the very large cerebellum and olfactory lobes were entirely uncovered by them. The bones of the two carpal rows alternate with each other, and there is a large third trochanter of the femur. The cervical vertebræ are opisthocœlous.

This group is then the ancestral type of the known *Perissodactyla,* that is of the horses, tapirs and rhinoceroses, and of the numerous extinct forms. Its systematic position may be schematically represented as follows:

Order PERISSODACTYLA; ungulate; digits of unequal lengths; carpal bones alternating; a postglenoid process. Astragalus with proximal trochlea, and without distal double ginglymus.

Suborder *Diplarthra;* astragalus distally plane or concave in one direction, and uniting with both navicular and cuboid bones; a third trochanter of the femur. The known families belong here.

Suborder *Condylarthra;* astragalus convex in all directions distally, only uniting with navicular bone; a third trochanter of femur.

Family *Phenacodontidæ.* Molar teeth tubercular; the premolar teeth different from the molars; five digits on all the feet.

Genera; *Phenacodus* Cope, and very probably *Catathlæus, Anacodon* and *Protogonia* Cope, and perhaps also *Anisonchus* Cope. These genera include fifteen species, all from the lower Eocene beds. I gave a synopsis of their differential dental characters in the Proceedings of the Philosophical Society, 1881, p. 487, where I included also the genus *Mioclænus.* I omit the latter from the family at present, as I believe it to be Artiodactyle.

PHENACODUS PRIMÆVUS Cope.

Parts of a dozen individuals of this species were obtained, and one almost entire skeleton in a block of soft sandstone. This includes nearly all parts of the four extremities, as well as the skull, from which but small portions are wanting.

Species of this genus, so far as determinable from the dentition, are numerously represented in Mr. Wortman's collection. About fifty individuals are referable to eight species. These present a great range in size, and some diversities of structure. They may be distinguished as follows:

I. Last inferior molar with oval outline; heel small; anterior inner cusp simple.

Size medium; length of true molars .025; depth of ramus at M. II, .018. *P. apternus.*

II. Last inferior molar wedge-shaped, with heel prominent; anterior inner cusp simple.

Large; true molars .041; P-m. IV .014; depth of ramus at M. II, .027. *P. primævus.*

Medium; true molars .027; depth at M. II .017; last molar smaller...... *P. vortmani.*

Smaller; true molars .022; depth at M. II .013; last molar elongate;.. *P. macropternus.*

Smaller; last four molars .027; P-m. IV .007; depth at M. II .013; last molar with short heel............................*P. brachypternus.*

Smallest; true molars .017; depth at M. II .012; heel long; cusps elevated..*P. zuniensis.*

III. Last inferior molar wedge-shaped, with prominent heel; anterior inner cusp double;

Least; last inferior molar .006; heel narrow; true molars (superior) .016. *P. laticuneus.*

Two other species have been described, the *P. sulcatus,* and *P. omnivorus* Cope. The former I suspect belongs to another genus. I am not now sure of the distinctness of the latter from *P. primævus.*

PHENACODUS HEMICONUS, sp. nov.

Represented by the posterior two superior molars of an individual intermediate in size between the *P. primævus* and *P. puercensis.* The posterior molar is peculiar in the very rudimental character of the posterior internal lobe, which is reduced to a mere wart on the cingulum. The posterior external tubercle is also rudimental, not exceeding the posterior inner in dimensions. The anterior tubercles, including the intermediate, are well developed, the internal exceeding the external. The cingulum is wide and crenate, and is only wanting on the external base of the crown. The penultimate molar does not differ so much from that of *P. primævus,* but the two internal cones are not so deeply separated at their base. The tubercles are all but little worn, and are conical in form, the external flattened on the external faces. Enamel wrinkled.

Measurements.		M.
Diameters of M. II	anteroposterior..................	.009
	transverse......................	.012
Diameters of M. III	anteroposterior..................	.010
	transverse......................	.013

The size of this species precludes the possibility of its identity with any of the other species described here.

PHENACODUS WORTMANI Cope. Bulletin U. S. Geol. Surv. Terrs. vi, 1881, p. 199. *Hyracotherium vortmani,* American Naturalist, 1880, p. 747.

Phenacodus puercensis Cope. Proceeds. Amer. Philos. Soc. 1881, p. 492.

An abundant species, represented by twelve mandibular rami in the collection, and by a nearly entire skeleton with perfect skull.

PHENACODUS APTERNUS, sp. nov.

Three rami, each of which supports the true molar teeth, indicate this species. The oval form of the posterior molar is due to the shortness of the heel, and the large size of the internal median tubercle, which projects inwards, giving a convex outline to the interior side of the crown. The external tubercles of all the true molars wear into crescents; and the anterior inner is more robust than the posterior inner.

PHENACODUS MACROPTERNUS, sp. nov.

This species is apparently rare, being represented by only one mandibular ramus, which supports the posterior three molars, and a possible second ramus with molars iv and v. The first and second true molars are much like those of *P. vortmani*, but the third is relatively larger, and has an especially elongate heel. In *P. vortmani* the last molar is constricted, and narrower than the penultimate. In *P. macropternus* there is a weak external, and no internal cingulum. The tubercles of the last two molars are quite regularly conical, while the external pair of the first molar, wear into crescents. Smaller than the *P. vortmani.*

PHENACODUS BRACHYPTERNUS, sp. nov.

Three mandibular rami are the only specimens of this species found by Mr. Wortman in the Big-Horn region. They all display the fourth premolar, which has the characters of this genus, as distinguished from *Mioclænus.* The species is materially smaller than the *P. vortmani*, and its last inferior molar is intermediate between those of the latter and the *P. apternus*, in form. Both the internal and external intermediate tubercles are very full, and give the tooth posterior width. The posterior or fifth tubercle is large, and gives the posterior outline of the crown a trifoliate form. The posterior median tubercles of the M. II and I, are well marked. The molars gradually increase in size forwards, and the fourth premolar is longer than any of them, and rather narrow. The heel of the P-m. III is short and wide. On the true molars a weak external cingulum. Enamel slightly wrinkled.

PHENACODUS ZUNIENSIS Cope. Proceeds. Amer. Philosoph. Society, 1881, p. 462.

Mr. Wortman obtained eleven mandibular rami of this species, in only one of which are the premolars preserved. Excepting the *P. laticuneus*, this is the smallest species of the genus. The molars have much the appearance of those of the Mesodont genus *Hyopsodus*, but may be distinguished by the size of the posterior median tubercle. The second true molar is the widest tooth, and the last molar is rather elongate, and its cusps are not exactly opposite to each other. The cusps of the molars are more elevated than in the other species, and those of the external side all have a distinctly crescentic section. The anterior inner cusp is narrow and simple. There is no cingulum of any kind.

This species was originally described from New Mexican specimens.

PHENACODUS LATICUNEUS, sp. nov.

This is the least species, and is represented by six superior molars and the last inferior molar in a fragment of the lower jaw. The latter tooth exhibits peculiar characters already mentioned. The superior molars differ from those known to belong to the *P. primævus* and *P. puercensis* in having a vertical fissure of the inner side which separates the bases of the two internal tubercles. This gives them some resemblance to the superior molars of the species of *Anisonchus*, but the important difference remains in the separation of the anterior inner tubercle from the intermediate tubercles. The three are confluent into a V in the genus last mentioned.

The external cusps of the superior molars are rather acute, and lenticular in section, their external sides forming a convex rib. There is no rib between the external sides. There is a strong anterior cingulum, which terminates externally in a low angular cusp. There is no cingulum on any other part of the crown. The second, third and fourth premolars have two external cusps, and much resemble the corresponding teeth in *Hyracotherium*. The second is longer than wide, and has an internal ledge ; the third is as wide as long and has a wide internal ledge ; the fourth is wider than long and has an internal, and two intermediate cusps, and an anterior and posterior cingulum. They all have a weak external cingulum, of which a trace exists in the true molars.

The last inferior molar has a double anterior inner cusp as in some *Mesodonta*, and the external anterior cusp is robust. All the cusps are conical and with round section, and their bases are close together. The outline of the base of the crown is almost an isosceles triangle with rather wide base in front.

Measurements.		M.
Length of last six superior molars		.0350
" true molars		.0160
Diameters of M. II	anteroposterior	.0055
	transverse	.0080
Long diameter base of P-m. II		.0050
Diameters P-m. III	anteroposterior	.0060
	transverse	.0060

ANACODON URSIDENS, gen. et sp. nov.

Char. gen. Known only from mandibles supporting molar teeth. Probably family *Phenacodontidæ*. Last inferior molar with heel. Crowns of molars without distinct cusps, but with a superior surface consisting of two low transverse ridges separated by a shallow valley. Unworn grinding surface with shallow wrinkles. Perhaps only three premolars.

Char. specif. Broken mandibular rami of two individuals constitute the basis of my knowledge of this species. It is of the size of the *Phenacodus primævus.* The last inferior molar is wedge-shaped with the very obtuse apex posterior. It displays two slight transverse elevations anteriorly which represent the usual cusps. Grinding surface generally nearly flat. The posterior half of the crown of the penultimate molar is flat, and is separated from the anterior half by a transverse groove. Its surface is marked by shallow branching grooves.

The molar preceding this one in the broken specimen is probably the first. It is possible from its slightly worn condition that it is the fourth premolar, but the form is that of a true molar. The surface of the crown is marked by shallow grooves not very closely placed. The three premolar teeth in advance of this tooth are broken off. Their bases are narrow. There are no basal cingula on the molars.

Measurements.		M.
Length of posterior true molars		.033
Diameters of M. III	anteroposterior	.015
	transverse	.010
Diameters of M. ? I	anteroposterior	.015
	transverse	.011
Depth of ramus at M. II		.030

The characters of the teeth of this species are something like that of some of the *Palæochœri* of the Miocene, and resemble more those seen in some of the bears.

Oligotomus osbornianus, sp. nov.

Char. gen. Dental formula; I. ?, C. ?, P-m. ? $\frac{4}{4}$; M. $\frac{3}{3}$. External faces of external lobes of superior molars separated by a ridge; anterior external cusp of cingulum little developed. Premolars of superior series different from true molars, with only one internal lobe. Fourth inferior premolar similar to the true molars. Cusps of inferior molars connected by diagonal ridges forming Vs. A diastema in front of the second premolar.

This genus is a good deal like *Lambdotherium*, so far as known. Its superior molars are much like those of *Aeoëssus*, and their intermediate and internal tubercles are those of *Hyracotherium.*

The two or three species known to me are of small size.

Char. spec. The true molars of both maxillary bones, with the fourth premolar of one side are preserved more or less perfectly, with four inferior molars on two fragments of the lower jaw.

The external tubercles of the superior molars are nearly erect, and have a lenticular section. The rib which separates their external faces is prominent, and terminates in a free apex. The base of each face is marked by a strong cingulum, but the posterior one is very short. There is a strong anterior basal cingulum, but no posterior or internal one. The anterior inner tubercle is larger than the posterior. The intermediate tubercles are sub-round, and are anterior to the transverse line of the interior ones. They do not join the latter excepting after very considerable wear. The external anterior cingular cusp is rather more prominent on the first than on the second true molar. The fourth superior premolar has a well marked external anterior cingular cusp, which is, however, low; and there is no ridge dividing the external faces of the external cusps. The single inner cusp is connected with the two external by two ridges, which diverge as they extend outwards. The anterior supports a tubercle close within the anterior external. There are strong anterior and posterior basal cingula and weak external and internal ones.

The third inferior premolar has a compressed ridge on the heel. The fourth premolar is like a true molar, with the anterior inner cusp well developed and elevated, and connected with the anterior and posterior external by oblique ridges. The inner posterior cusp is less conic in form than in the true molars, and the entire crown is somewhat contracted anteriorly. The true molars are characterized by the presence of a small median tubercle on the posterior border. There is a low external basal cingulum, which is wanting opposite the posterior cusp. Enamel generally smooth.

Measurements.		M.
Length of superior true molar series		.0210
Diameters of superior M. II	anteroposterior	.0080
	transverse	.0097
Diameters of P-m. IV	anteroposterior	.0085
	transverse	.0085
Length from inferior P-m. III to M. II inclusive		.0290
Diameters of P-m. IV	anteroposterior	.0080
	transverse	.0050
Diameters of inferior M. II	anteroposterior	.0075
	transverse	.0060
Depth of ramus between P-m. III and P-m. IV		.0150

As compared with the *O. cinctus*,* this species differs in its superior dimensions. The anterior inner cusp of the inferior molars is probably single, though the slightly worn condition of those teeth renders this point a little uncertain. In *O. cinctus* some of them at least are double.

This species was, to judge from the size of its teeth, about the size of a red-fox. The specimens of it above described were found by Mr. J. L. Wortman in the bad lands of the Big-Horn river, Wyoming. It is dedicated to my friend, Henry L. Osborne, of Princeton College, New Jersey.

SYSTEMODON TAPIRINUS Cope. American Naturalist, 1881, p. 1018.

Hyracotherium tapirinum Cope. Systematic Catalogue of the Eocene Vertebrata of New Mexico, 1875, p. 20. Report U. S. Geol. Surv. W. of 100th mer. Capt. G. M. Wheeler, iv. ii. p. 263. Pl. lxvi. figs. 12–16.

This species was abundant in Wyoming during the Wasatch epoch, jaws and teeth of more than twenty individuals having been brought by

* Annual Rept. U. S. Geol. Survey Terrs. 1872, p. 607.

Mr. Wortman from the Big-Horn. From these I learn that the dental system is different from that characterizing the species of *Hyracotherium.* There is no diastema posterior to the superior canine, while in the latter genus there are two. Anterior to the canine there is a considerable one in the *Hyracotherium.* This part is not preserved in any of the specimens of *S. tapirinum.* The characters mentioned have induced me to separate the latter as type of a distinct genus, *Systemodon.* An examination of the figures and descriptions given by Dr. Lemoine of his *Pachynolophus gaudryi* found by him in the neighborhood of Reims, shows that it belongs to the genus *Hyracotherium.* It is therefore distinct from either of the species of *Systemodon,* and is to be compared with the *H. craspedotum* of the Wind River country, with which it agrees in size.

SYSTEMODON SEMIHIANS, sp. nov.

This species was also abundant in the Big-Horn region, jaws and teeth of sixteen individuals having been obtained. Its dimensions are a little smaller than those of the *S. tapirinus,* especially as to the premolar teeth. There is also a short postcanine diastema, which is not seen in the *S. tapirinus.*

The proportions of the maxillary series are represented by a left maxillary and premaxillary bone, with all the teeth in place, but the crowns lost from the first premolar anteriorly. The crowns of the true molars are somewhat worn, so I confine the description of these to the premolars. The third and fourth have considerable transverse extent, the latter being wider than long. The second has scarcely any internal tubercle, but only a low postero-internal heel. The internal tubercle of this tooth is large in *S. tapirinus.* The crown has two cusps, the posterior lower. The last two premolars have two external cusps close together. They have also an anterior external cingular lobe, as in the true molars. There is a posterior external basal lobe in the third premolar, but none or a rudiment on the fourth. No internal cingulum on the premolars. The superior true molars, although worn, show a prominent anterior external basal lobe, and no complete internal cingulum The base of the crown of the first premolar is narrow antero-posteriorly, and it has two roots as in *S. tapirinus.* It is in close contact with the second premolar, and is separated from the base of the canine by a space a little less than its own anteroposterior diameter, and less than the diameter of the canine. The base of the crown of the latter shows that it is not a large tooth, and has a wide lenticular section. The base of the external incisor is rather large, and is compressed.

Measurements of superior teeth..		M.
Total length of superior series		.0720
" " " molar "		.0310
" " " premolar "		.0250
Diameters base of canine	anteroposterior	.0055
	transverse	.0040

Measurements of superior teeth.

		M.
Length of base of P-m. I		.0040
Diameters P-m. III	anteroposterior	.0070
	transverse	.0078
Diameters P-m. IV	anteroposterior	.0070
	transverse	.0090
Diameters M. III	anteroposterior	.0100
	transverse	.0125

Some superior molars in better condition than those last described, exhibit the following characters. The intermediate tubercles are fused with the internal, forming a continuous cross crest, but their apices are distinguishable. The external cusps are subconical and are well separated. The anterior and posterior cingula are strong, the external is weaker, and it is wanting from the posterior part of the internal base of the crown.

A portion of a mandibular ramus, supporting six molars, presents the following characters. The teeth are a little smaller than those of *S. tapirinus*, the reduction being especially visible in the premolars. The cones of the crowns are more distinctly separated by notches than in that species, and are quite distinctly conic. The anterior ledge of the true molars is distinct, and there is a median posterior tubercle of the first two, which is represented by the wide crenate-edged heel of the third true molar. The anterior-internal cusps of the last two molars is double or bilobed ; that of the first is last. The anterior cones of the fourth premolar are subequal, and the posterior external cone is elevated. There is a trace of the posterior internal. There is also an anterior ledge. The heel of the third premolar rises to a median blade and posterior cusp. The anterior cusp is elevated and compressed, and supports a small internal lateral cusp. The base of the crown of the third premolar is elongate. All the teeth are rather compressed, and there is only a trace of an external cingulum.

The ramus is compressed and moderately deep. The dental foramen is large, and its superior border is on a level with the posterior base of the crown of the third true molar. Its inferior base is in line with the base of the crown of the second true molar.

Measurements of mandible..

		M.
Length of last six molars		.0530
" true molars		.0310
Diameters third premolar	anteroposterior	.0065
	transverse	.0040
	vertical	.0052
Diameters second true molar	anteroposterior	.0092
	transverse	.0060
	vertical	.0062
Diameters third true molars	anteroposterior	.0120
	transverse	.0060
Depth of ramus at P-m. III		.0170
Depth of ramus at front of M. III		.0220

The nearest ally of this species outside of the genus *Systemodon* is probably the *Hyracotherium craspedotum* Cope. This species was brought from the Wind River bad lands, and does not occur in the Big-Horn collection. It is about the size of the *S. semihians*, but is a true *Hyracotherium*, with a diastema behind the first premolar. The strong cingulum which characterizes it is not found in the *S. semihians*, and the inferior molars are wider and more robust.

HYRACOTHERIUM CRASPEDOTUM Cope.

Bulletin U. S. Geol. Survey, Terrs., 1881, p. 199. American Naturalist, 1880, 747.

The dentition of this species is in its dimensions and proportions intermediate between the two species of *Systemodon*. Its three premolars equal four of those of the *S. semihians*, while the molars of the two species are about equal.

A specimen having the proportions of the *H. craspedotum* was found by Mr. Wortman on the Big-Horn, but unfortunately it does not exhibit the characteristic cingula of the two dental series. The second superior premolar, like that of *Systemodon semihians* has no internal tubercle. It is not certain whether there is any diastema posterior to the first superior premolar. I therefore cannot yet ascertain whether this specimen represents an undescribed species of *Systemodon* or *Hyracotherium*, or a strong variety of the *H. craspedotum*. The accompanying inferior true molars are intermediate in size between those of the latter species and the *H. vasacciense*.

HYRACOTHERIUM VASACCIENSE Cope.

This species differs from the *H. venticolum* in its deep mandibular ramus. A single specimen from the Big-Horn presents the same proportions. The posterior inferior molar is rather short.

HYRACOTHERIUM VENTICOLUM Cope.

Bulletin U. S. Geol. Survey, Terrs., 1881, 198.

Fifteen individuals of this species are included in the collections.

HYRACOTHERIUM ANGUSTIDENS Cope.

This was a very abundant species. Mr. Wortman's collection contains jaws and teeth of twenty individuals sufficiently well preserved for identification, and a large number of other pieces of jaws, etc., which may be reasonably inferred to belong here.

In my report on the Wind River collection*, I noticed three varieties of this species, which differ in the depths of the ramus at the line of junction of the fourth and fifth molars. The numbers are 12, 14, and 15.5 mm. respectively. The lengths of the first true molar also vary from 7 to 6.5 and 7.5 mm. respectively. The last true molar measures in all 10.0 mm. The majority of the Big-Horn specimens agree with the second variety, but two others occur, one a little smaller, and the other a little larger than the average. The former measures ; length of last molar .0090 ; of

* Bulletin U. S. Geol. Survey Terrs. vi, 1881, p. 198.

first molar .0067; depth of ramus at M. I, .0120. The dimensions of the larger variety are: length of M. iii, .110; of M. i, .0067; depth ramus .0165. The New Mexican forms originally described, exhibit combinations of several of these measurements.

PACHYNOLOPHUS VENTORUM Cope.

Bulletin U. S. Geol. Surv. Terrs., 1881, p. 197. American Naturalist, 1880, p. 747.

One mandibular ramus.

PACHYNOLOPHUS POSTICUS, sp. nov.

Both rami of a mandible represent this large species. They are somewhat injured, and the crowns of five of the molars only can be distinctly seen. The latter display the characters seen in the *P. ventorum* and other species of the genus. The transverse crests are well characterized, and the valley between them uninterrupted. They are closed at the inner extremity by a low ridge nearly at right-angles with the cross crest posterior to them, as in the species of *Rhinocerus*. The anterior of these bounds an anterior ledge, which is quite large on the last true molar. The latter has a rather narrow, but prominent heel, which rises posteriorly. The fourth premolar has an anterior ledge, and wide heel with a diagonal crest which is median in front. The third premolar is similar, but smaller. The only cingulum is seen on the anterior part of the external side of all the true molars.

Measurements.		M.
Length of crowns of posterior six molars		.0700
" "	true molars	.0440
Diameters P-m. iv	anteroposterior	.0095
	transverse	.0070
Diameters M. ii	anteroposterior	.0130
	transverse	.0095
Diameters M. iii	anteroposterior	.0180
	transverse anteriorly	.0092
Depth ramus at P-m. ii		.0280
" "	M. ii	.0310

ARTIODACTYLA.

MIOCLÆNUS BRACHYSTOMUS, sp. nov.

Char. gen. The typical specimen of this species is represented by all the molar dentition of both jaws excepting the anterior three superior premolars. It also includes pelvis, femur, the distal parts of the tibia and fibula, the entire tarsus and the proximal portion of the metatarsus.

The dental characters conform precisely to those of the other species of *Mioclænus*. There is but one internal cusp of the superior true molars, and the intermediate tubercles are present. The fourth premolar has one external and one internal lobe. The inferior premolars have simple crowns without interior cusps or tubercles.

The characters of the tarsus are of much interest, and demonstrate that *Mioclænus* is the oldest type of artiodactyle yet discovered, and that it is not altogether primitive in some of its characters. Members of this order have been found by Cuvier in the upper Eocene (*Dichobune, Anoplotherium,* etc.), but none have been determined as yet from the Suessonian of America. A species represented by teeth from the Siderolithic beds of Switzerland have been referred to *Dichobune* (*C. campichii* Pict.); but dental characters alone are not sufficient to distinguish that genus from *Phenacodontidæ**. Dr. Lemoine found astragali of a small Artiodactyle in the Suessonian of Reims, and has referred them to his supposed Suilline *Lophiochœrus peroni*. I have reported an astragalus from the Wind River formation of Wyoming Territory, which is almost exactly similar to those found by Lemoine. The specimen now described, enables me to characterize with some degree of completeness this interesting form, which precedes in time all the known American *Artiodactyla*.

The characters of the tarsus are typically those of the order *Artiodactyla*. The astragalus exhibits a distal trochlea which is continuous with the sustentacular facet, and which articulates with both cuboid and navicular. The distal portion of the fibula is free from the tibia, and its shaft becomes very slender. It is possible that a more perfect specimen would display it as continuous. Its distal extremity articulates with the ascending tuberosity of the calcaneum. The cuboid facet of the latter is narrow. The cuboid and navicular bones are distinct from each other and from the cuneiforms. The mesocuneiform is shorter than the ectocuneiform, and *is coössified with it*. There are probably four metatarsals. The median pair are distinct, but appressed, their section together, sub-circular. The lateral metatarsals are slender, the external one is wanting, but its facet on the cuboid bone is very small.

These characters are in general similar to those of the genus *Dichobune*, but Cuvier † does not state whether the cuneiforms are coössified in that genus or not. They are united in Anoplotherium.‡ *Mioclænus* differs from *Dichobune* in the presence of but one internal tubercle of the superior molars, and in the single external tubercle of the superior premolars. Both genera are referable to a family to be distinguished from the *Anoplotheriidæ* by the presence of the external digits. This has been already named by Gill the *Dichobunidæ*.

Char. specif. The bones are about two thirds the size of those of the Javan musk-deer (*Tragulus javanicus*). The transverse extent of the superior true molars is greater than the anteroposterior. The composition of the last molar is like that of the others. The external tubercles are lenticular in section and the emargination which separates them is apparent on the external face of the crown. The intermediate tubercles are small, and are entirely distinct from the large external tubercle. There

* See American Naturalist, 1881, December.

† Ossemens Fossiles, v, p. 183.

‡ Gaudry Enchainements d. Regne Animal, p. 147.

is a distinct cingulum which is only wanting from the inner base of the crown. The fourth superior premolar has a trilobate outline of the base of the crown, the base of the inner lobe being contracted where it joins the external part of the crown. The internal tubercle is conic, with a prolongation outwards and forwards. Intermediate tubercle not distinct. External, anterior, and posterior cingula.

In the inferior true molars the external tubercles wear into crescents. The crowns increase in size posteriorly, which is the reverse of the order of enlargement in some of the other species of the genus. The fifth tubercle of the last molar is rather small, but is well distinguished from the other cusps. The internal median cusp is small, the external median. large. The premolars are not so much larger than the true molars in this as in the typical species of the genus. The second and third are more elongate on the base than the fourth. The latter is also less compressed than those that precede it. It has a short wide heel, and a small anterior basal tubercle. In the second and third premolars the posterior edge of the principal cusp is sharp, and descends gradually to the posterior base of the crown. Both have small acute anterior basal tubercles. The first inferior premolar is one-rooted, and has a simple crown directed somewhat forwards. It is separated from the second by a short space. The teeth anterior to this point are lost.

Measurements.

		M.
Length posterior four superior molars		.0182
Diameters P-m. IV	anteroposterior	.0040
	transverse	.0042
Diameters M. II	anteroposterior	.0043
	transverse	.0060
Diameters M. III	anteroposterior	.0040
	transverse	.0060
Length of inferior molars		.0330
" " premolars		.0192
" " P-m. III		.0055
" " P-m. IV		.0045
Diameters M. I.	anteroposterior	.0040
	transverse	.0033
Diameters M. III	anteroposterior	.0052
	transverse	.0040
Depth of ramus at P-m. I		.0047
" " M. II		.0090
Length of astragalus		.0102
Width of trochlea behind		.0048
Diameters of cuboid	length	.0070
	width of middle	.0040

MIOCLÆNUS ETSAGICUS, sp. nov.

This, the largest species of the genus, is represented by the two rami of a mandible of an adult animal in good preservation. In their robust character the premolar teeth resemble those of the *M. turgidus*, but are not relatively so large, nor is the last true molar relatively so small, as in that species. The heel of the third premolar is obsolete, and that of the fourth is a wide cingulum. Neither exhibit an anterior basal tubercle, and in both the principal cusp is stout. The true molars widen posteriorly to the anterior part of the last molar. The latter contracts rapidly to a narrow heel. The tubercles are all subconic, and the median ones of the last molar are small. There are no cingula, and the enamel is smooth.

The ramus is not robust, and is of moderate depth. Its inferior border rises below the middle of the last molar tooth, and posteriorly. There is a "mental" foramen below the contact of the fourth premolar and first true molar.

Measurements.		M.
Length of bases of six posterior molars		.047
" " three premolars		.024
" " P-m. II		.009
" " P-m. IV		.008
" " P-m. IV		.005
Diameters basis of M. II	anteroposterior	.0075
	transverse	.0070
Diameter basis M. III	anteroposterior	.0084
	transverse	.0070
Depth of ramus at P-m. II		.0080
" " M. II		.0140

This species is named from the Crow Indian name of the Big-Horn river, *Etsagie*.

Concluding Remarks.

The paleontologist who has examined the preceeding list, will readily perceive that it represents fully the Wasatch fauna, with little admixture of earlier or later forms. The only genus which belongs to the Bridger or middle Eocene, which occurs in the Big-Horn basin, is *Pappichthys*, The characteristic Bridger genera *Hyrachyus*, *Palæosyops*, *Uintatherium*, and the *Tillodonta*, are absent, and their place is taken by *Phenacodus*, *Hyracotherium*, *Coryphodon* and *Tæniodonta*, as in New Mexico. Several genera are, as elsewhere, common to the two horizons, and two species cannot be distinguished in the parts preserved. Such as *Hyopsodus paulus* and *H. vicarius*. A closer comparison may be made with the Wind-River group, on which I published a report in the Bulletin of the U. S. Geological Survey of the Territories.* The following genera found in that formation have not been obtained from the Big-Horn. *Protopsalis*, *Lambdotherium*, *Palæosyops*, *Hyrachyus*.† Genera of the Big-Horn not obtained from the Wind-River: *Cynodontomys*, *Anaptomorphus*; *Mesonyx*,

*1881, Feb. p. 201.

† Since making my report on the Wind-River fauna, I have found the anterior part of the lower jaw of a species of this genus.

Deltatherium, Oxyæna; Manteodon, Ectacodon, Metalophodon; Anacodon, Oligotomus, Systemodon; Mioclænus. Three of these genera have been found in the Bridger, and five have been obtained in the lower Eocene of New Mexico. Five of the genera are new to science.

An especial feature of the Big-Horn collection, as distinguishing it from those brought from other regions of the Wasatch formation, is the presence of numerous species of *Phenacodus,* and of new and rare species and genera of *Coryphodontidæ.*

II. The Fauna of the Catathlæus Beds or Lowest Eocene of New Mexico.

A number of new species and genera from this horizon were described in my Paleontological Bulletin No. 33. The present paper adds a few to this list. Up to the present time no species of *Coryphodon,* and but few specimens of *Hyracotherium* have been discovered in this formation, thus exhibiting a marked contrast to the Wasatch beds. The predominant genus is *Catathlæus,* which is represented by one very abundant species. The genera of *Creodonta* are mostly distinct from those of the Wasatch. The Diplarthrous Perissodactyla, so numerous in the Wasatch, are rare here. The genus which is well represented in both formations, is *Phenacodus;* and *Mioclænus* occurs in both. *Mesodonta* are much less numerous than in the Wasatch, and *Amblypoda* have not yet certainly been found.

This is the only Tertiary formation where the Laramie genus *Champsosaurus* occurs. It is represented by three species.

Psittacotherium multifragum Cope.

American Naturalist, 1882, p. 156, Jan. 25th.

An interesting new form of this sub-order has been found in the *Catathlæus* beds (probably the Puerco formation) of New Mexico. It differs widely from the two genera hitherto known, *Anchippodus* and *Tillotherium.* Owing to the absence of the superior dental series, it is not possible to be sure which is the canine. The inferior dental formula may be therefore written, I. 2; C. 1; P-m. 3; M. 3; or I. 3; C. 0; P-m. 3; M. 3; or I. 3; C. 1; P-m. 2; M. 3. The first and second incisors are large and rodent-like, growing from persistent pulps; the second are the larger. The third, or canines, are small and probably not gliriform. There is no diastema. The first premolar (or canine) has a compressed crown with two cusps placed transversely to the jaw axis, and has a complete enamel sheath, and probably two roots. The succeeding tooth is also transverse, and is two-rooted, judging from the alveolus. The first and second true molars are rooted, and the crown consists of two transverse separated crests, each partially divided into two tubercles. On wearing, the grinding surface of each assumes the form of a letter B with the convexities anterior. The last inferior molar is injured. The rami are short, and the symphysis deep and recurved.

Specific characters. The base of the coronoid process is opposite the junction of the second and third true molars. The ramus is deep and moderately stout. The enamel of the first incisor does not extend below the alveolar border, at the internal and external faces, and does not reach it at the sides. It has a few wrinkles on the anterior face. The anterior enamel face of the second incisor is thrown into shallow longitudinal grooves with more or less numerous irregularities from the low dividing ridges. There is a deeper groove on each side of the tooth, and there are about a dozen ridges between these on the anterior face. Both cusps of the first premolar are conic, and the external is the larger. The second true molar is a little smaller than the first. The enamel of the premolars and molars is smooth, and there are no cingula.

Probable length of dental series, .0750; diameters of I. I: anteroposterior, .0120, transverse; .0066; diameters I. 2: anteroposterior, .0160, transverse, .0115; diameters P-m. I: anteroposterior, .0072; transverse, .0130; diameters of M. ii. anteroposterior, .0090, transverse, .0090. Length of true molars, .0038; depth of ramus at M. ii, .0360.

The short deep jaws of this animal must have given it a very peculiar appearance, not unlike that of a parrot in outline.

PSITTACOTHERIUM ASPASIÆ, sp. nov.

Represented by two mandibular rami of two individuals, one adult, the other nearly so, but with the last inferior molar not fully protruded. The latter specimen must be used for description, as it presents two molar teeth, while the other specimen has lost them.

The most obvious difference from the *P. multifragum* is its inferior size, which can be readily perceived from the measurements given. The posterior crest of the molars appears to have less transverse extent than in the larger species. This crest in the last inferior molar has a curved crenate edge, with a small conic tubercle at its external extremity. The anterior crest consists of two conic tubercles, whose apices converge, but whose bases are closely appressed, and only distinguished by a superficial fissure. The valley between the crests is uninterrupted. The preceding molar is larger, and its posterior crest is like that of the lost molar. The apex of the anterior crest is broken off.

The ramus deepens rapidly forwards, and contains the enormous alveolus for the incisors. The coronoid process leaves the alveolar border at the line separating the last two molars, or, in the smaller specimen, a little anterior to this point, and is quite prominent. The masseteric fossa is well marked, but shallows gradually anteriorly and inferiorly.

Measurements.

	M.
No. 1.	
Depth of ramus at penultimate molar	.027
Width of last molar anteriorly	.008
Length of crown of do.	.009
No. 2.	
Depth of ramus of penultimate molar	.029
" " at P-m. ii	.043
Length of five consecutive alveoli	.047

From the Puerco bed of N. W. New Mexico.

TRIÏSODON HEILPRINIANUS, sp. nov.

This species may be readily recognized as smaller than the *T. quiviren-sis*, and as having the anterior inner cusp of the inferior true molar of larger proportions than in the corresponding teeth of the latter species. It is only represented in my collection by a portion of a lower jaw, which supports only one well preserved molar. As the fourth premolar is not present, it is not positively ascertained that the species does not belong to *Ictops*.

The anterior cusp is very low, and is nearer the inside than the middle of the anterior border. The principal anterior cusps are opposite, and the external is a little the larger. The heel is larger than the basis of the anterior cusps, and has convex borders. Its internal border supports three tubercles, and the external border rises into a cutting lobe with lenticular section. Enamel smooth. No cingula, but the external base is injured.

Measurements.			M.
Diameters of inferior molar	vertical	of cusps	.0070
		of heel	.0052
	anteroposterior		.0110
	transverse		.0065

Puerco beds of New Mexico.

Dedicated to my friend, Professer Angelo Heilprin, of Philadelphia.

SARCOTHRAUSTES ANTIQUUS, gen. et sp. nov.

Char. gen. We have in evidence of the characters of this genus, the last two superior molars, the last one lacking the crown; and parts of both mandibular rami, which exhibit teeth as far posteriorly as the first true molar inclusive; all belonging to one individual. A part of a skeleton of a second individual, which includes a fragment of lower jaw, belongs probably to this species.

Sarcothraustes resembles both *Amblyctonus* and *Mesonyx*, but it is probably to the latter genus that it is allied. The last superior molar is transverse, much as in *Oxyæna*. The crown of the penultimate is subtriangular and transverse. It has two external subconic cusps and a single internal lobe, whose section on wearing is a V, each branch of the face extending to the base of the corresponding external tubercle. There are three small inferior incisors, and a large canine. There are probably only three inferior premolars, the first one-rooted. The crown of the second has no heel. The crown of the third has a short wide heel. The crown of the first true molar consists of an anterior elevated cone and a posterior heel. The latter is wide, having a posterior transverse, as well as a longitudinal median keel. The fragments of the supposed second individual include two large glenoid cavities with strong preglenoid crests, as in *Mesonyx*.

As compared with *Mesonyx*, this genus differs in the V-shaped crest of the penultimate superior molar; in *Mesonyx* it is represented by a simple cone. The last superior molar of *Mesonyx* is triangular and not transverse, but the composition of the crown of that tooth in *Sarcothraustes* must be known before the value of this character can be ascertained. If the view that *Sarcothraustes* has but three inferior premolars be correct, this character distinguishes it from *Mesonyx*, as do also the transversely expanded heels of the molars. The family *Mesonychidæ* may be for the present regarded as embracing the three genera of *Sarcothraustes, Mesonyx* and *Dissacus*.*

Char. Specif. The penultimate superior molar has a strong posterior cingulum which commences within the line of the internal bases of the external cusps, and rises into considerable importance behind the internal cusp. There is also an anterior cingulum which does not rise internally, and which is continuous with a strong external basal cingulum. The latter passes round the posterior base of the posterior cone, and runs into the posterior branch of the internal V. The posterior cone is smaller than the anterior cone, and its apex is well separated from the latter. The appearance of this tooth is something like that of a carnivorous marsupial.

The symphysis mandibuli slopes obliquely forwards, and is united by coarse suture. The ramus is stout and deep, as compared with the size of the molar teeth. The roots of the teeth are relatively large, especially those of the first two premolars. The crown of the canine is lost. The first premolar points forwards, nearly parallel with the canine, and divergent from the second premolar. The crown of the second premolar is small and subconic, and has a rudimental heel, and no anterior basal tubercle. The first true molar resembles considerably that of *Mesonyx*. There is a small anterior basal tubercle on the inner side of the principal cusp. The expansion of the heel is transverse only, there being no longitudinal lateral edges or tubercles. The enamel is obsoletely, rather coarsely wrinkled. There are two rather large mental foramina; the posterior below the anterior root of the first true molar, and the anterior below the posterior root of the second premolar.

Measurements.

		M.
Diameters of superior M. ii	anteroposterior externally	.015
	transverse	.024
Anteroposterior diameter of base of M. .iii		.0095
Anteroposterior diameter base of crown of inferior canine		.020
Length of bases of three inferior premolars		.038
Diameters inferior M. i.	anteroposterior	.019
	transverse	.0095
	vertical	.0110
Depth of ramus at P-m. iii		.0520
Width " "		.022

* American Naturalist, Dec., 1881.

CHAMPSOSAURUS PUERCENSIS, sp. nov.

I have already announced the discovery * of this Laramie genus in the Puerco beds of New Mexico, and described a species, *C. australis*, from that region. I now introduce two additional species from the same horizon. One of these is represented by a number of fragments which include three dorsal and four caudal vertebræ of apparently one individual. They represent an animal of larger size than any of those heretofore referred to *Champsosaurus*, excepting the *C. vaccinsulensis*. In all of the vertebræ the neural arch is more or less coössified with the centrum, and the animal had probably reached its full size.

One of the dorsal *centra* is split vertically and longitudinally, and shows the structure already figured by Leidy in the *Ischyrosaurus antiquus* † Leidy. The surface exposed displays two diagonal lines of fissure crossing each other at right angles. They indicate clearly the mode of origin of this amphiplatyan type of centrum. The centrum is first deeply amphicœlous as in the Theromorphous reptiles of the Permian. The conical cavities are filled by the ossification of the remaining portions of the notochord, forming a conical body which always remains distinct from the remainder of the centrum.

The articular faces of the dorsal centra are a little wider than deep, and the depth about equals the length of the body. They are not nearly so depressed as those of *C. australis*, and their outline is different. This is wider above and narrows below ; in both *C. australis* and *C. saponensis* the inferior outline is part of a circle. None of the dorsals preserved are keeled below. There is a fossa below the diapophysis which has a subvertical posterior boundary. The general surface (somewhat worn) does not display wrinkles near the articular faces. An anterior dorsal has a short compressed diapophysis with a narrow figure 8 articular surface, and its superior border is in line with the roof of the neural canal. The anterior caudals have subround articular faces ; the posterior are more oval and the bodies compressed. With greater compression, the length increases.

Measurements.

		M.
Diameters of an anterior dorsal	anteroposterior	.025
	vertical	.025
	transverse	.030
Height of costal facet of do.		.021
Diameters neural canal do.	vertical	.007
	transverse	.009
Diameters anterior caudal	anteroposterior	.024
	vertical	.021
	transverse	.021
Diameters posterior caudals	anteroposterior	.025
	vertical	.018
	transverse	.018

* American Naturalist, 1881. p. 669.

† Transac. Amer. Philos. Soc. 1860.

The typical specimen was found by Wm. Baldwin near the Puerco river, west of the Nacimiento mountain, New Mexico, in the typical locality of the Puerco formation.

Champsosaurus saponensis, sp. nov.

Represented in my collection by six cervical and several dorsal vertebræ, one only of the latter with well preserved centrum, parts of ribs, and various other bones, whose reference is not yet certain.

The cervical vertebræ include the os dentatum or centrum of the atlas. This shows its streptostylicate character in its distinctness from both the centrum and the free hypapophysis of the axis. Nevertheless it is more Crocodilian than Lacertilian in form. Its anterior face is transverse, with a little lip carrying forwards the floor of the neural canal, below which the face is leveled posteriorly. The inferior surface is narrow and transverse, as though adapted for the anterior part of the hypapophysis of the axis. At each side it terminates in a prominent tuberosity, as though for the attachment of a cervical rib as in the Crocodilia. The anterior face is bounded posteriorly by a transverse groove which terminates in a fossa on each side. The posterior articular face of the os dentatum is wider than deep. The lateral angles of the superior face are rounded, and its median portion is concave.

The axis displays a large facet for the hypapophysis. Behind it the inferior middle line is not keeled, but is coarsely wrinkled longitudinally. The posterior edge of the hypapophysial facet is the most prominent part of the inferior surface. The posterior articular face is deeper than wide. This is true of the faces of all the cervical vertebræ. The latter gradually increase in size posteriorly, and the dorsals become larger. The articular faces of all the centra are regularly rounded and not contracted below. The five cervicals are strongly keeled below ; the keel of the third centrum being split up anteriorly into narrow ridges. On the sixth the keel is more prominent and acute. The dorsal is not keeled. A trace of the parapophysis appears low down on the fourth cervical ; it rises and becomes prominent as a round tuberosity on the fifth and sixth. It appears on the superior edge of the centrum of the dorsal vertebra, where it is connected with the diapophysis. It is near the middle of the length of the centrum, and not near the anterior border as in *C. australis.*

The surfaces of the vertebræ are very smooth excepting where thrown into coarse wrinkles near the borders of the articular faces and near the hypapophysis. The edges of the articular faces are somewhat revolute on the sides in the cervicals, but not on the dorsal. They are impressed in the centre to a point, most strongly so as we pass forwards in the series. There is a fossa below the space anterior to the parapophysis of the dorsal vertebra, which is abruptly bounded below by a horizontal angle. A separate neural spine perhaps of a cervical vertebra, has the following form. It is stout, and is contracted rather abruptly at the apex from behind forwards. The section is broadly lenticular, angulate in front, and truncate behind. The posterior face has several longitudinal wrinkles, including a median raised line, and there are some more irregular wrinkles on the sides.

Measurements of vertebræ.			M.
Anterior face of os dentatum	width		.025
	depth (oblique)		.012
Posterior face of os dentatum	width		.020
	depth		.018
Length os dentatum above			.014
Diameters axis	posterior face	depth	.022
		width	.020
	length		.0185
Hypapophysial facet os dentatum	depth		.008
	width		.014
Diameters fourth cervical	length		.022
	anterior	depth	.0225
		width	.022
Diameters sixth cervical	length		.0215
	anterior	depth	.0245
		width	.0235
Spaces between parapophysis and diapophysis of do			.0040
Diameters of dorsal	length		.0265
	anterior	depth	.0260
		width	.0265
Height of neural spine of ?, from postzygapophysis			.0210
Anteroposterior width of do. at base			.0100

The portions of ribs are separated heads and shafts. The former are double and therefore cervical, and are quite large. If the shafts belong to them, the neck of this species must have been wide. The shafts are slender and are of dense bone. The section is oval at the middle, but towards the distal extremity becomes flattened and grooved and delicately line ridged on one side. The extremities of the long bones are without condyles but have concave surfaces like those of the ribs. The bodies are robust and angular. They may be abdominal ribs of unusual stoutness. From the Puerco beds, D. Baldwin.

Stated Meeting, January 6, 1882.

Present, 8 members.

President FRALEY in the Chair.

Letters of acknowledgment were received from the Anthropological Institute of Great Britain and Ireland (XV, 3 ; 107, 108) ; and the Linnean Society, London (105, 106).

Letters of envoy were received from the Academie der Wissenschaften, Wien, Sept. 30, 1881; Bibliotheca Nazionale Vittorio Emanuele, Roma, Oct. 20, and the Meteorological Office, London, December, 1881.

A letter asking exchange of publications was received from the U. S. Geological Survey, Washington.

A circular letter asking exchange of publications was received from the Société des Sciences de Finlande, Helsingfors, Dec. 10, 1881.

A circular letter, dated December, 1881, was received from Prof. Dr. Rüdinger, in behalf of the Comité für die Jubiläumsfeier des Herrn Geheimraths Dr. Th. v. Bischoff.

Donations for the library were received from the Royal Society of New South Wales; the Academies at St. Petersburg, Berlin, Vienna and Turin; Observatories at St. Petersburg, Turin, and the Cape of Good Hope; Bibliotheca Speculæ Pulcovensis, in St. Petersburg; Imperial Society of Naturalists, Moscow; Naturforscher Verein, Riga; German Geological Society, Berlin; Zoologischer Anzeiger, Leipsig; Verein für Erdkunde, Halle a-S; Verein für Naturkunde zu Cassel; Zoological Garden, Frankfurt; Oberhessische Gesellschaft, Giessen; M. Hugo von Meltzel; Royal Venetian Institute; Royal Lombardy Institute; Museum of Natural History, and Revue Politique, Paris; Society of Commercial Geography, Bordeaux; Revista Euskara, Pamplona; Flora Batava, Leyden; Royal Asiatic, Royal Astronomical, Royal Geographical, Meteorological, Geological, Zoological, Linnean and Antiquarian Societies, and the Victoria Institute, Meteorological Office, and Nature, London; Mr. John Evans, F.R.S.; Royal Geological Society, Dublin; Mr. Horatio Hale, Clinton, Canada; American Oriental Society, and American Journal of Science, New Haven; Dr. J. S. Newberry, New York; Franklin Institute, and the "American," Philadelphia; American Chemical Journal, Baltimore; U. S. Geological Survey, Washington; "The Virginias," Staunton, Va.; American Antiquarian, Chicago; and the National Museum, Mexico.

The death of Dr. Isaac Israel Hayes, on Dec. 17, 1881, was announced.

Dr. Brinton was appointed to prepare an obituary notice of the deceased.

The death of Dr. John W. Draper, on Jan. 4, 1882, aged 71 years, was announced.

Dr. Hammond was appointed to prepare an obituary notice of the deceased.

An obituary notice of Mr. W. Milnor Roberts was read.

Prof. Cope presented a fossil lower jaw from the Colorado basin.

Nominations were read.

Mr. Lesley was nominated Librarian.

The report of the Finance Committee was submitted.

The Committee on the Deposit of MSS. reported progress.

And the meeting was adjourned.

An Obituary Notice of William Milnor Roberts.

(*Furnished by Mrs. W. Milnor Roberts, and read before the American Philosophical Society, by Frederick Fraley, January 6, 1882.*)

William Milnor Roberts, C. E., whose death occurred at Soledade, province of Minas Geraes, July 14th, 1881, was one of the oldest and most active members of the engineering profession. He was of Quaker descent, and was born in the city of Philadelphia on the 12th of February, 1810. His education was received in the best private schools of that city, during which a special course in mathematics of two terms was spent under the eminent mathematician, Joseph Roberts. He also pursued a course of architectural drawing in the first school established by the Franklin Institute, under the distinguished architect, John Haviland. After entering the profession of engineering—there were no engineering schools at that time—he continued his studies, principally in mathematics, of which he was very fond, during the winter months, the summer being spent in the field.

Owing to his aptitude for mathematical studies and investigations, his father's friend, Samuel Mifflin, then president of the Union canal company, of Pennsylvania, advised his adoption of the profession of civil engineering, an advice which he very wisely followed. He received his first employment in that profession on the Union canal, of Pennsylvania, in the spring of 1825, he being then in his sixteenth year. His first employment was that of a chainman, his employer was the eminent canal engineer, Canvass White, and the chief of the party to which he was attached was Sylvester Welch. His progress in his profession from that time is shown by the fact that at the age of eighteen he was promoted by Mr. White to the charge of the most difficult section of the Lehigh canal, extending from Mauch Chunk down for a distance of sixteen miles. In 1829 he published a description of the Lehigh canal in *Hazard's Register.*

It was Mr. Roberts' rare good fortune to have been connected with the first railway enterprises in the United States, his career as an engineer being thus contemporaneous with the beginnings and growth of that greatest of agents in our modern civilization. Railway engineering in the United States began, in a crude way, in 1826 at the Quincy granite quarry, a tramway being then constructed for the transportation of stone from the quarry to the water, a distance of three or four miles. The first railway of any consequence, however, was the Mauch Chunk gravity road, nine miles in length, between the summit of Broad Top mountain and the head of the Mauch Chunk inclined plane. The first passenger car in the United States was put on this road in the early summer of 1827, and Mr. Roberts was one of the passengers on the first trip down the line. Since those first small beginnings, this first crude railway of nine miles, the railway system of the United States has grown to be the most powerful instrument of progress of our day, with its 95,000 miles of iron track netting the whole surface of the country and carrying wealth into almost every locality. Side by side with this wonderful material development, Mr. Roberts grew into eminence as an engineer, From his first beginning as a chainman, just one year before the first crude attempt at railway engineering, his career was one of steady, substantial growth until the closing hours of his life, crowned with the highest honors which his profession could bestow upon him, and ennobled by works whose perfection and usefulness will be an imperishable record of his worth and fame.

In the course of his long career of fifty-six years as an engineer, Mr. Roberts held so many and so varied positions of trust and responsibility that a bare enumeration of them would require more space than this brief sketch will admit. The more important of them may be summarized as follows: In 1829 Mr. Roberts' connection with the construction works of the Union and Lehigh canals was brought to a termination. In 1830 he was appointed resident engineer of the Union railroad and a feeder of the Union canal. From 1831 to 1834 he was senior principal assistant engineer on the Allegheny Portage railroad, during which time he had charge of repairs on the western division of the Pennsylvania State canal—from Johnstown to Pittsburgh—which had been damaged by the great flood of 1832. In 1835, in his 26th year, he received his first appointment as chief engineer, being called to fill that position on the Harrisburg and Lancaster railroad. In 1836 he accepted the chief engineership of the Cumberland Valley railroad which he held during that year and a part of 1837. During this time he planned and built the first combined railway and common road bridge, which crossed the Susquehanna river at Harrisburg. From 1837 to 1841 he filled the office of chief engineer on the Monongahela river improvements, the Pennsylvania State canal construction works, the Erie canal, and the Ohio river improvements. In 1841–42 he was a contractor on the Welland canal (Canada) enlargement. In 1843–44 he was chief engineer for the Erie canal company, and from 1845 to 1847 he was chief engineer and trustees' agent for the Sandy and Beaver canal company, of Ohio. In 1848 he was appointed by the Legislature of Pennsylvania to make a survey to avoid, if possible, the Schuylkill (Philadelphia) inclined plane. In 1849 he declined the chief engineership of the first projected railroad in South America, to accept that of the Bellefontaine and Indiana railroad, of Ohio, where he remained until 1851. From 1852 to 1854 he was chief engineer of the Allegheny Valley railroad, consulting engineer for the Atlantic and Mississippi railroad, contractor for the whole of the Iron Mountain railroad, of Missouri, and chairman of a commission of three appointed by the Pennsylvania Legislature to examine and report upon routes for avoiding the inclined planes of the old Allegheny Portage railroad. From 1855 to 1857 he was contractor for the entire Keokuk, Des Moines and Minnesota railroad, consulting engineer for the Pittsburgh and Erie, and Terre Haute, Vandalia and St. Louis railroads, and chief engineer of the Keokuk, Mt. Pleasant and Muscatine railroad.

In December, 1857, Mr. Roberts sailed for Brazil to examine the route of the Dom Pedro II railway with the purpose of bidding for its construction. In 1858, as the senior member of a firm of American contractors, he concluded a formal contract in the United States with the Brazilian minister, Sr. Carvalho de Borges, for the construction of this road, and in the following year he returned to Brazil and took active charge of the work. He remained on the work, which exhibits some of the finest railway engineering and construction in the world, until the completion of the contracted work in 1864. During the remainder of 1864 and a part of 1865 he visited various railways and public works in Brazil and the Platine republics, returning to the United States in the latter part of 1865.

Soon after his arrival in the United States Mr. Roberts took charge of the surveys for the Atlantic and Great Western railroad, which he completed in April, 1866. After some miscellaneous work in the West, he was appointed in 1866 by the Secretary of War, Edwin M. Stanton, as United States civil engineer-in-charge of the Ohio river improvement, which position he held until 1870, when he resigned to accept the chief engineership of the Northern Pacific railroad. In 1868-69 he held, also, the position of associate chief engineer of the great bridge over the Mississippi at St. Louis. He retained the position of chief engineer of the Northern Pacific until his departure for Brazil in January, 1879. During his occupation of this last position he examined and reported upon several railways and the water supply of the cities of Pittsburgh and Philadelphia. In 1874 he was appointed by the President of the United States as a member of a commission of civil and military engineers to examine and report upon plans for the improvement of the mouth of the Mississippi river. In 1877 he located the Nictaux and Atlantic railroad in Nova Scotia. During the year 1876 he held the position of vice-president in the American Society of Civil Engineers, and at the close of 1878 he was elected president of that society for the ensuing year.

Toward the close of 1878 Mr. Roberts accepted the appointment of the Brazilian Government for an examination of the ports and water-ways of the empire with reference to their improvement. His contract was for a period of three years, beginning with 1879, only six months of which remained unexpired at the time of his death. He left New York on the 4th of January, 1879, and arrived in this city on the 27th of the same month. He was at once charged with an examination of the port of Santos, and entered upon his new work in the following month of February. This task was completed in June, and on the 31st of August Mr. Roberts set out for an extended examination of the Upper Sao Francisco. He was accompanied on this survey by Prof. O. A. Derby, of the National Museum, Mr. Rudolf Wieser, assistant, and by several young Brazilian engineers. This survey was the most difficult and important one upon which Mr. Roberts was engaged, the field work alone occupying a period of over six months. After a long interval had elapsed, during which time he served on a commission to report upon the new water-works of this city, Mr. Roberts was commissioned with the examination of various northern ports, and in two separate trips made careful surveys of the ports of Pernambuco, Fortaleza, Maranhao, Victoria, Caravellas, and several other small ports.

Very recently he was instructed to examine the port of Rio Grande, but this work was afterwards deterred in order to have an examination made of the Rio das Velhas, province of Minas Geraes, during the season of low water. Accompanied by Prof. O. A. Derby, geologist, and Mr. J. W. de Aguiar, assistant, Mr. Roberts set out on this, his last survey, on the 2d of July, 1881. He was compelled to suspend his journey on the 7th, at a little settlement, or railway surveyors' camp, called Soledade, where an indisposition which had been troubling him for some days, developed into typhus fever. He died on the evening of July 14th, 1881, in the 72d year of his age, and was buried on the following day in the parish cemetery of Caramandahy, seven leagues beyond the city of Barbacena, Minas Geraes.

Stated Meeting, January 20, 1882.

Present, 7 members.

Vice-President, Mr. Price, in the Chair.

Letters were received from the Imperial Society of Naturalists of Moscow, dated Dec. 13, 1881, and January, 1882, asking the participation of this Society in the celebration of the 50th Anniversary of Mr. Charles Renard's connection with their Society.

A letter was received from the Franklin Institute, dated Jan. 9, 1882, requesting Transactions XV, 3, and Parts 1 and 3 of the Catalogue.

Donations for the Library were received from the Naturforscher Vereins, Riga; Zoologischer Anzeiger, Leipzig; Academia dei Lincei, Roma; Société de Géographie, and Revue Politique, Paris; M. le Vicomte H. de Charencey; Royal Academy, Brussels; Journal of Forestry, Nature and the Greenwich Observatory, London; Natural History Society, and American Statistical Association, Boston; Museum of Comparative Zoölogy, and the Astronomical Observatory of Harvard College, Cambridge; Franklin Institute, American Journal of the Medical Sciences, Journal of Pharmacy, the "American," and the Directors of the Reading Railroad, Philadelphia; West Chester Philosophical Society; U. S. National Museum, Washington; and the Ministerio de Fomento, Mexico.

On motion of Prof. Kendall, Mr. Lesley was elected Librarian.

The following members were placed upon the Standing Committees:

Finance.

Eli K. Price,
Henry Winsor,
John Price Wetherill.

Hall.

S. W. Roberts,
J. S. Price,
W. A. Ingham.

Publication.

J. L. LeConte,
D. G. Brinton,
E. Thomson,
C. M. Cresson,
G. H. Horn.

Library.

Eli K. Price,
C. P. Krauth,
R. S. Kenderdine,
E. J. Houston,
Henry Phillips, Jr.

A letter from Dr. J. T. Rothrock, of December 20, 1881, with a request for the loan of the Muhlenberg Herbarium to Dr. Gray of Harvard, was read; and it was, on motion,

Resolved, That the Secretary be authorized to deliver to the order of Dr. Gray, the Muhlenberg Herbarium, in whole or in part, on the receipt of his agent to return the same.

Resolved, That ten dollars be appropriated for the payment of the expense of labeling the Herbarium, in accordance with Dr. Gray's forthcoming work.

On scrutiny of the ballot-boxes the following persons were declared duly elected members of the Society:

Mr. William Blades, of London.
Mr. William Trautwine, of Philadelphia.
Rev. Samuel Savage Lewis, of Cambridge, England.
Mr. William Jefferis, of West Chester, Penn.
Hon. Washington Townsend, of West Chester, Pa.

And the meeting was adjourned.

Stated Meeting, February 3, 1882.

Present, 6 members.

President, Mr. Fraley, in the Chair.

Letters of envoy were received from the Musée Guimet, dated Lyons, January 7, 1882; H. Scheffler, Braunschweig, December 6, 1881; and the Torrey Botanical Club, 7 Waverly Place, N. Y. City, January 21, 1882.

A letter of thanks for the action of the Society at its last meeting in regard to the Muhlenberg Herbarium, was received from Dr. Asa Gray, dated Cambridge, January 25, 1882.

A letter from Mr. Leighton Hoskins, dated Philadelphia, February 3, 1882, requesting the loan of the volumes of the Ercolano Bronzi in the Library, was referred to the Secretaries with power to act.

A circular letter was received from the Royal Society of New South Wales, dated Sidney, November 2, 1881.

Donations for the Library were received from the Department of Mines, Melbourne; Royal Academies at Berlin, Rome, and Brussels; Zoologischer Anzeiger, Leipzig; Dr. Hermann Scheffler, Braunschweig; Revue Politique, Paris; Society of Commercial Geography, Bordeaux; Royal Astronomical Society, Cobden Club, and Nature, London; Natural History Society, Boston; Harvard College Library; American Journal, New Haven; Numismatic and Archæological Society, and Torrey Botanical Club, N. Y. City; Engineers' Club, Penn Monthly, the American, and Mr. Henry Phillips, Jr., Phila.; U. S. Census Bureau, Washington; and Prof. N. H. Winchell, St. Paul.

Prof. John Hagen's paper, "On the inclination of the apparent to the true horizon, and the errors rising thereof in Transit, Altitude and Azimuth-Observations," was submitted for the Proceedings.

Mr. Ashburner exhibited a specimen of Colorado Anthracite, and spoke of its composition.

Remarks on the subject were made by Messrs. Price and Britton.

Pending nomination No. 935 and new nominations Nos. 951 to 955, were read.

Mr. Henry Phillips, Jr., for the Committee on the Celebration of the Birthday of Franklin, made the following report, which was accepted and the Committee discharged.

January 28, 1882.

A special meeting of the Society was held this evening at six o'clock, at the Social Art Club, No. 1811 Walnut Street, pursuant to a resolution of the Society to celebrate the Birthday of Benjamin Franklin by a subscription dinner, at which were present:

President—Frederick Fraley.

Secretary—Daniel G. Brinton, M. D.

Curators—Charles M. Cresson, M. D., Henry Phillips, Jr.

Treasurer—J. Sergeant Price.

Councillors—Robert E. Rogers, M. D., Henry Winsor, William A. Ingham.

Members—S. D. Gross, M. D., Robert H. Allison, M. D., William Sellers, Eckley B. Coxe, William Pepper, M. D., C. N. Peirce, M. D., Joseph M. Wilson, J. Blodget Britton, Theo. G. Wormley, M. D., Wm. B. Rogers, Jr., B. B. Comegys, William Thomson, M. D., John Welsh, Morris

Longstreth, M. D., Henry Hartshorne, M. D., J. Price Wetherill, Carl Seiler, M. D., William Goodell, M. D., Frank Thomson, Robert Patterson, Edward D. Cope, Charles S. Wurts, M. D.

Dinner was then served, and interesting addresses were delivered by Frederick Fraley, President; S. D. Gross, M. D., Hon. John Welsh, Robert E. Rogers, M. D., William Pepper, M. D., Eckley B. Coxe, and E. D. Cope, and at 10 o'clock P. M. the meeting adjourned.

Mr. Ashburner introduced the subject of a bill before Congress for establishing a Government Bureau of Mines.

On motion of Mr. Price, the consideration of the propriety of the Society's recommending to Government either the establishment of such a bureau, or the establishment of an executive department to take charge of the agricultural, mining and commercial interests of the nation, was referred to a committee consisting of the President, Mr. Fraley, as Chairman, Mr. Ashburner and Mr. Price.

And the meeting was adjourned.

On the Inclination of the Apparent to the True Horizon and the Errors rising thereof in Transit, Altitude, and Azimuth-Observations. By John Hagen, S. J., College of the Sacred Heart, Prairie Du Chien, Wisconsin.

(*Read before the American Philosophical Society, February 3, 1882.*)

In the year 1875, Mr. Hann, editor of the "Zeitschrift der Oesterreichischen Gesellschaft für Meteorlogie," called attention to a special kind of irregularities in the figure of the earth, which hitherto were not sufficiently taken into account. According to him *the most important perturbation of the ellipsoidal level of the sea arises from the continents attracting the waters of the surrounding oceans.* (See Mittheilungen der geogr. Gesellsch. zu Wien, N. 12, 1875.) He supports his statement by the fact, that the continents are to be compared to large mountains, which by necessity, must disturb the level of the sea in the same way, as the Cordilleras of South America, the Apennines in Italy and the Shehallien in Scotland were able to deviate the plumb-line, and again by the fact, that the force of gravity on islands was in average found greater than was forecast by calculation, from which Dr. Hann concludes that the level of the oceanic islands be lower than that of the shores of the continents. He estimates in general the vertical distance between the disturbed and the undisturbed level of the sea to more than one thousand meters, and finally proposes the following problem to be solved :

To find such an Ellipsoid of Revolution, 1, as has the volume of the Earth; 2, that the sum of the Earth's elevations and depressions with regard to this Ellipsoid become a minimum.

This problem, however, as given by the author, seems to be indetermined, unless a third condition is added, viz.: that the rotation axis of the Ellipsoid is parallel to that of the Earth and their centres coincide.

Mr. Hann is of the opinion that the solution of this problem would afford the solution of another problem, open already a century ago, viz.: the answer to the question, why the meridian mensurations and the observations of the second's pendulum, made on different points of the surface of the Earth, afford such different values for the compression of the Earth? These observations, he says, ought to be reduced not to the actual level of the sea, but to the level of that regular ellipsoid to be found by the above problem, whose compression could then be found from these observations with greater accordance.

The treatise here published is intended not to solve Hann's problem, but to take one step farther towards its solution. This solution seems to be an impossibility as long as the inclination of the apparent towards the true horizon is not known, for as many places as possible, both as to magnitude and direction. On the following pages, therefore, the formulas shall be developed by which both the influence of this inclination on astronomical observations will be shown and the way suggested, how to determine its magnitude and direction. Astronomers are well aware of the influence that the deviation of the plumb-line exerts on finding the longitude and latitude of a place and have begun to distinguish between the *geodetic* and the *astronomical* position of a place. By the latter expression they mean the longitude and latitude of the apparent horizon; in other words, the *apparent* longitude and latitude of a place.* It is, however, evident, that for parallactic observations and especially for the transits of Venus and Mercury, not the apparent but the true longitude and latitude are needed. Consequently the following pages, though not giving direct means for finding the true position of an observatory, might be of some interest, as they at least call attention to the errors caused by the inclination of the horizon on astronomical observations.

Let the pole of the true or mathematical horizon be denoted by Z, and that of the apparent, or as we may call it, physical horizon by Z′, then the arc Z Z′ represents the inclination of the latter towards the former as to magnitude and direction. We resolve it into two rectangular components, one of which α may lie in the vertical plane of the instrument used, its positive direction being towards the "sight-line" of the observer, while the other component, β, may be positive right-hand of the observer. In case of an artificial horizon part of the inclination α may be caused by the

* Note.—About this distinction see Chauvenet's Manual of Spherical and Practical Astronomy, Vol. i, Art. 86, 160, 213.

instrument and the piers on which it rests, hence, the distance of the artificial horizon varying with the zenith distance of the object observed, this part of the inclination α will be a function of the zenith distance, while the rest as well as the inclination β will be the same for the same azimuth. Now it will not be difficult to convince oneself *that the inclination α cannot influence but the observation of zenith distances and the inclination β but that of azimuths and hour-angles.* Nor is it difficult to foresee, that the inclination α will have a similar effect as the flexure of the telescope and graduated circle on account of their gravity, while the inclination β is comparable to the inclination of the horizontal rotation axis to the true horizon. The former two are functions of the zenith distance and may therefore be represented by periodic series, whose terms involve the sines and cosines of its multiples, while the latter two are merely functions of the azimuth.

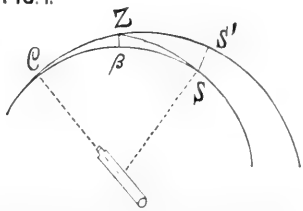
Part I.—*Influence of the inclination β on Azimuth- and Hour-angle Observations.*

We shall first suppose any altitude and azimuth instrument exactly adjusted so that the axis of collimation describes a great circle passing through the true zenith, and consider the influence exerted by the inclination of the artificial horizon on observations by reflection.

1. *Fundamental Formulas.*

If C denotes the point, in which the axis of collimation produced towards the eye-piece meets the celestial sphere, and Z the true zenith, the arc β will be perpendicular on the vertical plane C Z in the point Z. (Fig. 1.)

FIG. 1.



Again if through the end of the arc β and through C a great circle is put, the observed object S will be in this circle in the moment, when its reflected image passes over the middle thread of the telescope. From S let a perpendicular be drawn on the vertical plane of the instrument, which may be intersected in S^1, and let S and Z be joined by the arc of a great circle. Finally, let the small angles at Z and C be denoted respectively by d A and C, and β be taken positively right-hand of the observer. Then we are not to forget, that Z C = Z S, *i. e.*, equal to the true zenith distance z of the observed object in the moment of observation. Now in the isosceles triangle S Z C we have

$$\cos z = \cot C \sin dA - \cos z \cos dA,$$

or introducing the angle β instead of C by the formula

$$\tan \beta = \tan C \sin z$$

we have

$$(1 + \cos d A) \tan t \beta = \tan z \sin d A,$$

or simpler,

$$d A = 2 \beta \cot z, \qquad (1)$$

which is the *correction of the azimuth,* for observations by reflection. There the azimuth is to be reckoned from south to west etc., and β right-hand of the observer.

The *correction of the hour-angle* may be derived from formula (1) by means of the well-known differential formula,

$$dt = \frac{\sin z}{\cos \delta \cos p} d A,$$

where p denotes the parallactic angle and δ the declination of the observed object. Thus we find

$$dt = 2 \beta \frac{\cos z}{\cos \delta \cos p} \qquad (2)$$

For upper or lower culminations we have $\cos p = 1$, hence

$$dt = 2 \beta \frac{\cos z}{\cos \delta}. \qquad (2^1)$$

For the sake of verification, this last formula may also be derived in the following way. Considering the great circle C Z S^1 as the meridian and joining S with the north pole N we have in the triangle S S^1 N

$$\sin dt = \frac{\sin S S^1}{\cos \delta}.$$

But in the triangle S S^1 C we have in like manner

$$\tan S S^1 = \tan C \sin 2 z,$$

since Z S^1 may be put equal to z and finally we have as above

$$\tan \beta = \tan C \sin z,$$

hence,

$$\tan S S^1 = \tan \beta \frac{\sin 2z}{\sin z} = 2 \tan \beta \cos z$$

and consequently by combining the first and last equation and supposing dt and β to be very small angles

$$dt = 2 \beta \frac{\cos z}{\cos \delta}. \qquad (2^1)$$

2. *The azimuth instruments.*

The correction of the azimuth for the observation by reflection

$$d A = 2 \beta \cot z \qquad (1)$$

has the meaning, that in such observations *the actual reading of the azimuth is by d A too small,* as long as β is positive right-hand of the observer.

If we now compare this correction with that for the inclination of the horizontal rotation axis to the true horizon we find both coincide except their constants. For if b denotes the elevation of the right-hand end of this axis above the true horizon, the correction of the azimuth is

$$d\,A = \mp b \cot z \begin{cases} - \text{ for direct image.} \\ + \text{ " reflected "} \end{cases}$$

as may be found in any Manual of Spherical Astronomy. Joining both corrections we have

$$\text{for direct image } d\,A = - b \cot z$$
$$\text{" reflect. " } d\,A = (2\beta + b) \cot z = - (b - d) \cot z.$$

if we put

$$d = 2\,(\beta + b) \qquad (3)$$

Hence the usual formula for correcting azimuth observations is to be modified for observations by reflection. For direct observations this formula is

$$a = A + \varDelta A - b \cot z - c \operatorname{cosec} z, \qquad (4)$$

where a denotes the absolute azimuth of the observed object, A the actual reading, $\varDelta A$ the index correction of the circle, so that $A + \varDelta A$ denotes the azimuth counted from the meridian point of the circle. b denotes as above the elevation of the right-hand end above the true horizon and 90° + c is the angle formed by the axis of collimation with this same end. Hence for observations by reflection we have

$$a = A + \varDelta A - (b - d) \cot z - c \operatorname{cosec} z \qquad (5)$$

where z is not the reading of the vertical circle, but the zenith distance of the observed object. As we have defined the constant b as the inclination of the horizontal rotation axis to the *true* horizon, we, of course, cannot find it in the usual way with the striding level, this instrument being itself inclined to the true horizon by the unknown angle β. Hence we shall first find the constant $d = 2\,(\beta + b)$, which may be done in two ways, first by the striding level applied to the horizontal axis, which will give us

$$\beta + b = \tfrac{1}{2} d,$$

and secondly by observing the direct and reflected images of stars. Let θ be the sidereal time, when the direct image of a star passes over a certain azimuth and θ^1 the sidereal time, when the reflected image of the same star passes over the same azimuth, then we have the two equations

$$\text{direct image } a = A + \varDelta A - b \cot z - c \operatorname{cosec} z.$$
$$\text{reflect. " } a^1 = A + \varDelta A - (b - d) \cot z^1 - c \operatorname{cosec} z^1.$$

If now the observed star did not pass very near the zenith, we may neglect the two quantities

$$b\,(\cot z - \cot z^1) \text{ and } c\,(\operatorname{cosec} z - \operatorname{cosec} z^1)$$

as small of the second order and find by subtraction of the above equations

$$\frac{d}{2} = \beta + b = \frac{a^1 - a}{2} \tan z_0.$$

For z_0 may be taken the mean value of the two nearly equal zenith distances z and z^1, and if the instrument had no vertical circle, it may be computed from the declination, the latitude and the mean hour angle. Again we have

$$a^1 - a = \frac{d A}{dt} (\theta^1 - \theta),$$

where $\frac{d A}{dt}$ denotes the variation of the azimuth in the unit of time for the moment $\frac{1}{2} (\theta^1 + \theta)$.

Thus far it has been shown, how to find the value of d for one single azimuth, but it will be necessary to have the means of computing it for any azimuth. From the theory of the azimuth instruments it is known, that b is represented by the formula

$$b = i - i_0 \cos (A - A_0),$$

where i denotes the inclination of the horizontal axis to the azimuth circle, i_0 the inclination of this circle to the true horizon, while A is the azimuth of the observed object and A_0 a constant explained by the formula itself. The inclination β of the artificial horizon may be represented by a similar formula

$$\beta = - i_1 \sin (A - A_1), \tag{6}$$

where i_1 is the constant deviation of the plumb line caused by local irregularities in the figure and density of the earth, A_1 the azimuth of its direction and A the azimuth of the observed object. Hence we find

$$\begin{aligned} \tfrac{1}{2}d = \beta + b &= i - i_0 \cos (A - A_0) - i_1 \sin (A - A_1) \\ &= i - \cos A\, (i_0 \cos A_0 - i_1 \sin A_1) - \sin A\, (i_0 \sin A_0 + i_1 \cos A_1) \end{aligned}$$

or if we put

$$\left.\begin{aligned} i_0 \cos A_0 - i_1 \sin A_1 &= i_2 \cos A_2 \\ i_0 \sin A_0 + i_1 \cos A_1 &= i_2 \sin A_2 \end{aligned}\right\} \tag{7}$$

we find by a simple transformation

$$\tfrac{1}{2} d = \beta + b = i - i_2 \cos (A - A_2) \tag{8}$$

To find the three constants i, i_2 and A_2 three observations are sufficient, which may be equally distributed in the usual way. Let d_1, d_2, d_3 be the values of d, corresponding to the three azimuths A, $A + 120^0$, $A + 240^0$ we find from (8)

$$\begin{aligned} \tfrac{1}{2} d_1 &= i - i_2 \cos (A - A_2) \\ \tfrac{1}{2} d_2 &= i + \tfrac{1}{2} i_2 \cos (A - A_2) + \tfrac{1}{2} i_2 \sin (A - A_2) \sqrt{3} \\ \tfrac{1}{2} d_3 &= i + \tfrac{1}{2} i_2 \cos (A - A_2) - \tfrac{1}{2} i_2 \sin (A - A_2) \sqrt{3} \end{aligned}$$

and by adding and subtracting these equations

$$\begin{aligned} i &= \tfrac{1}{6} (d_1 + d_2 + d_3) \\ i_2 \cos (A - A_2) &= \tfrac{1}{6} (d_2 + d_3 - 2d_1) \\ i_2 \sin (A - A_2) &= \frac{1}{2\sqrt{3}} (d_2 - d_3.) \end{aligned} \tag{9}$$

If therefore either of the methods mentioned before, viz., by the striding level or by observations of the direct and reflected image, is applied to three different azimuths, dividing the circle into three equal parts, the three constants i, i_2 and A_2 may be found by these formulas, and hence also the constant $\frac{1}{2}$d may be computed for any azimuth by the formula

$$\tfrac{1}{2} d = i - i_2 \cos (A - A_2) \qquad (8)$$

Thus we see, that b cannot be obtained in the usual way, before the collimation constant c has been found. But if the time is known, we may succeed in finding c in the following way: Let θ be the sidereal time, when the direct image passes over any azimuth, and θ^1 the time, when the same star passes over the same azimuth of the reversed instrument, then we have the two equations

$$a = A + \varDelta A - b \cot z - c \operatorname{cosec} z$$
$$a^1 = A + \varDelta A - b \cot z^1 + c \operatorname{cosec} z^1.$$

If again the star in the moment of observation did not pass very near the zenith, the quantity b ($\cot z - \cot z^1$) may be neglected as small of the second order, hence we find by subtraction of the two equations

$$c = \tfrac{1}{2} (a^1 - a) \sin z_0$$

where z_0 is a mean value of z and z^1 and may be computed from the declination, the latitude and the mean hour-angle. Again we have

$$a^1 - a = \frac{d A}{dt} (\theta^1 - \theta)$$

where $\frac{d A}{dt}$ denotes the variation of the azimuth in the unit of time for the moment $\frac{1}{2} (\theta^1 + \theta)$.

If we now suppose the reading of the azimuth corrected as to the collimation constant, equation (4) becomes

$$a = A + \varDelta A - b \cot z. \qquad (4^1)$$

Again, if we observe the time of transit over the same azimuth for different stars, any two observations will afford an equation of this form.

$$b = \frac{a^1 - a}{\cot z - \cot z^1} = (a^1 - a) \frac{\sin z^1 \sin z}{\sin (z^1 - z)}.$$

The factor of ($a^1 - a$) will turn out very small, consequently, b will be found with great exactness, if any star near the zenith is combined with any near the horizon. The quantities a and z may be computed from the hour-angle t by the formulas

$$\sin z \sin a = \cos \delta \sin t$$
$$\sin z \cos a = - \cos \varphi \sin \delta + \sin \varphi \cos \delta \cos t,$$

where δ denotes the declination of the star and φ the latitude of the place. The latter equation may be changed into the following form, more convenient for logarithmic computation :

$$\sin z \cos a = - m \cos (\varphi + M),$$

if we put

$$\sin \delta = m \cos M, \ \cos \delta \cos t = m \sin M.$$

If thus b is found for any azimuth, ΔA may be computed from (4^1).

Yet b varies with the azimuth and is represented by the formula

$$b = i - i_0 \cos (A - A_0).$$

The constant i is already known from the equations (9) and hence it is enough to find b for any two azimuths in order to find i_0 and A_0. If we choose the two azimuths A and $A + 90^0$, we find

$$b_1 - i = - i_0 \cos (A - A_0)$$
$$b_2 - i = + i_0 \sin (A - A_0),$$

by which equations the two quantities i_0 and A_0 are fully determined. Thus we are able to compute b for any azimuth by the formula

$$b = i - i_0 \cos (A - A_0).$$

But from (7) we have the equations

$$\left.\begin{aligned} i_1 \sin A_1 &= + i_0 \cos A_0 - i_2 \cos A_2 \\ i_1 \cos A_1 &= - i_0 \cos A_0 + i_2 \sin A_2 \end{aligned}\right\} \qquad (10)$$

by which we finally find i_1 and A_1, *i. e.*, the constant inclination of the apparent to the true horizon, as far as it is caused by irregularities in the surface of the Earth, and the azimuth of its direction. This constant inclination i_1 however, is not yet the total inclination Z Z^1, since large instruments together with their piers may cause an inclination of the artificial horizon variable with the zenith distance of the observed object, as will be seen in Part II.

Finally, attention must be called to two things. First, if the observations mentioned above are made on different days, the positions of the stars are to be reduced to a common epoch, best to the beginning of the year. Secondly, though we have found the formulas for finding the constant inclination of the apparent to the true horizon as to magnitude and direction, we are not to forget, that these formulas suppose the perfect knowledge of the latitude and time of the place.

3. *The Transit instrument in the Meridian.*

The correction of the hour-angle for observations by reflection

$$dt = 2\,\beta \frac{\cos z}{\cos \delta} \qquad (2^1)$$

has the meaning, that in the moment, when the reflected image of any object passes over the middle thread of this instrument *its actual hour-angle is dt for upper transits and 180° + dt for lower transits*, if b is reckoned positive right-hand of the observer. Yet for these instruments the inclination β of the apparent horizon remaining always on the same side, it will be found more convenient to take β positive towards west and consequently to write the corrections for lower transits as follows:

$$dt = -2\,\beta \frac{\cos z}{\cos \delta}$$

while dt always denotes the increment of the hour-angle, which is reckoned in the usual way from south to west.

For upper culminations we have

$$z = +(\varphi - \delta) \text{ culmination south of the zenith}$$
$$z = -(\varphi - \delta) \quad \text{“} \quad \text{north} \quad \text{“} \quad \text{“}$$

and for lower culminations $z = 180^\circ - (\varphi + \delta)$, hence the corrections for the hour-angle are

$$\text{for upper culm, } dt = 2\,\beta\,\frac{\cos(\varphi - \delta)}{\cos\delta}$$

$$\text{“ lower “} \quad dt = 2\,\beta\,\frac{\cos(\varphi + \delta)}{\cos\delta}.$$

If again we compare this correction with the one for the rotation axis not lying parallel to the horizon, we find them coincident, except the constant. For if b denotes the elevation of the west end of the rotation axis above the *true* horizon, we have the usual formula for upper culminations

$$dt = \mp\, b\,\frac{\cos(\varphi - \delta)}{\cos\delta} \begin{cases} - \text{ for direct image} \\ + \text{ “ reflect. “} \end{cases}$$

and for lower culminations

$$dt = \mp\, b\,\frac{\cos(\varphi + \delta)}{\cos\delta} \begin{cases} - \text{ for direct image} \\ + \text{ “ reflect. “} \end{cases}$$

where dt has the same meaning as above. Joining the two corrections and putting $2(\beta + b) = d$, as before, we find

For upper culminations.

$$\text{direct image } dt = -\, b\,\frac{\cos(\varphi - \delta)}{\cos\delta}$$

$$\text{reflect. “ } dt = -\,(b - d)\,\frac{\cos(\varphi - \delta)}{\cos\delta}$$

For lower culminations. (11)

$$\text{direct image } dt = -\, b\,\frac{\cos(\varphi + \delta)}{\cos\delta}$$

$$\text{reflect. “ } dt = -\,(b - d)\,\frac{\cos(\varphi + \delta)}{\cos\delta}$$

where dt denotes the increment of the hour-angle. We need not consider separately the formulas for lower culmination, as we may deduce them from those for upper culmination at any time by simply substituting $180^\circ - \delta$ for δ.

In consequence of these considerations the formulas of Tobias Mayer, Bessel and Hansen are to be modified for observations by reflection as follows: Mayer's formula is the following

$$\tau = b\,\frac{\cos(\varphi + \delta)}{\cos\delta} + k\,\frac{\sin(\varphi - \delta)}{\cos\delta} + \frac{c}{\cos\delta}$$

where $\tau = -dt$ is the hour-angle east of the meridian, b the elevation of the west end of the rotation axis above the true horizon, $90° - k$ the azimuth of this west end and $90° + c$ its angle with the line of collimation. Bessel's formula is

$$\tau = m + n \tan \delta + c \sec \delta,$$

and finally, Hansen's formula

$$\tau = b \sec \varphi + n (\tan \delta - \tan \varphi) + c \sec \delta,$$

where n denotes the declination of the west end of the rotation axis and $90° - m$ its hour-angle. All these constants are in the following relations to each other :

$$\left.\begin{array}{ll} n = b \sin \varphi - k \cos \varphi & b = \quad n \sin \varphi + m \cos \varphi \\ m = b \cos \varphi + k \sin \varphi & k = - n \cos \varphi + m \sin \varphi \end{array}\right\} \quad (12)$$

For observations by *reflection* the constant b and consequently m and n are to be changed, say into b^1, m^1, n^1, by the following formulas :

$$\begin{array}{ll} b^1 = \quad - 2 \beta - b & = b - d \\ m^1 = m - 2 (\beta + b) \cos \varphi & = m - d \cos \varphi \\ n^1 = n - 2 (\beta + b) \sin \varphi & = n - d \sin \varphi. \end{array}$$

Hence the three formulas of Mayer, Bessel and Hansen become for observations by *reflection*,

$$\tau = (b - d) \frac{\cos (\varphi - \delta)}{\cos \delta} + k \frac{\sin (\varphi - \delta)}{\cos \delta} + \frac{c}{\cos \delta}$$

$$\tau = m + n \tan \delta + c \sec \delta - d \frac{\cos (\varphi - \delta)}{\cos \delta}$$

$$\tau = (b - d) \sec \varphi + (n - d \sin \varphi) (\tan \delta - \tan \varphi) + c \sec \delta.$$

As to determining the constants of these formulas, it will be seen, as in case of the azimuth instruments, that they cannot be found, unless the time of the place be known. First we will find the constant d, which may be done in two different ways, viz : by the striding level, which, being itself inclined to the true horizon by the angle β, cannot give the value of b, but it gives the value of

$$\beta + b = \tfrac{1}{2} d\,;$$

or by observing the transits of the direct and reflected image of a star. Let T and T^1 be the mean values of time for all the transits reduced to the middle thread for direct and reflected image, ΔT the clock correction on sidereal time and a the star's apparent right ascension, then is evidently $a = T + \Delta T + \tau$, hence

$$\text{for direct image } a = T + \Delta T \qquad + b \frac{\cos (\varphi - \delta)}{\cos \delta} + k \frac{\sin (\varphi - \delta)}{\cos \delta} + \frac{c}{\cos \delta}$$

$$\text{`` reflect ``} \quad a = T^1 + \Delta T + (b - d) \frac{\cos (\varphi - \delta)}{\cos \delta} + k \frac{\sin (\varphi - \delta)}{\cos \delta} + \frac{c}{\cos \delta}$$

and by subtraction

$$\frac{d}{2} = \beta + b = \frac{T^1 - T}{2} \frac{\cos \delta}{\cos (\varphi - \delta)} \qquad (13)$$

which determination will be the more exact, the greater cos $(\varphi - \delta)$, *i. e.* the nearer the observed star passed by the zenith.

The collimation constant is found in the usual way either by reversing the axis, or by using two horizontal collimating telescopes, and the constant n by observations of the upper and lower culmination. If then, we suppose the times of transit already corrected as to the errors arising from c and n, we find from Bessel's formula

$$\text{for direct image } a = T + \varDelta T + m$$

$$\text{" reflect. " } a = T^1 + \varDelta T + m - d\,\frac{\cos(\varphi - \delta)}{\cos \delta}$$

and from Hansen's formula

$$\text{for direct image } a = T + \varDelta T + b \sec \varphi$$

$$\text{" reflect. " } a = T^1 + \varDelta T + (b - d) \sec \varphi.$$

By these formulas it is made evident, that *neither m nor b can be found independently of the clock correction.* But if this is known, Bessel's formula will give the constant m, or Hansen's formula b. The azimuth constant k may be determined by observations of upper and lower transits or be computed from (12). Thus, b being found, we may finally determine

$$\beta = \frac{d}{2} - b.$$

i. e. the west inclination of the apparent to the true horizon.

4. *The Transit Instrument in the Prime Vertical.*

From the general formula

$$dt = 2\,\beta\,\frac{\cos z}{\cos \delta \cos p} \qquad (2)$$

we shall obtain the formula for the transit instrument in the prime vertical by finding the value of cos p for the azimuth $A = 90^\circ$ and substituting it in the above formula. We have in general

$$\cos p \sin z = \cos \delta \sin \varphi - \sin \delta \cos \varphi \cos t.$$

But for the prime vertical we have the three special equations

$$\sin z = \cos \delta \sin t$$

$$\cos \delta = \frac{\cos \varphi \cos z}{\cos t}$$

$$\sin \delta = \sin \varphi \cos z.$$

Substituting these quantities successively into the three members of the general equation we find

$$\cos p \cos \delta = \sin \varphi \cos \varphi \cos z \tan t.$$

But from the three formulas for the prime vertical follows

$$\tan t = \frac{\tan z}{\cos \varphi}$$

consequently,

$$\cos p \cos \delta = \sin \varphi \sin z,$$

hence we have for observations by reflection with the transit instrument in the prime vertical the correction of the hour-angle.

$$dt = \frac{2\beta}{\tan z \sin \varphi} \tag{14}$$

The meaning of this correction is, that in the moment, when the reflected image of any object passes the middle thread of this instrument, *the actual hour-angle of the object observed is* $90^\circ + dt$ *or* $270^\circ + dt$, β being positive right-hand of the observer. Yet as also for this instrument the inclination β of the apparent horizon remains always on the same side, it will be found more convenient to take β positive towards north and consequently to write the correction of the hour-angle as follows:

$$dt = \pm \frac{2\beta}{\tan z \sin \varphi} \begin{cases} + \text{ Star west} \\ - \text{ " east.} \end{cases}$$

If we now compare this correction with the one for the rotation axis not lying parallel to the horizon, we find them coinciding except their constants. Let θ denote the sidereal time, when the star passed over the true prime vertical, and T the clock time, when it passed the middle thread of the instrument, and finally, Δ T the correction of the clock on sidereal time, then the theory of this instrument gives us these formulas for *direct* observations

$$\theta = T + \Delta T + \frac{b}{\tan z \sin \varphi} + \frac{k}{\sin \varphi} + \frac{c}{\sin z \sin \varphi} \quad \text{Star west}$$

$$\theta = T + \Delta T - \frac{b}{\tan z \sin \varphi} + \frac{k}{\sin \varphi} - \frac{c}{\sin z \sin \varphi} \quad \text{" east}$$

where b denotes the elevation of the north end of the rotation axis above the true horizon, $180^\circ - k$ the azimuth of this same end, and $90^\circ + c$ its angle with the sight-line of the telescope. For observations by reflection, $180^\circ - z$ is to be substituted for z, which changes only the sign of b. But besides this, the artificial horizon being inclined to the north, the reflected image will be observed after the star passed over the prime vertical in the west and before it passed over the same in the east. Hence, if we put $d = 2(\beta + b)$ as before, the first fraction of the above equations becomes

$$-\frac{b + 2\beta}{\tan z \sin \varphi} = + \frac{b - d}{\tan z \sin \varphi} \quad \text{Star west}$$

$$+\frac{b + 2\beta}{\tan z \sin \varphi} = - \frac{b - d}{\tan z \sin \varphi} \quad \text{" east.}$$

Hence the two formulas for the transit instrument in the prime vertical are to be modified for *observations by reflection* in the following way:

$$\theta = T + \Delta T + \frac{b - d}{\tan z \sin \varphi} + \frac{k}{\sin \varphi} + \frac{c}{\sin z \sin \varphi} \quad \text{Star west}$$

$$\theta = T + \Delta T - \frac{b - d}{\tan z \sin \varphi} + \frac{k}{\sin \varphi} - \frac{c}{\sin z \sin \varphi} \quad \text{" east.}$$

Also in this case we shall see, that the constants cannot be found without the time and latitude of the place being known. First d may be determined, as in former cases, either by the striding level, which will give the angle

$$\tfrac{1}{2} d = b + \beta,$$

or by observing the direct and reflected image of a star either in west or in east. By subtracting the two corresponding equations we find

$$\frac{d}{2} = \beta + b = \frac{T^1 - T}{2} \tan z \sin \varphi,$$

where stars are to be chosen, that pass near the zenith, The collimation constant c may be determined by reversing the axis and observing in both cases the time of transit. As in this case the sign of c alone is changed, we find by subtracting the two corresponding equations

$$c = \frac{T^1 - T}{2} \sin z \sin \varphi,$$

where stars passing near the zenith are again preferable. Both operations may be performed by first observing the transits over some threads and then, after having moved the instrument, over the rest, and by reducing them to the middle thread, or if the observations are taken on different days, the rate of the clock must be known and added to the observed time.

Let us now suppose the time T being already corrected as to the collimation, then by observing the same star east and west we may find both constants b and k. In this case the equations are

$$\theta = T + \Delta T + \frac{b}{\tan z \sin \varphi} + \frac{k}{\sin \varphi} \text{ Star west,}$$

$$\theta^1 = T^1 + \Delta T - \frac{b}{\tan z \sin \varphi} + \frac{k}{\sin \varphi} \text{ `` east.}$$

By subtracting we have

$$b = \tan z \sin \varphi \left[\tfrac{1}{2} (\theta - \theta^1) - \tfrac{1}{2} (T - T^1) \right].$$

Should the clock corrections not be the same T^1 were to be corrected by the rate. Now $\frac{1}{2} (\theta - \theta^1) = t$ is the hour-angle of the star in the moment when it passes over the true prime vertical and may be computed from the latitude of the place and the star's declination by the formula

$$\cos t = \frac{\tan \delta}{\tan \varphi}$$

or better still from the formula

$$\tan \tfrac{1}{2} t^2 = \frac{\sin (\varphi - \delta)}{\sin (\varphi + \delta)}.$$

The errors in the observation of $T - T^1$ will also here be the smaller, the smaller tan z, *i. e.* the nearer the star passes the zenith. Now d and b being known we find the north inclination of the apparent horizon

$$\beta = \tfrac{1}{2} d - b.$$

By adding the above equations we find

$$k = \sin \varphi \left[\tfrac{1}{2}(\theta + \theta^1) - \tfrac{1}{2}(T + T^1) - \varDelta T\right],$$

or as $\frac{1}{2}(\theta + \theta^1) = a$ is the star's right ascension

$$k = \sin \varphi \left[a - \tfrac{1}{2}(T + T^1) - \varDelta T\right].$$

PART II.—*Influence of the inclination α on Altitude Observations.*

By α we have denoted that component of the inclination $Z\,Z^1$ of the apparent to the true horizón, which lies in the vertical plane of the instrument used. With large instruments part of this component may be caused by the instrument and its piers, and is, therefore, as was explained in the beginning, depending on the zenith distance of the object observed. The other part of α is according to former notations [see formula (6)]

$$q = i_1 \cos (A - A_1) \qquad (15)$$

and is caused by the constant local irregularities in the figure and density of the earth. The first part of α will have an effect on altitude observations quite analogous to the flexure of the instrument. This latter correction is generally represented by the series

$$\begin{aligned} &a^1 \cos z + a^{11} \cos 2\,z + a^{111} \cos 3\,z + \ldots \\ &+ b^1 \sin z + b^{11} \sin 2\,z + b^{111} \sin 3\,z + \ldots \end{aligned}$$

and its sign is understood so, that if z is the reading of the zenith distance of a star

$$z + a^1 \cos z + \ldots \quad + b^1 \sin z + \ldots.$$

represents the true zenith distance freed from flexure. If for instance N denotes the reading of the Nadir point (for which $z = 180^\circ$,)

$$N - a^1 + a^{11} - a^{111} + \ldots$$

will represent the true nadir freed from flexure.

By a similar formula the component α may be represented this way

$$\left.\begin{aligned} \alpha = q + a_1^{\,1} \cos z + a_1^{\,11} \cos 2\,z + a_1^{\,111} \cos 3\,z + \ldots \\ + b_1^{\,1} \sin z + b_1^{\,11} \sin 2\,z + b_1^{\,111} \sin 3\,z + \ldots \end{aligned}\right\} \quad (16)$$

For the nadir ($z = 180^\circ$) we have

$$\alpha_0 = q - a_1^{\,1} + a_1^{\,11} - a_1^{\,111} + \ldots$$

Now let z denote the reading of the instrument, ζ the true zenith distance of the object S observed, and N the reading of the nadir, then we shall have for direct observations (Fig. 2).

$$\begin{aligned} &z + a^1 \cos z + a^{11} \cos 2\,z + a^{111} \cos 3\,z + \ldots \\ &\quad + b^1 \sin z + b^{11} \sin 2\,z + b^{111} \sin 3\,z + \ldots \\ &- (N + 180^\circ - a^1 + a^{11} - a^{111} + \ldots) + \alpha_0 = \zeta \end{aligned}$$

Again let z^1 be the reading of an observation by reflection and we shall have

$$\begin{aligned} &z^1 - a^1 \cos z + a^{11} \cos 2\,z - a^{111} \cos 3\,z + \ldots \\ &+ b^1 \sin z - b^{11} \sin 2\,z + b^{111} \sin 3\,z - \ldots \\ &- (N + 180^\circ - a^1 + a^{11} - a^{111} + \ldots) + \alpha_0 = 180^\circ - \zeta + 2\,\alpha \end{aligned}$$

Let now the rotation axis of the instrument be reversed so that the graduation runs in the contrary direction and z^{11} be the reading of a direct observation and we shall have

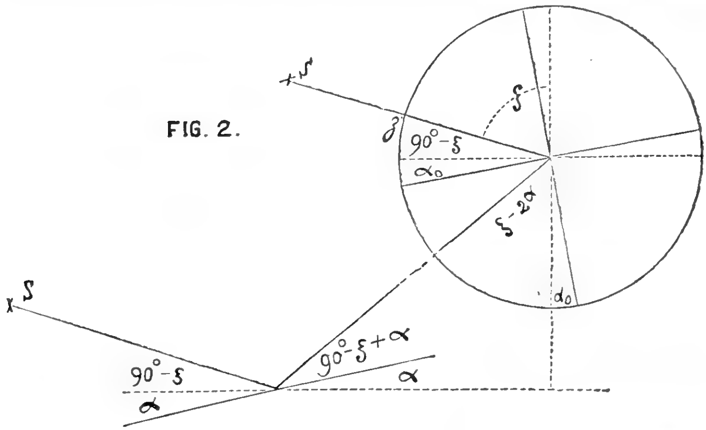
$$z^{11} + a^1 \cos z + a^{11} \cos 2z + a^{111} \cos 3z + \ldots$$
$$- b^1 \sin z - b^{11} \sin 2z - b^{111} \sin 3z - \ldots$$
$$- (N + 180^\circ - a^1 + a^{11} - a^{111} + \ldots) - \alpha_0 = 360^\circ - \zeta$$

Let finally z^{111} be the reading of an observation by reflection in the same position of the instrument, and we shall have

$$z^{111} - a^1 \cos z + a^{11} \cos 2z - a^{111} \cos 3z + \ldots$$
$$- b \sin z + b^{11} \sin 2z - b^{111} \sin 3z + \ldots$$
$$- (N + 180^\circ - a^1 + a^{11} - a^{111} + \ldots) - \alpha_0 = 180^\circ + \zeta - 2\alpha$$

But from the explanations in the first part, it is evident, that with obser-

FIG. 2.



vations by reflection a star is observed out of the vertical plane of the instrument, so that the azimuth of the star is by

$$d A = 2 \beta \cot z$$

greater than the azimuth of the reading. Hence, if we want to compare with each other the four equations given above, we are to reduce all the zenith distances to the same azimuth. This may be effected by the well-known formula

$$dz = \tan p \sin z \, d A,$$

which by substituting the above value of d A becomes

$$dz = 2 \beta \tan p \cos z. \qquad (17)$$

Here, as in Part I, p denotes the parallactic angle. The meaning of formula (17) is not, as if the inclination β of the artificial horizon could prevent the observer from reading the actual zenith distance of the star, it means that the actual zenith distance is by dz greater, than it would be, if the star were still in the azimuth of the instrument.

Hence, with the two observations by reflection mentioned above, the readings z^1 and z^{111} are to be diminished by $2\beta \tan p \cos z$, in order to have in all the four equations the same true zenith distance belonging to the same azimuth. If the observation by reflection is taken in the meridian, where tan p is very small, this correction may be omitted as small of the second order. The same value of dz may also be found by the usual differential formula

$$dz = \cos\delta \sin p \, dt$$

and the following formula, which was developed above

$$dt = 2\beta \frac{\cos z}{\cos\delta \cos p}.$$

If for brevity's sake we denote the apparent zenith point, corrected as to flexure, by Z_1 and put

$$Z_1 = 180^\circ + N - a^1 + a^{11} - a^{111} + \ldots$$

our four equations mentioned several times will become

$$\left.\begin{aligned}
\zeta &= z \quad + a^1 \cos z + a^{11} \cos 2z + a^{111} \cos 3z + \ldots \\
&\qquad + b^1 \sin z + b^{11} \sin 2z + b^{111} \sin 3z + \ldots \\
&\qquad - Z_1 + \alpha_0. \\
180^\circ - \zeta &= z^1 \quad - (a^1 - 2a_1^1) \cos z + (a^{11} - 2a_1^{11}) \cos 2z - \ldots \\
&\qquad + (b^1 - 2b_1^1) \sin z - (b^{11} - 2b_1^{11}) \sin 2z + \ldots \\
&\qquad - Z_1 - 2q + \alpha_0 - 2\beta \tan p \cos z. \\
360^\circ - \zeta &= z^{11} \quad + a^1 \cos z + a^{11} \cos 2z + a^{111} \cos 3z + \ldots \\
&\qquad - b^1 \sin z - b^{11} \sin 2z - b^{111} \sin 3z - \ldots \\
&\qquad - Z_1 - \alpha_0. \\
180^\circ + \zeta &= z^{111} - (a^1 + 2a_1^1) \cos z + (a^{11} + 2a_1^{11}) \cos 2z - \ldots \\
&\qquad - (b^1 + 2b_1^1) \sin z + (b^{11} + 2b_1^{11}) \sin 2z - \ldots \\
&\qquad - Z_1 + 2q - \alpha_0 - 2\beta \tan p \cos z.
\end{aligned}\right\} \quad (18)$$

These equation are sufficient to find the probable values of the constants a, b, a_1 and b_1 by observations of different stars. The constants a however can be eliminated, so that, to find zenith distances, we need not know but the constants b and q. For we find

$$\zeta - 180^\circ = \tfrac{1}{2}(z - z^{11}) + b^1 \sin z + b^{11} \sin 2z + b^{111} \sin 3z + \ldots + \alpha_0 \quad (19)$$

The b being found by this equation, the constants a, may be found by the following one

$$-\zeta = \tfrac{1}{2}(z^1 - z^{111}) + 2a_1^1 \cos z - 2a_1^{11} \cos 2z + \ldots$$
$$+ b^1 \sin z - b^{11} \sin 2z + \ldots - 2q + \alpha_0.$$

The constants a may be determined from

$$180^\circ = \tfrac{1}{2}(z + z^{11}) + a^1 \cos z + a^{11} \cos 2z + \ldots - Z_1$$

and afterwards also the b_1 from

$$180^\circ = \tfrac{1}{2}(z^1 + z^{111}) - a^1 \cos z + a^{11} \cos 2z - \ldots$$
$$- 2b_1^1 \sin z + 2b_1^{11} \sin 2z - \ldots - Z_1 - 2\beta \tan p \cos z.$$

The equations (18) and all the others developed from them show, that the true zenith distance ζ cannot be separated from the constant a, or, to speak more exactly, from the constant q, they giving always the value of ζ — q. Nor will it be possible to separate zenith distances from this inclination by *sextants* or *reflecting circles.* The inclination β perpendicular to the plane of the sextant or reflecting circle has indeed no influence on finding altitudes, yet this is the case with the inclination a in the plane of the instrument, all the readings of altitudes being too great by the angle a, if an artificial horizon is used, while in case of a sea horizon the dip will be affected by this inclination. Neither of these errors can be eliminated by these instruments. Thus by altitude observations the inclination of the artificial horizon may be found *as far as it depends on the attraction of the instrument and its piers,* but not as far as it depends on local irregularities of the earth.

Now to come to a conclusion, the question turns up to the astronomer, by what means he will find the latitude and the time of his place. Since in case that his apparent meridian line is not parallel to the true horizon, all observations of stars will give him the latitude not of his place, but of such places, whose true horizon is parallel to his apparent meridian line. And in like manner if the plane of his apparent meridian does not go through the centre of the earth, all observations of stars will furnish him with the time not of his place, but of such places as are lying in a plane parallel to his apparent meridian and touching the centre of the earth. Consequently, all the methods of finding the longitude by immediate transportation of time or by observation of signals *visible at the same instant* will give him the longitude not of his place, but of the places just defined.

He must therefore look out for other means to find the errors in the determination of the latitude and the longitude of his place, and consequently also the constants of correction for his instruments, and such means seem to be *geodetic mensurations* and the observation of *parallactic phenomena.* If as many places of the earth as possible are combined by such observations and mensurations and the condition is made, that the sum of the squares of differences between the calculated and observed longitudes and latitudes becomes a minimum, the probable errors in determining the position of these places may be found. The first method has been partially employed by Prof. Schmidt in Göttingen and later also by the U. S. Coast Survey.* On the instigation of the celebrated Gauss Prof. Schmidt made use of the different meridian mensurations to calculate the dimensions of the terrestrial ellipsoid, so that the sum of the squares of differences between the computed and observed latitudes was a minimum. He found for the mean error of latitudes 3″ .193. But it may be interesting to have the complete result of his computation here reprinted from his "Lehrbuch der mathem. u. phys. Geography, Göttingen, 1829, I. p. 199."

* Report for 1853.

Tarqui	3°	4′	30″.83 + 1″.87
Cotchesqui	0	2	37.83 — 1.87
Trivandeporum	11	44	52.59 — 0.58
Paudree	13	19	49.02 + 0.57
Punnæ	8	9	38.39 — 1.78
Putchapolliam	10	59	48.93 — 1.22
Dodagoontah	12	59	59.91 + 3.54
Namthabad	15	6	0.64 — 0.54
Formetera	38	39	56.11 + 3.40
Montjouy	41	21	45.45 + 2.55
Barcelona	41	22	47.16 + 0.82
Perpignan	42	41	58.01 — 4.16
Carcassone	43	12	54.31 — 1.02
Evaux	46	10	42.19 — 5.88
Pantheon	48	50	48.94 + 0.37
Dünkirchen	51	2	8.74 + 3.92
Göttingen	51	31	47.85 — 2.76
Altona,	53	32	45.27 + 2.76
Dunnose	50	37	8.21 — 1.86
Greenwich	51	28	40.00 + 0.94
Blenheim	51	50	27.09 + 3.01
Arburyhill	52	13	28.19 + 1.83
Clifton	53	27	31.99 — 3.91
Mallörn	65	31	31.06 + 1.31
Pahtawara	67	8	51.41 — 1.31

In like manner also mensurations of Parallels might serve to find the errors in longitude. Amongst the *parallactic* phenomena, which may contribute towards finding the errors in longitude and latitude, especially solar eclipses and occultations of stars are to be mentioned. If in the equation, which represents the condition of a certain place of the earth lying in the surface of the cone of shadow, not only the longitude, but also the latitude and sidereal time, are supposed to be erroneous,* very likely part of the errors, for which formerly the ephemerides were made responsible, must be ascribed to the inclination of the apparent horizon. Thus longitude and latitude of an Observatory being approximately corrected by any of these methods, the formulas given in the preceding pages will furnish the means of finding the constants of correction for the instruments, and finally also *the inclination of the apparent to the true horizon as to magnitude and direction.*

* Brünnow in his "Lehrbuch der Sphärischen Astronomie," p. 329, develops this equation, supposing only the Ephemerides to be erroneous, Chauvenet in his "Manual of Spherical and Practical Astronomy," 5th ed. vol. i, p. 523, regards the corrections of the coördinates of the place of observation as depending only upon the correction of the eccentrictity of the terrestrial meridian, supposing the latitude itself as well as the sidereal time to be correct.

Stated Meeting, February 17, 1882.

Present, 8 members.

Vice-President, Prof. KENDALL, in the Chair.

Letters accepting membership were received from Mr. Wm. W. Jefferis, dated West Chester, Pa., Jan. 25, 1882; and from Mr. W. Townsend, West Chester, Pa., Jan. 25, 1882.

The resignation of Rev. Samuel Longfellow from the Society was announced.

Letters of envoy were received from the Imperial Botanical Garden, St. Petersburg, dated, Dec. 22, 1881; and the Department of the Interior, Feb. 9, 1882.

Letters and postals acknowledging the réceipt of Proceedings, No. 109, were received from the Geological Survey of Canada; Maine Historical Society; New Hampshire Historical Society; Boston Public Library; Boston Athenæum; Museum of Comparative Zoology, Cambridge; Essex Institute, Salem; American Antiquarian Society, Worcester; Rhode Island Historical Society, and Brown University, Providence; Connecticut Historical Society, Hartford; University of the City of New York; New York Hospital; Astor Library; Prof. J. J. Stevenson; U. S. Military Academy, West Point; Mr. C. H. F. Peters, Clinton, New York; New Jersey Historical Society, Newark; Pennsylvania Historical Society, Philadelphia; Mr. Geo. Smith, Garrettford P. O., Pa.; Prof. C. L. Doolittle, Bethlehem, Pa.; Prof. Trail Green, Easton, Pa.; Mr. J. F. Carll, Pleasantville, Pa.; Maryland Historical Society, Baltimore; Mr. Wm. B. Taylor, Washington; Georgia Historical Society; Prof. J. M. Hart, Cincinnati; Dr. Robert Peter, Lexington; Mr. Danl. Kirkwood, Bloomington, Ind.; Chicago Historical Society; Prof. J. S. Campbell, Crawfordville, Ind.; and the Wisconsin Historical Society, Madison.

A letter dated, Feb. 3, 1882, was received from Prof. E. D. Cope, making a request that No. 95 of the Proceedings, containing Dr. Gabb's paper on Costa Rica, should be sent to Mr. Leon Fernandez, San José, Costa Rica, as he is preparing a history of that country.

A letter was received from the Librarian of Cornell College Library, concerning the completion of their sets of Proceedings and Transactions.

A letter was received from C. Zinckra, dated Leipsig, Jan. 22, 1882.

Circular letters were received from the Smithsonian Institution, Washington.

Donations for the Library were received from the Asiatic Society of Japan; St. Petersburg Imperial Botanical Garden; Swedish Bureau of Statistics; Zoologischer Anzeiger, Leipsig; Accademia dei Lincei, Rome; Société de Géographie, Annales des Mines, and Revue Politique, Paris; Revista Euskara, Pamplona; London Nature; Natural History Society, and Mr. Samuel Abbott Green, Boston; Essex Institute, Salem; New York Academy of Sciences; New Jersey Historical Society; Numismatic and Antiquarian Society, American Journal of Pharmacy, "The American," and Mr. Henry Phillips, Jr., Philadelphia; Mr. John H. B. Latrobe, Baltimore; Department of the Interior, Washington; and the Ohio Mechanics Institute, Cincinnati.

Mr. Britton exhibited some peats and lignites of Arkansas, and some Anthracites from the same State, and also some bituminous coals, showing the progress of the formation of coals.

Pending nominations, Nos. 935, 951–955 were read.

Report of the Officers and Council was read.

And the meeting was adjourned.

Stated Meeting, March 3, 1882.

Present, 7 members.

President, Mr. FRALEY, in the Chair.

The death of Robert Bridges, M.D., on February 20, 1882, in the 76th year of his age, was announced by the President.

The death of Mr. Thos. P. James, at Cambridge, Mass., on February 22, 1882, in the 79th year of his age, was announced by Mr. Briggs.

The President was authorized to appoint suitable persons to prepare obituary notices of each of the deceased.

A letter of envoy was received from the Musée Guimet, Lyons, dated February 3, 1882.

Letters of acknowledgment were received from the Offenbacher Verein für Naturkunde (108); American Statistical Association, Boston (109); Mr. T. P. James (109); Yale College Library, New Haven (109); Mr. Henry Phillips, Jr., Philadelphia (109); and the Wyoming Historical and Geological Society, Wilkesbarre, Pa. (108, 109).

A letter was received from the Librarian of the Franklin Institute, dated February 21, 1882, requesting Part 1st of the Catalogue. On motion it was ordered to be furnished.

Donations for the Library were received from the Editor of Zoologischer Anzeiger, Leipsig; Accademia dei Lincei, Rome; Révue Coléopterologique, Brussels; Wurttembergische Vierteljahrshefte für Landesgeschichte, Stuttgart; Revue Politique, Paris; Société de Géographie Commerciale, Bordeaux; Royal Academy of History, Madrid; Cobden Club, Journal of Forestry, and Nature, London; Prof. C. Schorlemmer, Manchester, England; Royal Dublin Society; Natural History Society, and Rev. E. F. Slafter, Boston; American Journal, New Haven; Franklin Institute, the American, Prof. E. D. Cope, Mr. J. Blodgett Britton, and Mr. Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Baltimore; U. S. National Museum, Sensus Bureau, Bureau of Education, U. S. Commission of Fish and Fisheries, and the War Department, Washington; Revista Cientifica Mexicana, Revista Mensual Climatologica, and Ministerio de Fomento, Mexico.

A necrological notice of the late Dr. John W. Draper, by Dr. Wm. A. Hammond, was read.

Prof. E. D. Cope read a paper entitled "On the Structure of some Eocene Carnivorous Mammals," illustrating his subject by the exhibition of various fossil remains.

New nomination No. 956, was read.

Pending nominations Nos. 935, and 951 to 955, were read.

And the meeting was adjourned.

An Obituary Notice of John W. Draper, M.D., LL.D. By William A. Hammond, M.D., Surgeon General U. S. Army (Retired List).

(Read before the American Philosophical Society, March 3, 1882.)

In the death of Dr. Draper, the American Philosophical Society has to regret the loss of one of its most distinguished members. He died at his residence at Hastings-on-the-Hudson, in the State of New York, on the fourth day of January, 1882, after an illness which had lasted with more or less severity for several months.

John William Draper was born at St. Helen's, England, May 5th, 1811. His early education was received at the Wesleyan School at Woodhouse Grove, and subsequently from private teachers. At a still later period he made especial study of Chemistry, Natural Philosophy and the higher Mathematics, taking high rank in the knowledge of these sciences.

In 1833 he came to the United States, intending to make it his permanent home. Here he seems to have had his attention for the first time turned to the profession of Medicine, for he entered the Medical Department of the University of Pennsylvania and graduated in 1836. He never practised medicine, however; probably he never had a patient. A few months after receiving his diploma, he was appointed Professor of Chemistry, Physiology and Natural Philosophy in Hampden-Sidney, College, in Virginia. He occupied this position for about three years, publishing during that period several important essays on chemical and physiological subjects. Some of these appeared in the *American Journal of Medical Sciences,* but the greater number in the *London, Edinburgh and Dublin Philosophical Magazine.*

In 1839 he resigned his professorship at Hampden-Sidney College, to accept that of Chemistry and Natural Philosophy in the newly inaugurated University of the City of New York. In 1841 on the origination of the Medical Department of the University, of which he was one of the founders, he was appointed Professor of Chemistry. In 1850 Physiology was combined with Chemistry and he held the joint chair. The union was continued till 1865, when Dr. Draper gave up the teaching of Chemistry in the Medical Department, continuing, however, to lecture on Physiology. In 1867 he resigned this professorship also, retaining, however, the Presidency of the Medical Faculty, which he had held from 1850. In 1873 he severed his connection altogether with the Medical Department, but continued to the day of his death to hold his professorship in the Department of Arts.

Dr. Draper was, early in his career, an experimenter in various departments of Natural Science. In 1840 he described the figures which are formed when coins are laid on polished glass and which are made visible by exposure to the action of a vapor. About the same time he began to interest himself in the discoveries being made by Daguerre and was the first to photograph the human face.

The chemical action of light was a favorite study with him. In 1844 he published his work on the "Forces which produced the Organization of Plants," in which he showed that the yellow ray of the solar spectrum is the most powerful in its influence over vegetation. One of the most important contributions made by him to science is that in which he demonstrates that all solid substances become incandescent at about the temperature of 977° F.

Dr. Draper did not confine his studies to the Natural Sciences strictly so-called. He was ambitious of distinction as a historian. His basis was, that nations are subject to the same laws as individuals and that in their migrations and stages of development they have been acted upon by purely physical causes. We are inclined to think that he carried his views in this respect, too far, and that he disregarded the undoubted influence of intellectual and emotional factors as creators and modifiers of history.

Dr. Draper's contributions to Scientific Periodicals and the Transactions of Medical Societies have been very numerous. One paper only was presented to the American Philosophical Society, and this was May 27th, 1843. He was elected a member of the Society January 19th, 1844, and consequently this memoir was submitted before he joined us: its title is, "On the Decomposition of Carbonic Acid and the Alkaline Carbonates by the Light of the Sun." It is published in Vol. III of the Proceedings.

His published volumes are as follows:

"A Treatise on the Forces which produce the Organization of Plants," 1844.

"A Text-Book of Chemistry," 1846.

"A Text-Book of Natural Philosophy," 1847.

"A Treatise of Human Physiology," 1856.

"History of the Intellectual Development of Europe," 1862.

"Thoughts on the Future Civil Policy of America," 1865.

"History of the American Civil War," 1867–70.

"History of the Conflict between Religion and Science," 1877.

In all these works Dr. Draper showed that he had read extensively and thought deeply. He had great facility for expressing himself with clearness and directness and hence for impressing his views upon others. Nevertheless it must be confessed, that his chief claim for distinction will rest upon his labors in Chemistry and Natural Philosophy. His "Treatise on Human Physiology" is in many respects fanciful and speculative, and theories are promulgated as well-founded which have no support from facts. His historical works are characterized by an entire absence of references to the sources of his information, and therefore they lost much of the value which they would otherwise possess for students.

In 1876 he was awarded the Rumford Medal by the American Academy of Arts and Sciences, for his researches on Radiant Energy. In 1881 he was elected one of the twelve honorary members of the Physical Society of London.

Stated Meeting, March 17, 1882.

Present, 10 members.

President, Mr. Fraley, in the Chair.

The death of Dr. Joseph Pancoast, March 7th, 1882, æt. 77, was announced by Mr. Eli K. Price. On motion Prof. Samuel D. Gross was requested to prepare an obituary notice.

Letters of acknowledgment were received from the Astronomische Gesellschaft, Leipsig (108), Free Public Library, New Bedford (109), and the Numismatic and Antiquarian Society of Philadelphia (109).

A letter was received from the Kaiserliche Universitäts-und Landes-Bibliothek, Strassburg, dated Feb. 16, 1882. The matter was referred to the Secretaries with power to act.

Donations for the Library were received from F. Sandberger; Zoologische Anzeiger, Leipsig; R. Accademia dei Lincei, Rome; Academie Royale, Bruxelles; Société de Géographie, and Revue Politique, Paris; Société de Géographie Commerciale, Bordeaux; Royal Astronomical Society and Nature, London; M. E. Wadsworth, Boston; Essex Institute, Salem; Journal of Banking Law; Pennsylvania Historical Society, Franklin Institute, Journal of Pharmacy, The American, Philadelphia; New Jersey State Geological Survey; American Chemical Journal; U. S. Signal Service Bureau, Washington; Historical Society of Wisconsin; Mercantile Library Association, San Francisco; Illinois State Museum of Natural History, and Prof. Lesquereaux, Columbus.

The President reported that he had requested Dr. Ruschenberger to prepare an obituary notice of Dr. Bridges, and Dr. Rothrock one of Thos. P. James, and that they had accepted the appointment.

Prof. Sadtler read a paper by Prof. Edgar F. Smith, and N. Wiley Thomas, on Corundum and Wavellite from localities as yet unknown to mineralogists, about six or eight miles from Allentown, Pa.

Mr. Phillips made a communication in reference to the progress of the New Dictionary of the English Language, now progressing under the auspices of the Philological Society.

Pending nominations Nos. 835, 951 to 956, and new nominations Nos. 957 and 958 were read.

The resignation of the Rev. Samuel Longfellow, of Germantown, Pa., was presented to the Society, and on motion accepted.

And the meeting was adjourned.

Corundum and Wavellite. By Edgar F. Smith and N. Wiley Thomas.

(Read before the American Philosophical Society, March 17, 1882.)

Specimens of these minerals from localities, as yet perhaps unknown to mineralogists, came under our examination some time ago, and thinking that a description of them might not be without some interest to specialists, we submit the following :

1. Early in January last, a piece of what was once a large hexagonal prism of corundum terminated by pyramids, was handed us. The specimen we received was an end piece exhibiting a perfect hexagonal form, with pyramidal ending, and on the broken surface of the crystal, the color observed was blue. The weight of this specimen is five pounds. The original complete crystal measured eight inches in length, and the diameter over the secondary axes is about four and one half inches. On the exterior surface are observable here and there, magnetite crystals and these were the cause of the destruction of the original crystal soon after it had been ploughed up. The farmer thinking he had made a valuable discovery and curious to know the appearance of the inside, broke the crystal into several pieces, one of these coming into our possession, after it had been carried about to various parties, for inspection and determination. Only very slight indications of any alteration are apparent on the exterior of the crystal. Soon after getting the above, we received another crystal —a double pyramid—about five and one-half inches long and weighing over five pounds. Since the reception of the preceding, we obtained several cigar boxes full of smaller, well-defined crystals. All of our specimens were found near Shimersville, Lehigh Co., Pa., and were thrown out while plowing. The district over which these crystals were scattered, and have been noticed, is rather extensive and is already under lease, and "prospecting" for larger quantities has been commenced. Quite a number of medium sized crystals were sent to the Weissport Emery Works,

there tested and declared excellent for technical purposes. We reserve our analyses of the above for a future communication.

2. The specimens of Wavellite are from the neighborhood of Macungie, Lehigh Co., Pa. They present radiating nodules on limonite; their color is white. These crystals were considered to be calamine, and on this account we experienced some difficulty in ascertaining the locality. Indeed, we were obliged to show qualitative proof of the absence of zinc to the parties interested, before being made acquainted with the history of the specimens. Our analyses were made of some of the well-defined crystals. The method of analysis pursued, was that described by Dr. F. A. Genth, in *Am. Journal of Science, etc.*, II. Vol. 23, p. 423.

Analysis.

Al_2O_3	36.66 %
P_2O_5	34.14
H_2O	28.32
Fl	*trace*
Limonite	0.60
	99.72

Chemical Laboratory of Muhlenberg College, Allentown, Pa., March 3, 1882.

Stated Meeting, April 7, 1882.

Present, 12 members.

President, Mr. Fraley, in the Chair.

Letters accepting membership were received from S. S. Lewis, Corpus Christi College, Feb. 4; and from Wm. Blades, Abchurch Lane 23, London, Feb. 18, 1882.

Letters of acknowledgment were received from the K. K. Central-Anstalt für Meteorologie, Wien (108); Verein für Erdkunde, Dresden (105–106); Franklin Institute, Philadelphia (Catalogue Part I.); Prof. Thos. C. Porter, Easton, Pa. (109); West Chester Philosophical Society (109); Mr. Asaph Hall, Washington (109); and the Smithsonian Institution (109).

Letters of envoy were received from the Central Physical Observatory, St. Petersburg, dated Feb. 1882; Prof. F. Reuleaux, Berlin, March 10, 1882; Verein für Erdkunde, Dresden;

U. S. Naval Observatory, Washington; and the Department of State, Washington, April 1, 1882.

Donations for the Library were received from the Academies at St. Petersburg, Berlin, Munich, Rome and Brussels; Prof. Reuleaux, Braunschweig; Herr. Aug. Tischner, and the Zoologischer Anzeiger, Leipsig; Herr. L. Rütimeyer, Zurich; Geographical Societies at Paris and Bordeaux; Baron J. De Baye, Chalon-sur-Marne; Royal Library at the Hague; Flora Batava, Leyden; Royal Astronomical Society, and Nature, London; Mr. M. E. Wadsworth, Boston; American Academy of Arts and Sciences; American Journal, New Haven; Mr. E. A. Barber, Mr. Lorin Blodget, Mr. Henry Phillips, Jr., Dr. Jayne, the Academy of Natural Sciences, Board of Directors of City Trusts, and the Editors of the "American," Philadelphia; Johns Hopkins University, Baltimore; U. S. Fish Commission, U. S. National Museum, U. S. Census Bureau, U. S. A. Department of Engineers, and the U. S. Naval Observatory, Washington, D. C.; The Virginias, Staunton, Va; American Antiquarian, Chicago.

A letter from the Wyoming Geological Society was referred to the Secretaries with power to act.

The death of Solomon W. Roberts, at Atlantic City, March 22, in the 71st year of his age, was announced by Mr. J. S. Price, and Mr. Fraley was requested to prepare an obituary notice of the deceased.

The death of Edouard Desor, at Nice, Feb. 23, in the 71st year of his age, was announced; and Mr. Lesley was appointed to prepare a notice.

The death of Dr. Robert S. Kenderdine, in Philadelphia, March 27, aged 51, was announced by Mr. J. S. Price, and the President was requested to appoint a proper person to prepare an obituary notice of the deceased.

Mr. Ashburner read a paper on "Estimation of Coal Areas and Coal Contents of the Anthracite Fields of Pennsylvania."

Prof. Cope read a paper on a new form of Marsupial Mammal from the Lower Eocene of New Mexico.

Prof. Cope read a paper on Archæsthetism.

Mr. Eli K. Price read the following report as Chairman of the Committee on the Michaux Legacy:—

"The course of lectures in Fairmount Park was successfully delivered by Dr. Rothrock in 1881, according to annexed statement.* The audience was interested and highly respectable; the number varying from two to four hundred.

"I recommend the continuance of the lectures for the present year; and that an appropriation be made of two hundred and eighty dollars ($280) for the lecturer, and fifty dollars ($50) for advertising. The course will be according to annexed schedule in manuscript." †

On motion it was ordered that an appropriation of $330 be made for the above objects, payable out of the Michaux Legacy.

Pending nominations Nos. 935 and 951 to 958 were read, and the meeting was adjourned.

Stated Meeting, April 21, 1882.

Present, 8 members.

President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the Glasgow Philosophical Society (107–108); the Royal Geological Society of Ireland, Dublin (XV, 3; 107–108); and the Franklin Institute, Philadelphia (108–109).

* In 1881, from April 23d to June 18th, on Saturdays at 4 P. M.:—Subjects—1. How and why we study Botany; 2. The Plants we Eat; 3. The Plants we Drink; 4. The Plants we Wear; 5. How we and the Plants Breathe and How we help each other; 6 and 7. Diseases of Plants.

II. From September 10th to October 8th:—8. Strange Marriage among Plants; 9. Forestry in Europe; 10. Want of Forestry in America and its Consequences; 11. How Trees are made; 12. How Plants Travel; 13. Weeds; 14. Botany for Winter.

† In 1882, on Saturdays, at 4 P. M., from April 22d to June 3d. Subjects—1, 2. Plants which have influenced Human History. 3, 4. How Plants are Constructed. 5, 6. How Plants are Organized. 7. Meat-eating Plants.

II. September 9 to October 21.—8. How Vegetation protects the Earth and influences Rain-fall. 9. What the Roots do and how they do it. 10. American Timber and its special value. 11, 12. Sick Plants. 13. Strength and Durability of Timber. 14. The Plants eaten by other Nations.

Letters of envoy were received from the Naturforschende Gesellschaft, Görlitz, dated Nov. 5, 1881; Naturhistorische Gesellschaft, Nürnburg, Nov. 16, 1881; Kgl. Hof-und-Staats-Bibliothek, München, Dec. 27, 1881; Meteorological Office, London, March, 1882; Canada Geological and Natural History Survey, Montreal, April, 1882; Department of the Interior, Washington, April 7, 1882; Louisiana Board of Health, New Orleans, March 30, 1882; and the Public Museum of Buenos Ayres.

Donations for the Library were received from the Academies at St. Petersburg, Copenhagen, Munich, Rome, and Brussels; Observatories at St. Petersburg, and Munich; Geological Society, Berlin; Natural History Societies at Görlitz, Chemnitz, Nuremburg, and St. Gall; Royal Society, Göttingen; Zoological Society, Leipsig; Royal Library, Munich; K. K. Geol. Reichsanstalt, and the Anthropologische Gesellschaft, Vienna; Herr Joachim Barrande, Prag; Musée Guimet, Lyons; Anthropological, and Geographical Societies, Ecole Polytechnique, and Revue Politique, Paris; Revista Euskara, Pamplona; L. G. De Koninck, Liège; Astronomical, Meteorological, Royal Geographical, Geological, and Royal Asiatic Societies, and Society of Arts, London; Geological Survey of India, Calcutta; Glasgow Philosophical Society; Geological and Natural History Survey of Canada; Prof. J. D. Whitney and Prof. Alex. Agassiz, Cambridge; American Antiquarian Society, Worcester; Prof. O. C. Marsh, New Haven; Prof. J. Henry Comstock, Ithaca; Capt. Jas. E. Cole, N. Y.; State Board of Agriculture, Harrisburg; Philadelphia and Reading R. R. Co.; U. S. Fish Commission, U. S. Entomological Commission, U. S. National Museum, and Census Bureau, Washington; Louisiana State Board of Health; National Museum, Mexico; and the Public Museum, Buenos Ayres.

Dr. Gross declined by letter, on account of numerous engagements, his appointment to prepare an obituary notice of Dr. Pancoast.

The death of Charles Robert Darwin, April 20, aged 73, was announced by Dr. Le Conte.

Dr. LeConte said:

In rising to announce the death of Charles Robert Darwin, which occurred on the nineteenth day of April, last, in the seventy-fourth year of his age, I have no intention to give a biographical sketch of his life, or his contributions to science. This labor of love will be performed fully by some of his compatriots, who have had the benefit of the sweet and instructive personal intercourse with him which has failed to be part of our earthly enjoyment. But what I do wish to manifest, as far as the feeble power of my language will permit, is the deep grief which we feel, at the loss of one, who has by his work and his writings, become a dear companion, and a guide in our scientific thought.

For, to no man more than to Darwin, does the present age owe as much, for the gradual reception of the modern method of close observation over the scholastic or *a priori* formulæ, which, up to a brief period, affected all biological investigations. To him, above all men, we owe the recurrence to the old Aryan doctrine of evolution (though in those ancient times promulgated under the guise of inspiration) as preferable, by reasonable demonstration, to the Shemitic views, which have prevailed to within a few years, and are still acceptable to a large number of well-minded but unthinking men. The doctrine of evolution, in its elementary form, means nothing more than that everything that exists has been derived from something that pre-existed; that the former is related to the latter as effect is to cause. And it is most pleasing evidence of the acceptability of this doctrine, that it is now heard from many pulpits in the land, as a strong illustration of the instructions which are thence given.

Therefore, while lamenting the death of Darwin, at a ripe old age, and losing the benefit of his vast store of learning, which could not much longer remain with us, we are grateful that we have lived in a generation in which he was a conspicuous example of the humble and holy men of heart, which other scientific men should endeavor—albeit, with much less capacity—to imitate.

And, finally, we offer to the bereaved family our most heartfelt sympathy in their affliction, and our trust that the well-chosen ancestral alliances will enable the descendants to worthily succeed in attaining the honor and usefulness which characterized our deceased colleague.

The death of John Lenthall, U. S. N., April 11, at Philadelphia, in his 75th year, was announced.

The death of Robert Christison, M. D., of Edinburgh, was reported as having taken place in 1880.

Mr. Chase communicated Photodynamic notes No. V.

Mr. H. C. Lewis described his observations of the aurora of April 19 and 20, proving its connection with the earth by the apparent motion of the corona eastward at the rate of 15° per hour.

Nominations Nos. 951 to 958 were read and balloted for.

Mr. Fraley reported that he had collected and paid over to the Treasurer the interest on the Michaux Legacy, due April 1, amounting to $133.07.

On scrutiny of the ballot boxes, the following were declared duly elected members of the Society:

951. Charles W. King, Fellow of Trinity College, Cambridge, England.

952. Rev. James W. Robins, D. D., Principal of the Episcopal Academy in Philadelphia.

953. Charles Sprague Sargent, A. B., Cambridge, Mass., Professor of Botany.

954. Franklin B. Hough, M. D., of Lowville, N. Y.

955. Stephen P. Sharples, of Boston, Mass., late Asst. Prof. Chem. Harvard College.

956. Charles Edward Rawlins, Esq., of Rock Mount Rainhill, Liverpool, England.

957. George de B. Keim, Esq., of Philadelphia.

958. Hamilton Andrews Hill, Esq., of Boston, Secretary of the National Board of Trade.

And the meeting was adjourned.

Photodynamic Notes, V. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, April 21st, 1882.)

158. *Synchronous Areas.*

Kepler's second law is grounded upon principles which must modify rotation and subsidence, so as to introduce harmonic tendencies among the synchronous areas which are described by different bodies, under the controlling activity of a common centre, as well as in the virtual areas which represent the reaction of the subordinate masses upon the centre of gravity of the system. In orbits of small eccentricity, the instantaneous area of a particle is nearly proportional to the square root of its mean radius vector. If we take $r = (\frac{1}{2})^3 = .125$, as a harmonic divisor, the first of these tendencies is shown by the principal planets, as may be seen in the following table :

Harmonic Areas.		Synchronous Areas.		Difference.
5 r	.625	Mercury	.6222	+ .0028
7 r	.875	Venus,	.8505	+ .0245
8 r	1.000	Earth,	1.0000	.0000
10 r	1.250	Mars,	1.2344	+ .0156
18 r	2.250	Jupiter,	2.2810	— .0310
25 r	3.125	Saturn,	3.0885	+ .0365
35 r	4.375	Uranus,	4.3799	— .0049
44 r	5.500	Neptune,	5.4803	+ .0197

All the differences are within the limits of probable error, .03125, except Saturn's. Jupiter's area is nearly $\frac{3}{4}$ of Saturn's, and the combined masses of these two planets is so great as partially to override the simple tendencies of subsidence towards the chief centres of condensation and nucleation, Earth and Sun.

The synchronous areas of Mercury and Mars, the outliers of the dense belt, are nearly in the ratio 1 : 2 ; Venus and Earth, 7 : 8 ; Uranus and Neptune, 4 : 5. The difference is less than $\frac{1}{46}$ of the probable error in the first of these comparisons ; less than $\frac{1}{2}$ of the probable error in the second ; less than $\frac{1}{109}$ of the probable error in the third ; the "probable error," in each case, being $\frac{1}{4}$ of the common divisor, or the deviation which would be admissible without weakening the evidence of harmonic tendency in a *vera causa.*

159. *Virtual Areas.*

The virtual areas of synchronous reaction, or the instantaneous areas which a particle, at Sun's mean distance, would describe about the principal planets if it were not restrained by stronger influences, vary as $\sqrt{m\ r}$. *Vis viva* may be represented by orbital areas, as well as by distances of projection against uniform resistance, therefore we may add a third law to

Laplace's two laws of constant sums, viz :—*The sum of all the instantaneous virtual areas in a system will always remain invariable.*

From Alexander's harmony (Note 156, p. 605) it follows, that the ratio between the virtual areas of Jupiter and Saturn is nearly the reciprocal of the ratio of their direct areas. The harmonic influence of the repeated nodal action of this ratio, upon subordinate planetary aggregation, is shown in the following table :

Harmonic Areas.		Virtual Areas.		Difference.
α	40.256	Jupiter,	40.587	— .331
$\beta = \frac{3}{4}\alpha$	30.192	Saturn,	30.063	+ .129
$\gamma = \frac{3}{4}\beta$	22.644	Neptune,	22.675	— .031
$\delta = \frac{3}{4}\gamma$	16.983	Uranus,	16.782	+ .201
ε	1.000	Earth,	1.000	.000
$\zeta = \frac{3}{4}\varepsilon$	.750	Venus,	.749	+ .001
$\eta = \frac{2}{5}\varepsilon$	.400	Mars,	.404	— .004

The greatest proportionate difference is that of Uranus, $1\frac{1}{5}$ per cent. The harmonic change from the outer to the inner belt of planets, $\delta \div \varepsilon = 16.983$, represents the orbital retardation at the chief centre of condensation, Earth. If Earth were rotating with the speed which it would have if Laplace's limit coincided with its equatorial surface, its time of rotation would be $2\pi\sqrt{\frac{r}{g}} = 5073.6$ seconds ; $86164.1 \div 5073.6 = 16.983$. The synchronous virtual area of Mars differs by less than $4\frac{1}{2}$ per cent. from $\frac{3}{4}$ of $\frac{3}{4}\,\zeta$. This is less than 18 per cent. of the probable error.

160. *Laplace's First Law of Stability.*

The first of the two laws in which the author of *Mécanique Céleste* embodied his discoveries in relation to the stability of the solar system, is thus stated ; "If the mass of each planet be multiplied by the product of the square of the eccentricity and square root of the mean distance, the sum of all these products will always retain the same magnitude." By combining the first and third of these factors, $m\sqrt{r}$, we get the quotient of mass by orbital velocity, together with the following suggestions of nodal influence:

	$m\sqrt{r}$		Semi-axes major.
Jupiter	$722.19 = 5.184^4$	γ_5	5.203
Saturn,	$279.46 = 9.695^{\frac{5}{2}}$	γ_6	9.539
Neptune,	$93.82 = 30.146^{\frac{4}{3}}$	γ_9	30.037
Earth,	1.00	γ_3	1.000

Jupiter's exponent represents the variable ratio of subsidence-acceleration to orbital velocity ; Saturn's the product of orbital time by mean distance; Neptune's, the variable ratio of Laplace's limit to nucleal radius.

161. *Orbital Momentum.*

The division of $m\sqrt{r}$ by r gives the product of mass by orbital velocity, or orbital momentum, together with the following suggestions of photodynamic or nebular activity :

	$m \div \sqrt{r}$	Cardinal Radii.	
Jupiter,	$138.81 = 5.178^3$	γ_5	5.203
Saturn,	$30.68 = 9.800^{\frac{3}{2}}$	β_6	10.000
Uranus,	$3.35 = 20.567^{\frac{2}{5}}$	α_7	20.679
Neptune,	$3.12 = 30.483^{\frac{1}{3}}$	α_8	30.470
Earth,	1.00	γ_3	1.000

Jupiter's exponent represents the ratio of its photodynamic orbital volume to that of Earth ; Saturn's, the ratio of orbital times ; Uranus's the influence of mean rotary *vis viva* in an elastic medium ; Neptune's the influence of a centre of linear oscillation in an elastic medium.

162. *Coefficient of Solar Torsion.*

In applying the oscillatory equation, $t = \pi\sqrt{\frac{l}{g}}$, at the centre of gravity of a stellar system, let t represent the duration of an oscillation or half-rotation, g the acceleration of gravity at the stellar equatorial surface, $\pi^2 l$ the stellar modulus of light or the height of a homogeneous æthereal atmosphere which would propagate undulations with the velocity of light. Then, if the stellar rotary oscillation is due to the reaction of cosmical inertia against æthereal influence, gt is equivalent to the velocity of light, v_λ.

In Coulomb's formula of torsional elasticity, $f = \frac{\pi^2 a^2 W}{2\,gt^2}$, W represents a weight suspended by a wire, a the coefficient of the radius of torsion, f the coefficient of torsion for the extended wire, g gravitating acceleration, t time of oscillation when the force of torsion is removed. Applying this formula to solar rotation, we have

$$f = \frac{m}{2} = \frac{W}{2} \cdot \frac{\pi^2 a^2 r_0}{gt^2}\,; \;\therefore\; \pi^2 a^2 r_0 = gt^2 = \pi^2 l.$$

But gt is the velocity which would be communicated by gravity, at Sun's surface, in one oscillation of half-rotation, or the velocity of light ; gt^2 is the modulus of light at Sun's surface ; $a^2 r_0$ is the theoretical length of a pendulum, at Sun's surface, which would oscillate once in each half-rotation ; $a\, r_0$ is the length of an equatorial radius rotating with Sun and having the superficial orbital velocity, $\sqrt{gr}$, at its remote extremity. These are the same results as have been already derived from simple gravitating and radiodynamic considerations, Notes 17, 48, 100, etc. Their statement in this form may be satisfactory to some readers who have not followed the foregoing investigations through all their details.

163. *Harmonic Categories.*

The simple discovery of so many harmonies, in all departments of physical science, would be interesting, even if it were accidental or wholly empirical. The fact that the discovery has sprung from systematic investigations, under the guidance of well-known laws, adds much to its importance. The following results seem to be especially important, and somewhat typical.

1. The equality of *gt*, in the solar oscillations of half-rotation, to the *velocity of light*. Notes 17, 162, etc.

2. The relations of mass and *vis viva* which satisfy cosmical tendencies to nodality, subsidence, oscillation and orbital revolution. Notes 5, 23, 79, 91, 156, 158–61.

3. The far-reaching evidence of elastic influence which establishes measurable progressive relations between the solar system and the fixed stars. Notes 46, 111–5, 130–2, 155.

4. The simplicity of the relations between elastic and cosmical *vis viva*, which furnish data for approximate estimates of Sun's mass and distance by means of barometric fluctuations. Notes 104–5.

5. The relations of magnetic and cosmical *vis viva*, together with the evidence which they furnish of the dependence of solar and lunar magnetic disturbances upon thermal and tidal influences. Notes 2, 116–22, 125–6.

6. The curiously symmetric harmony in Mars and its satellite-system. Note 28.

7. The varied harmonies of spectral lines, together with the relations of planetary positions to luminous nodes. Notes 36–45, 109, 141–2, 144–53, 157.

8. The confirmations of predictions which were founded upon evidences of the influence of harmonic laws. Notes 33, 133, etc.

9. The interchangeable convertibility of physical units. Notes 90, 96.

10. Atomic phyllotaxy. Notes 135–9, 143. Although Gerber's divisors were found empirically, they represent natural elementary groups. His utter want of suspicion that they had any physical meaning makes them much more important than they would have been if his investigations had been biased by a preconceived hypothesis. The kinetic theory of gases necessitates harmonic action, and the tendency to division in extreme and mean ratio leads to one of the most simple kinds of harmony. There is no necessary inconsistency between the doctrine of atomic phyllotaxy and Prout's hypothesis.

164. *Mercury's Virtual Area.*

The fundamental ratio of successive virtual areas, $\frac{3}{4}$, represents the ratio of the locus of linear centre of gravity of a simple pendulum to the locus of its centre of oscillation, as well as the exponential ratio of nucleation to limitation in an elastic medium. The intermediate step between the harmonic areas for Mars and Venus, Note 159, may, perhaps, be distributed, partly among the asteroids, partly in satisfying special requirements of the dense belt, and partly in the variations of æthereal *vis viva*. The mass of Mercury is so imperfectly known that it is unsafe to put much trust in the accuracy of any merely harmonic indications of its value, but its virtual area is unquestionably of the same order of magnitude as $(\frac{3}{4})^3$ of that of Mars, or $\frac{729}{4096}$ of that of Earth. This would give, for an approximate estimate of the quotient of Sun's mass by that of Mercury, 4054440. The two intermediate steps may, perhaps, be partly absorbed by the intra-Mercurial harmonic nodes and the meteoroids of the zodiacal light.

165. *Relative Masses of Neptune and Mars.*

An intermediate step between the virtual areas (Note 159) and the nodal masses (Note 156), is indicated by the ratio between the masses at the outer limits of the supra-asteroidal and the intra-asteroidal belts. The quotient of the square of Neptune's harmonic virtual area, 22.644^2, by its harmonic radius, 30.036*, is 17.071; the quotient of the squared area of Mars, $(\frac{3}{4})^6$, by its harmonic radius, 1.669, is .10664; the ratio of the masses and the mass-ratio of Sun to Mars are approximately shown in the following proportions:

$$m_8 : m_4 : : 17.071 : .10664 : : 160.09 : 1$$
$$m_0 : m_4 : : (160.09 \times 19380 = 3102544) : 1$$

166. *Various Harmonic Indications and Tests.*

If κ represents Earth's limiting nucleal radius (Note 159), the corresponding atmospheric radius would be $\kappa^{\frac{4}{3}} = 43.653$. Herschel's locus of incipient subsidence, in the controlling two-planet belt, or Saturn's secular aphelion, is 1.0843289 times the outer limiting locus of the belt (Stockwell, *Smithson. Contrib.*, 232, p. 38); $\kappa^{\frac{4}{3}} \div 1.0843289 = 40.258$, which is, with close approximation, the ratio of the instantaneous virtual area at the inner locus of the controlling belt, to the corresponding area at the chief centre of condensation. The tendency of exponents, in elastic media, to become coefficients of elastic *vis viva*, is shown in Note 159. If we use the symmetrical harmonic areas for Mars and Mercury, the percentages of difference between the harmonic and virtual areas are, respectively, $\frac{5}{6}$ of .01, $\frac{3}{7}$ of .01, $\frac{1}{7}$ of .01, $\frac{6}{5}$ of .01, $\frac{1}{7}$ of .01, .045, .099. In testing the combined harmonic influences of a *vera causa* which is subject to internal perturbations, there is room for a possible deviation of 50 per cent. and a probable deviation of 25 per cent. The combined probability that the approximations in Note 159 are owing to æthereal influence is, therefore, $30 \times \frac{175}{3} \times 175 \times \frac{125}{6} \times 175 \times \frac{50}{9} \times \frac{250}{99} = 15664091727 : 1$.

The following points of symmetry and alternation may be noted in the nodal mass-factors of the two outer planets, Note 156:

1. The tendency to equality of mean orbital *vis viva* in Earth, Uranus and Neptune, as indicated by the factors γ_3, γ_7 and γ_8.

* Proc. Am. Ph. Soc., xiii, 239.

2. The nodal modification of Neptune's mass by Earth's secular aphelion, and of the mass of Uranus by Earth's secular perihelion.

3. The nodal modification of Neptune's mass by its own mean perihelion, and of the mass of Uranus by its own mean aphelion.

4. The modification of Uranus by Jupiter, and the corresponding modification of Neptune by Uranus.

167. *Earth's Modulus of Rotation and Jupiter's Eccentricity.*

Let g_β represent the sum of the gravitating accelerations of Sun and Earth at Earth's equatorial surface; t, time of Earth's rotary oscillation ($\frac{1}{2}$ sidereal day); ρ_o, Sun's equatorial semi-diameter; r_3, Earth's semi-diameter; ρ_a, mean projection of centre of gravity of Sun and Jupiter from ρ_o; $\rho_a \div \rho_o$, Jupiter's maximum secular eccentricity; ρ_3, Earth's semi-axis major; $g_\beta t^2$, Earth's modulus of rotation. Then

$$g_\beta t^2 : \rho_3 : : \rho_a : \rho_o.$$

The photodynamic or oscillatory values of Sun's mass and distance, Note 91, give for Sun's gravitating acceleration of Earth $\frac{m_o}{m_3}\left(\frac{r_3}{\rho_3}\right)^2 = 331776 \times (3962.8 \div 92785700)^2 = .000605184$ of Earth's equatorial gravitating acceleration. If we adopt Everett's value for g, $g_\beta t^2 = 1.000605184 \times 32.091 \times 43082^2 \div 5280 = 5643840$ miles; $\rho_a \div \rho_o = .0608265$. Stockwell's value (*Smith. Cont.*, 232, p. 38), is .0608274.

168. *Axis of Central Subsidence and Rupture.*

The influence of the interstellar photodynamic paraboloid is shown in the boundaries of the belt of greatest condensation. The locus of incipient rupture, Mercury's secular perihelion, is about $\frac{1}{6}$ of the locus of incipient subsidence, secular aphelion of Mars. Stockwell's values for the two loci are .2974008 and 1.736478. This gives for the major axis of the several incipient ellipses, described by the subsiding particles from the outer portion of the belt, $.2974008 + 1.736478 = 2.0338788$. Let g_0, g_3 represent equatorial superficial gravitating acceleration of Sun, Earth, respectively; m_5, m_3, masses of Jupiter, Earth; t_a, time of Jupiter's orbital revolution; t_β, time of Earth's rotation; ρ_3, Earth's semi-axis major; ρ_n, asteroidal radius equivalent to major axis of incipient ellipses of dense belt. Then

$$\frac{t_a}{t_\beta} \times \frac{m_3}{m_5} \times \frac{\rho_n}{\rho_3} = \frac{g_0}{g_3}$$

$$4332.58482 \div 316.617 \times 2.0338788 = \frac{g_0}{g_3} = 27.8316$$

$$\frac{m_o}{m_3} \times \frac{g_3}{g_o} = \left(\frac{r_0}{r_3}\right)^2$$

$$331776 \div 27.8316 = 11920.8$$

$$\frac{r_0}{r_3} = \sqrt{11920.8} = 109.183$$

$$r_0 = 109.183 \times 3962.8 = 432669 \text{ miles.}$$

$$\rho_3 \div r_0 = 92785700 \div 432669 = 214.45$$

These results may be compared with those which were given in Notes 91, 113 and 156, the extreme range of difference being less than $\frac{1}{40}$ of one per cent.

169. *Earth's Incipient Subsidence.*

If the various relations which are shown in the foregoing note are due to Earth's atmospheric and nucleal subsidence from the centre of the dense belt $\left(\frac{\rho_n}{2} = 1.0169394\right)$, its secular aphelion should be $\left(\frac{\rho_n}{2}\right)^4 =$ 1.0695. Stockwell gives (*op cit.*, p. 38) 1.0677352, upon the assumption that $\frac{m_0}{m_3} = 368689$. On page xi of his Introduction he gives 1.0693888; on page xvii he gives a series of values which yield, by interpolation, 1.0691 for the photodynamic mass-ratio, $\frac{m_0}{m_3} = 331776$.

170. *Progression of Fundamental Atomicities.*

Thomas Bailey, (*Phil. Mag.*, Jan. 1882, p. 35), gives a series of atomic weights corresponding to minimum volumes, which are members of the geometric series a, ab, ab^2, ab^3, ab^4, the value of b being $\frac{1}{6}$ of a and the value of a being 10. This suggests an atomic parabolic motion, like that in the photodynamic or interstellar paraboloid, in which $\xi = \frac{1}{6}$. We may also notice that 6 is the product of the two phyllotactic numbers, 2 and 3.

171. *Perissad Phyllotaxy.*

The indications of phyllotactic tendency in various departments of physics, have induced me to test Gerber's groupings of chemical atoms by methods which seem to me to be perfectly legitimate. In order to remove all effects of personal equation or bias, as well as of accidental or empirical coincidence, I adopt Clarke's recalculation of atomic weights (*Phil. Mag.* [5] 12, 109–10), and my strictly phyllotactic divisors (Note 136), instead of Gerber's empirical divisors. In view of the *a priori* probability of tendency to division in extreme and mean ratio, I assume that the ratio of probability to improbability, in each instance, is equivalent to at least $\frac{1}{4} D : (T - O)$; D being the phyllotactic divisor, T the theoretical atomic weight or nearest exact multiple of D, and O the observed atomic weight taken from Clarke's table. I have added Rb and Tl to Gerber's list of monatomic elements, and Bo to his trivalent list.

Monatomic Group; $D_1 = .768$.

		T.	O.	T-O.	Probability.
Li	9 D_1	6.912	7.007	.095	192 : 95
Na	30 D_1	23.040	22.998	.042	192 : 42
K	51 D_1	39.168	39.019	.149	192 : 149
Cs	173 D_1	132.864	132.583	.281	192 : 281
Fl	25 D_1	19.200	18.984	.216	192 : 216
Cl	46 D_1	35.328	35.370	.042	192 : 42
Br	104 D_1	79.872	79.768	.104	192 : 104
I	165 D_1	126.720	126.557	.163	192 : 163
Ag	140 D_1	107.520	107.675	.155	192 : 155
Rb	111 D_1	85.248	85.251	.003	192 : 3
Tl	265 D_1	203.520	203.715	.195	192 : 195

Three of the elements, Cs, Fl and Tl, indicate a probability that the phyllotactic approximation may be merely accidental. The aggregate probability that the combining equivalents of the monatomic elements are modified by phyllotactic tendencies, or the product of all the separate probabilities, is more than 5610 times as great as the probability that the approximations are accidental.

Trivalent Group; $D_3 = 1.559$.

		T.	O.	T-O.	Probability.
N	9 D_3	14.031	14.021	.010	389.75 : 10
P	20 D_3	31.180	30.958	.222	389.75 : 222
As	48 D_3	74.832	74.918	.086	389.75 : 86
Sb	77 D_3	120.043	119.955	.088	389.75 : 88
Bi	133 D_3	207.347	207.523	.176	389.75 : 176
Au	126 D_3	196.434	196.155	.279·	389.75 : 279
Bo	7 D_3	10.913	10.941	.028	389.75 : 28

All the indications in this group are in favor of phyllotactic influences, the aggregate ratio of probabilities being more than 108426 : 1. Multiplying this by the monatomic ratio we get, for the aggregate perissad ratio, $>$ 608375000 : 1.

172. *Artiad Phyllotaxy.*

Di- or Tetratomic Group; $D_2 = 1.996$.

		T.	O.	T-O.	Probability.
O	8 D_2	15.968	15.963	.005	499 : 5
S	16 D_2	31.936	31.984	.048	499 : 48
Se	40 D_2	79.840	78.797	1.043	499 : 1043
Te	64 D_2	127.744	127.960	.216	499 . 216
Mg	12 D_2	23.952	23.959	.007	499 : 7
Ca	20 D_2	39.920	39.990	.070	499 : 70
Sr	44 D_2	87.824	87.374	.450	499 : 450
Ba	69 D_2	137.724	136.763	.961	499 : 961
C	6 D_2	11.976	11.974	.002	499 : 2

		T.	O.	T-O.	Probability.
Si	14 D_2	27.944	28.195	.251	499 : 251
Ti	25 D_2	49.900	49.846	.054	499 : 54
Zr	45 D_2	89.820	89.367	.453	499 : 453
Sn	59 D_2	117.764	117.698	.066	499 : 66
Hg	100 D_2	199.600	199.712	.112	499 : 112
Mo	48 D_2	95.808	95.527	.281	499 : 281
W	92 D_2	183.632	183.610	.022	499 : 22
U	60 D_2	119.760	119.241	.519	499 : 519

Two of these elements, Se and U, give adverse indications; the aggregate ratio of favorable to adverse probabilities is more than 17173770000000 : 1. I have taken ½ of Clarke's estimate for U, in order to compare it with Gerber's assumed atomicity.

Supplementary Artiad Group.

Barker, in *Johnson's Cyclopædia,* gives other artiad elements which Gerber places in his group of metals. In order to complete the comparisons which are based upon valency they are inserted here:

		T.	O.	T-O.	Probability.
Gl	7 D_2	13.972	13.695	.277	499 : 277
Al	14 D_2	27.944	27.009	.935	499 : 935
In	57 D_2	113.772	113.398	.374	499 : 374
Zn	33 D_2	65.868	64.905	.963	499 : 963
Cd	56 D_2	111.776	111.770	.006	499 : 6
Cu	32 D_2	63.872	63.173	.699	499 : 699
Pb	103 D_2	205.588	206.471	.883	499 : 883
Pd	53 D_2	105.788	105.737	.051	499 : 51
Pt	97 D_2	193.612	194.415	.803	499 : 803
Yt	45 D_2	89.820	89.816	.004	499 : 4
Ce	70 D_2	139.720	140.424	.704	499 : 704
La	69 D_2	137.724	138.526	.802	499 : 802
Di	72 D_2	143.712	144.573	.861	499 : 861
Er	83 D_2	165.668	165.891	.223	499 : 223
Th	117 D_2	233.532	233.414	.118	499 : 118
Cr	26 D_2	51.896	52.009	.113	499 : 113
Fe	28 D_2	55.888	55.913	.025	499 : 25
Mn	27 D_2	53.892	53.906	.014	499 : 14
Ni	29 D_2	57.884	57.928	.044	499 : 44
Co	30 D_2	59.880	58.887	.993	499 : 993
Ru	52 D_2	103.792	104.217	.425	499 : 425
Rh	52 D_2	103.792	104.055	.263	499 : 263
Ir	97 D_2	193.612	192.651	.961	499 : 961
Os	99 D_2	197.604	198.494	.890	499 : 890

The first sub-group, Glucinum to Thorium, inclusive, consists of dyads and tetrads, and gives 40911 : 1 for the combined ratio of probabilities. The other sub-group is hexad, giving the aggregate ratio 11611 : 1. The total aggregate ratio of the artiad elements is more than $81585(10)^{17}$: 1.

173. *Metallic Phyllotaxy.* $D_4 = 1.247$.

		T.	O.	T-O.	Probability.
Gl	11 D_4	13.717	13.972	.255	311.75 : 255
Al	22 D_4	27.434	27.009	.425	311.75 : 425
Sc	35 D_4	43.645	43.980	.335	311.75 : 335
Cr	42 D_4	52.374	52.009	.365	311.75 : 365
Fe	45 D_4	56.115	55.913	.202	311.75 : 202
Ga	55 D_4	68.585	68.854	.269	311.75 : 269
In	91 D_4	113.477	113.398	.079	311.75 : 79
Zn	52 D_4	64.844	64.905	.061	311.75 : 61
Cd	90 D_4	112.230	111.770	.460	311.75 : 460
Mn	43 D_4	53.621	53.906	.285	311.75 : 285
Ni	46 D_4	57.362	57.928	.566	311.75 : 566
Co	47 D_4	58.609	58.887	.278	311.75 : 278
Cu	51 D_4	63.597	63.173	.424	311.75 : 424
Pb	166 D_4	207.002	206.471	.531	311.75 : 531
Tl	163 D_4	203.261	203.715	.454	311.75 : 454
Rb	68 D_4	84.796	85.251	.455	311.75 : 455
Ru	84 D_4	104.748	104.217	.531	311.75 : 531
Rh	83 D_4	103.501	104.055	.554	311.75 : 554
Pd	85 D_4	105.995	105.737	.258	311.75 : 258
Ir	154 D_4	192.038	192.651	.613	311.75 : 613
Pt	156 D_4	194.532	194.415	.117	311.75 : 117
Os	159 D_4	198.273	198.494	.221	311.75 : 221
Yt	72 D_4	89.784	89.816	.032	311.75 : 32
Ce	113 D_4	140.911	140.424	.487	311.75 : 487
La	111 D_4	138.417	138.526	.109	311.75 : 109
Di	116 D_4	144.652	144.573	.079	311.75 : 79
Er	133 D_4	165.851	165.891	.040	311.75 : 40
Th	187 D_4	233.189	233.414	.225	311.75 : 225

The aggregate ratio is 1386.8 : 1, the mean ratio for a single comparison being somewhat less than 4 : 3. The indication of phyllotactic tendency is, therefore, comparatively slight, and far less satisfactory than in the grouping according to valency.

174. *General Test of Atomic Phyllotaxy.*

Computors who are accustomed to calculations of probable error, and who have not given any special attention to the harmonic influences of æthereal vibrations, may, perhaps, question the propriety of making any allowance for an *a priori* probability of division in extreme and mean ratio. For the satisfaction of all doubts upon this point it may be well to apply some test which will be rigid enough to fulfill the broadest requirements of mathematical likelihood. If we substitute $\frac{3}{16}$ D, for $\frac{1}{4}$ D, in the ratio of probability to improbability, we provide for requirements of linear oscillation, orbital motion and gravitating tendency. In such limited ranges of comparison as are possible for the chemical elements, most mathematicians would, perhaps, be satisfied with this substitution. All doubt should be removed by introducing the coefficient of probable error, .674489, and using $.674489 \times \frac{1}{4} D = .168622 D$. If we let n represent the number of terms in a given group, the ratios of probability, which have been found in Notes 171–3, should be multiplied by $.674489^n$, in order to give results which are entirely independent of any *a priori* assumption. We then find

For the monatomic	group, Note	171	73.75 : 1
" trivalent	" "	171	6885.88 : 1
" di- or tetratomic	" "	172	21253910000.00 : 1
" supp'y artiad	" "	172	37337.33 : 1
" aggregate valency			$403(10)^{18}$: 1
" metallic group, Note 173			1 : 44.33

The mean ratios, for single representatives of the several groups, are the following :

For the monatomic group	1.478 : 1
" trivalent "	3.534 : 1
" 1st artiad "	4.050 : 1
" 2d " "	1.550 : 1
" aggregate valency	2.235 : 1
" metallic group	1 : 1.145

The uniform character of the phyllotactic indications, in the groupings which are based upon similitudes of chemical affinity, is very satisfactory. To all who are willing to attach weight to *a priori* considerations, the following statement of mean ratios may be acceptable :

For the monatomic	group, Note	171	2.192 : 1
" trivalent	" "	171	5.223 : 1
" 1st artiad	" "	172	6.005 : 1
" 2d "	" "	172	2.299 : 1
" aggregate valency			3.313 : 1
" metallic group,	"	173	1.295 : 1
" perissads			3.076 : 1
" artiads			3.423 : 1
" hydrogen unit			2.084 : 1

The last result was quite unexpected. It was obtained by assuming .250 as a probable mean difference from exact multiples of H, and treating all the values in Clarke's table in the same way as in the phyllotactic examinations of Notes 171–3, so as to obtain, for each element, the ratio, $\frac{1}{4}$ H : (T–O). Although the aggregate evidence of phyllotactic influence upon valency, (3.313 : 1), is nearly 1.6 times as great as the evidence of hydrogenic influence upon general atomicity, the mathematical probability of the latter is satisfactorily established. I am not aware that the views of Prout and Dalton have ever before been tested in any way like this.

175. *Combination of Harmonic Influences.*

In my studies of cosmical harmony I have often had occasion to speak of the simultaneous operation of different oscillatory tendencies. Similar tendencies, involving similar modifications of resulting rhythms, must exist in the various forms of molecular activity. Dr. Thomas Hill, whose participation in Peirce's investigations of planetary phyllotaxy have given him an interest in other like researches, having suggested that the surd, $\frac{1}{2}(3-\sqrt{5})$, might be more closely represented in the atomic ratios than its phyllotactic approximations, I have tried it upon each of the foregoing groups. I find some evidence of its influence, but the combinations of phyllotactic ratios which are represented by my two divisors, .768 and 1.996, are much more satisfactory. Therefore it seems probable that, although the differences of internal work may prevent any precise atomic commensurability, there are as close approximations to precision in the elementary atoms as there are in plants and in planets.

176. *Fourier's Doctrine of Elasticity.*

The early views of Rittenhouse and other American investigators,* are corroborated by the following extract from Fourier's "*Theorie analytique de la chaleur,*" which is cited by Melsens in his report on Hirn's experimental investigations of the relation which exists between the resistance of the air and its temperature (*Bull. de l'Acad. Roy. de Belgique,* [3] 2, p. 252, 8 *Octobre* 1881).

Art. 53. "La chaleur est le principe de toute élasticité ; c'est sa force répulsive qui conserve la figure des masses solides et le volume des liquides. Dans les substances solides, les molécules voisines céderaient à leur attraction mutuelle, si son effet n'etait pas détruit par la chaleur qui les sépare. Cette force élastique est d'autant plus grande que la température est plus élevée ; c'est pour cela que les corps se dilatent ou se condensent, lorsqu'on élève ou lorsqu'on abaisse leur température."

177. *Test of Atomic Divisors by Arithmetical Means.*

The superiority of the combined phyllotactic divisors, over the surd divisors, Gerber's empirical divisors and the hydrogen unit, may be further shown by comparing the mean percentages of difference from exact multiples of the several divisors, in each of Gerber's groups :

	$\frac{1}{2}(3-\sqrt{5})$.	$\frac{1}{2}(\sqrt{5}-1)$.	H.	Gerber.	Phyllotactic.
For the monatomic group	.2549	.2404	.2034	.2140	.1804
" trivalent "	.2322	.2312	.1303	.0878	.0878
" di- or tetratomic "	.2385	.2755	.2140	.1072	.1044
" metallic "	.2598	.2543	.2342	.2635	.2546
" combined aggregate	.2501	.2563	.2086	.1931	.1847

* See Proc. Amer. Phil. Soc., xvi, 298 *seq.*

We find, therefore, that in this comparison the evidence of phyllotactic influence upon valency is more striking than that of the hydrogen unit or of Gerber's empirical divisors. In Gerber's special metallic group, however, the hydrogen unit furnishes the nearest, and Gerber's divisor the most remote approximation.

178. *Probable Errors of Atomic Remainders.*

If the deviations from exact multiples of the several divisors are treated as errors of observation, in order to determine the "probable error," we get the following results :

	Accidental.	H.	Gerber.	Phyllotactic.
For the perissads	± .0502	± .0433	± .0371	± .0300
" artiads	± .0294	± .0280	± .0178	± .0180
For all the elements	± .0266	± .0236	± .0163	± .0154

The legitimacy of this treatment may be questioned, but it cannot be charged with any unjust partiality. The artiads furnish an instance in which Gerber's empirical divisors give the nearest approximation. The hydrogen unit is still the least satisfactory of all.

179. *Deduced Laws of Atomicity.*

Notes 171–8 seem to justify the following conclusions :

1. If all the atomic weights were accurately determined, they would be found to be exact multiples of the hydrogen unit.
2. Chemical combinations are influenced by phyllotactic laws, or by tendencies to division in extreme and mean ratio.
3. Artiad and perissad combining units are different, but connected by phyllotactic ratios.
4. Metallic structure is controlled by phyllotactic laws.

180. *Phyllotactic Relations to Oxygen.*

In Note 138 I showed that 37 of the elements, according to Clarke's table, may be more nearly measured by $\frac{1}{16}$ O, while 26 approximate more closely to exact multiples of H. If we take $\frac{1}{8}$ O $= 1.995$ H, we get Gerber's di- or tetratomic divisor, from which others may be deduced by simple phyllotactic ratios :

Phyllotactic.		Gerber.	
α	1.995	D_2	1.995
$\beta = \frac{1}{2}\,\alpha$	.9975	H	.9997
$\gamma = \frac{5}{13}\,\alpha$	.7673	D_1	..769
$\delta = \frac{5}{8}\,\alpha$	1.2469	D_4	1.245
$\varepsilon = \frac{5}{4}\,\delta$	1.5586	D_3	1.559

The following comparative tables introduce all of Clarke's recalculated atomic weights :

Monatomic ; β, γ, H, D_1.

	Phyllotactic.		Gerber.		Clarke.	Δ_1	Δ_2	Δ_3
H	β	.9975	H	.9997	1.0000	.0000	.0025	.0003
Li	9 γ	6.9057	9 D_1	6.921	7.0073	.0010	.0147	.0125
Na	30 γ	23.0190	30 D_1	23.070	22.998	.0001	.0009	.0031
K	51 γ	39.1323	51 D_1	39.219	39.019	.0005	.0029	.0051
Cs	173 γ	132.7429	172 D_1	132.268	132.583	.0031	.0012	.0024
Fl	25 γ	19.1825	25 D_1	19.225	18.984	.0008	.0103	.0125
Cl	46 γ	35.2958	46 D_1	35.374	35.370	.0106	.0021	.0001
Br	104 γ	79.7992	104 D_1	79.976	79.768	.0029	.0004	.0026
I	165 γ	126.6045	165 D_1	126.885	126.557	.0035	.0004	.0026
Ag	140 γ	107.4220	140 D_1	107.660	107.675	.0030	.0024	.0001
Tl	265 γ	203.3345	265 D_1	203.785	203.715	.0014	.0019	.0003
Rb	111 γ	85.1703	111 D_1	85.359	85.251	.0029	.0009	.0013

I have added Tl and Rb to the elements which Gerber included in his monatomic group. Δ_1, Δ_2 Δ_3, are the ratios of the differences between H, γ and D_1, respectively, and the values which may be found by a division of Clarke's atomicities by the theoretical atomicities. The arithmetical mean values correspond with the order of arrangement, viz. : Δ_1, .0028 ; Δ_2, .0034 ; Δ_3, .0036.

Di- or Tetratomic ; $a = D_2$.

	Phyl., Gerber.		Clarke.	Δ_1	$\Delta_2 = \Delta_3$
O	8 D_2	15.96	15.9633	.0023	.0002
S	16 D_2	31.92	31.984	.0005	.0020
Se	39 D_2	77.805	78.797	.0026	.0126
Te	64 D_2	127.68	127.960	.0003	.0022
Mg	12 D_2	23.94	23.959	.0017	.0008
Ca	20 D_2	39.90	39.990	.0002	.0023
Sr	44 D_2	87.78	87.374	.0043	.0046
Ba	69 D_2	137.655	136.763	.0017	.0065
C	6 D_2	11.97	11.9736	.0022	.0003
Si	14 D_2	27.93	28.195	.0069	.0095
Ti	25 D_2	49.875	49.846	.0031	.0006
Zr	45 D_2	89.775	89.367	.0041	.0046
Sn	59 D_2	117.705	117.698	.0026	.0001
Hg	100 D_2	199.50	199.712	.0014	.0011
Mo	48 D_2	95.76	95.527	.0049	.0024
W	92 D_2	183.54	183.610	.0021	.0004
U	120 D_2	239.40	238.482	.0020	.0038

These are the same elements as are embraced in Gerber's second group. The arithmetical mean values of the deviations are, Δ_1, .0025 ; Δ_2, Δ_3, .0033.

Tri- or Pentavalent ; ε, D_3.

	Phyllotactic.		Gerber.		Clarke.	Δ_1	Δ_2	Δ_3
N	9 ε	14.0274	9 D_3	14.031	14.021	.0015	.0005	.0007
P	20 ε	31.1720	20 D_3	31.180	30.958	.0014	.0069	.0071
As	48 ε	74.8128	48 D_3	74.832	74.918	.0011	.0014	.0012
Sb	77 ε	120.0122	77 D_3	120.043	119.955	.0004	.0005	.0007
Bi	133 ε	207.2938	133 D_3	207.347	207.523	.0023	.0011	.0009
Au	126 ε	196.3836	126 D_3	196.434	196.155	.0008	.0012	.0014
Bo	7 ε	10.9102	7 D_3	10.913	10.941	.0054	.0028	.0026
Ta	117 ε	182.3562	117 D_3	182.403	182.144	.0008	.0012	.0014
V	33 ε	51.4338	33 D_3	51.447	51.256	.0050	.0035	.0037

I have added Bo, Ta and V to the elements which Gerber included in this group. The arithmetical mean values of the deviations are, Δ_1, .00208 ; Δ_2, .00212 ; Δ_3, .00215.

Metallic ; δ, D_4.

	Phyllotactic.		Gerber.		Clarke.	Δ_1	Δ_2	Δ_3
Gl	7 δ	8.7283	7 D_4	8.715	9.085	.0094	.0408	.0411
Al	22 δ	27.4318	22 D_4	27.390	27.009	.0003	.0154	.0141
Sc	35 δ	43.6415	35 D_4	43.575	43.980	.0005	.0078	.0092
Cr	42 δ	52.3698	42 D_4	52.290	52.009	.0002	.0069	.0054
Fe	45 δ	56.1105	45 D_4	56.025	55.913	.0016	.0035	.0020
Ga	55 δ	68.5795	55 D_4	68.475	68.854	.0021	.0040	.0055
In	91 δ	113.4679	91 D_4	113.295	113.398	.0035	.0006	.0009
Zn	52 δ	64.8388	52 D_4	64.740	64.905	.0015	.0010	.0025
Cd	90 δ	112.2210	90 D_4	112.050	111.770	.0021	.0040	.0025
Mn	43 δ	53.6167	43 D_4	53.535	53.906	.0017	.0054	.0069
Ni	46 δ	57.3574	47 D_4	58.515	57.928	.0012	.0099	.0101
Co	47 δ	58.6043	47 D_4	58.515	58.887	.0019	.0048	.0063
Cu	51 δ	63.5919	51 D_4	63.495	63.173	.0027	.0066	.0051
Pb	166 δ	206.9854	166 D_4	206.670	206.471	.0023	.0025	.0010
Ru	84 δ	104.7396	84 D_4	104.580	104.217	.0021	.0050	.0035
Rd	83 δ	103.4927	84 D_4	104.580	104.055	.0005	.0054	.0050
Pd	85 δ	105.9865	85 D_4	105.825	105.737	.0025	.0024	.0008
Ir	155 δ	193.2695	155 D_4	192.975	192.651	.0018	.0032	.0017
Pt	156 δ	194.5164	156 D_4	194.220	194.415	.0021	.0005	.0010
Os	159 δ	198.2571	159 D_4	197.955	198.494	.0025	.0012	.0027
Yt	72 δ	89.7768	72 D_4	89.640	89.816	.0020	.0004	.0020
Ce	113 δ	140.8997	113 D_4	140.685	140.424	.0030	.0034	.0019
La	111 δ	138.4059	111 D_4	138.195	138.526	.0034	.0009	.0024
Di	116 δ	144.6404	116 D_4	144.420	144.573	.0029	.0005	.0011
Er	133 δ	165.8377	133 D_4	165.585	165.891	.0007	.0003	.0018
Th	187 δ	233.1703	187 D_4	232.815	233.414	.0018	.0010	.0026
Ytter	139 δ	173.3191	139 D_4	173.055	172.761	.0014	.0032	.0017

The mean deviations are, Δ_1, .00227 ; Δ_2, .00521 ; Δ_3, .00515. In order to complete the data for comparisons of probable error, I repeat this group, with artiad divisors.

Metallic, II; $a = D_2$.

Gl	5 D_2	9.975	.0890	Ru	52 D_2	103.740	.0046
Al	14 D_2	27.930	.0329	Rd	52 D_2	103.740	.0030
Sc	22 D_2	43.890	.0020	Pd	53 D_2	105.735	.0000
Cr	26 D_2	51.870	.0027	Ir	97 D_2	193.515	.0045
Fe	28 D_2	55.860	.0009	Pt	97 D_2	193.515	.0046
Ga	35 D_2	69.825	.0139	Os	99 D_2	197.505	.0050
In	57 D_2	113.715	.0028	Yt	45 D_2	89.775	.0005
Zn	33 D_2	65.835	1.041	Ce	70 D_2	139.650	.0055
Cd	56 D_2	111.720	.0004	La	69 D_2	137.655	.0063
Mn	27 D_2	53.865	.0008	Di	72 D_2	143.640	.0065
Ni	29 D_2	57.855	.0013	Er	83 D_2	165.585	.0018
Co	30 D_2	59.850	.0161	Th	117 D_2	233.415	.0000
Cu	32 D_2	63.840	.0104	Ytter	87 D_2	173.565	.0046
Pb	103 D_2	205.485	.0048				

The mean deviation is .00885.

181. *Comparative Summary.*

Although I have shown in Note 149, that Schuster's test will often fail to detect harmonies which really exist, it may be used with advantage in many instances of comparative probability. The following tables seem to furnish indisputable evidence of phyllotactic influence upon atomicity.

Logarithms of Probability.

Groups.	Phyllotactic.	Gerber.	Hydrogen.
Monatomic,	3.7476668	3.6572183	5.1634821
Tri- and Pentavalent,	5.2591327	5.2591327	3.8626605
Di- and Tetratomic,	12.0650575	11.9044217	5.1740365
Metallic,	3.0609802	1.2331805	6.1850405
Aggregate,	24.1328372	22.0539532	20.3852196
Mean,	.3770756	.3445930	.3185191

Arithmetical Residuals.

Groups.	Phyllotactic.	Gerber.	Hydrogen.
Monatomic,	.1672	.1947	.2842
3 and 5,	.0926	.0926	.1423
2 and 4,	.1059	.1442	.2119
Metallic,	.2487	.2523	.2247
Mean,	.1748	.1912	.2199

Relative Probability.

Groups.	Phyllotactic.	Gerber.	Hydrogen.
Monatomic,	1.2315	1.0000	32.0822
3 and 5,	24.9156	24.9156	1.0000
2 and 4,	7780740.	5375080.	1.0000
Metallic,	67.2666	1.0000	89507.6
Aggregate,	5592.649	46.637	1.0000
Mean,	1.144	1.062	1.0000

Relative Residuals,

Groups.	Phyllotactic.	Gerber.	Hydrogen.
Monatomic,	1.0000	1.1645	1.6998
3 and 5,	1.0000	1.0000	1.5367
2 and 4,	1.0000	1.3617	2.0009
Metallic,	1.1068	1.1229	1.0000
Mean,	1.0000	1.0938	1.2580

The "logarithms of probability" are deduced from the first four groupings of Note 180, by the method and with the phyllotactic values which were adopted in Notes 171–4. They assign a greater degree of importance to the strictly phyllotactic than to Gerber's approximately phyllotactic divisors, in every instance; a greater degree of importance to the hydrogen divisor than to either the strictly phyllotactic or the approximately phyllotactic divisors, in the monatomic and metallic groups; a greater degree of importance both to the phyllotactic and to Gerber's divisors than to the hydrogen divisor, in the 3 and 5, 2 and 4, aggregate and mean groups.

The "arithmetical residuals" are deduced from the first four groupings of Note 180, by dividing the differences from exact multiples of the several divisors by the respective divisors, by the method which was adopted in Note 177. In this aspect of the question, as in Note 177, the hydrogen unit is most important in the metallic group; the phyllotactic divisors, in each of the other groups; Gerber's coinciding with the phyllotactic in the tri- and pentavalent groups.

The "relative probability" and "relative residuals" are found by taking the least value in each group as the unit. The indications are, of course, the same as in the systems of grouping from which they were derived. In the metallic group the probability of predominant hydrogen influence is 89507.6 times as great as that of Gerber's divisors, or 1330.6 times as great as that of the phyllotactic divisors. In the di- and tetratomic group the phyllotactic probability is more than 7780740 times as great as that of the hydrogen divisor, or 1.4475 times as great as that of Gerber's divisors. The aggregate phyllotactic probability is 15592.649 times as great as that of the hydrogen divisor, or 119.918 times as great as that of Gerber's divisors.

182. *Synopsis of Probable Errors.*

The following tables are computed on the hypothesis that the atomic weights are exact multiples of the several divisors. The percentages of the divisors which represent (T—O) ÷ D,* are treated as errors of observation, and the probable errors are deduced in the usual way. Those percentages may evidently vary between 0 and ± .5.

* See Note 171.

Probable Errors.

Groups.	Surd I.	Surd II.	Hydrogen.	Gerber.	Phyllotactic.
Monatomic,	± .0529	± .0545	± .0552	± .0490	± .0407
3 and 5,	± .0588	± .0556	± .0445	± .0253	± .0253
2 and 4,	± .0438	± .0497	± .0439	± .0357	± .0218
Metallic,	± .0375	± .0385	± .0358	± .0358	± .0361
Aggregate,	± .0232	± -0242	± .0222	± .0200	± .0181

Relative Probable Errors.

Groups.	Surd. I.	Surd. II.	Hydrogen.	Gerber.	Phyllotactic.
Monatomic,	1.3001	1.3401	1.3571	1.2038	1.0000
3 and 5,	2.3211	2.1933	1.7559	1.0000	1.0000
2 and 4,	2.0101	2.2764	2.0109	1.6361	1.0000
Metallic,	1.0473	1.0752	1.0004	1.0000	1.0085
Aggregate,	1.2812	1-3394	1.2274	1.1079	1.0000

Surd I is $\frac{1}{2}(3 - \sqrt{5})$; Surd II, $\frac{1}{2}(\sqrt{5} - 1)$. The groupings and the phyllotactic divisors are the same as in the foregoing note. Phyllotactic precedence is shown in eight of the groups; Gerber's approximately phyllotactic in four; hydrogen in one. Surd divisors take precedence of hydrogen in four of the groups. They suggest the probability that dextro- and lævo-gyration may be phyllotactic phenomena, originating in tendencies to division in extreme and mean ratio.

183. *Probabilities of the Surd Divisors.*

In order to show the character of the evidence to which I referred in Note 175, and thus complete the comparative examination which I have undertaken, I add the following tables.

	Logarithms of Probability.		*Arithmetical Residuals.*	
Groups.	Surd I.	Surd II.	Surd I.	Surd II.
Monatomic,	.6805664	.9997215	.240	.239
3 and 5,	1.4766962	1.1496250	.231	.226
2 and 4,	3.4829337	.1602944	.238	.275
Metallic,	1.7491278	1.4979853	.260	.266
Aggregate,	7.3893241	3.8076262	.247	.258
Mean,	.1154582	.0594942	....	....

The arithmetical residuals are so near Schuster's limit that they furnish but slight evidence of harmonic influence. The mean probabilities, 1.304 and 1.147, are also comparatively small, but inasmuch as each of the groups indicates a decided probability, while the aggregates are more than 24,500,000 and 6420 respectively, any hypothesis of accidental determination must be rejected. Perhaps the most important use which we can make of the results is to extend the comparisons of the foregoing note, so as to add further cogency to the proof of phyllotactic sway.

Relative Probability.

	Phyllotactic.	Gerber.	Hydrogen.	Surd I.	Surd II.
Aggregate	$21145(10)^{16}$	$1763(10)^{15}$	$378(10)^{14}$	3816.8	1
Mean	2.078	1.928	1.815	1.138	1
Residual	1.476	1.349	1.173	1.044	1

184. *Another Comparative Summary.*

If we take the percentages of deviation, instead of the fractional deviations from exact multiples of the several divisors, and divide by the number of hydrogen units which most nearly represents each of Clarke's atomic weights, we obtain data for computing other probabilities and probable errors, which are given below :

Logarithms of Relative Probability.

Groups.	Phyllotactic.	Gerber.	Hydrogen.	Surd I.	Surd. II.
Monatomic	5.0490205	4.6466652	5.7455887	.0000000	2.7689906
3 and 5	4.5555159	4.5555159	2.8622287	.0000000	.0090219
2 and 4	12.2941388	10.7902815	4.5435830	1.0009281	.0000000
Metallic	.5855468	.0000000	4.1708538	.2005275	.2278172
Aggregate	21.2824664	18.7910070	16.1207986	.0000000	1.8043741
Mean	.3325385	.2936095	.2518875	.0000000	.0281933

Probable Errors.

Groups.	Phyllotactic.	Gerber.	Hydrogen.	Surd I.	Surd II.
Monatomic	± .00117	± .00153	± .00100	± .00393	± .00328
3 and 5	± .00042	± .00042	± .00059	± .00290	± .00264
2 and 4	± .00035	± .00039	± .00050	± .00221	± .00161
Metallic	± .00065	± .00098	± .00117	± .00076	± .00096
Aggregate	± .00036	± .00051	± .00028	± .00103	± .00090

185. *Incipient Phyllotaxy.*

The probable errors both in Note 182 and in Note 184, seem to give more indications than are furnished by the relative probabilities, of surd influence upon atomicity. There is room, however, for a reasonable doubt whether those indications are other than accidental, and it would undoubtedly be desirable, if it were possible, to find some more satisfactory test of probabilities which are so near to the boundary line between normal and casual coincidences. In the aggregate probabilities, hydrogen stands between the surd divisors and the phyllotactic divisors. The latter were tested by elements which are denser than hydrogen, and, therefore, have a greater atomic inertia. Is it not likely that the former may find their rightful province in a more æthereal region, either in the primitive "subsidence" of nebulous matter or in the undulations which precede subsidence? Cyclical tendencies may naturally become more marked as solidification increases.

186. *Foreshadowings.*

The greatest superiority of S_1 over S_2, as well as of the phyllotactic and approximately phyllotactic divisors over the hydrogen divisor, is found in the di- and tetratomic group. The aggregate probability of hydrogen influence on atomicity is more than 9,900,000,000,000 times as great as that of S_1, or more than 37,800,000,000,000,000 times as great as that of S_2, or more than 242,700,000,000,000,000,000 times the probability of accidental coincidence. Each of these numbers should be multiplied by 5592.6 to give the probability of the phyllotactic divisors. The lowest surd probability in either group is that of S_2 in the di- and tetratomic group, which is only 1.446 : 1, or a little more than 13 : 9. Even this ratio, however, is satisfactory as indicative of incipient action, and suggestive of researches in the "nascent state," the "fourth state of matter," or in some other approximation to the æthereal condition. The artiad and metallic elements seem also to offer fields for important future discovery in regard to modifications of phyllotactic tendency by condensation or combination.

187. *Hydrogen Shares the Phyllotactic Probabilities.*

In the foregoing notes I have treated hydrogen as outside the phyllotactic group, in order to find the probability of the hypotheses of Dalton and Prout as compared with other reasonable hypotheses. As a member of the phyllotactic group, and the most general of the phyllotactic divisors, it shares all the probabilities of the group. Therefore, if there is any value in mathematical tests, the views of Berzelius, Turner, Marignac, Stas and Clarke, as to the importance of the hydrogen atom, should be accepted, rather than those of Thomas Thomson and Dumas.

188. *Inertia and Elasticity.*

Thus the evidences are multiplying, in every direction, of the importance of giving great heed to the blended sway of inertia and elasticity, in all physical researches. The moment of inertia is of especial importance, inasmuch as material particles, in an elastic medium, become the seats of living forces which enable us to apply the laws of composition and resolution of forces, to composition and resolution of motions. The principles which I applied successfully, in 1863, to barometric estimates of the Sun's mass and distance, have been abundantly exemplified in every field in which I have sought for evidences of their influence, and now they are found at the very threshold of material structure, where cohesive and chemical attractions first show themselves.

189. *Phyllotaxy of Central Force.*

I have already spoken of the appearance of the phyllotactic numbers 1, 2, 3, 5 and 8, in crystallization, and especially in the mimicry of frost-pictures. The simplest phenomena of central force introduce the first three phyllotactic powers; Kepler's third law gives the phyllotactic fractional exponent $\frac{3}{2}$; the actions and reactions of elasticity and inertia in nucleation, assign, as I have shown, the product of two phyllotactic exponents, $2 \times \frac{3}{8} = \frac{3}{4}$, in the ratio of variability between the nucleal radius and Laplace's limiting radius; the relations between density and distance, in elastic media, change exponential to numerical coefficients. All of these phyllotactic relations spring from simple and elementary mathematical principles, to which the actions of central force must yield. If we call the fundamental force radiodynamic, we may be continually reminded of its alternating centripetal and centrifugal tendencies. If we call it photodynamic, the term will be naturally suggestive of the all-pervading elasticity or quasi-elasticity which propagates the rays of light and thus becomes the medium through which we get all our knowledge of heavenly bodies, as well as the largest portion of our knowledge of all earthly phenomena.

190. *Phyllotaxy of Virtual Areas.*

The planetary virtual areas, Notes 159 and 164, are jointly related through the last two of the elementary phyllotactic principles of the foregoing note. Beginning with the largest and primitively central planetary mass, the laws of nucleation and elasticity, acting first outwardly from the Sun and then inwardly, help to determine the reactionary *vis viva* of Saturn, Neptune, Uranus, Earth, Venus, Mars and Mercury, in regular succession. In passing from the extra-asteroidal to the intra-asteroidal group, another phyllotactic succession of phyllotactic ratios shows itself, the ratio between the harmonic areas* of Uranus and Earth being, within less than $1\frac{1}{4}$ per cent., $(\frac{8}{5})^6$, the exponent being the phyllotactic product 2×3. This is also the coefficient of orbital retardation at the centre of the belt of greatest condensation; it is the $\frac{3}{4}$ power of the ratio between the harmonic areas of Jupiter and Earth, thus pointing to Uranus as a nucleal locus for which Jupiter represents Laplace's limit; the locus of secular perihelion, or incipient rupture, for Uranus, is nucleally central between the mean loci of Jupiter and Neptune; Uranus and Earth are at opposite extremities of a major-axis which would be traversed by light in the same time that Sun would rotate, if it were condensed until its present equatorial radius became Laplace's limiting radius. These five accordances present a chain of phyllotactic and photodynamic influences which seems worthy of further study.

191. *Optical and Thermal Relations in Organic Liquids.*

Brühl (*Ber. Berl. Chem. Ges.* xiv, 2533, Nov. 1881; cited in *Am. Jour. Sci.* [3], xxiii, 234), finds that progressive oxidation has the same influence on the optical as on the thermal properties of organic liquids, the refractive power diminishing as the amount of oxygen is increased, precisely as the heat of combination diminishes. Removal of hydrogen or its replacement by oxygen produces the same effect, so that both the above physical values

* The ratio of the actual virtual areas is within $\frac{1}{23}$ of one per cent. of $(\frac{8}{5})^6$.

are greater for the hydrocarbons than for the alcohols, aldehydes, acids, etc., derived from them.

192. *Subsidiary Phyllotaxy.*

Gerber (*Les Mondes,* [3] i, 145), after referring to the accuracy with which the atomic weights of nearly one-half of the chemical elements have been determined, says :—"Un pareil degré de rigueur ne saurait être atteint dans l'application des lois d'Avogadro, de Dulong et Petit, de Mitscherlich. Celles-ci, comme il a été dit, sont des *lois de conditions,* dont nous ne possédons qu' une formule provisoire." The phyllotactic approximations are so much closer than those which are here spoken of, that we may well hope for some important results from their subsidiary employment in stoichiometry.

193. *Glucinum.*

Gerber (*l. c.* pp. 146-9), thinks that the law of Dulong and Petit accords better with the atomic weight which Nilson and Petersson assign to Glucinum, 13.65, than with the one which is adopted by Mayer and Mendelejeff, 9.1. The same thing may be said of the phyllotactic and the approximately phyllotactic divisors, for $13.65 = 11 \times 1.245 - .045 = 11 \times 1.247 - .067$, while $9.1 = 7 \times 1.245 + .385 = 7 \times 1.247 + .371$, the residuals being, respectively, 8.5 and 5.5 times as great in the latter case as in the former. This single change would increase the superiority in relative probability, of the phyllotactic divisors over the hydrogen divisor, more than twelve fold.

194. *"The Principles of Magnetism."*

Charles Morris (*Jour. of Sci.,* [3] iv, 71) objects to the magnetic theories of Ampère and Weber, as follows : "The Ampèrian theory is constantly and gravely repeated in text-books, to the present day, without a hint being given of the indisputable fact that it is quite at variance with the principles of energy, as now understood. It is easy to imagine a constant current of electricity, and make it answer a definite purpose, but the truth is that no such thing exists as a constant current of electricity, in the Ampèrian sense." He goes on to speak of the currents of static electricity as being instantaneous, while those of galvanic and thermo-electricity consist of instantaneous components and cease when the chemical or thermal equilibrium is restored. But is the equilibrium in the terrestrial thermal and gravitating currents ever restored? In 1864 (*Proc. A. P.. S.*, ix, 357, foot-note) I showed that the opposing forces of rotation, elasticity and gravitation must produce oscillations. In various preceding and subsequent papers I showed that those oscillations must produce constant currents of such descriptions as Ampère supposed.

195. *Dogmatism.*

Many modern investigators, who pride themselves on their freedom from the dreams of metaphysics, continually fall into ways which they theoretically condemn. There is fully as much dogmatism in physics as in metaphysics. Whenever it springs from a well-grounded conviction, which has been once thoroughly tested and which always courts a repetition of tests, it is not only unobjectionable but it is highly commendable. On the other hand when it is merely theoretical, or the outgrowth of inveterate prejudice, it has no rightful place in any discussion which claims to be scientific.

196. *Numerical Tests.*

There has been an immense amount of valuable mathematical analysis which has been misunderstood, or but partially understood, for want of being properly tested. Results are never valid except for the data which they embody; they are always subject to modification by neglected, unknown or new data. The "opprobrium of thermodynamics" amounts to nothing more than the statement that, from the data which have been discussed hitherto, there appears to be a universal tendency to physical stagnation and death. The principle of equal action and reaction ought to furnish some means of escape from this opprobrium. The way of escape seems to have been indicated by the identification of a common operative velocity in light, electricity, chemistry and gravitation. A single theoretical result which has been quantitatively verified, is worth more than a thousand that are thought to be beyond the reach of verification. The theory of dependent connection between stellar rotary oscillations and the reaction of cosmical inertia against æthereal influence (Note 162 *et al.*), having been verified by the test of our Sun, seems likely to open the way for a general recognition of an æthereal reaction which will yield an exact compensation for all physical actions, affording a more satisfactory explanation of stellar light and heat than can be drawn from meteoric or shrinkage hypotheses.

197. *Velocity of Gravitating Action.*

Objections have been urged against the possibility of making gravitation the effect of light undulations unless we first overthrow Laplace's conclusion, that gravity must act with at least a hundred million times the velocity of light and that its action may be regarded as instantaneous. I answer :— 1. I have never claimed that any physical phenomenon is the effect of another physical phenomenon, but merely that the phenomena of light and gravitation are so related as to show that they may be effects of a common cause. 2. The rapidity of action and the rapidity with which the results of the action are propagated are two entirely different things. 3. If the results of gravitating and luminous actions and reactions are identified in stellar rotations, it is altogether likely that the forces upon which these results depend act with equal speed. 4. Even if it should be found necessary to propagate gravitating undulations with a hundred million times the velocity of light, it would be as easy to suppose a gravitating æther, with a ratio of elasticity to density which is $(100,000,000)^2$ times that of the luminiferous æther, as it is to suppose a luminiferous æther. 5. All nebular, æthereal, and other unverifiable hypotheses are useful only so far as they serve to coördinate categories of phenomena which occur as they would if the hypotheses were true. 6. I showed, long ago, that no merely physical theory or hypothesis has ever been framed which would explain the instantaneous transmission of velocity, and that such transmission, if it exists and is not physical, must be regarded as spiritual.

198. *Varying Gravitating Velocities.*

The foregoing objections may be further obviated by a consideration of the fact that gravitating velocities begin with mere tendencies to motion, and that some time must elapse before the velocity becomes appreciable. The difficulty which Faraday found, in reconciling the conservation of energy and the correlations of force with gravitating tendencies which vary inversely as the square of the distance, is a mathematical difficulty which is equally involved in heat, light, electricity and all other manifestations of radiant energy. The element of constancy may be found in a uniform elementary velocity, as in the general expression for stellar gravitating acceleration, $g_n = \frac{v_\lambda}{t_n}$ in which g_n is the acceleration of a particle at the distance n, v_λ, is the velocity of light, and t_n is the time of a single oscillation or half-rotation if the star were uniformly expanded until it had a radius equal to n.

199. *Commensurability and Incommensurability.*

In his original paper (*Math. Monthly*, i, 245), Chauncey Wright said: "But if now we seek a uniform and symmetrical distribution as well as a thorough one, the interval between the successive points must be constant, and if the circumference is to be indefinitely subdivided, this interval is, of course, incommensurate." Such indefinite subdivision can hardly be looked for in any of the ordinary concrete physical phenomena, hence we find that the chemical and other approximations which we have examined are better represented by exact phyllotactic ratios than by the surd distributive tendencies. Still it seems likely that the want of precise commensurability, which is found in Clarke's table, may arise from a residual tendency to indefinite subdivision, and for this reason we may find that no increased accuracy in the determination of atomic weights will lead to the establishment of any series of divisors which are absolutely exact. I can think of no case in which the incommensurability of the surd divisors seems likely to be more completely represented than in the Ampèrian currents (Note 194).

200. "*Celestial Chemistry.*"

Dr. T. Sterry Hunt (*Proc. Camb. Phil. Soc.*, reprinted in *Am. Jour. Sci.*, Feb. 1882), recites "certain views enunciated almost simultaneously by the late Sir Benjamin Brodie, of Oxford, and" himself, in the line of development and extension of "the remarkable perception of great chemical truths which is apparent in the queries appended to the third book of Newton's *Optics*, as well as in his hypothesis touching Light and Color." Brodie's first announcement of the assumed existence of certain ideal elements was read before the Royal Society, May 3, 1866, and in the Spring of 1867 Hunt "spent several days in Paris with the late Henri Sainte-Clàire Deville, repeating with him some of his remarkable experiments in chemical dissociation, the theory of which [they] then discussed in its relations to Faye's solar hypothesis." I first invited attention to the "nascent" cosmical equation, or the equation which marks the limiting velocity between tendencies to cosmical aggregation and to cosmical dissociation $v = \frac{gt}{2}$, on Dec. 18, 1863 (*Proc. Am. Phil. Soc.*, ix, 284 7). On April 1, 1864 (*Ib.*, p. 357), I said : "Absolute rest is apparently an impossible condition of matter, for, to whatever extent the action of opposing forces may be relatively neutralized, the inconceivable rapidity of æthereal, planetary and stellar motions produces a constant change of place. * * * The sum of all the instantaneous energies is the same, whether the particle fall freely for any given time, or remain apparently at rest. All the potential energy which is transformed in one case into the actual energy of motion, in the other is counteracted by an equivalent and opposite actual energy of elasticity." On July 15, 1864 (*Ib.* p. 408), I suggested "that one of the most probable results of the rotation of the Earth with its atmosphere, in an æthereal medium, would be the production of two systems of oscillations, moving with the rapidity of light." In October and December, 1864, I presented to the American Philosophical Society the "Numerical relations of gravity and magnetism," for which the Society awarded its Magellanic gold medal, as furnishing "good reason to hope that by the application of mechanical laws to the several phases of the æthereal undulations which produce the phenomena of light, heat, electricity, polarity, aggregation and diffusion, we may obtain a clearer understanding, not only of all the meteorological changes, but also of seismic tremors, crystallization, stratification, chemical action, and general morphology," (*Ib.*, p. 439). On Sept. 21, 1866 (*Op. cit.*, x. 269), I gave my first indication of the photodynamic importance of Earth's situation at the centre of the belt of greatest condensation, and on April 2, 1869 (*Ib.*, xi, 106–7), I showed that Sun's nascent or dissociative velocity is the velocity of light.

201. *Nitrogen and the Perissads.*

If Newton's belief that the inter-stellar æther is an expanded, universal atmosphere, is true, it seems likely that the two principal constituent gases of our own atmosphere may be everywhere as abundant, relatively, as they are within the reach of our immediate observation. Even if this is not the case, we may reasonably look for some special mathematical evidences of the importance of two gases which have so wide a local diffusion, and which have so large a sway in chemical combination and in organic growth. In Note 54 I showed that a large number of the elements contain either 7 or 8, as one of the factors of the integers which most nearly represent their atomicity according to the hypotheses of Dalton and Prout. These two numbers denote respectively the simplest phyllotactic sub-multiples of N and O. If we use the former as a divisor of the perissads, treating the remainders as in the foregoing notes, we get the following results :

$D_p = 7.$

	Coefficient of D.	Remainder.	Log. R.
Li	1	+ .0073	$\bar{3}$.8633229
Na	3	+ 1.998	.3005955
K	6	— 2.981	.4743620
Cs	19	— .417	$\bar{1}$.6201360
Fl	3	— 2.016	.3044905
Cl	5	+ .370	$\bar{1}$.5682017
Br	11	+ 2.768	.4421661
I	18	+ .557	$\bar{1}$.7458552
Ag	15	+ 2.675	.4273238
Tl	29	+ .715	$\bar{1}$.8543060
Rb	12	+ 1.251	.0972573
	Sum of Monatomic logarithms		$\bar{2}$.6980170
N	2	+ .021	$\bar{2}$.3222193
P	4	+ 2.958	.4709982
As	11	— 2.082	.3184807
Sb	17	+ .955	$\bar{1}$.9800034
Bi	30	— 2.477	.3939260
Au	28	+ .155	$\bar{1}$.1903317
Bo	2	— 3.059	.4855795
Ta	26	+ .144	$\bar{1}$.1583625
V	7	+ 2.256	.3533391
	Sum of Tri- or Pentavalent logarithms		$\bar{2}$.6732404

Log. of Monatomic probability ; log. $1.75^{11} — \bar{2}.6980170 = 3.9754016$
" Tri- and Pentavalent " ; " $1.75^9 — \bar{2}.6732404 = 3.5141020$
" Total Perissad 7.4895036

202. *Oxygen and the Artiads.*

If we use 8 as a divisor of the Artiads, we get the following results :

$D_a = 8.$

	Coefficient of D.	Remainder.	Log. R.
O	2	— .0367	$\bar{2}$.5646661
S	4	— .016	$\bar{2}$.2041200
Se	10	— 1.203	.0802656
Te	16	— .040	$\bar{2}$.6020600
Mg	3	— .041	$\bar{2}$.6127839

	Coefficient of D.	Remainder.	Log. R.
Ca	5	— .010	$\bar{2}.0000000$
Sr	11	— .626	$\bar{1}.7965743$
Ba	17	+ .763	$\bar{1}.8825245$
C	1	+ 3.9736	.5991841
Si	4	— 3.805	.5803547
Ti	6	+ 1.846	.2662317
Zr	11	— 1.367	.1357685
Sn	15	— 2.302	.3621053
Hg	25	— .288	$\bar{1}.4593925$
Mo	12	— .473	$\bar{1}.6748611$
W	23	— .390	$\bar{1}.5910646$
U	30	— 1.518	.1812718
	Sum of Di- and Tetratomic logarithms		$\bar{8}.5932287$
Gl	1	+ 1.085	.0354297
Al	3	+ 3.009	.4784222
Sc	5	+ 3.980	.5998831
Cr	7	— 3.991	.6010817
Fe	7	— .087	$\bar{2}.9395192$
Ga	9	— 3.146	.4977587
In	14	+ 1.398	.1455072
Zn	8	+ .905	$\bar{1}.9566486$
Cd	14	— .230	$\bar{1}.3617278$
Mn	7	— 2.094	.3209767
Ni	7	+ 1.928	.2851070
Co	7	+ 2.887	.4604468
Cu	8	— .827	$\bar{1}.9175055$
Pb	26	— 1.529	.1844075
Ru	13	+ .217	$\bar{1}.3364597$
Rd	13	+ .055	$\bar{2}.7403627$
Pd	13	+ 1.737	.2397998
Ir	24	+ .651	$\bar{1}.8135810$
Pt	24	+ 2.415	.3829171
Os	25	— 1.506	.1778250
Yt	11	+ 1.816	.2591158
Ce	18	+ 3.576	.5533975
La	17	+ 2.526	.4024333
Di	18	+ .573	$\bar{1}.7581546$
Er	21	— 2.109	.3240766
Th	29	+ 1.414	.1504494
Yb	22	— 3.239	.5104109
	Sum of Metallic logarithms,		2.4334051

Log. of Di- and Tetratomic probability;		log. 2^{17} — $\bar{8}.5932287$ =	12.5242813
" Metallic	"	" 2^{27} — 2.4334051 =	5.6944049
" Total Artiad	"		18.2186862
" Aggregate, Per. and Art.	"		25.7081898
" Mean	"		.4016920

By reference to Notes 181 and 183, it will be seen that the aggregate probability of atmospheric phyllotactic influence is more than 37.6 times as great as that of simple phyllotactic influence, more than 4510 times as great as that of Gerber's divisors, more than 210363 times as great as that of the hydrogen divisor, or more than 2,083,840,000,000,000,000 times as great as that of the first surd divisor.

203. *Precipitability.*

The Philosophical Magazine for March 1882, contains two papers, one by Mills and Bicket, the other by Mills and Hunt, on chemical equivalence, as estimated by "equivalent precipitability of sulphates, by sodic carbonate, from an aqueous solution." Among the conclusions which they have drawn from their work the following seem to be especially noteworthy:—1. Precipitability is a linear function of mass. 2. There is some evidence that the precipitabilities of the commixed and separate sulphates are mathematically related in a simple manner. 3. Within moderate limits, precipitation is not traceably affected by temperature. 4. Two elements belong to the same group when, in saline solutions of identical genus, they may be equally precipitable. The simplicity and character of these conclusions are such as to suggest æthereal influence, a suggestion which is strengthened by the final equation, $\nu = \delta = .3819$; ν and δ being, respectively, the ratio of precipitability to the quantity of nickelous and cadmic sulphate taken. The ratio is the same, to the fourth decimal place, as the first surd divisor in extreme and mean ratio, .381966, thus indicating a beginning of phyllotactic tendency which is very satisfactory.

204. *Electrical Conductivity of Gases.*

Edlund (*P. Mag.* [5] xiii, 201), cites the experiments of Edm. Becquerel (*Ann. de Ch. et de Ph.* [3] xxxix, 377), showing "that gases begin to be conductors when heated to the temperature of redness, after which their conductivity increases in proportion as the temperature rises above that point," the conductivity increasing as the density of the gas diminishes. This approach to the æthereal condition is also an approach to the fundamental æthereal *vis viva*, which is shown by the identity of velocity in the propagation of luminous undulations, the electrical "ratio," and the gravitating reactions of stellar rotation.

205. *Ratio of Æthereal Elasticity to Density.*

In my first approximation to the ratio between atmospheric and æthereal elasticities (*Proc. Amer. Phil. Soc.*, ix, 440), I followed Herschel, in supposing that the velocity of light, in the interstellar spaces, is uniform, and that, consequently, the elasticity of free æther varies directly as its density. The same conclusion would follow from Newton's views (See Note 200), and is involved in Edlund's discussions of the relations of electricity to heat. Every additional evidence of harmonic relations, that is brought to light through the application of the laws of gaseous elasticity to the kinetic æther, is also an additional evidence of the truth of the hypothesis that all physical energy is transmitted by means of a universally diffused elastic medium.

206. *Spectrum of Lightning.*

Schuster (*P. Mag.*, [5] vii, 319), gives some of his measurements, at different times, of lines or bands in the lightning-spectrum, comparing the means with two measurements which Vogel had deduced from his own observations. The harmonic character of the lines is clearly shown by the following tables. The value of a, in the harmonic divisors, is .01578.

Schuster.	Mean.	Vogel.	Harmonic.	Harmonic Divisors
5592			5592	1
5348				
5329	5334	5341	5339	$1 + 3a$
5325				
5260			5260	$1 + 4a$
5175				
5193	5182	5184	5183	$1 + 5a$
5177				

207. *Torsion, Flexion and Magnetism.*

G. Wiedemann (*La Lumière Electrique*, vi, 90), in speaking of results obtained by the torsion of wires and the flexure of rods, says that the phenomena correspond so closely with those of magnetism that the words "torsion" and "magnetism" are almost always interchangeable. This is a further illustration of the identity of fundamental *vis viva*, which was spoken of in Note 204, and which is especially exemplified by the application of Coulomb's torsional coefficient to solar rotation (Note 162). My earliest "numerical relations of gravity and magnetism" (*Proc. Amer. Phil. Soc.*, ix, 355—60, 425—40, *et al.*) were based upon the mechanical consequences of rotation in an elastic medium.

208. *Phyllotaxy and Atomic Heat.*

The constant product of atomic weight by specific heat, 6, which is indicated by the law of Dulong and Petit, is equivalent to the continued product of the first three numbers of the phyllotactic series $1 \times 2 \times 3$. Were this an isolated fact, little importance could be attached to it, but when we bring it to the test of mathematical probability, it becomes suggestive of relations which may, perhaps, lead to important discoveries. In the following comparison D indicates the estimate of atomic heat which deviates least from 6 (*Meyer, Modernen Theor. d. Chem.* Ed. of 1880, 90, 106); δ_1, the ratio of deviation from exact correspondence with the theoretical value; C, the observed multiples and values of the perissad and artiad divisors (Notes 201—2); δ_2, their deviation from the theoretical values:

	D	δ_1	C	δ_2
Li	6.6	.1000	1 × 7.0	.0000
Na	6.7	.1167	3 × 7.7	.1000
K	6.5	.0833	6 × 6.5	.0714
Fl	5.	.1667	3 × 6.3	.1000
Cl	6.4	.0667	5 × 7.1	.0143
Br	6.7	.1167	11 × 7.3	.0429
I	6.8	.1333	18 × 7.0	.0000
Ag	6.	.0000	15 × 7.2	.0286
Tl	6.8	.1333	29 × 7.0	.0000
Rb	6.4	.0667	12 × 7.1	.0143
N	5.	.1667	2 × 7.0	.0000
P	5.9	.0167	4 × 7.7	.0429
As	6.1	.0167	10 × 7.5	.0714
Sb	6.	.0000	17 × 7.1	.0143
Bi	6.5	.0833	30 × 6.9	.0143
Au	6.4	.0667	28 × 7.0	.0000
Bo	5.5	.0833	2 × 5.5	.0714
O	4.	.3333	2 × 8.0	.0000
S	5.7	.0500	4 × 8.0	.0000
Se	6.	.0000	10 × 7.9	.0125
Te	6.	.0000	16 × 8.0	.0000
Mg	6.	.0000	3 × 8.0	.0000
Ca	6.8	.1333	5 × 8.0	.0000
Sr	6.4	.0667	11 × 7.9	.0125
Ba	6.4	.0667	17 × 8.0	.0000
C	5.5	.0833	1 × 12.0	.5000
Si	5.7	.0500	4 × 7.0	.1250
Ti	6.4	.0667	6 × 8.3	.0375
Zr	6.	.0000	11 × 8.1	.0125
Sn	6.5	.0833	15 × 7.8	.0250
Hg	6.3	.0500	25 × 8.0	.0000
Mo	6.9	.0167	12 × 8.0	.0000
W	6.1	.0167	30 × 7.9	.0125
Gl	5.6	.1000	1 × 9.1	.1375
Al	5.8	.0333	3 × 9.0	.1250
Cr	6.4	.0667	7 × 7.4	.0750

	D	δ_1	C	δ_2
Fe	6.3	.0500	7 × 8.0	.0000
Ga	5.5	.0833	9 × 7.7	.0375
In	6.5	.0833	14 × 8.1	.0125
Zn	6.1	.0167	18 × 8.1	.0125
Cd	6.	.0000	14 × 8.0	.0000
Mn	6.7	.1167	7 × 7.7	.0375
Ni	6.4	.0667	7 × 8.3	-0375
Co	6.3	.0500	7 × 8.4	.0500
Cu	6.	.0000	8 × 7.9	.0125
Pb	6.3	.0500	26 × 7.9	.0125
Ru	6.3	.0500	13 × 8.0	.0000
Rd	6.	.0000	13 × 8.0	.0000
Pd	6.3	.0500	13 × 8.1	.0125
Ir	6.3	.0500	24 × 8.0	.0000
Pt	6.3	.0500	24 × 8.1	.0125
Os	6.2	.0333	25 × 7.9	.0125
Ce	6.3	.0500	18 × 7.8	.0250
La	6.2	.0333	17 × 8.1	.0125
Di	6.4	.0667	18 × 8.0	.0000

This comparison shows that the general deviations from Dulong and Petit's law, while they are of the same order of magnitude, are much greater than the deviations from the perissad and artiad divisors.

209. *Secondary Character of Perissad Phyllotaxy.*

Although the fractions which are formed by successive approximations to the surd divisors represent phyllotactic dextro- and lævo-gyration, other series of a higher order may spring from greater initial differences. If we skip the first even number, we get the series 1, 3, 4, 7, 11, 18, etc. Hence we see that the fundamental perissad and artiad divisors both start from the phyllotactic number which most nearly represents the first surd divisor, 3, and are formed by adding the next artiad number for the perissad divisor, and the next perissad number for the artiad divisor. The coefficient of atomic heat is also formed from the same representative of division in extreme and mean ratio by taking its simplest artiad multiple, 2 × 3.

210. *Comparison of Probabilities.*

In looking more closely into the deviations which are given in Note 208, we find the following indications of superiority in the perissad and artiad divisors:

1. The approximation of the observed values within .05 of the theoretical values occurs 19 times in my columns, and only 9 times in those of Dulong and Petit.
2. The average deviations are, $\delta_1 = .0642$; $\delta_2 = .0344$.

3. The sums of the logarithms of the reciprocals of deviation, which indicate the aggregate relative probabilities of normal influence, are : 70.4555173 ; 89.2627807.

4. The ratio of aggregate probabilities is, therefore, $P_1 : P_2 : : 1 : 64159 (10)^{14}$. The ratio of mean probabilities, $P^{\frac{1}{55}}$, is $p_1 : p_2 : : 1 : 2.1976$.

5. Testing the hydrogen unit in a like way, I find the average deviation, $\delta_3 = .0024$; $\Sigma \log (1 \div \delta_3) = 152.5459742$; log. relative probability, taking P_D as the unit, 82.0904569. This gives, $P_3 = 12315 (10)^{78}$; $p_3 = 31.0852$.

6. In accordance with the principle of least squares, these values of p should be reduced inversely as the fundamental divisors. This gives $p_1 : p_2 : p_3 : p_4 : : 1 : 1.71 : 4.44 : 5.08$; $\log (P_2 \div P_1) = 12.8482860$; $\log (P_3 \div P_1) = 35.6100415$; $\log (P_4 \div P_1) = 38.8306765$; p_4 and P_4 being respectively, the mean and aggregate probabilities of the phyllotactic divisors (Note 181). The corresponding mean relative probabilities for S_1, S_2, and Gerber's divisors are respectively, 2.78, 2.45, 4.72.

211. *Suggestions for Further Investigation.*

The ratio between p_1 and p_3, in the foregoing note, has been gradually diminished by successive approximations, and by making allowance for theoretical considerations, which have seemed to justify the adoption of some exact multiple or submultiple of an atomic weight which had been previously accepted. The ratio between p_1 and p_2, favorable as it already is for the latter, is based upon a comparison of the latest revision of the atomic heats with the first crude application of the perissad and artiad divisors. If Dulong and Petit's law is entitled to great weight in determinations of atomicity, a still stronger claim may be urged in behalf of divisors which have a mean probability that is more than 70 per cent. greater. If Dumas's proposed modification of Prout's hypothesis were applied to Si and Cr, their atomicities would be very closely represented by $\frac{7}{2} \times 8$ and $\frac{13}{2} \times 8$; P is very nearly $\frac{5}{9} \times 8 \times 7$, or very nearly $\frac{40}{9}$ of the monatomic phyllotactic divisor ; Na is about 30 times the monatomic divisor or 2×11, 11 being the phyllotactic number which follows 7 in the secondary series (Note 209) ; Bo is 7.018 times its proper phyllotactic divisor. Si, Cr, Na and P may, perhaps, have tendencies towards the opposite group, perissad or artiad, the investigation of which may throw light upon the beginnings of valency.

212. *Chemical Electricity.*

Davy's discovery of potassium laid the foundation of electrolysis, introducing polarity as an important modifier of chemical attraction. The attractions and repulsions of Sir William Thomson's hypothetical vortex-atoms involve gyroscopic tendencies to maintain uniform planes of rotation, which must aid the normal arrangements of æthereal particles (*Proc. Am. Phil. Soc.*, xii, 408) in the determination of axial and polar, centrifugal and centripetal relations. Hence arise various combinations of motion and tendencies to motion, which are obedient to simple mechanical laws, and which give rise to the different classes of radiodynamic phenomena which we call gravitating, electric, magnetic, thermal, chemical, etc. In consequence of the universality of motion, which seems to make absolute equilibrium an absolute impossibility, the tendencies to division in extreme and mean ratio are never repeated in the same exact plane, but they partake of a more or less intricate spiral character, such as is uniformly shown in vegetable growth. The comparative relative stability of axes, even in ultimate molecules and atoms, must produce æthereal oscillations which are parallel to the axis, as well as those which are radial and tangential (*Op. cit.*, ix, 408), giving rise to solenoidal currents, such as are assumed in Ampère's hypothesis.

213. *Earth's "Pulsation Period."*

Proctor (*Contemporary Rev.*, March, 1882, p. 479), speaks of "the time when the Earth's rotation began to approach to synchronism with her pulsation period" or "the period of vibration of her mass after any impulse (affecting the whole Earth) had been received from without. The Earth would as certainly have had such a pulsation period as the vibrating substance of a bell has." This admission is interesting as an evidence of increasing recognition of the truths which are involved in Herschel's doctrine of nebular elasticity or quasi-elasticity, and which are the groundwork of all my harmonic researches. Proctor, however, in trying to explain the supposed retardation of Earth's rotation, overlooks the more than three hundred-fold acceleration which Laplace's hypothesis would require.

214. *The "Reproach" of Thermodynamics.*

The hypothesis that stellar systems are cooling, condensing and giving out heat, imparting their *vis viva* to the luminiferous æther without receiving anything in return, and that, consequently, all things are tending to ultimate physical stagnation and universal death, is so unphilosophical and altogether unsatisfactory as to show that some important element must have been overlooked. If we were granted infinite elasticity, or a medium acting under elastic laws but without density, Laplace's supposed instantaneous transmission of gravitating action might be represented by well-known physical formulæ. In other words, if we could conceive of a material medium endowed with qualities which are not material, some of the difficulties of pure materialism would be removed. What name could be given to such a medium, but spirit? Spiritual, conscious, "upholding" and controlling power is conceivable ; without such a conception, the most important of all phenomena are wholly inexplicable. Any hypothesis that an unconscious universe could ever have wound itself up like a clock, is childish ; the belief that, after having wound itself up, it would allow itself to run down without winding itself up again is more childish still. The confession that we can see no escape from final stagnation imposes no restraint on the universe; it is only a confession of our own shortsightedness. He who sees the necessity of a Wise, Everlasting and Almighty Omnipresence, also sees that the present order of things must continue as long as its Ruler wills. He who sees that the Omnipresent Power acts "in ways which may be represented by harmonic or cyclical undulations in an elastic medium," also sees that more is implied in the equality of elastic action and reaction than has yet been fathomed by the sounding line of the most skillful analysis.

215. *Tides.*

The danger of hasty generalizations from investigations which are necessarily of a partial character, is well illustrated by the various speculations which have been set forth about tidal action. The equilibrium-hypothesis and each of the dynamic hypotheses have severally considered important relations and interactions between the disturbed and disturbing bodies, but the incompleteness of them all is shown by our inability yet to explain some of the phenomena which are of daily occurrence, as well as by our complete ignorance as to the normal position of the tidal crests. Bernouilli, and Laplace for certain mean depths of ocean, assumed that it should be high water under the moon; Laplace for other depths, Delaunay and Airy have given satisfactory evidences of tendencies to high tide when the moon is in the horizon; sailors have a prevalent belief that the high water, in mid-ocean, lags about three hours behind the moon; many mathematicians think that either friction or inertia may produce such lagging, but it has never been shown that there is any tidal friction, or that inertia can delay any normal tidal action. Some of the most satisfactory results have been reached through considerations of the elasticity which is involved in wave-propagation, but the inter-molecular elasticity, the extent to which the several particles of water are free to fall towards or recede from the attracting body, and the variations of weight consequent on variations of gravitating tendency, have not been sufficiently studied.

216. *Barometric Analogy.*

Fortunately, upon at least one of the foregoing points, we can ask nature a simple question, to which she gives a satisfactory answer. Is there any evidence of tidal disturbance of weight? Yes, in the daily fluctuations of the barometer. They are certainly tidal, even if we fail to see in them any likeness to the ocean tides. The air, which is heated and expanded by the sun's rays, is carried forward by the earth, in its orbital revolution and daily rotation, with a continual tendency of each particle to maintain the instantaneous direction of its motion. This tendency is represented, not by the simple momentum of the particles, but by their *vis viva*, and is accompanied by gravitating tendencies, which are sometimes antagonistic and sometimes co-operative, towards the earth and towards the sun. Their own elasticity concurs with the elasticity of any intervening medium, in adjusting their relative positions to the ever-varying requirements of equilibrium, and causing harmonic oscillations which are easily traceable by means of systematic barometric observations. There can be no friction, provided the adjustments are made by the simple approach or separation of particles, and such appears to be the case. In the most thorough series of observations that has been published for any station near the equator, the harmonic oscillations are of the simplest character conceivable, representing the quarter-daily sums of the instantaneous tendencies and the changes in atmospheric weight so accurately as to give an estimate of Sun's distance, which differs by less than one-half of one per cent. from the latest astronomical estimates (*Proc. Am. Ph. Soc., ix, 287; x, 375–6, foot note.*)

217. *Ratio of Tidal Adjustments.*

Sir William Thomson has found a partial solution of the theoretical requirements of terrestrial rigidity, in his theory of vortex atoms. Perhaps the solution may be completed by supposing an intermolecular elasticity which is greater than that of glass, instead of a rigidity which is greater than that of glass. The influence of atmospheric pressure on the height of ocean tides, which has been noticed by many observers, suggests the likelihood that the whole mass of the earth may contribute to the adjustments of equilibrium which satisfy tidal tendencies. If that is the case, the entire change which would be required in the distance between any two molecular centres is less than $\frac{1}{4000000}$ of their mean distance, even at the spring tides, when the sun and moon combine their disturbing energies. The whole adjustment might be accomplished, through æthereal elasticity, in less than $\frac{1}{20}$ of a second, but it only needs to be accomplished four times in about 25 hours.

218. *Summation of Tendencies.*

The triumphs of calculus spring from the fact that its differentials represent only tendencies and its integrals are summations of tendencies. No integration or series of integrations can be rightly looked upon as conclusive, unless it has been extended to all the tendencies which can have any bearing upon the problem which we are examining. Nothing is more certain than mathematics, except our knowledge of our own spiritual existence and faculties. Neither in mathematics nor in psychology, however, is it safe to assign any value to our results beyond their necessary relations to the data from which they were obtained. Delaunay's hypothesis of tidal friction undoubtedly follows from his postulates, and if we accept it, we may be satisfied with the explanation which it gives of apparent lunar retardation, but his postulates are not all axiomatic; they do not cover the whole ground; and the errors in the lunar tables may spring from some portion of a cycle of mutually compensating perturbations. The tidal tendencies are towards accelerated rotation in two of the quadrants and towards retarded rotation in the other two, the sum of the accelerating being exactly equal to the sum of the retarding tendencies. No evidence has ever been adduced of any actual lagging of the water to maintain the normal position of the tidal crests relatively to the moon. There are many reasons for believing that the apparent westward motion, with a mean equatorial velocity of 1000 miles an hour, is only a motion of form, maintained by the combined influences of intermolecular elasticity, atomic elasticity or quasi-elasticity, variations of pressure on account of varying attraction, and such wave propagation as may be needed for the adjustment of opposite meridional and horizontal, static and dynamic tendencies. The adjustment may be brought about, as I have shown in Note 217, without any frictional diminution of the speed of rotation.

219. *The Moon and the Chief Planetary Belt.*

The importance of Earth's position, at the centre of the belt of greatest condensation, is further shown by the harmonic reactions between the Jupiter-Saturnian belt and Earth, with its satellite. The shortening of rotation-period which would represent a nebular contraction of Sun from Jupiter's to Earth's mean locus, corresponds to the shortening which would represent a contraction from Moon's semi-axis major to Laplace's terrestrial limit; the ratio between Moon's synodic and sidereal periods corresponds to the ratio between the locus of Saturn's incipient subsidence (secular aphelion) and axis-major. The time of rotation, in an expanding or contracting nebula, varies inversely as the square of radius:

$(\rho_5 \div \rho_3)^2 = 5.2028^2 = 27.06912.$
Sidereal month ÷ day = 27.32166.
Synodic ÷ sidereal month = 1.08087.
Saturn's sec. aph. ÷ mean* = 1.08433.

220. *Stability of Rotation-Periods.*

The relations of stellar rotation to oscillations which are propagated with the velocity of light, the relations of primary planetary rotation to planetary revolution, the relations of molecular rotation to electric, magnetic and tidal phenomena, the constancy of tendencies to harmonic oscillation, the confirmation of nebular theories which is afforded by the foregoing note, and the principle that no change in the *vis viva* of a system can take place without foreign action, all indicate a stability of rotation which is inconsistent with the hypothesis of tidal friction. Moreover, the closeness of accordance between the mean daily thermal and hygrometric adjustments of elasticity and the tidal variations of atmospheric pressure (*Proc. Am. Ph. Soc., ix, 284–6, 291–3, 346–8*), an accordance which is also shown in the lunar-monthly barometric tides (*Ib., 395–9; Proc. Roy. Soc. xiii, 329–33*), furnishes additional grounds for believing that rotation is only modified revolution, that its period is deter-

* According to Stockwell.

mined by a summation of all the tendencies to revolution which bear upon each and all the molecules of the rotating body, and that tidal variations of weight or pressure are as important in earth- and ocean-tides as in atmospheric tides.

221. *"There is much Virtue in If."*

Some extracts from a lecture by Dr. Ball, the Astronomer Royal of Ireland, have lately been largely copied by the newspapers. They contain a statement that the moon was once only 40,000 miles away, and that it thus acted as a geological engine of transcendent power. The statement is somewhat qualified by the proviso that if the present tides are three feet, and if the early tides were 216 times their present amount, then it is plain that the ancient tides must have been 648 feet. This qualification is not sufficient, and it is misleading, because it will be generally understood as covering all the points about which there is any uncertainty. Science in its claims of exactness, cannot afford to hazard any claims which can be easily refuted. It is true that there are many astronomers who believe that Delaunay's views are correct, but there are probably few who think that they have been conclusively demonstrated. If the moon pulls the ocean-waters around the earth, in a direction opposite to its daily rotation, at the rate of a thousand miles an hour, or at any less rate; if the friction, which would result from such a pull, is not compensated in some way which is not yet fully known; if there is a bulge of tidal water which cannot fully keep up with the moon, and which, by its attraction on the moon, tends to retard its orbital velocity; if all the mathematical conclusions which it seems reasonable to draw from such supposed retardation are correct, and if the "reproach" of thermodynamics must be accepted without qualification, the moon may be receding from the earth.

222. *Weakness of the Postulates.*

In examining the provisos of the foregoing note, we find:—In the first place, no tidal currents have ever been observed which indicate a lagging tendency in ocean waters. Secondly, there is no evidence whatever to show that the earth's rotation has been retarded by friction. Thirdly, there is no evidence to show that the moon's orbital motion has been retarded by the ocean tides. Fourthly, the number of elements which must enter into any calculation of planetary disturbances is so great that no prudent mathematician ever looks for more than an approximation to such results as he desires. Fifthly, the difficulties which are encountered in trying to explain irregularities of orbital motion, are vastly enhanced when we come to deal with the complicated tendencies of planetary rotation. Sixthly, there is as much reason to believe that the moon may be gradually falling to the earth, as there is to believe that the earth may be gradually falling to the sun. Seventhly, the accelerating and retarding tendencies of æthereal elasticity and resistance are but little understood. Eighthly, all of the possible compensatory adjustments, to which I have referred in foregoing notes, should be thoroughly investigated before forming any conclusive opinion respecting Delaunay's hypothesis. Ninthly, even after such investigation, the remembrance of other possible unknown influences should prevent anything like dogmatical assertion.

223. *The "Ifs" of Elasticity.*

I shall not shrink from any criticism such as is implied in the following "retort courteous": If there is a universal æthereal medium; if it is endowed with an elasticity somewhat like that of gases; if its velocity of wave-propagation can be expressed by the ordinary formula of relation between elasticity and density; if the laws of harmonic vibration in elastic media, which have been mathematically deduced, are correct; if the æthereal *vis viva* can be shared with chemical atoms and cosmical masses; if nebular "subsidence" has been governed by the laws of gravitation; if all kinds of energy are simple functions of mass and velocity, and "if all the mathematical conclusions which it seems reasonable to draw from" these hypotheses are correct, the general postulate that "all physical phenomena are due to an Omnipresent Power, acting in ways which may be represented by harmonic or cyclical undulations in an elastic medium" may be accepted as a good working hypothesis.

224. *Acceptance of the Issue.*

These provisos cover the whole ground, as fully as I could wish. I have never claimed, nor have I believed, that any scientific thesis can be freed from the limitations which are involved in its fundamental assumptions. While I fully believe in the impossibility of anything acting except where it is, in the existence of a universal elastic medium which is governed by radiodynamic and harmonic laws, and in the uniformity of physical force, I am well aware that they are incapable of mathematical demonstration and I have repeatedly acknowledged that the nebular and æthereal hypotheses have no scientific value beyond such helpful coördination of phenomena as they may furnish. The tidal "ifs" are mere assumptions, adduced in order to account for an apparent retardation which is altogether problematical and which, if it should prove to be real, may be followed by an equivalent acceleration; the elastic "ifs" are all intrinsically probable, and instead of having been assumed for a special purpose they represent simple and natural generalizations from a wide range of independent physical phenomena. The tidal ifs are like Bacon's "barren virgins;" the elastic ifs have already led to the discovery of a vast number of natural harmonies and the field for further like discovery widens so rapidly that every physical atom seems to contribute its individual melody, to the ever-resounding and ever-changing choral strains which constitute the music of the spheres. Although centripetal and centrifugal activities may be expressed by identical formulæ, it is difficult, if not impossible, to form any definite conception of attracting pulls. Elastic thrusts are exemplified by every breath that we draw, every object that we see, every sound that we hear, and Anderssohn* has experimentally shown that they can adequately represent all varieties of gravitating and electromagnetic phenomena.

225. *A Scientific Statement of the Tidal Problems.*

The "Astronomy for Schools and Colleges," by Newcomb and Holden (Ed. of 1879, p. 167), speaks with true scientific caution, as follows:— "The theory of the tides offers very complicated problems, which have taxed the powers of mathematicians for several generations. These problems are in their elements less simple than those presented by the motions of the planets, owing to the number of disturbing circumstances which enter into them. The various depths of the ocean at different points, the friction of the water, its momentum when it is once in motion, the effect of the coast-lines, have all to be taken into account. These quantities are so far from being exactly known that the theory of the tides can be expressed only by some general principles which do not suffice to enable us to predict them for any given place."

226. *Cometary Spectra.*

The uncertainties of measurement and the harmonic indications which are given in spite of those uncertainties may be illustrated by comparing observations of like objects by different reporters. Tacchini gives (*Ann. de Chim. et de Phys., xxv, 286*) measurements of the spectral lines in comet *b*, 1881, which correspond satisfactorily with lines in Hesselber's carbon spectrum. The harmonic accordance is equally satisfactory.

Harmonic.	Tacchini.
$37527.7 \div 68 = 551.9$	552.1
$37527.7 \div 73 = 514.1$	514.1
$37527.7 \div 81 = 463.2$	463.1

Thollon (*Ib.*, 287–8) compares the same spectrum with three different spectra of carbon compounds, viz: A, electric arc, Jamin's lamp measurements made by M. Bigourdan; B, cyanogen, coil and condenser, Salet; C, blue flame of illuminating gas, Lecoq de Boisbaudran.

Harmonic.	Thollon.	A.	B.	C.
$31479 \div 56 = 562.1$	562	562.2	563.0	562.9
$31479 \div 61 = 516.0$	516	516.5	516.3	516.1
$31479 \div 67 = 469.9$	470	470.4	470.0	470.6†

The harmonic divisors for Tacchini's measurements are sums of successive or nearly successive phyllotactic numbers: $81 = 5 + 8 + 13 + 21 + 34$; $73 = 81 - 8$; $68 = 73 - 5 = 13 + 21 + 34$. In the harmonic divisors for Thollon's measurements, $56 = 7 \times 8 =$ product of the artiad and perissad divisors, and the middle line is an arithmetical mean between the other two.

* *Der Mechanik der Gravitation*, Breslau, 1874; *J. B. des Bres. Phys. Ver.*, 1881–2.

† Boisbaudran does not give this line, but he gives 473.8 and 467.5, the arithmetical mean being 470.65.

227. *Identity of Spectral Lines in Different Elements.*

Young (*Am. Jour. Sci., xx, 355*) and Liveing and Dewar (*Proc. Roy. Soc., xxxii, 225–31*) have shown that many of the lines in different elementary spectra, which have been supposed to be identical, really differ slightly in refrangibility and can be separated by a sufficient increase of dispersive power in the trains of prisms. The number of separations which has already been effected makes it very doubtful whether any case of absolute coincidence can be found, where two elements are present in the spectral incandescence. This has been thought, by some, fatal to Lockyer's and Thalen's hypothesis that all the lines are modifications of a few basic lines. That such a generalization is too hasty, may be shown by the following considerations: 1. Atoms are continually subject to incommensurable, as well as to commensurable tendencies. 2. There are often various harmonic tendencies, which are simultaneously operative, the final harmonic adjustment being determined by the relative magnitude of the individual tendencies. 3. The well-known experiment of oscillating balls, suspended from a horizontal cord, shows that the cyclical vibrations are modified by each member of a harmonic group. 4. The slight fluctuations in the lines of the solar spectrum make it probable that there are similar fluctuations in chemical and cometary spectra. 5. This probability is increased by the differences of measurement which are made by different observers at different times. 6. Propositions 2 and 5 are both illustrated by the two harmonies which represent Tacchini's and Thollon's measurements (Note 226).

228. *Lithium Harmonies.*

Liveing and Dewar (*Proc. Roy. Soc., xxx, 93–9*) have observed three lines in the spectrum of lithium (3913, 3984 and 4273), besides Boisbaudran's line, 4131.7. The harmonies are shown below.

Harmonic Divisors.	Harmonic Quotients.	Observed.
1	4273.02	4273
$1 + 7a$	4132.78	4131.7
$1 + 15a$	3983.37	3984
$1 + 19a$	3912.65	3913

The coefficient of the first addition to the harmonic divisor is the same as the perissad divisor and as Prout's coefficient of Li. The second and third additions are respectively the artiad divisor and ½ the artiad divisor. The harmony is nearly as satisfactory, if we combine these lines with those which are given by Huggins (*see Proc. Am. Ph. Soc., xvii, 297*).

Harmonic Divisors.	Harmonic Quotients.	Observed.
1	6107.37	6107.3
$1 + 40a$	4796.64	4794.8
$1 + 48a$	4599.23	4599.3
$1 + 63a$	4269.74	4273.
$1 + 70a$	4131.49	4131.7
$1 + 78a$	3984.31	3984.
$1 + 82a$	3914.50	3913.

The coefficients of a are, 5×8, 6×8, 9×7, 10×7, $10 \times 7 + 8$, $10 \times 7 + \frac{3}{2}$ of 8, being made up of multiples or sums of the phyllotactic numbers, 2, 3, 5 and 8, and the secondary phyllotactic number, 7.

229. *Relations of Central Force to Thermal Constants.*

I have shown (*Proc. A. P. S., xiv, 651*) that the ratio of heat under constant volume to heat under constant pressure, as deduced from purely theoretical considerations, is $\pi^2 + 4 : 2\pi^2$, or 1 : 1.4232. The elements for computing this ratio are: 1, the synchronism of oscillations, under the action of central forces, in all orbits which have the same major axis; 2, the kinetic theory of gases, which supposes that all the paths of clashing particles are rectilinear, and therefore in orbits of unitary eccentricity, one extremity of each path corresponding with the centre of a synchronous circle; 3, the consequent ratio of mean rectilinear *vis viva*, or mean *vis viva* of constant gaseous pressure, to synchronous mean circular *vis viva*, or mean *vis viva* of constant volume; 4, the thermodynamic doctrine that equal quantities of heat correspond to equal increments of *vis viva* and to equal increments of temperature; 5, the proportionality of mean *vis viva* to mean distance of projection against uniform resistance; 6, the determination of the radial locus at which the mean velocity of linear oscillation, or of mean gaseous pressure, would be acquired both in centrifugal and in centripetal motion. This theoretical determination of the ratio of specific heats proceeds on the hypothesis of Boscovich, that central forces continue to act, at all distances from the centre, with accelerations which vary inversely as the square of the distance. There are many reasons for believing that this law does not hold, even in the æthereal condition, within the radius of inertial aggregation, and it seems likely that careful experiments may bring to light many kinds of deviation from the theoretical value, the study of which will greatly extend our knowledge of atomic and molecular structure. The most accurate experimental determinations of the ratio that have been published hitherto seem to range between 1 : 1.4053 and 1 : 1.421. These values indicate an orbital eccentricity of from .9874 to .9985.

230. *Tests of Thermal Relations by Solar Mass and Distance.*

The estimates which I have hitherto made of the central energies of the solar system, from measurable tendencies to equilibrium between gravitating and explosive or centripetal and centrifugal energies (*Proc. A. P. S., xii, 392–4, xix, 354, et al.*), have been based upon the supposition that all the calorimetric measurements were made under constant pressure. C. v. Than (*Abstr. in Jour. Chem. Soc., March, 1882, p. 265.*) gives five estimates for the heat of combustion of H_2O, from which estimates of solar mass and distance may be deduced by the method of Note 16.

	Observers.	θ	ρ	m
At constant volume	Andrews,	33,880	92,760,000	331,500
	v. Than,	33,822	92,839,400	332,350
At constant pressure	J. Thomsen,	34,218	93,071,400	334,850
	Favre and Silbermann,	34,426	92,789,800	331,820
	Schuller and Wartha,	34,471	92,729,200	331,170

The observations were made respectively in 1848, 1881, 1873, 1852 and 1877. The corresponding molecular heats, as given by Naumann (see Note 16) for three of the above observers, differ slightly from 2 $\times$ the above values of θ, the greatest difference being $\frac{2}{9}$ of one per cent. The mean values, if we allow equal weight to the present note and to Note 16, after making the proper correction in the observations at constant volume, are $\rho = 92,739,500$; $m = 331,280$. This value of ρ differs by less than $\frac{1}{383}$ of one per cent. from the mean of the combined results in Note 15 (92,737,100).

231. *Molecular Volume of Solids.*

E. Wilson (*Proc. Roy. Soc., xxxii, 457–91*) discusses the relations of molecular volume to chemical constitution, furnishing new evidence of harmonic oscillation. He states the three following propositions, and thinks that his tables lend comparatively greater support to the third, while the first and second must, for the present, be considered more hypothetical:

(i.) When any number of *similar* atoms combine, the volume of the resulting molecule is equal to that of the uncombined atom.

(ii.) When dissimilar atoms combine, the volume assignable to each atom is some simple submultiple or aliquot part of its atomic volume, and the resultant molecular volume is the sum of those volumes.

(iii.) Every element in its various compounds is capable of assuming different volumes bearing a simple proportion to one another, such as 1 : 2, 1 : 3, 2 : 3, &c.

He also adduces evidence in support of Kopp's conjecture that elements may undergo different degrees of condensation in different radicles of the same compound, and he shows the agreement of his results with those which were obtained by Loschmidt from gaseous interdiffusion.

232. *Variability of Crystalline Angles.*

F. Pfaff (*Jour. Chem. Soc., June, 1881, Abstr. p. 356*) has made a series of measurements, from which he concludes that the limits of admissible correction of measured angles by calculation from rational axial sections must be carried further than has hitherto been the case. W. H. Perkin (*Ib. Aug., 1881, 409–452*), in discussing the isomeric acids obtained from coumarin and the ethers of hydride of salicyl, gives seven sets of crystalline measurements, with forty-nine comparisons of calculated and observed angles. Taking the range between the limits of observation, which are given in twenty-six of the comparisons, or the deviations of the observed from the calculated values, in the other twenty-three comparisons, the variability is more than one per cent. in one-third of the whole number of measurements, viz: .155, .121, .067, .056, .055, .054, .046, .044, .021, .019, .018, .016, .016, .015, .012, .011. The mean variability of the forty-nine measurements is .017. These facts may have an important bearing upon many questions of radiodynamic probability, especially in regard to the adjustment of commensurable and incommensurable tendencies.

233. *Pressure.*

The experiments of Tresca and Spring, together with those of Crookes, Pictet and Cailletet, show that it is impossible to fix any boundaries between any two of the adjacent states of matter, æthereal, gaseous, liquid, solid, crystalline. J. and P. Curie (*Comptes rendus, lxxxxi, lxxxxii*) confirm Faraday's hypothesis that magnetized and dielectric bodies should tend to contract in the direction of the lines of force and to dilate at right angles to those lines, a tendency which, as I have shown,* is propagated with the velocity of light. They suppose that between the opposed faces of two contiguous layers of molecules there is a constant difference of tension, involving a condensation of electricity which depends on the distance between the two layers. By experiments with tourmaline and hemihedral crystals with inclined faces they are led to attach primary importance to the form of the molecules, the extremity which corresponds with the most acute solid angles being always negative on dilatation and positive on contraction. They deduce the following laws:

1. The two extremities of a tourmaline crystal develop quantities of electricity under pressure which are equal, but of opposite kind.
2. The quantity developed by a given increase of pressure is equal to that which is developed by an equal diminution of pressure, but of opposite kind.
3. This quantity is proportional to the variation of pressure, is independent of the length of the crystal, and for the same variation of pressure per unit of surface is proportional to the surface.

All of these results have an important bearing upon the old maxim that "nothing can act except where it is," and on Newton's consequent belief that the phenomena of gravitation can be more satisfactorily explained by æthereal pressure than by attracting pulls. They may also help to explain the formation and sublimation of heavy metallic elements, by the immense pressures to which the interior of condensing nebulæ are subjected. Many of the aggregating and dissociative tendencies of "subsidence," of which my planetary harmonies have given abundant evidence, may be exemplified chemically as well as cosmically.

234. *Test of Harmonic Probability.*

I have endeavored, in my various physical papers, to collect *facts*, through the guidance of well-known laws, and to account for them by a

*See citations in Note 200.

reference to those laws, without introducing any new hypotheses. I have already compared various phyllotactic harmonies with other chemical hypotheses, and Note 232 furnishes data for extending the tests of mathematical probability. In my first paper on the harmonic interferences in the spectra of chemical elements (*Proc. A. P. S., xvii, 297–301*) I examined the measured wave-lengths of 128 lines, in twenty-one different spectra. The greatest mean deviation of the measured lines in either spectrum from lines which are rigidly harmonic, is less than $\frac{1}{3}$ of one per cent., the mean deviation in the whole number of lines being less than $\frac{1}{13}$ of one per cent. The mean deviations in the several spectra are as follows: $\frac{1}{20}$, $\frac{1}{37}$, $\frac{2}{7}$, $\frac{1}{56}$, 0, $\frac{1}{14}$, $\frac{1}{14}$, $\frac{1}{176}$, $\frac{1}{11}$, $\frac{1}{16}$, $\frac{1}{102}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{412}$, $\frac{1}{37}$, $\frac{1}{9}$, $\frac{1}{10}$, $\frac{1}{29}$, $\frac{1}{25}$, $\frac{1}{66}$, $\frac{1}{13}$ of one per cent. The greatest deviation in any single line is one per cent., and there is only one line which has a deviation of more than $\frac{1}{2}$ of one per cent., which is only $\frac{1}{31}$ as great as the greatest deviation in Perkin's set of crystalline measurements, or less than $\frac{1}{3}$ as great as his mean variability. Later comparisons, of which Notes 226 and 228 may be taken as examples, show approximations which are still closer. The greatest deviation in Tacchini's cometary measurements is $\frac{1}{27}$ of .01, and the mean deviation $\frac{1}{51}$ of .01; the greatest deviation in Thollon's measurements is $\frac{1}{4699}$, and the mean deviation $\frac{1}{7740}$; the greatest deviation in the first lithium spectrum of Note 228 is $\frac{1}{3826}$, and the mean deviation $\frac{1}{7837}$; the greatest deviation in the second spectrum of the same note is $\frac{1}{1310}$, and the mean deviation $\frac{1}{4380}$.

235. *Spectrum of the Great Nebula in Orion.*

On the 7th of March, 1882, Huggins (*Am. Jour. Sci.*, [3] *xxiii, 335*) obtained a photograph of the spectrum of the nebula in Orion, with an exposure of 45 minutes. His former researches showed that the visible spectrum of gaseous nebulæ contains four bright lines, 5005, 4957, and two of the hydrogen lines, β and γ. The photograph has also a strong line in the ultra-violet, at the position of λ 3730, or nearly so. Some of the harmonic relations of the lines are given in the following table:

Harmonic.	Observed.
$525405 \div 105 = 5003.86$	5005
$525405 \div 106 = 4956.65$	4957
$525405 \div 108 = 4864.86$	4861
$525405 \div 121 = 4342.19$	4340
$525405 \div 141 = 3726.28$	3730

The greatest deviation is $\frac{1}{10}$ of one per cent., and the mean deviation $\frac{1}{20}$ of one per cent.

236. *Magnetic Estimate of Æthereal Density.*

Newton's æthereal hypothesis, Faraday's electric hypothesis and my own numerical relations (See Note 200) are exemplified in the following combined harmonies: Let v_0 represent Earth's mean orbital velocity which is due to Sun's attraction ; v_3, corresponding magnetic component of circular orbital velocity which Earth would communicate to an æthereal particle ; θ_o, specific heat of water ; θ_3, specific heat of typical gas ; d_o, density of Sun ; d_3, density of Earth ; δ_o. mean density of æther in Earth's orbit under influence of Sun's attraction ; δ_3, density of Earth's atmosphere at mean locus of magnetization. Then

$$v_3 : v_o :: \theta_3 : \theta_o \quad (1)$$
$$d_3 : d_o :: \delta_3 : \delta_o \quad (2)$$

The given values are, $v_o = 18.476$ m. ; $\theta_3 = .23773\ \theta_o$; $d_o = .25491\ d_3$. The required values are v_3, δ_3 and δ_o. From (1) we find

$$v_3 = .23773 \times 18.476 = 4.3924\text{m}.$$

At Earth's equatorial surface, $\sqrt{gr} = 4.9073 = 1.1172\ v_3$; the magnetic component of this velocity in Earth's orbital plane is $v_m = \cos. 23^\circ 28' \times 4.9073 = 4.501 = 1.0248\ v_3$; the mean locus of magnetization is therefore, $1.0248^2 \times 20{,}923{,}654$ ft. from Earth's centre $= .05028 \times 20{,}923{,}654 = 1{,}051{,}985$ ft. from Earth's surface. According to Babinet's formula (*Smiths'n Tables*, D, p. 68) the normal density of the air diminishes $\frac{1}{2}$ at the altitude

$$Z = 52494 \text{ ft.} \times \frac{30 - 15}{30 + 15} = 17498 \text{ ft.} = 1{,}051{,}985 \div 60.12$$

The atmospheric density at the locus of magnetization is, therefore $\delta_3 = 1 \div 2^{60.12} = 1 \div 1{,}252{,}920{,}900{,}000{,}000{,}000$; the æthereal density, $\delta_o = \delta_3 \times .25491 = 1 \div 4{,}915{,}148{,}000{,}000{,}000{,}000$. The density of hydrogen is .0692, or, according to this estimate, $340{,}128{,}200{,}000{,}000{,}000\ \delta_o$. This is 2.07 per cent. greater than the estimate which was based on the ratio of projectile gaseous energy to æthereal energy (Note 35). The significance of proportion (1) is increased by the cosmical relations of Joule's equivalent (*Proc. A. P. S.*, xix, 20). The agreement would be exact if we take $\rho_3 = 92{,}809{,}500$ miles.

237. "*Subsidence*" *Estimate of Æthereal Density.*

Subsidence towards the three chief centres of nebulosity, (Jupiter), condensation, (Earth), and nucleation, (Sun), should be influenced by æthereal harmonies. If we take the estimate of Sun's mass which satisfies the requirements of subsidence and oscillation (331776 ; Notes 5, 23, 91) and the British Nautical Almanac value for Earth's distance, measured in Sun's semi-diameters (214.45), $\rho_3 = 92{,}785{,}700$ miles ; the mean projectile locus of the chief centre of gravity in the system (c. g. Sun and Jupiter at mean perihelion) $= 1.018\ r_o = r_c$; L_o (solar modulus of light ; Note 75) $= 474657\ r_o = 465896\ r_c$; the mean locus of magnetization, $l_3 = r_c \times \rho_3 \div L_o = 199.1555$ miles $= 1{,}051{,}541$ ft. $= 60.09498 \times 17498$. This gives, for the ratio of hydrogen density (δ_h) to æthereal density,

$$\delta_h = 334{,}280{,}400{,}000{,}000{,}000\ \delta_o$$

which exceeds the estimate of Note 35 by less than $\frac{1}{3}$ of one per cent.

238. *Rotation Estimate of Æthereal Density.*

The hypothesis that hydrogen is the simplest known form of æthereal condensation and that all other chemical elements are condensed hydrogen, together with the theory that stellar rotation is due to æthereal harmonic oscillations (Notes 17, 34, 198 *et al.*), requires that the linear oscillations of the kinetic gaseous theory should be made circular, within the stellar nucleus. Since gaseous density varies inversely as volume, the æther-hydrogen hypothesis is satisfied by the proportion

$$\pi L_o^3 : r_o^3 :: \delta_h : \delta_o$$

$$\therefore \quad \delta_h = 335{,}961{,}800{,}000{,}000{,}000\ \delta_o$$

which is $\frac{1}{2}$ of one per cent. greater than the estimate of the foregoing note.

239. *Æthereal Elasticity.*

The velocity of light (v_λ), according to the subsidence estimate, is $92{,}785{,}700 \div 497.827 = 186{,}381$ miles. The velocity of sound in hydrogen, according to Dulong, is 4163 ft. If we designate the ratio of elasticity to density ($e \div d$), for hydrogen and æther respectively, by ε_h and ε_o, the proportionality $v \propto \sqrt{\varepsilon}$ gives

$$\varepsilon_o : \varepsilon_h :: (186381 \times 5280)^2 : 4163^2 :: 55{,}880{,}460{,}000 : 1$$

for the relative elasticities under the same density. If we adopt the rotation estimate of comparative density, we have

$$e_o : e_h :: 1 : 6{,}012{,}151$$

for the relative elasticities at normal density.

240. *Æthereal Density at Mean Planetary Loci.*

The æthereal density should be $\frac{1}{2}$ as great as at Sun's surface at $\frac{2}{3}\,L_o = 316{,}438\ r_o = 1448.343$* ρ_3. At any other locus, ρ_n, it should be $(\frac{1}{2})^n$, n being equivalent to $(\rho_n \div 1448.343\ \rho_3)$. This gives, for the relative rotation estimate of æthereal density at Sun's surface and at the several planetary mean distances :

Sun	1.00000
Mercury	.99981
Venus	.99965
Earth	.99952
Mars	.99927
Jupiter	.99751
Saturn	.99544
Uranus	.99086
Neptune	.98573

* Allowing for rupturing centre of gravity of Sun and Jupiter.

241. *Validity of Estimates.*

All estimates of this character are, of course, only provisional, and they can claim no validity, as I have heretofore shown, beyond the accuracy with which they represent the data upon which they are based. That all the æthereal elements which I have considered are important, that they are more far-reaching than those which have been introduced into any like discussion of which I have any knowledge, that their influence has been rightly stated, and that they will contribute, by collation with Thomson's and other estimates, to a more satisfactory solution of many physical problems than is yet attainable, I fully and unhesitatingly believe. Sun's orbital motion, and questions connected with the retardations which change revolution into simple rotation, are among the considerations which seem likely to modify the values that are given in the five foregoing notes and in Note 35.

Note on the Aurora of April 16–17, 1882. By H. Carvill Lewis.

(*Read before the American Philosophical Society, April 21, 1882.*)

The aurora of Sunday evening, April 16–17, 1882, was probably one of the most remarkable, both as to beauty and scientific interest, that has been observed in this latitude. It is especially noteworthy on account of the brilliant *corona* which continued well defined for several hours, and whose apparent motion eastward, through space, could, therefore, be determined. Several other unusual features, such as an *auroral curtain*, and hyperbolic curves of light, were also displayed. The attendant solar and magnetic phenomena have also been of great importance in determining a theory of the aurora.

The aurora was noticed as soon as twilight had ended as a faint glow along the northern horizon. At 8.30 it was a low arch, probably not over 10 degrees high. It gradually rose higher, and left a dark segment below it. At 10 P. M. the arch was some 20 degrees high, and was constantly increasing in brilliancy. Bright short white acicular streamers now appeared in the north, and sometimes rose as high as 40 degrees. These occasionally assumed a reddish color, and were frequently wafted along the arch towards the west. The aurora now fluctuated greatly in brilliancy, sometimes nearly disappearing, and then flashing out brighter than ever.

At 11.15 the arch had become brighter and much longer, though still of low altitude. Bright acicular streamers were crowded closely together at the western end of the arch, while in the east a second arch was now formed. The auroral arch now began to rise rapidly. At 11.20 the upper arch was 40 degrees high. Long narrow streamers were rapidly forming over the whole northern sky, and were traversed from base to apex with swift, tremulous waves of light. At the same time a mass of fine red color appeared in the north-west, and flashed alternately bright and dark, as though a red cloud illuminated by heat lightning. This mass of red color moved rapidly westward and was preceded by remarkable flashes of red. At 11.25 the aurora had risen nearly to the zenith, and was of great brilliancy. Numerous narrow streamers, covering the entire northern half of the sky, were flashing bright and dark with great rapidity, while fine crimson patches appeared independently in several portions of the sky.

At 11.30, or a few minutes later, the whole aurora from all sides moved with a bound toward the zenith. Streamers shot up from north, east and west with rapid, tremulous motions, reaching higher and higher with each pulsation, until, after apparently several ineffectual attempts, they all converged at a point nearly on the meridian nineteen degrees south of the zenith to form a corona of great beauty. This corona, which at first was unsteady and continually broken into detached segments, had become, at 11.40 P. M., a constant feature. Streamers now radiated from it in every direction, south as well as north. The whole sky seemed in motion except this one point. Rapid waves traveled along the narrow streamers from the horizon nearly up to the corona, while great nebulous masses and broad bands of crimson light flashed out in different portions of the sky. These masses of red light, particularly noticeable in the north-west, had no definite form, and showed no undulating pulsations like those of the thread-like streamers, but either hung steadily in the sky for some minutes, or else were illuminated with flashes like lightning. The impression was given that these red portions of the aurora were distinct phenomena, disconnected from the greenish-white streamers, and, perhaps, at a greater distance from the earth.

The centre of the corona appeared to be some 12 degrees east of Arcturus. At 11.50, the centre of the corona was estimated to have the position R. A. 204°, Dec. 21° 30′.

At midnight the corona, a perfect star of light, had become wonderfully beautiful. The brilliancy of the whole aurora was concentrated at this point, the horizon being comparatively dark. Remarkable coruscations of light surrounded the corona, and these were often curved so as to approach in form a hyperbola of large eccentricity, whose transverse axis passed through the centre of the corona. The streamers between the corona and the northern horizon now united into remarkable concentric hyperbolic curves of great brilliancy, whose vertices were stationary near the corona, and whose tremulous arms, made up of many streamers, reached to the northern horizon. This form recalled the drawings made of the coma of certain comets, and suggests interesting analogies.

Still more closely did these curves of light resemble those assumed by iron filings in the vicinity of a magnet, and it is probable that they were identical.

The centre of the corona was now at R. A. 207°, Dec. 21° 30′.

At 12.10 A. M., and during the half-hour following, occurred the most magnificent sight of the evening, to which no description can do justice. The streamers, whose mass was now concentrated in the corona, had detached themselves from the northern horizon to form an *auroral curtain* of great beauty. The curtain hung some twenty degrees above the horizon, and was continually changing in form and color. The streamers, whose lower ends formed its fringe, were united above in bright hyperbolic or magnetic curves, which approached the corona within ten degrees, and which remained constant while the lower part of the curtain waved to and fro in waves of light.

The following very rough diagram may serve to illustrate the general positions of the corona and curtain:

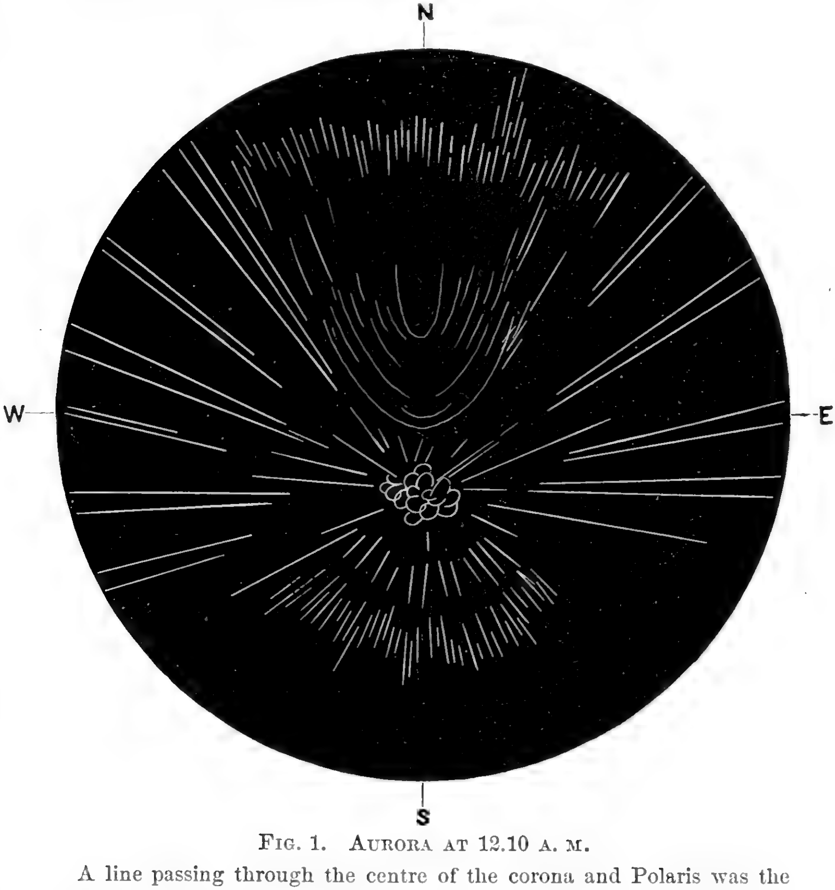


Fig. 1. Aurora at 12.10 A. M.

A line passing through the centre of the corona and Polaris was the transverse axis of the hyperbolic curves, of which a mere suggestion is made in the diagram.

The corona itself was a somewhat elliptical crown of radiating streamers, within which was a permanent nebulous mass of light, having a *curdled* appearance. This inner curdled mass was continually moving and heaving like the sea, and was often traversed by dark rifts. It continually drifted eastward to vanish suddenly, and to be continually replaced by other cloud-like forms at the centre. Meanwhile the brilliant flashes of red light, disconnected, apparently, with the other phenomena, appeared

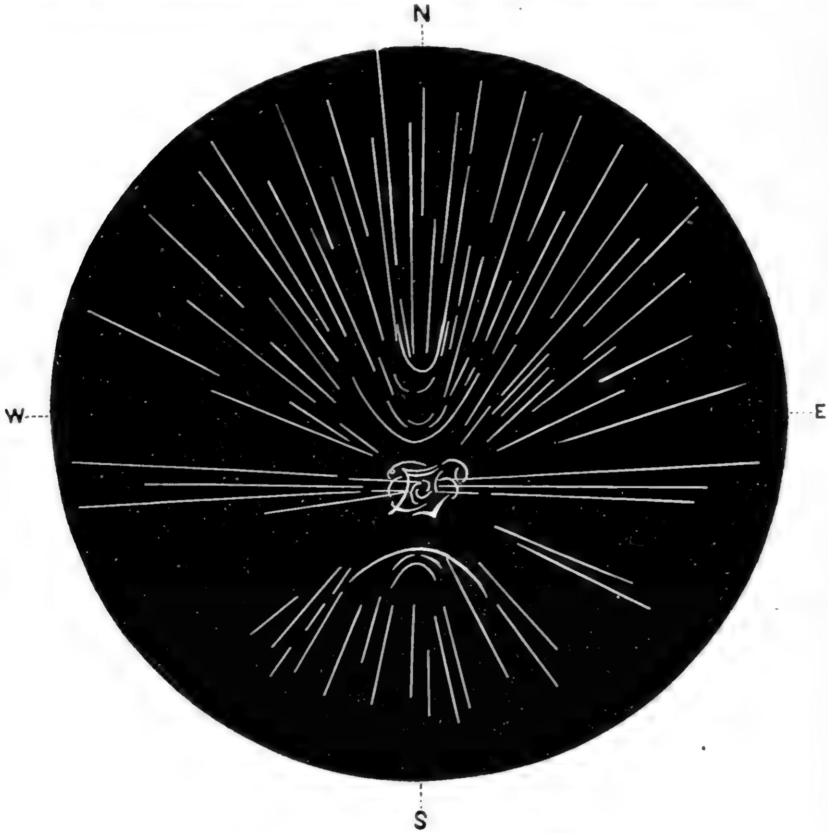


FIG. 2. AURORA AT 12.25 A. M.

in many portions of the sky, and often continued to form a back-ground for the quivering white streamers.

The streamers south of the corona presented quite a different appearance from those to the north. They were quite short, and were often broken into two or more segments, which fluctuated to and fro, but did not extend lower than some thirty degrees above the southern horizon. At 12.20 Arcturus occupied almost the precise centre of the corona.

At 12.25 the remarkable sight was presented of two hyperbolic curves of light, the larger one lying in the north, the smaller to the south of the corona, and each pointing in an opposite direction to the other. The smaller hyperbola was bounded by an inverted arch of light in the south, some 30 degrees above the horizon. Straight lines of light, like a conjugate axis, passed east and west from the central point between the hyperbolas. The definite boundary of the southern auroral curtain may furnish data for a determination height of the aurora above the earth's surface. The appearance of the sky at this time is rudely represented in Fig 2.

It is evident that the phenomena now seen was no mere effect of perspective. The auroral streamers had become curved in obedience probably to the laws of magnetic force around a pole.

At 12.35 the corona was near R. A. 215°, Dec. 20° 30′, and at 12.45 near R. A. 216°, Dec. 20° 30′. At times the corona was a perfect star-like crown, with a small white cloud of light in the centre. Sometimes, however, it would vanish completely for a few moments, to reappear with greater brilliancy. The curdled cloudy matter within it occasionally took fantastic curved forms, and at the same time the surrounding streamers would form curves at their extremities close to the corona. Once the streamers above and below the corona moved for a short space slowly around it, in the direction of the hands of a clock.

At 1.05 A. M. the corona was estimated at R. A. 224°, Dec. 20°, and at 1.10 at R. A. 226°, Dec. 20°. By this time it had become fainter, and it frequently disappeared for a period. The aurora in the north continued until daylight. Special attention was directed to mapping at intervals during the continuance of the corona, its exact position among the stars, in order, if possible, to determine any proper motion of its own. The central point could always be determined by projecting the paths of streamers to their converging point.

The following map represents the approximate successive positions of the centre of the corona, and the time of each observation. With the exception of the position given for 11.40 P. M., which was estimated from memory, the positions here given are as plotted at the time upon the star-map.

Upon examination of this map it is at once evident that during the two hours in which it was observed, the corona had an eastward motion through space, and that this motion was at the rate of 15 degrees an hour, or precisely the direction and amount of the earth's rotation upon its axis. It was as if the corona had been fixed permanently to the earth, and the observation is a strong confirmation of the theory that the aurora is a truly terrestrial appendage.*

* The writer has previously (v. Proc. A. A. A. S., Boston, 1880, vol. xxix., p. 245), described a phenomenon noticed in the aurora of May 2, 1877, which, though less conclusively, leads to the same deduction. In that case an auroral comet-like streamer remained in a constant position, with regard to certain trees, for the space of nearly an hour, being apparently fixed to the earth like a great pointer, while the stars and the zodiacal light revolved past it.

The arc described by the corona was not perfectly coincident with a parallel of declination, but, if the observations are correct, had an inclination of somewhat over 2 degrees. The pole of this arc would be considerably west of the true north. Moreover the corona was always about 3 degrees east of the meridian, a fact also indicating that the radiant point of the streamers was west of north. The corona was constantly 18 to 20 degrees south of the zenith.

It is of interest to note in this connection that each of these facts has a direct relation to the position of the magnetic needle at Philadelphia. The magnetic pole is about 5 degrees west of the true pole, and the magnetic zenith is about $18\frac{1}{4}$ degrees south of the true zenith. The corona was, therefore, within one degree of the magnetic zenith. Parallax may, per-

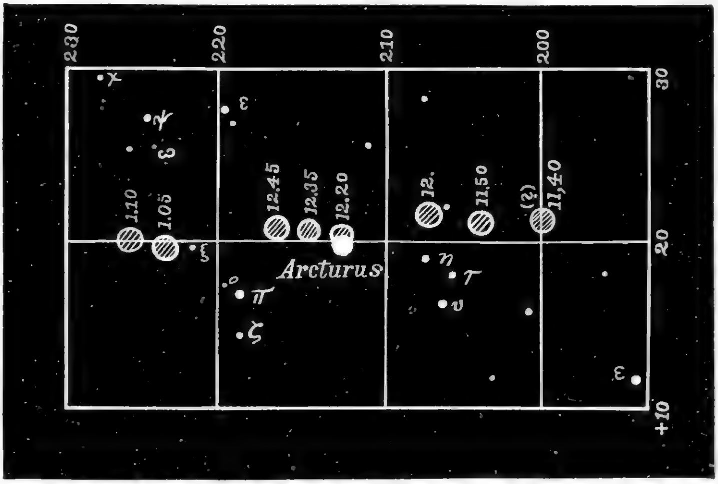


Fig. 3. Map of Positions of Corona.

haps, account for the deviation, if any such exists. The position of the auroral streamers and of the corona is seen, therefore, closely to conform to the lines of magnetic force, and the connection between the two phenomena is evident.

The electrical effects of the aurora were very marked, confirming the belief that the aurora is an electrical or magnetic discharge through remote portions of our atmosphere. The telegraph wires over a large portion of the country were strongly affected by electrical currents. The wires leading from Chicago to New York, to Washington, to Milwaukee, and to Omaha, are stated to have been worked without batteries, and, after grounding the wires, messages to have been sent on the strength of the "auroral current" alone. The Atlantic cable suffered similar electrical disturbances.

The influence of an aurora upon the telegraph wires is very different from the local and transitory effects of a thunderstorm, and can always be recognized. The electrical disturbances at Philadelphia continued from midnight until eleven o'clock on Monday morning. At the office of the Western Union Telegraph Company in New York it is reported that the wires began to be affected soon after ten o'clock and that before eleven the wires in every direction were frequently interrupted. It is said that whenever an auroral current of like polarity with the battery reached the wires it neutralized the current completely and broke the circuit. In like manner auroral currents of opposite polarity, which were both powerful and frequent, would intensify the current to such a degree as to make it unsafe to use the wires. At such times brilliant sparks appeared at the ends of the keys and repeaters, which would soon burn the instruments if not disconnected. The change of polarity in the auroral current was very intermittent. Sometimes it occurred very rapidly, and at other times ten or fifteen minutes would intervene without change of current. Similar electrical phenomena are reported from many parts of the country, indicating an electrical storm of great extent.

There was no wind at Philadelphia during the aurora, and the mild spring-like weather before and during the few days since has undergone no change of consequence. Observations of this nature upon a number of auroras have led the writer to think that the popular idea that the aurora is either the cause or the result of change of weather is a fallacy. Local thunderstorms and several severe tornadoes have however occurred since the aurora in several parts of the country.

On the night of April 19–20 a second aurora appeared. There had been a severe thunderstorm early in the evening—the occasion of loss of life and property in different portions of the State—and some time after the sky had cleared, at about 1.30 A. M., there appeared a fine aurora, with high and bright streamers. As before, the telegraph wires were affected, the disturbance at Philadelphia continuing from 1 A. M. to 11.30 A. M.*

The occurrence of remarkable auroral displays at this time is a striking confirmation of the periodicity of those phenomena. It is just ten years since the last auroras of importance occurred, and the period of 10 to 12 years between maximum auroral displays may be regarded as firmly established. The coincidence of this period with that of most numerous sunspots shows a direct connection between the electrical condition of the earth and the sun. At the present time the sun is exhibiting remarkable disturbances. Upon the sun's disc are numerous and large spots which are continually changing in shape, and are traversed by solar cyclones of unusual energy. Large groups of sunspots are now visible to the naked

* The writer is indebted to the officers of the Western Union Telegraph Company for information. He also takes pleasure in acknowledging the kindness of Mr. T. F. Townsend, Signal Service Officer at Philadelphia, who has contributed his personal observations upon the aurora for use in the present paper.

eye, and one of the spots is said to be the largest which has appeared for ten years.

The theory is not improbable that sunspots are the result of solar electrical or magnetic storms, and that auroras are the result of a disturbed electrical condition of the earth, caused by induction from the sun. The common cause for both phenomena is probably cosmical.

Postscript.—Since this paper was presented, reports of an unusual auroral display have come from all sections of the country. The aurora was visible across the continent from the Atlantic to the Pacific coast. At San Francisco it is reported as the most brilliant seen for many years. A bright crimson light appeared at 8.30 P. M., and the aurora showed various colors. At Omaha a crimson sheet across the sky is described as its most remarkable feature. At Kansas City it was said to be the finest aurora since 1872, and at 12.30 the whole northern sky was lit up by streamers and red flames. At Warrenton, Mo., where it is described as the most remarkable ever seen, the light was so brilliant that signs 150 feet distant could be read. A white arch of light, extending from east to west, advanced southward at midnight to within 35 degrees of the southern horizon, and the corona was visible. At St. Louis it was seen early in the evening, and it is stated that at 11 P. M. there was no electrical disturbance in the telegraph wires. At Baltimore and Washington it was described as unusually fine, and consisting, first of a band of white light, later of shafts of colored light shooting through it, and afterwards of tremulous streamers moving with lightning rapidity, from north to south, while clouds of red fire hung in the northwest. At Richmond, Va., it was seen distinctly at 3 A. M., and is reported as the finest ever seen. At Boston, electrical disturbances were noticed shortly after the appearance of the aurora, and continued till late in the afternoon of the 17th. The wires from Boston to Albany and from Boston to New York were worked without the battery, that to New York having been worked by the auroral current alone for three hours consecutively.

In England, France, Belgium, Germany and Italy similar electrical perturbations were observed. Upon the French telegraphic lines the perturbations were so frequent from April 16th to April 20th that special measures were taken by the authorities to meet the contingency. Electrical equilibrium was restored on the 21st.

It is also of the greatest interest to learn that in England, where, so far as known, no aurora was seen, there occurred a great magnetic storm at the precise time that the aurora appeared in America. Mr. G. M. Whipple, of the Kew Observatory, in a communication to *Nature* of April 20, says "a magnetic storm of unusual intensity raged from about midnight of the 16th to midnight of the 17th," and that "a tremendous spot which appeared on the sun's disk on the 13th, is now rapidly approaching the central meridian, and a group observed on Saturday in advance of it, has undergone considerable change in the interval."

In *Nature* of April 27th, he further reports that "the magnetic disturbance began at 11.45 P. M. (6.45 P. M. Philadelphia time), April 16th, by an increase of the declination, an augmentation of the horizontal force and a diminution of the vertical force. The movements of the declinometer became gradually more rapid after 2 A. M. on the 17th (9 P. M. Philadelphia time), whilst its oscillations extended farther and farther from its normal position, principally in the direction of increased *westerly* declination. From 4.30 to 9 A. M. (11.30 P. M. to 4 A. M. Philadelphia time) the horizontal force had diminished so much that the trace frequently passed off the paper, and the register was lost for a while. The minimum of vertical force occurred at 5.55 A. M." (12.55 A. M. Philadelphia time). He states that the disturbance did not die out till about 8 P. M. on the 17th.

"During the 18th and 19th the magnets were unaffected, but at 3.45 A. M. of the

20th (10.45 P. M., April 19th, Philadelphia time), a second disturbance set in, commencing with a rapid increase of declination, the first swing of the magnet carrying it nearly a degree to the westward, whence it returned at 4.30 A. M. Its mean position was reached at 6 A. M. (1 A. M. Philadelphia time) and then its oscillations became very rapid, and continued so until 2 P. M., after which hour they became less. Both forces were also simultaneously disturbed, but their movements were much more limited than on Monday."

It is at once seen that there is a most remarkable coincidence in time between the magnetic storm in England and the aurora as seen here. The second magnetic storm also occurs simultaneously with the second aurora, and an absolute proof of the direct connection between the two phenomena is hereby established. It is interesting, also, to note that the magnetic disturbances for the most part slightly preceded the aurora, while on the other hand the electrical effects upon the telegraph wires were subsequent. This fact suggests magnetism as the primary cause of the aurora. The magnetic curves assumed by the streamers also favor this theory. The red flashes in the sky were probably accompanying electrical discharges, and many auroral effects may be due to the continual transmutation of the two forces.

Stated Meeting, May 5, 1882.

Present, 4 members.

Letters accepting membership were received from the Rev. Dr. Robins, No. 1821 Delancey Place, Philadelphia, April 26; from C. S. Sargent, dated Arnold Arboretum, Harvard University, Director's office, Brookline, Mass., April 26; from S. P. Sharples, A. M., No. 114 State street, Boston, April 29; from Franklin B. Hough, Department of Agriculture, Washington, D. C., May 2, and from George De B. Keim, No. 2009 Delancey Place, Philadelphia, April 25, 1882.

A photograph of M. Milne Edwards was received in a letter dated Muséum d'Histoire Naturelle, Paris, April 7, with a request for Nos. 97, 102, 103 to complete a set of the Proceedings.

Letters of acknowledgment were received from the New Hampshire Historical Society (110); Museum of Comparative Zoölogy (110); American Antiq. Society (110); Rhode Island Historical Society (110); Connecticut Historical Society (110); Astor Library (110); New Jersey Historical Society (110);

C. L. Doolittle (110); Traill Green (110); T. C. Porter (110); W. B. Taylor (110); J. H. C. Coffin (110); J. J. Stevenson (110); Georgia Historical Society (110); H. Phillips, Jr., (110); Wyoming G. and Historical Society (110); Numismatic and Antiquarian Society (110); Buffalo S. N. S. (110); J. M. Hart (110); Chicago Historical Society (110), and the Royal Bavarian Academy (107, 108, Trans. XV, 2).

Letters of envoy were received from the Geological Survey of India, Calcutta, Jan. 4; the Royal Bavarian Academy, Feb. 18, and Mr. Wm. Blades, 23 Abchurch Lane, London, April 17, 1882.

Donations to the Library were reported from the Geological Survey, India; Academia dei Lincei; S. C. Geog., Bordeaux; Royal Astronomical Society; London Nature; Mr. W. Blades; Harvard University; Boston Society of Natural History; American Historical Society; American Philological Society; Silliman's Journal; Mrs. T. P. James; American Chemical Society; American Society of Civil Engineers; Franklin Institute; Journal of Pharmacy; Mr. H. Phillips, Jr.; American Chemical Journal; U. S. National Museum; Com. Internal Revenue; Weather Signal Bureau; Board of Health, New Orleans, and Academy of Sciences, St. Louis.

The death of Ralph Waldo Emerson, at Concord, Mass., April 27, aged nearly 80, was announced.

On motion of Mr. Phillips the President was requested to consider various communications from Professors James Hall, Geo. H. Cook, and J. P. Lesley, and to memorialize the President of the Senate of New York for the complete publication of the Palæontology of that State.

And the meeting was adjourned.

Biographical Sketch of Thomas Potts James. By J. T. Rothrock.

(Read before the American Philosophical Society, May 19, 1882.)

In the line of botanists binding the present to that remote past, when our flora was as unknown accurately to Americans, as to the rest of the world, but few survive. Darlington, Sullivant, Torrey, James, within recent years have dropped out of the chain. The interest attaching to such men is more than an ordinary one. They were the last generation to which our botanical pioneers belonged, and they witnessed not only the rise of a republic in politics, but the rise of a republic in science. They could remember when in all this broad land there were not a score of botanists; when the science of plants and plant life held no recognized place in the colleges of this country; when the literature of our flora was almost exclusively foreign; when the commonest implements of exact research came from over the ocean. With them nearly the whole scientific tradition of the country disappeared. Later events find prompt and wide circulation in our scientific periodicals, but much that would interest the future is lost to the world when one of these honored witnesses leaves us to join the host that went before.

Thomas Potts James, in memory of whom this brief sketch has been prepared, is the latest whose loss we deplore.

Mr. James was born at Radnor, in Pennsylvania, on September 1, 1808. He died suddenly of paralysis at Cambridge, in Massachusetts, on Feb. 22, 1882. His ancestors were among the leaders of thought and action before and during the Revolution. They arrived in Pennsylvania earlier than Penn. His grandfather, Thomas Potts, after raising a company and being commissioned captain in 1776, raised a battalion and was made its colonel. He was also a member of the convention which assembled in Philadelphia on July 9, 1776, to form the new government. Washington and his staff were frequent guests at his house, and in it many important public letters were written. As the friend and intimate associate of Franklin it is not strange that he was one of the original members of this society.

He was also among the earliest to develop the iron interests of Pennsylvania. A great uncle of Mr. James, Dr. Jonathan Potts, was Deputy Director-General of the Hospital in the Northern Department during the Revolution, and was subsequently made Director-General of the Hospital in the Middle Department when this State and New Jersey became the seat of war.

Another great uncle, Samuel Potts, was a member of the convention which framed the Constitution of Pennsylvania, and was also elected Associate Judge. The name of the family is still perpetuated in Pottstown.

Coming then from such a stock it is not strange that the subject of this sketch developed marked intellectual traits. Indeed it would have been stranger if he had not.

Mr. James' love of botany appears to have been an early one. As stated in the Potts' memorial by the authoress, his wife and congenial life companion,—"From his youth he devoted his leisure to the study of botany, and, having acquired a knowledge of phænogamous plants, he turned his attention to the cryptogamia, making the musci a specialty." "He received his early education in Trenton, N. J., intending to enter Princeton College, but was prevented by circumstances," etc.

There are some men who acquire all the mental discipline that a college course could confer without entering those halls of learning. Mr. James was one of these. It may be doubted whether he would have earned any more honored name, or placed the future bryologists of the land under any greater obligations if he had taken an academic degree.

For almost forty years he was engaged in the drug business in this city, but never allowed the cares of trade to crowd science out of mind, and though not at the time enabled to devote all, or even much of his attention to botany, yet the years were far from being unproductive in the science to which he was so deeply attached. In 1853 the third edition of (that work, which will always be a classic book of science) Darlington's Flora Cestrica appeared. To this Mr. James contributed the portion describing the class of Anophytes, *i. e.*, Mosses and Liverworts. Though hardly thirty pages long it represents an amount of labor which is now past belief. It may in part be regarded as a pioneer work. To say nothing of the labor involved in collecting the material for that short paper, there were the critical determinations of the species and the always perplexing questions of synonyms to settle. It is needless to say that these duties were most conscientiously done, for Mr. James never worked in any other manner. Every line which he ever wrote upon a scientific subject was most carefully considered. In December, 1855, he published in the Proceedings of the Philadelphia Academy of Natural Sciences, "An enumeration of Mosses detected in the Northern United States, which are not comprised in the Manual of Asa Gray, M. D., some of which are new species."

Mr. Lesquereux informs me also that about this time he wrote another paper of similar character to the above but where, or what its exact title is neither of us can say. In the Smithsonian Report for 1867 there appeared in "A Sketch of the Flora of Alaska," prepared by the present writer, a list of the "Anophytes determined and compiled by Thomas P. James." Extending over but two pages, that list still represents a conscientious search through all the botanical literature of the region in order to bring together in a single view its entire moss flora ; then, too, there are his original determinations of the specimens coming from that region which were placed in his hands.

In 1871 he published another catalogue with important notes in the now famous Volume V (of the Clarence King Surveys) which represents Mr. Watson's earliest labor in the science in which he has since become so distinguished.

In 1878 another catalogue of Western Mosses was published by Mr. James in Volume VI of the Wheeler Survey. It contains short notes, and descriptions of the less known species.

In the Proceedings of the American Academy of Arts and Sciences for February, 1879, conjointly with Leo Lesquereux, he published "Description of some new Species of North American Mosses."

At the time of his death Mr. James was engaged with Mr. Lesquereux in the preparation of "A Synopsis of North American Mosses," a work which is of greater magnitude and importance than its modest title would indicate. Together they had advanced to the Hypnaceæ, and of it Mr. Lesquereux writes to me "If I have time to finish this work, it must be published in both names."

I cannot forbear quoting what his distinguished colleague has written of Mr. James in a private letter to me. It is of far greater worth than any statement of mine can be :

"An excellent microscopist and delineator; an ardent collector of Mosses, he constantly devoted himself to their study. I came to this country in 1848, and it was only a little after my arrival here that he began sending me his mosses for determination. Our connection continued until his death. I received a letter from him but a few days before this. When I was obliged to abandon the use of the microscope he worked constantly upon sketches of all the interesting or doubtful American species and prepared for the descriptive part of which I took charge. He had, moreover, to give much time to the examination of collections of mosses sent for determination from various parts of the continent, those of E. Hall from Oregon, Macoon in Canada, Wolff and others from Illinois, so that his work and influence in the Bryology of North America have been very great, though his publications are limited to a few catalogues or memoirs." Then follows this touching tribute from his associate in what was to have been the crowning task of his active life : "As a colleague, as a man of truth, of honor, I regret him very much, but still more as an old friend. We were about the same age and I expected he would survive me for a long time." Surely such testimony from one who had constant relations with Mr. James for more than thirty years, in the same line of work, is praise indeed, and speaks volumes for the integrity and amiability of both.

In this connection I may add how cheerfully he always aided those who appealed to him for assistance in naming what to them were doubtful and difficult species. However badly prepared the specimens might have been, however common, or however worthless the material was to him, the same careful reply was always sent to the inquirer. These demands upon his time were frequent and serious ; indeed we may fairly say that during his earlier years they were detrimental to his business. But from sympathy with, and desire to aid any fellow-student he tolerated these appeals to the very last. It is almost a pity that time which had become so valuable to science, during his later, most productive years, was so freely given away.

Mr. James was as modest as he was painstaking and accomplished. It was only after the repeated solicitations of his life-long friend, Prof. Gray, that he undertook the preparation of the Synopsis of North American Mosses in conjunction with Mr. Lesquereux. When, however, he consented, he began the task with all the eager earnestness of youth. Two years of constant work made it requisite that he should rest; and with this end in view he took a trip to Europe in 1878. But even there all the time he could give was spent in association with Schimper of Strassburg, then the head of European bryology, in comparing our American species and in settling synonyms. For a whole month Prof. Schimper gave his afternoons to labor with Mr. James in this task. The result of that visit will be apparent in placing our own moss flora in proper relation with that of Europe. His industry and singleness of purpose at a time when most men seek rest were wonderful. During the last two years of his life he labored "from ten to twelve hours each day over the mosses; often three or four hours at a time without moving from his table." Only a few weeks before his death when reminded by Mrs. James that he had already worked fourteen hours that day, and remonstrated with for writing by gaslight, his reply was, "this work must be done and I have no time to rest."

The end came, and came suddenly, but he was not unprepared for it. No one whose life was as devout as his, and who lived with such entire charity toward all men, could be unprepared.

February 22, 1882, Ash-Wednesday, Mr. James left his study and attended to his religious duties in the Chapel of the Protestant Episcopal Theological Seminary of Harvard University. It was to him the very gate to Heaven, though he little knew how soon he was to pass through and into the eternal world. Services being over he returned to his work. Leaving his study, he went into an adjoining room where he was seized by paralysis of the left side, and this was followed by loss of speech and then coma, from which without awakening he passed calmly away.

We may well imagine how profound the grief over the loss of such a husband and father would be. But it was hardly less deep in the hearts of his habitual associates. A letter received from Professor Gray, who stood by as Mr. James departed, contains a passage too sacred even for a biographical sketch, but which indicates a suppressed anguish and a sense of personal bereavement more clearly than any phrase set in intentional mournful measure could do. In another place Professor Gray has given his estimate of the man, and in a single sentence explained the cause of his own noble grief—because Mr. James "*was admirable in all his relations.*"

Mr. James' active interest in botanical science, and the estimation in which he was held by his colleagues, are clearly indicated by the association he had in the learned societies of this land. He was

"Fellow of the American Academy of Arts and Sciences,

"Fellow of the American Association for the Advancement of Science, "Member and sometime Officer of the American Philosophical Society,

"Treasurer of the American Pomological Society for 27 years,

"Officer of the American Pharmaceutical Society, and also of the Philadelphia Drug Exchange,

"Professor of Botany to the Pennsylvania Horticultural Society,

"Member of the Boston Society of Natural History,

"Honorary Member of the Massachusetts Horticultural Society,

"And of other kindred Associations."

During one of the absences of an honored member of this Society in Europe Mr. James was his substitute as librarian. There are those still living who remember how very acceptable his services were in that capacity.

This would be a one-sided and very imperfect sketch of Mr. James if it made no allusion to his public spirit as a citizen. Whatever was in the interest of education or of philanthropy interested him. During the late war he was thoroughly "Union" in his sympathies, and did duty with the First Regiment of the National Guard. He was also a member of the Union League, and an active associate of those who upheld the Government under all circumstances. His loyalty nevered wavered.

In December 1851, he married Isabella Batchelder. This most fortunate union was the result of an acquaintance which began but fifteen months before, and which grew out of a correspondence between Dr. Darlington, Miss Batchelder, Mr. James, and Dr. Gray, relative to the publication of the letters of John Bartram. For more than thirty years Mr. James found in his wife a sympathy in all his work, and a cultured mind capable of appreciating and aiding in his own literary labor.

Such marriages are blessings to both the contracting parties. Mrs. James and four children survive, and now reside in Cambridge, Massachusetts, whither he removed from here in 1867.

We mourn over the loss of Mr. James not only because he was dear to a large circle of friends, or because he was an active promoter of science, but also because his death leaves his favorite study with but one prominent representative in this land, a representative full of years and of honor.

But there is no younger botanist on whom the mantle has fallen; none appear to take up the work as these veterans cease from their labors, and in this event the world is made poorer from the loss of our former associate.

Gentle, genial man, though we realize how serious a loss your departure has been to science here, we do not mourn for you as for those over whom we have no hope; neither may we question the wisdom of the decree which opened your eyes to the full glory of the celestial splendor you had so long, patiently, trustingly waited to see.

Stated Meeting, May 19, 1882.

Present, 9 members.

President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from C. W. King, dated Trinity College, Cambridge, England, May 5, 1882.

Letters of acknowledgment were received from Messrs. Downes, Hilgard, Goodfellow, Schott (109); American Ethnological Society (109); U. S. Naval Observatory (109); State Historical Society Wisconsin (110); Asaph Hall (110); C. H. F. Peters (110); Kansas State Historical Society (110); American Ethnologicol Society (110); Boston Public Library (110); Maryland Historical Society (110), and Poughkeepsie Society of Natural History (109, 110).

Donations for the Library were received from the Academia dei Lincei; Société Géographique, Paris; S. C. Geog., Bordeaux; London Nature; Academy, Brussels; Museum of Comparative Zoölogy; Cincinnati Observatory, and the Geological Survey of Canada.

Prof. Rothrock read, by appointment, an obituary notice of Thomas P. James.

Mr. Lesley read, by appointment, an obituary notice of Edward Desor.

The Rev. C. G. Ames was requested to prepare an obituary notice of Ralph Waldo Emerson.

The death of Wm. S. Vaux, at Philadelphia, May 5, aged 60, was announced, and Mr. Law appointed to prepare an obituary notice of the deceased.

The death of Chas. M. Wheatley, at Phœnixville, May 6, aged 60, was announced.

The death of Dr. George Smith, at Media, Delaware County, March 10, 1882, aged 78, was announced, and Dr. Brinton was appointed to prepare an obituary notice of the deceased.

A "Contribution to a monograph of the North American

Syrphidæ, by Dr. S. W. Williston," was presented through the Secretary, with a letter from the author, dated New Haven, Yale College Museum, May 12, 1882.

"The Classification of the Ungulate Mammalia" was read by Prof. Cope.

New nominations, Nos. 959, 960, 961, were read.

The President reported that he had forwarded a memorial to the President of the New York Senate, in favor of the completion of the Palæontology of New York.

Power was given to the Hall Committee to procure a copy of the portrait of Dr. Geo. B. Wood; and the President was empowered to fill the vacancy caused by the death of Sol. W. Roberts, a member of that Committee.

Authority was given the Librarian to purchase Vols. I–XII Transactions of the American Philological Association.

And the meeting was adjourned.

Contribution to a Monograph of the North American Syrphidæ. By Dr. S. W. Williston.

(*Read before the American Philosophical Society, May 19, 1882.*)

The Syrphidæ form one of the most difficult families of Diptera to classify. Although composed throughout the world of about one hundred and forty described genera, they present no characters that will decisively distinguish any considerable number. As a natural result, many genera have been loosely formed and more loosely described, until the difficulty in identifying species without the aid of numerous types has become extremely great. The present paper is the result of many hours tedious labor in identifying a considerably large amount of material wholly without the aid of types. Prepared two or three years ago it has been rewritten and changed many times; that it is free from error yet I do not presume to hope, but from my own experience in the difficulties that are met with in working with the aid of books alone, I believe that it will materially aid in the study of our species.

In Osten Sacken's catalogue of American Diptera—a work indispensable to all entomologists—fifty-seven genera are recorded as having been creditably recognized from North America. *Toxomerus* of Macquart I have resuscitated, and have also recognized an interesting new species of *Senogaster* Mac., hitherto known only from South America. Since the publication of the catalogue four new genera have been described by M. Bigot and the writer, making in all sixty-two genera now known from North America. As regards the distribution of these genera twelve are peculiar to our fauna, viz: *Eupeodes, Copestylum, Hadromyia, Eugeniamyia, Eurhinamallota, Teuchocnemis, Pterallastes, Polydonta, Crioprora, Somula, Merapioidus,* and *Mixogaster.* The first four of these, with *Catabomba,* have never yet been found in the Eastern States, while the following are not yet known west of the one hundredth meridian, viz: *Triglyphus, Pyrophæna, Doros, Ocyptamus, Rhingia, Teuchocnemis, Pterallastes, Senogaster, Somula, Temnostoma,* and *Milesia.* Of these no doubt the distribution will yet be found more extensive. Indeed the wide distribution of species and genera of the family over our continent will not readily be paralleled by any other family of insects.

In the present paper I have given a list of all the described species known west of the one hundredth meridian. These with the species described as new, reach yet but eighty-six; of them fifty-four are known only from the West, while thirty-two, or over one-third, are distributed from the Atlantic to the Pacific regions.

Five genera, of one or two species each, namely: *Triglyphus, Pyrophæna, Copestylum, Arctophila,* and *Pterallastes,* are unknown to me; their systematic positions have in consequence been wholly drawn from descriptions and figures. They, together with such species as are unknown to me, are preceded by an asterisk. An exclamation point indicates that the locality, or localities, preceding it are given from specimens that I have examined. It has not been deemed necessary to repeat any of the bibliographical references or synonomy that are given in Osten Sacken's catalogue, except such as will facilitate the identification of species. The specimens which I have examined in the preparation of this paper, from Washington Territory, Oregon, and Kern County, California, were collected by Mr. H. K. Morrison; from Mendocino county, California, by Mr. O. T. Baron, and from Wyoming, Colorado, and Kansas, by Mr. E. W. Guild and myself. The species that I have identified, or described, or that have been previously recorded from the West, are printed in small capitals.

I desire to express my thanks to Mr. W. H. Patton and Drs. G. H. Horn and H. A. Brous, for kind favors in the preparation of this paper. To Baron C. R. von Osten Sacken, of Heidelberg, I am much indebted for his kindly interest and advice.

The following table of generic groups is based essentially upon that of Schiner's in his Austrian Diptera. It seems impossible to improve its general features so far as our American genera are concerned.

Table of groups of genera.

J.—Small cross-vein of the wing distinctly before the middle of the discal cell, usually straight and rectangular. Hind femora usually slender, not thickened ; the third longitudinal vein rarely much bent into the first posterior vein, usually straight or very gently curved.

1—Antennæ longer than the head.......................... **I.**

2—Antennæ as long or shorter than the head.

a—Marginal cell open, *i. e.*, the second longitudinal vein terminates in the border of the wing.

a—Face not tuberculate, nor distinctly carinate ; not excavated below the antennæ in profile ; hyperstoma not produced. (Small, nearly bare species, with short oval abdomen).......... **II.**

aa—Face tuberculate, or hyperstoma produced.

*—Abdomen in outline, linear or oval, never narrowed toward the base, or club-shaped. (Tegulæ of usual size.)

†—Body uniform metallic green, or metallic green and black ; abdomen oval or elongate, never slender ; femora not thickened, nor facial tubercle dissimilar in male and female. **III.**

††—Black with luteous, reddish or yellow, when uniformly black the hind femora thickened.................. **IV.**

†††—Black or greenish black, with yellow or yellowish stripes or bands, or face more or less yellow.

§—Face black, abdomen slender, with yellow or greenish yellow interrupted cross-bands.................. **V.**

§§—Face partly or wholly yellow, abdominal markings yellow.

π—Dorsum of thorax with yellow lateral stripes.... **VI.**

$\pi\pi$—Dorsum of thorax without yellow lateral stripes. **VII.**

—Abdomen contracted toward the base, more or less club-shaped **VIII.

aa—Marginal cell closed and petiolate......................... **IX.**

JJ—The small cross-vein at or beyond the middle of the discal cell, *i. e.*, the discal section of the fourth longitudinal vein beyond the small cross-vein, is but little longer or much shorter than the section before it ; small cross-vein nearly always oblique, the posterior femora frequently thickened.

α—Antennæ with a distinctly dorsal bristle.

β—Third longitudinal vein bent deeply into the first posterior cell

γ—Marginal cell closed and petiolate......................... **X.**

$\gamma\gamma$—Marginal cell open.................................... **XI.**

$\beta\beta$—Third longitudinal vein gently curved.

δ—Arista plumose.

ε—Marginal cell closed.............................. **IX.**

$\varepsilon\varepsilon$—Marginal cell open................................ **XII.**

$\delta\delta$—Arista bare or pubescent........................... **XIII.**

$\alpha\alpha$—Antennæ with a subterminal bristle or terminal style....... **XIV.**

I.

J.—Small cross-vein before the middle of the discal cell.

1. Antennæ longer than the head.

A.—Scutellum flattened, with two obtuse points ; face evenly rounded, pubescent, without tubercle ; eyes separated in both sexes, narrowly in the male ; first posterior cell with a stump of a vein from the third longitudinal ; dark or black species, unrelieved by light markings.. **Microdon.**

MICRODON sp. nov.? Washington Territory, California!

This is the first time this genus has been recorded from the Pacific coast; eight or nine species are known from the eastern part of the continent.

AA.—Scutellum without points; third antennal joint elongate; face produced downward, obtusely tuberculate, yellow with black median stripe; dorsum of thorax with lateral, yellow, interrupted stripes; abdomen oval, arched, with yellow bands; eyes pubescent, **Chrysotoxum.**

This is one of those genera of Syrphidæ, whose species are hard to distinguish and require much material to satisfactorily study.

CHRYSOTOXUM (?) DERIVATUM Walk., Washington Territory; Mt. Hood, Oregon. Apparently a common species. The femora are mostly black, and the lateral margins of the abdomen yellow, otherwise it agrees with *C. laterale* Lw., Cent. v, 42.

II.

Δ.—Small cross-vein before the middle of discal cell.
 1.—Antennæ as long or shorter than the head.
  a.—Marginal cell open.
   a.—Face without turbercle or hyperstoma not produced.

B.—Abdomen of only four apparent segments; very small species (2–5 mm.) black or greenish black, the ground color unrelieved by lighter spots, stripes or bands........................***Triglyphus.**

BB.—Abdomen of from five to seven segments; third joint of antennæ oblong.

C.—Face evenly rounded, not at all projecting in outline (hind femora moderately swollen); face dark without yellow............**Pipiza.**

A single species of this genus is recorded by Osten Sacken (West. Dipt. p. 322) from Sonoma Co., Cal. In Europe the species are very numerous.

CC.—Face slightly carinate below, partly or wholly yellow, eyes pilose, in life usually with bright stripes (small, mostly finely punctulate; abdomen oval, obtusely rounded behind, black or black and red, not banded)...**Paragus.**

The species of this genus like the preceding are very difficult to satisfactorily distinguish. Three species are recorded from the Eastern States and I have at least three more yet unnamed from the Pacific regions.

PARAGUS DIMIDIATUS Lw., Cent. iv, 63. Western Kansas, Colorado!

III.

Δ.—Small cross-vein before the middle of discal cell.
 1.—Antennæ as long or shorter than the head.
  a.—Marginal cell open.
   aa.—Face tuberculate, or hyperstoma produced.
    *.—Abdomen oval, never narrowed toward the base, or club-shaped.
     †.—Uniform metallic green, metallic green and black, or black species; hind femora never swollen.

D.—False vein of wing usually indistinct or absent; front in ♀, or face also (♂♀) with transverse wrinkles; hind border of scutellum sharp; small, oval, metallic, nearly bare species.............. **Chrysogaster.**

a.—Outer posterior angle of first posterior cell obtuse. *Chrysogaster.*
aa.—Outer posterior angle of first posterior cell rectangular or acute.. *Orthoneura.*

The character given is that usually taken as the distinction between the two genera, but is very unreliable and misleading, and, moreover, separates closely related species; the length of the antennæ is equally unreliable; I place all the species in Meigen's genus. There are sufficient plastic characters to render the tabulation and identification of our species a comparatively easy matter. At all events, it is evident that *Orthoneura* cannot be used in Loew's or Schiner's sense even as a sub-genus for the North American species.

Our species may be tabulated as follows:

a.—Third joint of antennæ ovate or orbicular .... *b.*
—Third joint of antennæ elongate.................................. *e.*
b.—Third joint of antennæ ovate.................................. *c.*
—Third joint of antennæ orbicular .... *d.*
c.—Dorsum of thorax opaque black (♂)...................... **nigripes.*
—Dorsum of thorax not black opaque, with dark stripes; finely punctulate; tip of fourth vein bent inwards............... *nigrovittatus.*
d.—Outer posterior angle of first posterior cell not obtuse......... *latus.*
—Outer posterior angle of first posterior cell obtuse......... *ustulatus.*
e.—The ultimate section of fourth longitudinal vein joins the third beyond the tip of second vein, the dark clouds not continuous nor in the same line; second joint of antennæ nearly as long as third; eyes with distinct linear markings; posterior borders of second and third abdominal segments brown............................... *nitidus.*
—Ultimate segment of fourth vein joins the third opposite or before tip of second, abdomen not fasciate.............................. *f.*
f.—Cloud from tip of second vein continuous or in same line with ultimate section of fourth vein; eyes with markings; second joint of antennæ nearly as long as third.................. *bellulus,* sp. nov.
—Second joint of antennæ considerably shorter than third, abdomen shining brassy on the sides, the disc more or less opaque; eyes nearly unicolorous; stigma brown .... *g.*
g.—Second joint of antennæ half as long as third; the third joint somewhat narrowed beyond the middle.................... *pictipennis.*
—Antennæ not longer than the face, second joint short.... *stigmatus,* sp. nov.

Chrysogaster stigmatus, sp. nov.

♂♀. Antennæ black, not longer than the face, first joint short, second joint twice as long, about one-fourth as long as third. Face deep green, shining, nearly smooth, with sparse pile, and a silvery white triangular spot on each side near the eye above; hyperstoma much projecting. Frontal triangle (♂) swollen, distinctly fossulate, front (♀) with well marked lateral grooves. Eyes uniform. Thorax and scutellum shining green, finely punctulate, with obscure pile. Abdomen broad, black, with short appressed white pile, but little shining, in the male the entire margin with the hypopygium shining brassy green, the venter shining like the border. Wings fuscous, stigma brown, outer anterior angle of first posterior cell obtuse. Legs black. Long. corp. 6–7 mm. California.

CHRYSOGASTER BELLULUS, sp. nov.

♂♀. Antennæ reddish-brown, a little longer than the face, second joint a little shorter than third. Face green black, lightly rugose, white pilose, hyperstoma moderately produced downward. Frontal triangle (♂) not swollen, front (♀) with well marked lateral rugosities, eyes with irregular narrow linear markings. Thorax and scutellum bright green, scabrous, with four narrow coppery stripes. Abdomen oval, a little darker green, more shining on the borders, punctulate. Legs black, base and tips of all the tibiæ, and first joints of tarsi yellowish-red. Wings nearly hyaline, slightly clouded in the outer cells, stigma brownish, last section of fourth vein straight, rectangular, joining the third nearly at right angles opposite the tip of second vein, clouded with brown, the cloud either extending across to tip of second vein or more or less interrupted in front of the third. Long. corp. 6–7 mm., Washington Territory, California.

Differs from *C. nitidus* Wied., which it closely resembles, in its larger size, the second joint of antennæ proportionately a little shorter, and the concavity of lower part of face being less, in the absence of abdominal fasciæ, and in the termination of the fourth vein.

CHRYSOGASTER NIGROVITTATUS Lw., Zeit. f. Ges. Naturw. 1876, p. 323. Colo., Washington Terr. ! Calif.

DD.—Face and front without transverse wrinkles; false vein always present, the fourth vein never bent inwards toward the tip; face usually with distinct tubercle, third joint of antennæ never elongate. Small or medium sized species, more or less pilose, abdomen never slender. **Cheilosia.**

This genus, a very large one in Europe, has hitherto consisted of but seven described species, none of them from west of the Rocky Mountains. I describe here five additional ones from the Western regions, two of them belonging to the division with pilose eyes hitherto undescribed in this country.

Three or four of Dr. Loew's species are unknown to me, but this writer's familiarity with the genus enables his species to be placed with a good deal of certainty from the descriptions alone. In the identification of species described in but one sex, it should be remembered that in the female the pilosity of the eyes is less, the antennæ usually lighter colored, and the third joint larger.

a.—Eyes distinctly pilose..*b.*
—Eyes bare..*c.*
b.—Third joint of antennæ (♂) small, oval, blackish; face with sparse long pile; wings not lighter toward the base....*occidentalis*, sp. nov.
—Third joint of antennæ (♀) larger, subquadrate, reddish; wings lighter toward the base..................................*lasiophthalmus*, sp. nov.
c.—Scutellum with bristly hairs on its border..........................*d.*
—Scutellum without bristly hairs on its border.........................*h.*
d.—Humeri, scutellum, and lower part of the face, luteous; face strongly excavated above; arista pubescent.................................*e.*
—Black shining; arista pilose (except in *tristis*).....................*f.*
e.—All the femora except the apex black.....................**leucoparea*
—Hind femora, except base and apex, black.................**pallipes.*
f.—Legs black, knees, base and apex of tibiæ and more or less of the tarsi, luteous...*g.*
—Anterior legs luteous, posterior blackish with the base and apex of femora and tibiæ and last joints of tarsi luteous..............*plumata.*
g.—Second and third segments of abdomen, except anterior angles, opaque (♂)...*tristis.*
—Second and third segments of abdomen wholly shining (♂).........
cyanescens.
h.—Abdomen with distinct, entire cross-bands, legs, except the posterior femora, red...*rufipes*, sp. nov.
—Abdomen without metallic bands...*i.*
i.—Second and third segments of abdomen opaque (♂)...............*j.*
—Abdomen wholly shining..*k.*
j.—Legs black...................................*nigripennis*, sp. nov.
—Legs luteous, femora black...............................**capillata.*
k.—Legs black...*comosa.*
—Legs in large part luteous...............................*parva*, sp. nov.

CHEILOSIA TRISTIS Lw., Cent. iv, 71. British America. Three male specimens from Oregon and Washington Territory agree so closely with the description of this species, that I believe it to be the same. I have no other specimens with which to compare them.

CHEILOSIA COMOSA Lw., Cent. iv, 66. Colorado! Red River of the North. The previous remarks will apply equally well to this species.

CHEILOSIA OCCIDENTALIS, sp. nov.

♂.—Frontal triangle black, with black pile, swollen with a depression; antennæ black, third joint somewhat brownish, nearly orbicular, small, arista with scarcely perceptible pubescence. Face shining black with sparse lutescent pile, scarcely concave from base of antennæ to tip of tubercle, deeply and shortly concave below the latter. Eyes thickly pilose, lutescent below, fuscous above. Thorax deep green black, with brown or blackish pile, intermingled with shorter lutescent. Abdomen oval, not at all slender, deep, somewhat metallic green, shining, pile lutescent, longer than in the thorax, especially on the sides of the anterior segments, the dorsum in the middle nearly bare. Legs black with black and lutescent pile, tibiæ reddish at base and extreme tips. Tegulæ light yellow, halteres yellow. Wings smoky brown, darker in front and at the root. One specimen. California. Long. corp. 11 mm.

An additional species from California has larger, more reddish subquadrate third joint of antennæ, arista short pilose, no pile that I can distinguish in the face, and the pile of the body shorter.

Cheilosia lasiophthalmus, sp. nov.

♂.—Frontal triangle moderately swollen, with an impressed longitudinal line, and light yellowish pile. Antennæ brownish red, third joint rather large, nearly square, arista bare, black. Face deep black, shining with yellowish pubescence, slightly excavated below the antennæ, considerably produced below the eyes, a well-marked groove begins at the base of the antennæ, runs obliquely outward to the eye, and then curves downward near the eye into the cheek. Posterior orbits below broadly dusted with yellow. Eyes thickly reddish-yellow pilose. Thorax metallic green, shining, thickly covered with light yellow pile, on the pleuræ bushy. Abdomen broad oval, shining black, with abundant pile like that of the thorax. Tegulæ light yellow. Legs black with yellow pile, femora at the tips, base and tips of tibiæ, and basal joints of intermediate tarsi, yellow or luteous. Wings subhyaline, with an indistinct brownish spot near the middle, basal part yellowish. Long. corp. 10–11mm. Four specimens. Colorado.

Female specimens that may belong to this species from California have the pile much shorter and more grayish. They are too badly preserved, however, for me to determine with any degree of assurance.

Cheilosia rufipes, sp. nov.

♀.—Front and face shining black, the former on the sides and the latter except the tubercle lightly covered with minute gray pubescence. Antennæ blackish, third joint twice as long as wide, reddish on the under side, arista bare. Thorax metallic green, lightly punctulate, pile very short, whitish; scutellum with an indistinct, transverse groove. Abdomen black, with a metallic reflection, smooth, shining, elongate oval, with a small tuft of whitish pile on the side of the second segment, and very short, elsewhere; second segment with large oval spots in front, narrowly separated; third segment with broad cross-bands in front, attenuated in the middle; the fourth segment with similar but less attenuated; the fifth segment partly or wholly, bluish green. Legs red, posterior femora annulate near the middle, or almost wholly brown or blackish, terminal joints of tarsi infuscated. Wings hyaline, stigma dilutely yellow. Long. corp. 8–9 mm. Washington Territory, California. Five specimens.

The abdomen is not sufficiently fasciated to place it among the *Melanostomæ;* in everything else it presents the characters of *Cheilosia*.

CHEILOSIA NIGRIPENNIS, sp. nov.

♂.—Deep black, eyes bare. Frontal triangle and face shining black, the former fossulate, the latter very slightly excavated below the antennæ. Antennæ small, basal joints black, third joint reddish-brown or brown, rounded. Thorax black, nearly opaque, with short black pile above and longer on the pleuræ and scutellum, the latter shining. Abdomen short, broadly oval, depressed, opaque black with a bluish cast, pile on the sides of the anterior segments, reddish-yellow, anterior angles of third and fourth segments, shining metallic. Tegulæ with blackish border, and a fringe of black pile. Legs black. Wings blackish in front, clearer behind, veins black. Long. corp. 7–8 mm. Three specimens from Mt. Hood, Oregon.

CHEILOSIA PARVA, sp. nov.

♀—Shining greenish-black, with a brassy reflection. Eyes bare. Front and face shining, the former with short, fuscous pile, the latter moderately excavated below the antennæ, tubercle broad, obtuse. Antennæ black, third joint oval, somewhat reddish below. Thorax and abdomen with short, lutescent pile, sparse on the latter, which is elongate oval. Legs luteous; the anterior femora toward the base, rings of the tibiæ, and terminal joints of tarsi and the posterior legs except the ends of femora, base and tips of tibiæ, brown or blackish. Wings lutescent, veins black. Long. corp. 5–6 mm. Mt. Hood, Oregon.

IV.

Δ.—Small cross-vein before the middle of the discal cell.
 2.—Antennæ shorter than the head.
  aa.—Face tuberculate or hyperstoma produced.
   *.—Abdomen linear or oval, never club-shaped.
    ††—Black with luteous, reddish or yellow; if uniformly black, the hind femora thickened.

E.—Hyperstoma produced into a long, slender porrected snout; femora slender (the third longitudinal vein joins the costa beyond the tip). **Rhingia.**

The single American species of this genus *R. nasica* Say, is very common in the Eastern States, but I have never seen a *Rhingia* from beyond the Mississippi.

EE.—Face not produced into a snout like hyperstoma, femora more or less thickened.
 F.—Face not produced, extending but little beyond the eyes, in ♂ much more tuberculate than in ♀; hind femora usually with spines below, abdomen oval. Mostly black species or with luteous markings at base of abdomen, scutellum, humeri, cheeks, etc.......... **Myiolepta.**

Four species have been described from Eastern North America, and the genus is now recorded for the first time from the West.

Myiolepta varipes Lw., Cent. ix, 79. Virginia.

Specimens very closely allied to this species, if not the same, I have from Washington Territory and Kern county, California. The lateral margins of the second segment and basal parts of all the tarsi are luteous. In the male the facial tubercle is prominent, though small.

Myiolepta bella, sp. nov.

♀.—Black, shining. Front with very short black pile above; face bare, much produced, in profile briefly convex in the middle of the concavity between antennæ and tip. Antennal basal joints nearly black, third joint large, orbicular, red, arista black. Thorax with short, black pile, somewhat intermixed with yellowish, longer on the border of the scutellum. Abdomen very shining with short, whitish pile, longer and bushy on the sides of the second segment. Halteres light yellow. Legs black with black pile. Wings smoky or brownish toward the end. Stigma brown. Long. corp. 7-8 mm. Three specimens, Washington Territory; Mt. Hood, Oregon.

FF.—Face more or less produced, extending considerably below the eyes. Either wholly or in large part luteous or reddish, the arista frequently pubescent or pilose.

G.—Face carinate, abdomen oval.................. **Brachyopa.**

Our species may be tabulated as follows:

a.—Arista distinctly pubescent; face and antennæ yellow or yellowish-red .... *b.*

—Arista bare.. *c.*

b.—Dorsum of abdomen brown........................ **ferruginea.*

—Dorsum of abdomen yellowish-red, with brown incisures, and a brownish median line.................................. *notata.*

c.—Face and front brownish, densely clothed with grayish pollen, abdomen mostly brown................ .... *vacua.*

—Face yellow, upper part of front (♀) brownish-black, antennæ yellow, third joint large; abdomen reddish-yellow with brownish incisures.................................... *media*, sp. nov.

Brachyopa? notata O. S., Cat. Dipt. 247. White Mts., N. H. (O. Sacken); Mt. Hood, Oregon; Washington Territory!

Brachyopa vacua O. S. Canada (O. S.); Kern Co. California!

A single female specimen from this locality agrees so closely with Baron Osten Sacken's description that I believe it to be the same species. The legs and antennæ are, however, more reddish than brownish, and the wings are quite hyaline, more so than the preceding.

Brachyopa media, sp. nov.

♀.—Face and lower part of front reddish-yellow, the latter projecting rather more than *notata;* antennæ the same color or a little lighter, the third joint very large, arista brown, yellowish at the base, front in the upper two-thirds black, grayish pollinose. Dorsum of thorax nearly black, with short white pile and thick gray pollen, leaving three darker stripes, scutellum red; abdomen yellow, the segments with narrow posterior brownish lines. Legs reddish-yellow, the hind tibiæ somewhat brownish, terminal joints of tarsi fuscous, or black, hind femora a little incrassate. Wings hyaline with a slightly yellowish tinge; first posterior cell briefly petiolate, the base of second posterior cell is an obtuse angle, about midway between the two preceding species. Long. corp. 6–7 mm. One specimen, Kern county, California.

GG.—Face more produced, obtusely tuberculate; abdomen long (xylotiform); with scutellar, postalar, dorsopleural and mesopleural bristles. All the femora thickened and irregularly spinose..... **Eugeniamyia** Wlstn.

Eugeniamyia rufa Wlstn., Canada Entomologist, Vol. xiv, p. 80, California!

V.

A.—Small cross-vein, before the middle of the discal cell.
  2.—Antennæ shorter than the head.
    a.—Marginal cell open.
    aa—Face tuberculate.
      *.—Abdomen elongate, not club-shaped.
        †††.—Black or greenish-black, with yellow or yellowish or ferruginous interrupted abdominal cross-bands.
          §.—Face black.

H.—"Wings not longer than the abdomen; ocellar tubercle large, prominent; abdomen depressed, long, elliptical, somewhat narrowed at the base, the lighter markings ferruginous or orange-yellow" (Schiner)....................................*__Pyrophæna.__**

HH.—Wings longer than the abdomen; ocellar tubercle not unusually large, abdomen more slender, the cross-bands yellow, or greenish-yellow.

I. Anterior tibiæ and metatarsi of male dilated............**Platycheirus.**

Platycheirus quadratus Say. Washington Territory, Kern Co., California!

I cannot distinguish specimens from these localities from our Eastern ones; the color of the hind legs vary much as they do in the East.

? Platycheirus hyperboreus Staeger.

Another species from Washington Territory does not differ in any noteworthy degree from a female specimen of *hyperboreus* identified by Baron Osten Sacken, but the male's tibiæ are not dilated. I am strongly inclined to believe that the dilatation is nothing more than a specific character, and that the name *Platycheirus* should be given up as misleading, and all the species placed under *Melanostoma*. *P. quadratus*, is variable, and only a large amount of material will settle the question whether they are a group of closely allied species, or merely varieties; in the former case, the genus should be retained, in the latter, it should be united with *Melanostoma*.

II.—Anterior tibiæ and tarsi of male not dilated..........**Melanostoma.**

MELANOSTOMA TIGRINA O. S., West Dipt. 323, Washington Territory, California ! common.

MELANOSTOMA SCALARIS Meigen ; Schiner, Fauna Austr. Dipt., 291, Colorado ! Europe and North America.

VI.

J.—Small cross-vein before the middle of the discal cell.
2.—Antennæ short.
a.—Marginal cell open.
aa.—Face tuberculate, hyperstoma not produced.
*.—Abdomen oval or elongate, not club-shaped.
†††.—Black or greenish-black, with yellow markings.
§§.—Face wholly or in part yellow.
π.—Dorsum of thorax with yellow lateral stripes.

J.—Abdomen with seven visible segments, the hypopygium unusually large..**Sphærophoria.**

I have numerous specimens of this genus from the Western regions, among which there are probably four or five species. I recognize, however, only one species, viz :

SPHÆROPHORIA MICRURA O. S., West Dipt., 330, California !

* SPHÆROPHORIA SULPHURIPES Thomson, Eugen. Resa, 501 (*Syrphus*), O. S., l. c., Calif.

JJ.—Abdomen not showing more than six segments, hypopygium not unusually large.

K.—Eyes of male with an area of enlarged facets above ; abdomen rather slender, fourth segment with yellow median stripes and oblique side spots..................................**Allograpta.**

* ALLOGRAPTA FRACTA O. S., West Dipt., p. 331. Santa Monica, Cal.

KK.—Eyes of male without area of enlarged facets (fourth segment of abdomen fasciate).

L.—Thorax with a median, dorsal, cinereous line ; ocellar tubercle remote from vertex ; slender species.

M.—Posterior femora enlarged and bent................**Toxomerus.**

TOXOMERUS GEMINATUS (Say). Washington Territory ! California, Eastern States.

Scæva geminata Say, Compl., Wr. ii, 80.

Toxomerus notatus Macq., Dipt. Exot., 5 Suppl., 93.

Mesograpta geminata Schiner, Novara Exped. O. S. Cat. Dipt. p. 125, West. Dipt., p. 330.

MM.—Postorior femora simple..........................**Mesograpta.**

MESOGRAPTA MARGINATA (Say), O. S., Kern Co. Cal. ! Atlantic States, common.

LL.—Thorax without median dorsal cinereous stripe, ocellar tubercle as usual ; abdomen more oval.

N.—Head obtusely conical, front plane, face receding, third joint of antennæ orbicular..**Doros.**

NN.—Front more rounded, face less receding, third joint of antennæ large, elliptical..............................**Xanthogramma.**

a.—Bands of abdomen entire or sub-interrupted..................*felix.*

b.—Bands of abdomen broadly interrupted :

Xanthogramma divisa, sp. nov.

♂♀.—Face and cheeks yellow, or reddish-yellow. Front metallic greenish-black, continued as a broad stripe to the base of the antennæ, somewhat expanded below, on the sides yellowish. Antennæ black, somewhat reddish below on the sides of the second and third joint near the base, third joint oval obtuse as in *felix,* but a little smaller. Dorsum of thorax deep metallic green with yellow lateral stripes, pleuræ yellowish with white pile. Scutellum a somewhat translucent yellow, its base narrowly black. Abdomen : first segment with a small yellow spot on each side just under the halteres, second segment with an oval spot on each side, somewhat attenuated toward the middle, third and fourth with large rectangular spots, separated by nearly their own width ; fifth with an anterior fascia narrower in the middle and encroaching slightly upon the preceding segment. Legs yellow, anterior and middle femora sometimes narrowly brown annulate near the base, posterior legs mostly brownish or blackish, except the base of femora and knees. Wings hyaline, with a smoky tinge, stigma yellowish. Long. corp. 9–11mm. Eight specimens. Washington Territory.

VII.

Δ.—Small cross-vein before the middle of the discal cell.

2.—Antennæ short.

a.—Marginal cell open.

aa.—Face tuberculate, hyperstoma not produced.

*.—Abdomen oval.

†††.—Black, or greenish-black, with yellow markings.

§§.—Face wholly, or in part, yellow.

ππ.—Dorsum of thorax uniform, without lateral stripes.

O.—Thickly pilose species ; abdomen quite oval, broader beyond the middle ; face perpendicular, somewhat projecting below and reaching far back under the eyes. (Basal portion of abdomen yellow, terminal portion black, wings with dark spot. *L. lucorum*)......**Leucozona.**

Leucozona lucorum (Linné), Schiner—Meig. Beschr. iii, 313 ; Tab. 30, f. 27 (*Syrphus*) ; Mt. Hood, Oregon ! Europe ; North America.

OO.—Rather bare species ; abdomen with yellow bands, either all entire, or one or all interrupted.

P.—Eyes of male with an area of enlarged facets above ; front very convex ; hypopygium very small..................**Catabomba.**

Catabomba pyrastri (Linné), O. S. Meig., System Beschr. iii (*Syr-*

phus.) Europe and Western America. Very abundant in the Pacific regions.

PP.—Eyes of male without area of enlarged facets above; front moderately convex; hypopygium not very small.

Q.—Sixth abdominal segment of male as long as two preceding together, but narrower, somewhat tubular, unsymmetrical; on underside of seventh segment two long linear sub-parallel appendages, arcuate, bidenticulate at end, embedded in grooves when at rest. In the female fifth segment half as long as preceding. Scutellum much raised, exposing metanotum............................**Eupeodes.**

EUPEODES VOLUCRIS O. S., West Dipt., 329. Washington Territory, Kern county, California. ! Nevada, Utah, Colorado, common.

QQ.—Hypopygium without slender appendages, sixth segment of male not peculiar; fifth segment of female one-third or one-fourth as long as preceding.

R.—Third longitudinal vein with a distinct sinuosity; third joint of antennæ elongate-oval..................................**Didea.**

Table of Species:

a.—Third joint of antennæ obtusely pointed; third longitudinal vein, with a considerable sinuosity. Abdominal cross-band of second and third abdominal segments broader towards, but not quite reaching, the lateral margin.......................................*fuscipes.*

aa.—Third joint of antennæ more evenly oval; the third longitudinal vein less sinuous;

b.—Abdominal cross-bands attenuated at outer ends, and usually quite meeting the lateral margins:

DIDEA LAXA O. S., Cat. Dipt. 245. White Mts.; Mt. Hood, Oregon; Washington Terr. !

bb.—Abdominal cross-bands nearly obsolete:

? DIDEA ALCIDICE.

Syrphus Alcidice Walker, List, etc., iii p. 579. Hudson Bay Terr.; Osten Sacken Cat. Dipt., 2d Ed., p. 244, note 205.

A single specimen from Mt. Hood, Oregon, resembles *D. laxa* very much, but the two small oval yellow spots of the second segment, the remaining segments being dark metallic green with an opaque, black longitudinal line, seem to indicate a distinct species, and apparently Walker's *Alcidice*. The generic differences of both these species, however, from some species of *Syrphi* (*e.g.*, *S. lapponicus*), are feeble.

RR.—Third longitudinal vein straight or gently curved; third joint of antennæ short oval....................................**Syrphus.**

This genus appears to be a prominent one in the Western regions; many of the Eastern species appear, and others have strong resemblances. Two species which present well marked characters, I describe as new. The following table contains, with the exception of *dimidiatus. tarsatus*, and *fumipennis*, all of the known species north of Mexico. It is composed of the two tables given by Osten Sacken (Proc. Bost. Soc. N. H., 1875, p. 138, and West. Dipt., p. 325), united, with the addition of the species herein described.

SYRPHUS.

a.—Second and third cross-bands of abdomen never interrupted........*b.*
—Three principal cross-bands broadly interrupted..................*i.*
b.—First cross-band broadly and distinctly interrupted in both sexes....*c.*
—First cross-band narrowly interrupted in the male; not interrupted in the female..*h.*
c.—Abdomen elongated, narrrow, linear......................*diversipes.*
—Abdomen oval...*d.*
d.—Femora black at the base...................................*e.*
—Femora yellow at the base......................*ribesii* ♀, *protritus.*
e.—Abdominal cross-bands do not reach the lateral margins...........*g.*
—Abdominal cross-bands reach quite the lateral margins...........*f.*
f.—Eyes pubescent..*torvus.*
—Eyes glabrous...*ribesii* ♂.
g.—Cross bands attenuated on the sides.....................*opinator.*
—Cross-bands reach the sides in nearly their full width; not attenuated near the ends..*Lesueurii.*
h.—Face yellow..*abbreviatus.*
—Face with brown stripe.................................*americanus.*
i.—Abdomen elongated, narrow, linear...........................*j.*
—Abdomen oval...*l.*
j.—Eyes pubescent..............................*velutinus,* sp. nov.
Eyes glabrous...*k.*
k.—Antennæ inserted on yellow ground.................*umbellatarum.*
—Antennæ inserted on black ground...................*geniculatus.*
l.—Eyes pubescent...*m.*
—Eyes glabrous..*o.*
m.—Abdominal spots straight.....................................*n.*
—Abdominal spots coarctate in the middle, sometimes broken in two; face conspicuously brown or black in the middle........ { *amalopis.* *intrudens.*
n.—Face yellow; third longitudinal vein straight.............*contumax.*
—Facial stripe and front black......................*velutinus,* sp. nov.
o.—Abdominal spots lunate, face with black on the tubercle ..*lapponicus.*
—Abdominal spots straight, face without black....*disjunctus,* sp. nov.

SYRPHUS LAPPONICUS Zett., Dipt., Scand. ii, 701, 3. Wyoming Terr., Kansas, Oregon, Southern California, New England! Greenland, Europe. Specimens taken in Connecticut, late in October, have the sinuosity of the third vein as strongly marked as in any Western ones. The species is widespread and common.

SYRPHUS OPINATOR O. S., West. Dipt., 327, Oregon, Washington Terr., California! Apparently a common species, as twenty-five specimens are in my collection.

Syrphus ribesii Linné, O. S., Pr. Bos. Soc. Nat. Hist., 1874, 139. Oregon, California, New England! Europe. Male specimens with the basal portion of the femora black, agree quite with Eastern specimens.

*Syrphus protritus O. S., West. Dipt., 328 Marion Co., California. Unknown to me.

Syrphus Lesueurii Macq., O. S., Pr. Bos. Soc. Nat. Hist., 1875, 143. Washington Terr.! A single specimen agrees closely with those from New England.

*Syrphus intrudens O. S., West. Dipt., 326. California. Unknown to me.

Syrphus americanus Weid., O. S., Pr. Bos. Soc. Nat. Hist. 1875, p. 145. Female specimens agree quite with New England ones, and I have little doubt of their identity. Calif., Oregon!

*Syrphus fumipennis Thomson, Eugenies Resa, 490, California.

Syrphus velutinus, sp. nov.

♂♀.—Eyes distinctly pubescent. Face obscurely yellow, with a broad median black stripe, extending to the oral margin; antennæ deep black. Frontal triangle brassy black, extending to the base of the antennæ. Front (♀) black, brassy in the middle. Thorax greenish-black, with a metallic lustre, and rather abundant rufous pile, pleuræ white pollinose, the pile more whitish. Scutellum black in the basal part, subtranslucent yellowish at the margin. Abdomen long (shaped nearly like *Platycheirus*) nearly parallel on the sides towards the end of the fourth segment; the color opaque black with short black pile and three interrupted cross-bands; the first pair of spots in the second segment, broad, nearly square, separated by less than half their width, whitish-yellow, second and third pairs narrow, rectangular, separated by about their own width, not attenuated before the lateral margins, bluish-white. Legs black, terminal half of anterior and middle femora, anterior and middle tibiæ, except brownish rings beyond the middle, yellow. Wings hyaline, stigma brown. Long. corp. 11–12 mm. Two specimens. Mt. Hood, Oregon.

Syrphus disjunctus, sp. nov.

♂.—Eyes bare. Frontal triangle blackish, with a brassy reflection; face reddish-yellow with a bluish reflection, without any stripe or spot on the tubercle, cheeks black, the oral border behind, yellow. Antennæ brownish-black, the basal half of third joint yellowish-red. Thorax metallic green black, with short reddish pile, longer on the scutellum; scutellum bluish opalescent, black at the base. Abdomen black, with three pairs of bright yellow spots, the first pair small oval, second and third pairs nearly square, rather broader on the outer sides, separated by a very distinct black space from the lateral margins, fifth segments on the anterior corners, yellow. Legs sordid yellow, anterior and middle femora toward the base, and posterior legs except more or less of the tip of femora and base of tibiæ brown or brownish-black. Wings tinged with brownish, the stigma darker, third longitudinal vein very slightly curved. Long. corp. 9–10 mm. Four specimens. Washington Ter.

VIII.

1.—Small cross-vein before the middle of the discal cell.
2.—Antennæ short.
a.—Marginal cell open.
aa.—Face tuberculate or hyperstoma produced.
**.—Abdomen contracted toward the base, more or less club-shaped.

S.—Posterior femora slender; wings usually with brown; face tuberculate; hyperstoma retreating; longer, more slender species......... **Bacha** (*Ocyptamus*).

The differences between these two genera I cannot satisfactorily make out. I have two species of *Bacha* from California, both of which seem different from:

*Bacha lemur O. S., West Dipt., 331, Cal., New Mexico and:

*Bacha angusta O. S., West Dipt., 332, California.

SS.—Posterior femora swollen; hyperstoma produced; short, small species.

T.—Hyperstoma produced anteriorly, in profile deeply concave from antennæ to tip; third joint of antennæ nearly orbicular; the fourth longitudinal vein joins the third in a right or acute angle.. **Sphegina.**

Three species from Washington Territory and Oregon correspond pretty well with S. lobata Lw., S. infuscata Lw. and S. rufiventris Lw., but in the absence of better material in this genus, I will not venture to describe them.

TT.—Hyperstoma produced more downward, in profile very slightly concave from antennæ to tip, the fourth longitudinal vein joins the third in nearly a right or obtuse angle......................**Ascia.**

Ascia metallica, sp. nov.

♂♀.—Front and face metallic bronze black, shining, the latter white pollinose. Antennæ black, third joint brownish-black below, near the base red. Thorax metallic-green black, finely punctured. Abdomen like the thorax, the third segment, in the female, with two, small or indistinct, spots near the front; in the male the front half except the angles red. Legs with the anterior and middle femora, except the base and ends, the posterior coxæ, femora, except the basal fourth, tibiæ, except the basal third and tips, and the posterior metatarsi black, other parts light yellow. Wings hyaline. Long. corp. 4–5 mm.

Three specimens, Mt. Hood, Oregon.

The black of the legs, in one specimen, includes a larger part, with a portion of the anterior and middle tarsi.

IX.

Δ.—Small cross-vein before the middle of discal cell.
  2.—Antennæ shorter than the head.
    aa.—Marginal cell closed and petiolate.

U.—Second and third joints of antennæ elongate; arista very densely plumose, appearing like a solid mass................ ***Copestylum.**

* COPESTYLUM MARGINATUM (Say), O. S. Say, Compl. Wr. ii, 360 (*Volucella*). Mexico, Texas.

UU.—Third joint of antennæ elongate; arista feathery plumose.. { **Volucella, Temnocera.** }

* VOLUCELLA AVIDA O. S., West Dipt., 333. California. Mexico.

VOLUCELLA SATUR O. S., l. c., Colorado. Utah!

VOLUCELLA FASCIATA Macq., Dipt. Exd., ii. 2, 21, 1. Western Kansas! Texas, Colorado, Mexico.

VOLUCELLA FACIALIS, sp. nov.

♂♀. Closely related to *V. evecta* Walk., but differs in the face being quite yellow, with yellow pile, and the dorsum of thorax and pleuræ being covered with black pile.

Face yellow, yellow pilose, cheeks black, shining, bare. Antennæ: first two joints brownish-black, third joint red, or reddish-brown, arista darker, black plumose. Front in female yellow, darker at the vertex, yellow pilose; frontal triangle (♂) black, or brown with shorter yellow pile, vertex with tuft of long yellow pile. Thorax black, shining, the dorsum broadly black pilose, in front and behind and on the sides with longer yellow pile, pleuræ with black pile. Abdomen black, shining, second segment except the middle third or half, and narrow posterior border, light yellow, the narrow posterior part of third, the fourth and fifth segments conspicuously red pilose, other parts of abdomen with shorter black pile. Legs black, black pilose, basal portion of tibiæ and all the tarsi dark red. Wings hyaline, the veins with brown clouds, a brown spot opposite the small cross-vein. Long. corp. 14–15 mm. Three specimens. California.

The posterior part of the abdomen in *V. evecta* is usually black pilose without any trace of the red, but rarely in some specimens the abdomen is marked precisely like *facialis*, and hence it is quite probable that specimens of the California species may sometimes lack the rufous pile. The black pile of the thorax will at once distinguish the species or variety if it should prove to be such, as in a large number of specimens of *evecta* I have never found any with such thoracic pile. However, as regards its specific distinction, see *Eristalis flavipes melanastomus* Lw.

The genus *Temnocera* is an unsatisfactory one, and I believe ought to be suppressed. The characters relied upon are the more slender third joint of antennæ, and the presence of bristles on the scutellum.

I do not know either of the following species :

*TEMNOCERA SETIGERA O. S., West Dipt., 334, New Mexico.

*TEMNOCERA MEGACEPHALA Lw., Centur. 15, 57. California.

X.

JJ.—The small cross-vein at or beyond the middle of the discal cell, oblique.

a.—Antennæ with a distinctly dorsal bristle.

β.—Third longitudinal vein deeply sinuous.

γ.—Marginal cell closed and petiolate.

V.—Thorax never with yellow spots ; wings hyaline or with a dark spot ; face obtusely tuberculate.................................**Eristalis.**

Eighteen species of Eristalis are recognized by Baron Osten Sacken as having been described from America, north of Mexico. More than twice as many names have been given, chiefly by Walker and Macquart, but the facilities enjoyed by Osten Sacken, together with his well-known accuracy and faithfulness, render it unnecessary to any further discuss the most of them at present.

Since the publication of this catalogue two species have been published by Bigot in the *Annales des Soc. Ent. de France,* 1880, 216–217. *E. parens* is given below in part ; *E. zonatus* = *E. transversus* Wied.

I have endeavored to tabulate below all of the species known to me, and have added the diagnoses, or descriptions, of all the remaining, with the addition of what I identify as *E. Meigenii* Wied., a South American species = *E. androclus* O. S. (non Walker, undescribed, see catalogue, etc.), together with two new ones. The genus though large, and especially predominating in America, is readily defined, showing comparatively little structural variation. The eyes are contiguous, or sub-contiguous, usually pilose, although in some species, as *tenax*, occupying only a spot in the middle ; in *æneus* they are nearly bare, being sparsely pilose near the top. The third joint of the antennæ is sub-quadrate, thus at once distinguishing it from *Volucella* and *Temnocera*. The face is never produced, in nearly all of the species with a not very prominent tubercle, with a median stripe and cheeks black, bare, and shining. From *Milesia* and *Pteroptila* it may readily be distinguished by the absence of distinct yellow spots or stripes on the dorsum of the thorax, which is, however, sometimes distinctly fasciate or vittate with dull gray or olivaceous ; from the latter genus also by the absence of pubescence on the wing, though, indeed, this character is only relative. There is a tendency to differences of coloration and markings between the male and female, sometimes so striking as to cause one to doubt their relationship. Such differences may consist in the absence of yellow upon the abdomen, or in the presence of stripes of the thorax. The wings show scarcely any variation ; the third longitudinal is deeply bent into the first posterior cell, and the marginal cell is closed, the latter character separating it from all other North American genera except the ones previously mentioned.

ERISTALIS.

1.—Arista naked or indistinctly pubescent............................2.
—Arista pilose or distinctly pubescent (near the base)...............3.
2.—Scutellum of the same color as thorax, abdomen without light markings, shining, eyes nearly bare, spotted in life, dorsum of thorax in female distinctly vittate......................................*æneus.*
—Scutellum yellowish translucent, lighter than the thorax ; abdomen unicolorous, shining blackish, with indistinct or subobsolete side spots on second segment, pile of eye mostly confined to an elongated vertical elliptical line. Size and appearance of a honey-bee....*tenax.*
3.—Thorax with thick or long pile, posterior border of third segment not velvety black, wings mostly with a brown spot...................4.
—Thorax and abdomen nearly bare, or with short, not wooly pile, the abdominal segments usually with lighter hind borders. Less *Bombus*-like...8.
4.—Tarsi red, large species ; humble bee-like..........................5.
—Tarsi dark, smaller species...6.
5.—Thorax wholly yellow pilose above..........................*flavipes.*
—Thorax with black pile in the middle when seen from the side......
flavipes var. *melanostomus.*
6.—Abdomen with yellow or reddish on the sides of the second segment only, thickly mostly black pilose elsewhere, posterior half of third, and the fourth segment shining ; legs black...............*Bastardi.*
—Third segment with yellow or red, the pile of the abdomen almost wholly yellowish, and long..7.
7.—Abdomen mostly reddish-yellow with a nearly equal median black stripe ; eyes barely meeting in the male ; legs black.*montanus*, sp. nov.
—Third segment with a smaller reddish-yellow spot in the side, second segment velvety black, third with a triangular velvety expansion in front..*occidentalis*, sp. nov.
8.—Third abdominal segment with a posterior velvety black cross-band *not interrupted* in the middle.......................................9.
—Third abdominal segment with a distinctly interrupted band, or else wholly shining. Not with a complete band.......................13.
9.—Thorax with transverse olivaceous fasciæ, front narrow above (♀).10.
—Thorax without such fasciæ..11
10.—Hind femora not swollen, second segment of abdomen with large spots, third segment in the male, with anterior rectangular spots wanting in the female, and hind borders of second, third and fourth segments yellow. Legs varying from almost wholly yellow with black on tips of hind femora and tibiæ, to black with yellow knees...
transversus.

—Hind femora distinctly swollen, bands of thorax conspicuous, third segment of abdomen in female often with red or yellow side spots, otherwise resembling the previous species very much, and like it quite variable .... *cinctorum.*

11.—Third segment of abdomen broadly and conspicuously yellow, joining the yellow of the second segment in front, the velvety fascia of third segment abbreviated on the sides ; thorax with indistinct stripes ; eyes of male touching each other very slightly...........?*Meigenii* Wied.

—Third segment of abdomen without yellow, eyes of male broadly contiguous......... 12

12.—Front of female narrow. Deep bluish-black, scutellum scarcely different, the abdomen with dull or obsolete triangular spots, the hind borders of the segments indistinct or absent, conical ; tips of femora, the posterior at the base especially in the female, basal half of tibiæ, and more or less of basal joints of anterior and middle tarsi, light yellow. Wings with a dark spot........ ....*saxorum.*

—Front of female broad. Lighter markings of abdomen (the lateral triangles and posterior borders) usually quite distinct, sometimes nearly obsolete ; third and fourth segments with a velvety median triangular expansion with its base in front ; tips of femora, anterior and middle tibiæ, except tips and basal half of posterior tibiæ yellow. Wings sometimes with a distinct brown spot................*hirtus.*

13.—Third segment without (or with very minute) velvety markings, abdomen mostly shining, second, third, and fourth segments with fringe of white pile...14.

—Third segment of abdomen with an anterior spot, and a posterior interrupted velvety black fascia, second segment with sub-obsolete triangular yellow spots, posterior border of segments narrow or indistinct ; basal half of all the tibiæ yellowish-white. Wings pure hyaline.......... ....*dimidiatus.*

14.—Second segment of abdomen with yellow triangles, and a posterior uninterrupted or subinterrupted velvety cross-band, posterior margin of segments 2–4 yellowish-white, with a fringe of pale golden yellow hairs. (Length 9–13 mm.)............................*stipator.*

—Second segment except the metallic side spots that extend the whole length of the segment, velvety black ; third segment with a velvety triangle in front, the fourth with similar, but very small ; the yellowish-white hind borders fringed less conspicuously with light colored pile..*Brousii,* sp. nov.

Eristalis inornatus Lw., Centur. vi, 68. Red River.

Diagnosis, translation. ♀. "Sub-brassy black, shining, clothed with rather long lutescent pile ('pube') ; front broad, near the eyes black pilose, but the vertex itself with luteous pile ; eyes pilose ; antennæ reddish ferruginous, the first two joints black, the arista pilose ; face, except the usual stripes yellow, with dilutely lutescent pile and pollen ; scutellum wholly testaceous; each segment of the abdomen except the first with a black posterior fascia, second and third emarginate and velutinous, the following sub-shining and in the posterior margin, very narrowly yellow. Feet black, extreme apex of the femora, the basal half of anterior and posterior tibiæ, the middle tibiæ except the apical third and the first joint of the middle tarsi, pallid yellowish; 'alæ hyalinæ, vena disci colore subfusco late circumfusis.'" Long. corp. $6\frac{1}{4}$ lin., Long. al. $4\frac{5}{6}$ lin.

Eristalis obscurus Lw., l. c. 67. Red River.

Diagnosis, translation. "♀. Brassy black shining. clothed with rather long dilutely lutescent cinerous pile; front broad, above black pilose; eyes pilose, antennæ reddish ferruginous, first two joints black, arista pilose, face except the usual stripes yellow testaceous, white pollinose and white-pilose; scutellum brown, black near the base; each abdominal segment except the first with a posterior black fascia, not emarginate and with a very slender posterior yellow margin; feet black, apex and base of all the femora, the basal third of anterior and posterior tibiæ, intermediate tibiæ except the apex, and the first two joints of all the tarsi pallid yellowish; wings pure hyaline, veins of the disc clouded with fuscous. Long. corp. 5–$5\frac{1}{2}$ lin., long. al., $4\frac{1}{3}$–$4\frac{2}{3}$ lin.

ERISTALIS LATIFRONS Lw., l. c. 65. Matamoras, Texas, Iowa.

Diagnosis, translation. "♂♀. Black, moderately shining, wholly pallidly pilose; antennæ fuscous, setæ bare, luteous; scutellum testaceous; second segment of the abdomen with two sub-triangular testaceous spots, posterior margin pallid, posterior margins of the following segments pallid, in front pallidly pollinose; feet black, the knees, tibiæ, except the apex, and the base of the intermediate tarsi, pallid flavescent; eyes of the male contiguous, in the female by the front broadly separated. Long. corp. $5\frac{1}{4}$–$5\frac{1}{3}$ lin., long. al. $4\frac{1}{6}$–$4\frac{1}{2}$ lin.

Eristalis atriceps Lw., l. c. 64. White Mts., Canada.

Diagnosis, translation. "♂. Black, shining; head wholly concolorous, antennæ obscurely rufous, arista bare; scutellum and two spots of the second abdominal segment brown; posterior margin of the second, third, and fourth abdominal segments pallid yellow; wings hyaline, costa except the apical third fuscous-clouded. Long. corp. $4\frac{1}{3}$–$4\frac{5}{12}$ lin., long al. $3\frac{5}{6}$ lin."

Eristalis pilosus Lw., l. c. 70. Greenland.

Diagnosis, translation. "♂♀. Black, thickly clothed with long yellow pile; eyes black pilose; antennæ black, arista bare; face black; thorax unicolorous, opaque; scutellum luteous; first two abdominal segments opaque, secured on each side with a dilutely lutescent spot; third segment black, with two opaque spots, confluent in an abbreviated fascia; two ultimate segments brassy [metallic], black, shining, with a minute triangular spot, opaque; pile of the dorsum lupinous, on the sides of the middle black, remainder yellow ; wings pure hyaline, veins fuscous black, in the female with blackish spots.—Long. corp. 5½–6½ lin., long. al. 4⅓–5½ lin."

Eristalis œstriformis Walker, List, etc., iii, 573 (*Syrphus*). Hudson's Bay Territory.

"Mas. Niger, thoracis pilis anticis nigris pootecis fulvis, scutello fulvo, abdomine pilis albis nigris fulvisque fasciato, antennis piceis, pedibus nigris, alis limpidis fusco unimaculatis.

"Body black ; head clothed with dull tawny hairs, shining and prominent in front ; mouth pitchy ; feelers pitchy ; bristle ferruginous, downy; eyes pitchy, each with a broad stripe of short black hairs ; all the facets very small ; chest clothed with short black hairs, and on the hinder part with pale tawny hairs ; scutcheon tawny, very thickly clothed with pale tawny hairs ; abdomen nearly oval, broader and a little longer than the chest, clothed with white hairs at the base, with black hairs in the middle, and with bright tawny hairs towards the tip ; legs black, clothed with short black hair ; knees pitchy ; shanks and feet clothed beneath with tawny down ; hind feet tawny ; claws and foot cushions tawny ; tips of claws black ; wings colorless ; large dark brown spot in the disk ; wing ribs pitchy ; veins black, ferruginous towards the base and along the free borders ; poisers ferruginous. Length of the body 7 lines ; of the wings [spread] 14 lines."

Eristalis albiceps Macq., Dipt. Exot. ii, 2, 56, 41, Carolina.

"Ater. Thorace antice duabus fasciis transversus albidis. Abdominis primo, secundo tertioque segmentis maculis lateralibus flavis. Facie frontique albis. Long. 4 l. ♂."

"Face testacie, a duvet blanc et bande nue, luisante. Partie antérieure du front a duvet et poils blancs. Antennes testacées. Yeux nus. Thorax d'un noir velonté ; la seconde bande transversale sur la suture ; ecusson fauve. Abdomen, les taches latérales laissant un espace etroit entrélles ; celles du troisième segment n'atteignant pas le sord posterieur ; incisions jaunes ; quatrième à petits poils noire. Cuisses noires, à genoux fauves ; jambes jaunes, à extremité braune ; tarses noirs. Balanciers jaunes. Ailes hyalines ; à base un peu jaunatre ; cellule basilaire externe s'étendant jusqu'à la moitié de la discoidale."

Eristalis parens Bigot, Dipt. Nouv. xxi, Annal Ent. Soc. Fr., 1878, 216. Diagnosis, translation. ♂. Eyes pilose, arista at the base briefly pilose (similar to *E. arbustorum*) ; antennæ reddish-brown ; face black, on the sides obscurely cinereous pilose ; thorax black, densely fulvous pilose ; scutellum fulvous ; teguhe testaceous ; abdomen, second segment, on each side, with a broad spot, triangular, fulvous, third with similar, but narrower, spots, narrowly margined with yellow ; femora obscurely reddish-brown, knees and tibiæ pallid testaceous ; apex broadly reddish-brown, tarsi obscurely red, apex slightly infuscate; wings nearly hyaline, base and external border, dilutely and very pallidly infuscated. Long. 13mm. North America.

Eristalis tenax (Linné), Meig. Atlantic and Middle States, Washington Territory! Europe, Asia, Africa. A single specimen from the Pacific coast agrees in every respect with Eastern ones. The distribution of this species is remarkable; although at present very abundant in the region of New England, it was never observed or known to collectors longer ago than 1874!

Eristalis flavipes, var melanostomus Lw., Centur. vi., 69. I have a single female specimen from Oregon that I doubtfully refer to this species. While the dorsum of the thorax is black pilose the yellowish pile of the abdomen is confined to the terminal segments. I have collected large numbers of *flavipes* in Connecticut, and among them I have found *typical* specimens of *melanostomi* and others agreeing quite with the specimen from Oregon, while still others have the yellowish pile of the abdomen more or less intermixed with black. A typical *melanostomus* presents a very different appearance from *flavipes*, and yet from the collection I have, I doubt the specific distinction. The name *melanostomus* may be retained, however, to express the difference, more particularly of the dorsal thoracic pile.

Eristalis stipator O. S., West. Dipt., 336. Colorado, Western Kansas! New Mexico, California.

Eristalis hirtus Lw., Cent. vi, 66; O. S. West. Dipt., 335. Wash. Terr., Oregon, California, Colorado! A very common species, over thirty specimens are in my collection. They show a considerable variation as observed by Osten Sacken (l. c.).

Eristalis (?) Meigenii Wied., Aus. Zwei. Ins. ii, 177, 35, pl. x., fig. 15. (*E. androclus* O. S.), Brazil (Wied.) New England! Utah, Alaska (see O. Sacken. West. Dipt, 337). This species agrees so closely with Wiedman's figure and description of *Meigenii* from Brazil, that I believe it to be the same. I shall, however, send specimens for comparison with South American ones.

Eristalis montanus, sp. nov.

♂.—Eyes thickly pilose, sub-contiguous; front and face reddish-black with yellow pile, the facial stripe and cheeks black, shining; antennæ brownish-black, arista bare. Thorax black, densely covered with yellow pile, the scutellum yellow. Abdomen reddish-yellow, with thick reddish-yellow pile, first segment black; second segment in the middle opaque black, narrowed behind, in the third segment the black is confined to a broad median stripe, opaque in front, shining behind; fourth segment similar, wholly shining, hypopygium black. Legs black with black pile, all the tibiæ at the base yellowish-red. Wings hyaline with a brown spot. Long. corp. 12 mm. One specimen. Wyoming Territory.

Eristalis occidentalis, sp. nov.

♂ ♀.—Eyes pilose, front (♀) brownish-black, dusted with yellow on the sides, face on the sides thickly covered with same colored dust, and whitish-yellow pile, median stripe and cheeks shining black; antennæ reddish-brown, arista red pubescent. Thorax black, with rather short, thick, yellow pile; scutellum sub-translucent yellow with longer pile. Abdomen black, thickly covered with yellow pile more or less intermixed with black at the incisures, second segment on the sides broadly yellow, in the middle wholly opaque; third segment on the sides with smaller reddish spots, extending one-half or two-thirds of the way back, and a broad, shining cross-band narrowly interrupted in the middle; fourth segment shining, with a small opaque spot in front. Legs black with black pile, knees and basal third of all the tibiæ yellow. Wings hyaline with a small dark brown spot. Long. corp. 10–12 mm. Four specimens. Washington Territory.

Eristalis Brousii, sp. nov.

♀.—Eyes with short whitish pile; front brownish-black in the middle, thickly covered with red dust on the sides, pile below yellowish, black near the ocelli, face with whitish pile and yellowish-white dust, narrowly shining black in the middle, cheeks black, shining; antennæ brownish-black, arista brownish-yellow, sparsely pilose. Thorax on the dorsum brownish-olivaceous, somewhat brassy on the sides; in the middle forming two rather broad stripes, inclosing a narrow black stripe that is broadest beyond the suture; pleuræ black with longer whitish pile, the pile of the dorsum rather short reddish-yellow; scutellum reddish-brown. Abdomen black, sub-metallic shining, with very short whitish pile, posterior margins of second, third and fourth segments broadly whitish-yellow, the velvety black occupies the whole of the middle of the second segment, expanding narrowly outward in front of the whitish posterior margin; third segment has the velvety black confined to a triangle on the anterior part, extending narrowly backward; fourth segment with a small spot in front. Legs black with white pile, tips of femora and basal third of all the tibiæ yellow. Wings hyaline with an indistinct brownish spot. Long. corp. 10–12 mm. Three specimens. Massachusetts, July 3.

For some time I was inclined to consider this the female of what I identify as *E. Meigenii* Wied.

VV.—Wings covered with minute pile, brown on anterior portion; thorax often with yellow spots................................**Pteroptila.**

PTEROPTILA CRUCIGERA (Wied.), Aus. Zwei. ii, 105, 2. Georgia! Florida, Texas, Central America.

XI.

JJ.—Small cross-vein at or beyond the middle of discal cell.
  α.—Arista dorsal.
    β.—Third longitudinal vein deeply sinuous.
      γγ.—Marginal cell open; posterior femora swollen.

W.—Face carinate..see XIII.
WW.—Face tuberculate, or rounded, not carinate.
X.—Face of male less tuberculate than in female, body uniformly black, without markings.
Y.—Hind tibiæ of male with a strong projecting spine in middle. **Teuchocnemis.**
YY.—Hind tibiæ of male without such spine..............***Pterallastes.**
XX.—Face alike in both sexes, abdomen in male at least (except *Mallota*) not uniform.
Z.—Hind coxæ with spur, duller in the female, hind femora with triangular protuberance, hind tibiæ with terminal spur (♂ abdomen mostly red, ♀ nearly black)........................**Polydonta.**

Polydonta curvipes (Wied.), Aus. Zwei. ii, 149, 3. O. S. West. Dipt., 338. New England ! California. The probability is that the species somewhat doubtfully referred to this by Osten Sacken, l. c., is the same.

ZZ.—Hind legs without such spurs or protuberances.
a.—Third joint of antennæ broad, face concave below the antennæ (thorax not vittate, thickly pilose) abdomen without bands.......................................**Mallota.**

Mallota Sackeni, sp. nov.

Mallota posticata O. Sacken, West. Dipt., 338.

♂. Differs from *M.* (?) *posticata* of the Eastern States in a dark brown spot on the wing, in the marginal cell being closed in the border, and in the eyes of the male not being contiguous, otherwise quite like the Eastern species.

Frontal triangle and face gray with yellow pile, broad facial stripe and cheeks deep black, shining; antennæ black, third joint more or less brownish. Dorsum of thorax and pleuræ with long dense yellow pile, scutellum yellow, similarly pilose, abdomen deep shining black, nearly bare, legs deep black, with black pile, middle and posterior tarsi brownish-red, posterior femora very much thickened. Wings hyaline with a large brown spot, reaching from the origin of the third vein to the small cross-vein, the second longitudinal enters the costa at tip of the first, not at some distance beyond, as in the specimens I have of the Eastern species. Long. corp. 14mm. Washington Territory. Two specimens.

aa.—Third joint of antennæ ovate, face excavated or not below the antennæ, thorax, or at least abdomen, with markings....**Helophilus.**

Helophilus latifrons Lw., Cent. iv, 73. Wyo. ! Northern States, Nebraska, California.

Helophilus mexicanus Macq. (*H. polygrammus* Lw. Cent. x. 55. See also O. Sacken, Catalogue, Errata.) Apparently a very common species. I have seventeen specimens from Washington Territory and California.

Helophilus, sp. A small species from Wyoming, apparently undescribed.

XII.

ΔΔ.—Small cross-vein at or beyond the middle of discal cell.
α.—Arista dorsal.
ββ.—Third longitudinal vein gently curved.
δ.—Arista feathery plumose.
ε.—Marginal cell open.

b.—Thickly pilose ; abdomen without bands, short, thick, arched ; hind femora strongly thickened, tibiæ much bent ; face straight, extending back under the eyes, conical, pointed ; wings with a brown spot. . . . . ***Arctophila.**

*ARCTOPHILA FLAGRANS O. S., West. Dipt., 335. Colorado Mountains.

bb.—Less pilose ; abdomen with bands ; hind femora slender ; face truncate . . . . **Sericomyia.**

SERICOMYIA CHALCOPYGA Lw., Cent. iii, 20. Washington Territory, Mt. Hood, Oregon ! Sitka. A dozen specimen from the two former localities, I have no doubt belong here ; the male not described by Loew, differs in having the third segment wholly opaque.

XIII.

ΔΔ.—Small cross-vein at or beyond the middle of discal cell.
α.—Arista dorsal.
ββ.—Third longitudinal vein gently curved.
εε.—Arista bare or pubescent.

c.—Marginal cell closed ; thorax with yellow markings ; abdomen fasciate ; antennæ short . . . . **Milesia.**
cc.—Marginal cell open.
d.—Long, slender, abdomen narrower toward the base (wings more or less brownish) . . . . **Ocyptamus** (Bacha).
dd.—Abdomen never linear or club-shaped.
e.—Face distinctly carinate, convex or nearly perpendicular in profile, hyperstoma not produced, eyes bare, hind femora incrassate, with a triangular protuberance . . . . . . **Tropidia.**

TROPIDIA QUADRATA (Say). Compl. Wr. 1, 14 (*Xylota*). Washington Terr., California, New England !

ee.—Face without a distinct median ridge or carina, or if somewhat carinated, the hyperstoma produced.
f.—"All the femora strongly thickened and spinose below ; tarsi crassate. Face tuberculate ; antennæ short, third joint as long as two preceding. Small cross-vein subnormal ; first posterior cell acute at outer anterior angle, rounded on outer posterior part, the section of vein at distal end of cell, sinuate. Body proportionately short and broad, bare, with minute squamæ." Loew, Century v, 38. Small species . . . . ***Lepidomyia.**
ff.—All the femora not strongly thickened and spinose below. Mostly large species.
g.—Nearly bare species, especially on the abdomen, the pile never long nor dense ; eyes bare.

h.—Face descending but very little below the eyes, arched or subcarinate, never tuberculate.

i.—Third segment of abdomen in male very much contracted, cylindrical, the hind femora much swollen, with bifid spine below at the tip. Eyes very large, face small...... **Senogaster** Macq., Hist. Nat. Dipt. 2.

Senogaster Comstocki, sp. nov.

♂.—Head globular, large, composed almost wholly of the eyes which meet in front for a short distance above the antennæ, the vertical triangle narrow, long; a small but very distinct area of enlarged facets on each side above the antennæ. Frontal triangle and face small, the latter arched, subcarinate, short, concave from antennæ to tip, yellow with silvery glisten, and a brownish median stripe. Cheeks narrow, antennæ reddish-yellow, first joint very short, second nearly equilaterally triangular, third joint oval, arista bare. Thorax black, with four narrow, but conspicuous olivaceous stripes, the outer pair extending from the more reddish, somewhat swollen humeri. Pleuræ black, with a conspicuous broad white-dusted vertical patch; scutellum black, yellow at the tip; abdomen brownish-black; first segment as broad as thorax, nearly black, yellow on the sides; second segment elongate, scarcely half as wide behind, with two silvery elongate spots; third segment of the same length, narrow, cylindrical, yellow in front; fourth segment as long as preceding, with the globular hypopygium forming a spheroidal mass. Legs yellow, hind femora much swollen, arcuated, black, becoming red at the tip, below at the end with slender process, and beyond a smaller tooth-like one, hind tibiæ arcuated with a triangular projection at the end, hind tarsi brownish, wings nearly hyaline, third longitudinal vein gently curved. Long. corp. 12 mm., long. al. 8 mm., N. Y., Cornell University. Prof. J. H. Comstock.

The present species is a very interesting addition to our fauna. Hitherto, so far as I can learn, but one species is known, *S. cærulescens* Mac., l. c. and Dipt. Exot. 11, 2, 72, Tab. 13, f. 3, from Guiana, South America. I take much pleasure in dedicating it to Prof. Comstock, whose work in Entomology is so favorably known.

ii.—Hind femora more or less swollen with spines or bristles below, abdomen elongated, somewhat flattened, not contracted in the middle. Thorax without distinct yellow markings.

j.—Hind femora very much swollen; small cross-vein at right angles to longitudinal veins.. **Syritta.**

Syritta pipiens Linné. Meigen Zweifl. Ins. iii, 213. Europe. Common apparently over all of North America.

jj.—Hind femora never remarkably swollen, hind coxæ often with a spinous process, small cross vein of wing always oblique... **Xylota.**

Xylota obscura Lw., Cent. vi, 55. Mt. Hood, Oregon; Wash. Terr. Calif. ! Red River of the North. Specimens from the former localities agree so closely with Loew's description that I believe them to be the same.

XYLOTA EJUNCIDA Say. Compl. Wr. 1, 15; Pl. 8, fig. 4. Wash. Terr., Calif. ! New England. Numerous specimens from these localities resemble so closely the Eastern ones, that I scarcely doubt their identity. The third joint of the tarsi varies from yellowish to quite black, and the spine or tubercle of the hind coxæ is quite distinct; the antennæ vary somewhat is color. Is *X. quadrimaculata* Lw. really a distinct species? Observe the discrepancy between the diagnosis and description as regards the male coxæ.

XYLOTA PIGRA (Fab.) Meigen. Oregon, Wash. Terr., Calif. ! Europe and North America. Common.

XYLOTA, sp. nov. Colorado.

Differs from *S. bicolor* Lw. in the presence of long coxal spines; in all the tarsi except the last two joints, the anterior and middle tibiæ, and the posterior tibiæ at base and tips being yellowish-red.

hh.—Face descending more or less below the eyes, often obtusely tuberculate. Thorax either with distinct spots or abdomen banded.

k.—The sixth vein beyond the junction of the posterior basal cross-vein, extends forwards subparallel to the border, the discal cell rounded on its posterior angle, hind femora swollen (and with a triangular protuberance below on outer part; anterior part of wings more or less clouded).

l.—Second joint of antennæ, elongate; antennæ about as long as head... **Mixtemyia.**

ll.—Second joint of antennæ not elongated, the antennæ shorter than head... **Spilomyia.**

SPILOMYIA INTERRUPTA, sp. nov.

♂♀.—Very closely allied to *S. longicornis*, but seems to show a constant difference in that the first, third and fifth cross-bands are distinctly though narrowly interrupted, and that the last section of the sixth longitudinal vein is distinctly shorter, scarcely more than half as long as the posterior basal cross-vein. The posterior side of the hind femora are in some specimens quite black. Washington Territory.

The generic differences between our species of Mixtemyia and Spilomyia are very trivial.

kk.—The last section of the sixth vein short, running directly into the border of the wing, hind femora not swollen, nor with spines or projection below.

m.—Antennæ inserted high up on a conical projection, front very short, face much produced directly downwards, obtusely tuberculate, antennæ shorter or longer than the head...... **Sphecomyia.**

SPHECOMYIA VITTATA (Wied.) O. S., Wied. Aus. Zwei., ii, 87, and 91 (*Psarus ornatus*). Eastern States ! Colorado.

*SPHECOMYIA BREVICORNIS O. S., West. Dipt., 341. California.

SPHECOMYIA PATTONII, sp. nov.

♂ ♀. Antennæ reddish-black, very short, joints nearly of the same length; the first cylindrical, the second sub-triangular, the third rounded, reddish below; arista reddish. Face golden yellow, with a black stripe reaching from the antennæ to the oral margin, cheeks black; front in female black with a golden spot on each side. Thorax black, a large spot on the pleuræ and a smaller one under it, humeri and basal part of scutellum yellow. Abdomen black; first segment with a narrow posterior border, second segment with two narrow yellow cross-bands; the anterior one near the middle of the segment broadly interrupted, the posterior marginal one entire; third and fourth segments similar, the middle cross-bands successively a little wider and less broadly interrupted; fifth segment nearly all yellow. Femora brownish-black at the base, becoming reddish at the end, especially on the posterior pair. Anterior tibiæ, except the base and tarsi, quite black, middle and posterior tibiæ and tarsi, except the last two joints, reddish-yellow. Wings tinged with brownish along the veins, hyaline in the middle of the cells. Long. corp. 13–14 mm. Two specimens. Washington Territory.

This species is very like *Sphecomyia brevicornis* O. S., but differs in the antennæ being still shorter, and the picture of the abdomen different.

mm.—Antennæ short, situated low down, near the middle of head in profile, the projection less prominent; face not much produced, not longer than the front..... .... **Temnostoma.**

gg.—Larger pilose species, the abdomen always with short, furry pile; dorsum of thorax never with yellow markings other than on the humeri.

n.—Scutellum, margin and pleura of thorax with bristly hairs; face distinctly tuberculate; femora slender; abdomen uniform metallic, not banded.......................... **Chrysochlamys.**

The following table of the North American species I reproduce from Osten Sacken (West. Dipt., 340), without change:

Arista black.. *crœsus.*

Arista reddish.

Leg entirely reddish-yellow.............................. *dives.*

Anterior femora at base and tips of all the tarsi black.... *buccata.*

All the femora brown; tibiæ likewise infuscated........ *nigripes.*

CHRYSOCHLAMYS CROESUS O. Sacken. West. Dipt., 341. Washington Terr., California! Utah.

nn.—Thorax without any bristly hairs.

o.—Face short, not produced, extending but very little below the eyes, shorter than the front, concave from antennæ to tip, not tuberculate, transversely arched, hind femora more or less thickened.

p.—Abdomen elongate, hind femora with short spinous bristles below.................................... **Brachypalpus.**

Brachypalpus pulcher Wlstn. Can. Entomologist, vol. xiv, p. 78. Oregon, Washington Terr. Readily recognized by the abdominal segments being broadly banded and bordered behind by brilliant brassy or bronze, the fourth segment in the male wholly so. The first segment in the male with a narrow posterior border extending across from its side spots.

pp.—Abdomen very broad, thorax densely pilose, very large species..... **Hadromyia** Wlstn, l. c.

Hadromyia grandis Wlstn., l. c. Washington Terr. The present species is the largest Syrphid of which I have any knowledge ; it measures nearly an inch in length by a third of an inch in width across the abdomen.

oo.—Face produced, longer than the front.

q.—Face produced forwards, pointed, concave from antennæ to tip, not tuberculate, subcarinate, eyes of male contiguous or nearly so in front of ocellar tubercle, hind femora thickened, usually with bristly points below, abdomen without yellow markings. **Crioprora.**

A.—Dorsum of thorax beset with thick or yellowish or yellowish-rufous pile, on the pleura black ; wings with brownish clouds along the veins.

a.—Front in female broad, beset with yellow pile.........**alopex* O.S.

b.—Front in female narrow, beset with black pile..*femorata*, sp. nov.

B.—Dorsum of thorax beset with long grayish or whitish pile, above on pleuræ yellowish-white, abdomen dark bluish-metallic (in the male with black opaque second segment, and a black opaque cross-band on third)... { *cyanella* O. S. / **cyanogaster* Lw. }

I have never seen a specimen of *cyanogaster ;* it is probably distinct from *cyanella,* although the description applies quite well to my female *cyanella.* A comparison is needed of specimens from the Atlantic and Pacific States in order to make the description of Loew's species more complete.

*Crioprora alopex O. S., West Dipt., 338 (*Pocota*). California.

Crioprora cyanella O. S., l. c., 339. California. Osten Sacken's description, as usual, is quite accurate.

Crioprora femorata, sp. nov.

♂♀. Everywhere deep shining black. Front in female narrower than in *cyanella,* with black pile, eyes in male less contiguous than in *cyanella ;* the face a little less produced and more obtusely pointed. Antennæ reddish-brown, arista yellow. Thorax and scutellum with rather abundant yellow pile, black on the pleuræ. Abdomen with a brassy reflection, black pilose, intermingled with longer yellow on the sides of the second segment. Legs wholly black pilose, the anterior tibiæ and tarsi with golden pubescence. Hind femora in the male much thickened in the male and bent with a row of short spinous tubercles below, posterior coxæ obtusely tuberculate, and tibiæ in lower third strongly bent; in female the femora and tibiæ not bent, the former swollen but the tubercles indistinct. Wings with brown clouds along the vein and a very dark spot near the tip of auxiliary, the inner portion of the cells hyaline. Long. corp. 15–16 mm. Washington Territory.

pp.—Face, not evenly concave, tuberculate; hind femora slender.

g.—Face produced downwards and forwards, proboscis long; eyes of male well separated, abdomen uniformly black, short, broad...... **Eurhinamallota** Big.

Bul. Soc. Ent. Fr. Apr. 1882, No. 6, p. 78, *Brachymyia* Williston, Can. Entomologist, Vol. xiv, p. 76, May, 1882.

EURHINAMALLOTA LUPINA, Wlstn., l. c. California.

EURHINAMALLOTA NIGRIPES Wlstn., l. c. Northern and Southern California. I know this species only in the female; should the male's eyes be found to be contiguous in front of the ocellar tubercle, I know of no other character to separate it from *Eriophora*, Phillipi Ver. Zool. Bot. Gesells. Wien., 15, 735, 1865, pl. 26, fig. 36.

qq.—Face produced directly downward, more or less arched or tuberculate in the lower part.

r.—Eyes of male separated by the ocellar tubercle. Antennal prominence very conical, abdomen with 3–4 pairs of large oval, oblique yellow side spots.............................. **Somula decora.**

rr.—Eyes of male more or less contiguous in front of the ocelli; antennal prominence conical.............................. **Criorrhina.**

Table of species.

a.—Abdomen wholly black.............................. **armilata.*

b.—Three basal segments and base of fourth black, remainder yellow.... *analis.*

c.—Second segment with triangular lateral spots; in female the anterior margins of third and fourth in the sides with yellow spots; humeri yellow.............................. *humeralis*, sp. nov.

d.—Second segment with an interrupted cross-band, third and fourth with entire cross-band, attenuated in the middle behind and on the sides.. *scitula*, sp. nov.

CRIORRHINA HUMERALIS, sp. nov.

♂ ♀.—Face yellow, shining with a semi-translucency; cheeks black; front in female on upper half, black; whitish pollinose on the sides below the vertex, frontal triangle in male like the face; antennæ yellow, somewhat infuscated on the first two joints and on upper part of third; thorax black, with short thin yellow pile; scutellum black, the edge luteous; abdomen black, with recumbent, not abundant yellow pile; second segment with triangular yellow spots, in the female the third and fourth, with rectangular yellow spots on the anterior margins, fifth mostly yellow except a narrow median line and the tip; legs yellow, front and middle, and a ring on distal part of posterior femora, posterior tibiæ in middle, posterior metatarsi, and three last joints of all the tarsi brown; wings hyaline. Long. corp. 10–11 mm. Two specimens. Washington Territory.

I suspect that the male may also show in some degree the abdominal markings other than the spots on second segment, and that the coloration of the legs may be variable.

CRIORRHINA SCITULA, sp. nov.

♂♀. Face yellow, in profile with a well marked obtuse tubercle; cheeks black; front in female black on upper three-fourths, with grayish-red club and short black pile; frontal triangle in male yellow; eyes contiguous for a longer distance than in *analis*, the antennal protuberance not so great. Antennæ yellowish-brown or blackish-brown, the second joint sometimes yellow with black above, third joint always of a lighter color below; thorax black, shining, dorsum with blackish pile, yellowish on the borders; humeri yellow with smaller confluent yellow pleural spots; mesopleuræ gray pilose and pollinose; scutellum black, the edge sometimes narrowly luteous; abdomen black; second segment with two large yellow spots rather narrowly separated, with rounded heads and narrowed toward the margins; third segment with a yellow cross-band on the anterior margin, doubly convex behind, the greatest convexity being toward the middle, with sharp median angular incision, and attenuated nearly to a point on the sides of the abdomen; fourth segment similar in female, in male wholly black or with triangular spots on anterior margin and reddish behind; hypopygium red or yellow. Anterior coxæ white pollinose in front, femora black except the extreme tips, anterior and middle tibiæ and metatarsi, yellow or reddish-yellow; posterior tibiæ yellow at the base and tip; terminal joints of anterior and middle tarsi black; posterior tarsi fuscous or black; wings nearly hyaline, rather more clouded toward the front. Long. corp. 11–13 mm. Eight specimens. Washington Territory, Oregon.

This species has the face in profile similar to that of *Milesia notata* Wied. ("Genus novum" O. S. Catalog. p. 138) as figured by Macquart.

XIV.

ΔΔ.—Small cross-vein beyond the middle of discal cell, oblique.
aa.—Antennæ with a subterminal bristle or terminal style.

s.—Third joint of antennæ produced above into a long conical process, inclined forward and terminating in the thickened arista; abdomen oval black, with three interrupted metallic cross-bands; third longitudinal-vein straight............................**Merapioidus** Bigot.

Merapioidus villosus Bigot., Bul. Soc. Ent. Fr. 1879, p. 64. Georgia!

ss.—Antennæ longer than the head, second and third joints swollen, terminating in a short thickened style; third longitudinal vein strongly angulated, emitting a stump of a vein into the first posterior cell...**Ceria.**

Table of species :

a.—Antennal projection of the front very short ; first joint of antennæ nearly as long as last two together.......................* *signifera.*

—Antennal projection nearly as long as first joint of antennæ, the latter scarcely longer than the second joint.

b.—Second, third and fourth segments of abdomen each with two yellow spots and posterior margin....................* *pictula.*

—Abdomen without such spots, banded.

c.—Second segment of abdomen much shorter than the third ; front of female black with yellow spots...........*abbreviata.*

—Second segment of abdomen nearly as long as third ; front of female yellow below, black above..............*tridens.*

CERIA TRIDENS Lw., Cent. x, 57. Loew's description applies very well to a single male specimen from Southern California, except that the cheeks are wholly black, and the hind tarsi yellow at the base. Other specimens from Washington Territory, however, that are apparently of the same species, have the anterior and middle femora black, except the extreme tips, the posterior black, except at the base, the tibiæ fuscous near the outer ends, one of the pleural spots and the supra-alar vittula entirely wanting. The female differs in the front being black on the upper two-thirds ; the second and third segments of the abdomen strongly marked with whitish pollen, and the legs almost wholly yellow, the anterior femora being blackish in front, the posterior lightly fuscous near the tip. A female *abbreviata* taken with a male at New Haven, has its legs yellow also with fuscous markings of the femora ; the front is black with four small yellow spots.

Stated Meeting, June 16, 1882.

Present, 4 members.

President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from C. E. Rawlins, dated Rockmount, Ramhill, England, May 12, 1882.

Mr. P. H. Law accepted his appointment to prepare an obituary notice of the late Mr. Vaux, by letter dated May 23, 1882.

A request for exchanges (to be dated back at least to 1875) was received from the Société Zoologique de France, No. 7 Rue des Grands Augustins, Paris, in a letter dated May 27, and signed H. Pierson, Sec. Adjt. On motion the Librarian was directed to send full sets of Proceedings and Transactions to the Society.

A request for exchanges was received from the Leander McCormick Observatory of the University of Virginia. Action postponed.

A letter of envoy was received from Dr. B. A. Gould, Cordova.

Letters of acknowledgment were received from the Public Library of N. Bedford (110); the R. Institution, London (109), and the Wyoming Historical and Geological Society (75, 77, 88, 99).

Donations for the Library were received from the Mining Surveyors at Melbourne; Prague Observatory; Dr. A. Tischner, Leipsig; Dr. G. D. E. Weyer in Kiel; Turin Academy; Academia dei Lincei; Geographical Societies in Paris and Bordeaux; London Astronomical Society; London Nature; British Topographical Society; Mr. Chas. Edward Rawlins, Jr.; R. Geological Society of Cornwall; Boston Natural History Society; Middlesex Institute; American Journal of Science; American Museum of Nat. History; Chas. W. Shields, D.D.; Buffalo Young Men's Association; New Jersey Historical Society; Philadelphia Academy Natural Sciences; Zoölogical Society; Engineers' Club; Journal of Pharmacy; Mr. H. C. Lewis; American Pharm. Association; Penna. Magazine; American Chemical Journal; American Journal of Mathematics; Peabody Institute; U. S. National Museum; Fish Commission; G. M. Wheeler (U. S. Geographical Surveys); University of Virginia; Missouri Historical Society; Ministerio de Fomento; Revista Mexicana; Observatory at Cordova (B. A. Gould); American Philosophical Association.

The death of W. B. Rogers, at Boston, May 30, aged 77, was reported by the Secretary; and Dr. R. E. Rogers was appointed to prepare an obituary notice of the deceased.

The following communications were made:

"Revision of the Dermestidæ of the United States," by Horace F. Jayne, M.D., with 4 plates.

"Radiant Heat an Exception to the Second Law of Thermodynamics;" by H. T. Eddy, Ph.D., University of Cincinnati.

Pending nominations Nos. 959, 960, 961, and new nominations Nos. 962, 963 were read.

C. G. Ames was appointed by the President in the place of the late S. W. Roberts as a member of the Committee on the Hall.

And the meeting was adjourned.

Radiant Heat an Exception to the Second Law of Thermodynamics.

By H. T. Eddy, Ph.D., University of Cincinnati.

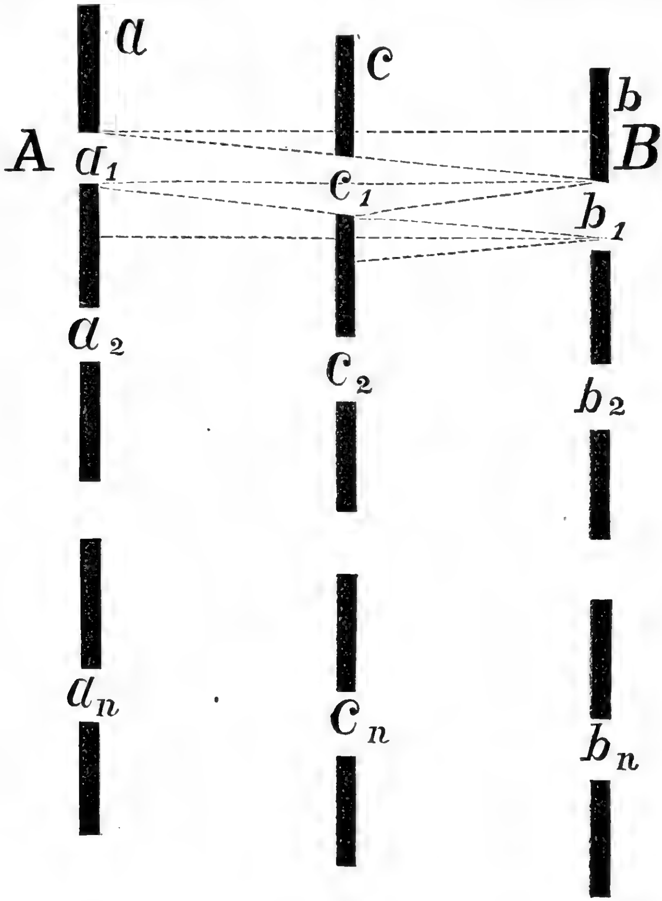
(*Read before the American Philosophical Society, June 16, 1882.*)

Since the radiation of heat takes places by propagation through space at a certain finite velocity and not instantaneously, it is quite possible for occurrences to intervene during the exchange of radiations between two bodies such as to essentially change the distribution of heat which would otherwise have ultimately taken place.

To make this evident, let us employ first a mechanical analogy. In the accompanying figure, let there be three parallel screens, a, b and c, the latter between the two former and all three perpendicular to the plane of the paper. Let them be pierced respectively by series of equidistant apertures $a_1\ a_2\ .\ .\ .\ a_n$, $b_1\ b_2\ .\ .\ .\ b_n$, $c_1\ c_2\ .\ .\ .\ c_n$, situated in the plane of the paper, and let these apertures be so placed that $a_1\ b_1\ c_1$ are upon one straight line, not quite at right angles to the screens; then are $a_2\ b_2\ c_2$, etc., and $a_n\ b_n\ c_n$ upon lines parallel to $a_1\ b_1\ c_1$. Now conceive the screens $a\ b\ c$ to have a common uniform velocity u in the direction from the c_2 to c_1.

Also let a series of projectiles be discharged from any fixed position A at the left of the screen a at such instants as to pass the first one through the aperture a_1, the second through a_2, etc., and let the direction of discharge be perpendicular to the screens, and the velocity v such that each one shall just reach the screen b in time to pass through the first aperture of that screen which crosses its path. Then would the screens $a\ b\ c$ in no way interfere with the passage of these projectiles. Let us denote the space at the left of a as the space A, and that at the right of b as the space B. Then if there be a continuous discharge of projectiles from all points of the space B, only a part of them can pass through the apertures of a. Such however as succeed in passing a will pass b and c also.

Again, let a second discharge of projectiles take place from the space B but directed toward the left perpendicularly to the screens, so that these projectiles move in a precisely opposite direction from those first mentioned. Let the projectiles from B have the common velocity v'. Such of these projectiles as succeed in passing through the apertures of b will impinge on c at points between its apertures, in case c be placed at a proper distance from b. Let the surface of c which faces b be perfectly reflecting, and let the parts between its apertures be either concave or a series of inclined



planes so directed that each of the projectiles on rebounding will pass back through one of the apertures in b. When the velocity v' of the projectiles is large compared with that of the screens u, the projectiles can be made to return through b very nearly perpendicularly, either by returning each projectile through that aperture from which it started or through some following one.

The paths of the projectiles relative to the screens can be readily found by impressing upon the projectiles, in addition to their velocities v or v', a velocity $-u$, numerically equal and opposed to that of the screens, while the screens themselves are at rest. The composition of these velocities will give the required relative velocity.

In order to apply the mechanical analogy just considered to the case in hand, let us replace the supposed projectiles by radiations which emanate from warm bodies situated in the spaces A and B, and let the only radiations at first considered be those in a direction perpendicular to the screens.

It is then evident that with such series of apertures as are represented in the figure the screens a b c could be given such a velocity u, as accompanied by reflections from c would transfer radiations from the body A to B unaccompanied by a compensating transfer from B to A, and thus the body B would be heated at the expense of A. Even if radiations at the apertures in a and b be not confined to rays perpendicular to the screens, but take place instead in the manner usual at plane surfaces, it is still evident that the usual interchange of radiations has been effectively interfered with, and that the body B would be heated at the expense of A. In case the radiations from the body B are reflected back through the same apertures from which they started, it is quite unnecessary to have the series of apertures in the screen a at equal distances. It is only necessary that the series of apertures in b and c correspond to that in a. Indeed each aperture in b can be conceived to be completely surrounded by a concave semi-cylindrical reflector attached to c, of such a form as to return to b all radiations from it when moving with the velocity u. This can certainly be effected if the apertures in b are mere points and can be closely approximated to when they are small. Now, if there be in this cylinder a proper aperture for the admission of the normal radiations from A through a, it is evident that the radiations passing through this aperture from B, being oblique, are, when the bodies are of equal temperature, less than those of A passing through the same aperture, according to the well known law of radiations, that the intensity is proportional to the cosine of the angle between the ray and the normal to the radiating surface. It is seen that with sufficiently large value of u, it would be possible to overcome any difference of temperature however great.

In order to form an estimate of the amount by which the radiation from A to B exceeds that escaping from B through c, let us suppose that the temperature of A and B are equal and that the velocity v of the radiations, from both A and B is the same, and further, let the screen c be midway between a and b at a distance p from each. Let the problem be to compute the ratio between the radiations which pass through a given aperture, as c_1, from a_1 and from b_1 respectively, on the supposition that the heat radiates from the equal apertures a_1 and b_1 as from plane surfaces in the usual manner.

Suppose that the linear dimensions of the apertures are infinitesimal compared with p, and let the letters a_1 b_1 c_1 considered as numerical magnitudes designate the areas of the apertures a_1 b_1 c_1 respectively. Let θ be the angle between a ray and the normal to the surface from which it radiates. Let a sphere of radius p be supposed to be described about some point of b_1 as a center, and let s be the area of that part of its surface included within the cone of rays passing from the center to the periphery of the aperture c_1;

then $$\frac{s}{p^2}=\frac{c_1}{r^2}\cos\theta \qquad (1)$$

in which r is the distance passed over by the ray from b_1 to c_1.

Also $$p=r\cos\theta \qquad (2)$$

therefore $$s=c_1\cos^3\theta \qquad (3)$$

Now the heat radiated from b_1 is directly proportional to the area b_1, to the area s and to $\cos\theta$, but inversely proportional to p^2; hence

$$\frac{b_1\, s}{p^2}\cos\theta=\frac{b_1\, c_1}{p^2}\cos^4\theta \qquad (4)$$

is proportional to the heat radiated from b_1 through c_1.

Similarly $$\frac{a_1\, c_1}{p^2} \qquad (5)$$

is proportional to the heat radiated from a_1 through c_1 since it passes c normally. Now the heat passing from b_1 to c_1 must evidently move in a direction to overtake the aperture c_1, and to do this it must evidently take a direction such that θ is defined by the equation

$$\tan\theta=\frac{2u}{v},\ \text{ or }\ \cos^2\theta=\frac{v^2}{v^2+4u^2} \qquad (6)$$

Hence by comparing expressions (4) and (5), and substituting from (6) it appears that the heat radiated from a_1 through c_1 is greater than that radiated by an equal surface b_1 through c_1, in the ratio of $(v^2+4u^2)^2$ to v^4, in case the temperatures of a_1 and b_1 are equal. If the temperature of a_1 were lower than that of b_1 this ratio would be diminished; but by increasing u, the ratio can still be made to exceed unity, thus confirming the observations previously made. Neither is it essential that the radiations all take place at the same velocity. The reflectors can be arranged for some one velocity and they will then send back the radiations to B which have that velocity.

Perhaps the most simple ideal arrangement for effecting the proposed interference with the radiation naturally taking place between two bodies, is to suppose the apertures distributed around the circumference of equal circles upon three parallel disks fixed upon a common central axis, so that the plane of the paper in the figure becomes the surface of a circular cylinder, in which case the required velocity u can be given to the apertures by simple rotation. Let us, for brevity, call such an arrangement a *radiation syren*, or simply a *syren*, as it slightly resembles in its mechanical details the acoustic instrument called by that name.

Now, theoretically, no expenditure of energy is necessarry to preserve the uniform velocity of the moving parts of this syren, and once started with a sufficiently high velocity of rotation and proper adjustment of reflectors it would transfer heat from the body A to B regardless of their *temperatures*, provided no radiations are permitted except those perpendicular to the disks, excluding of course all radiations to and from all bodies other than A and B. It would also, as before shown, transfer heat from a colder body to a hotter, even though the radiation follow the general law of radiations from plane surfaces.

It is needless to state that the action of the syren, regarded as a possible physical process, is directly at variance with the hitherto accepted axioms and conclusions respecting the second law of thermodynamics.

It is true, we should at first thought be inclined to the belief that the laws of heat should suffer some modification, in case we assume differing rates of propagation not infinite, but we should hardly be prepared to admit the startling conclusions which must flow from such modification, if the physical process just sketched be admitted to be valid, and these I shall now proceed to develop.

I think it may be readily perceived that the axiom of Clausius, upon which he founds the second law, viz. : that "heat cannot of itself pass from a colder into a hotter body," when applied to radiations, implicitly assumes that the heat is radiated with infinite velocity, for it takes no account of the states of relative rest or motion of the bodies between which heat passes.

The axiom of Thomson, "it is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of surrounding objects," is obnoxious to the same criticism, and, as I have stated elsewhere,* these should not be called *axioms* at all, since we are not in a position to bring sufficient experience to bear upon them to affirm their validity or want of validity. Indeed, if the process of the syren be admitted to be possible, we are now in a position to assert that there exists an unexplained contradiction, which does not permit us to consider them as applicable to radiations of heat propagated at finite velocities.

What, it seems to me, the just quoted statements of Clausius and Thomson really asserted, was the historical fact, that at the date when they were made, no one had as yet invented any machine, or discovered any principle on which it was possible to construct a machine, which could successfully accomplish what these said had not been done ; and it was further implied that no such machine could probably ever be invented nor any such principle discovered.

In complete accord with this statement is that of Kirchhoff, made in his lectures upon the Theory of Heat, during the summer semester of 1880, in which he said, if correctly reported, that the second law cannot be (at

*Thermodynamics, New York, 1879.

present) proved, but it, so far, has never been found in disagreement with experience.

It is well known that Maxwell has proposed a process to accomplish this very object, namely to transfer heat from a colder to a hotter body, in the following manner: If we suppose minute beings, endowed with senses sufficiently acute and having a corresponding agility, to guard minute openings in the diaphragm separating two portions of the same gas, which openings are only large enough for a single molecule to pass at once, they would be able without expenditure of energy to open and close the openings in such a way as to allow each molecule impinging at an opening to pass through or not, as they should choose. If they permitted only those molecules having more than the mean vis viva to pass in one direction and only those having less than the mean to pass in the opposite direction, then the gas on one side of the diaphragm would gain energy at the expense of that on the other side. That this process is actually at present beyond human ability does not show that we may not at some future time be able to accomplish what Maxwell proposed. If this be admitted, then the conclusions which I shall draw later from lack of generality in the second law of thermodynamics flow to a limited extent from the possibility of this process.

But Maxwell's process assumes the kinetic theory of gases as its basis, and stands or falls with it.

And if the second law is a necessary ultimate mechanical principle, holding for all bodies great and small, the above consequence of the kinetic theory of gases being in contradiction to the second law is fatal to the validity of the kinetic theory. But I do not now so regard the second law. I am compelled to regard it as merely an approximation in the case of radiations, and to regard it in general, with Maxwell and with Boltzmann,* as merely the mean result flowing from the laws of probability; though it had previously seemed to me possible to show it to depend upon fundamental considerations respecting the nature of heat as a form of energy, as was stated in my work previously referred to.

To avert to the consequences which are thus made to flow from the established fact of the finite velocity of radiant heat, we may mention that if the law of the dissipation of energy is no longer to be regarded as of universal validity, it being obviated by the process of the syren, it is just as possible to avail ourselves of the heat stored in cold bodies as in hot ones, and thus to employ the heat of a glacier to drive a steam engine, or to perform other like feats heretofore regarded as impossibilities. When I say it is just as possible, I do not imply that it is now just as practicable, or perhaps ever will be so.

That these observations are just, is seen when we reflect that the process of the syren simply heats a given body at the expense of any other, regardless of temperatures, by a method requiring the expenditure of no

*Weir. Sitzb. Band. lxxvi, lxxviii.

energy. It thus appears that it is possible to avail ourselves of the heat existing in bodies below the lowest thermometric levels of surrounding objects.

It may be objected that the syren renders a perpetual motion a possibility. That depends upon the definition of perpetual motion which we adopt. In the popular acceptation of that term, the process of the syren, as well as that of Maxwell, would make something near that possible. But when correctly viewed, the process of the syren does not imply the possibility of a perpetual motion, any more than does combustion or using the available energy of any chemical process.

It simply proposes to employ the finite amount of energy, existing in a given body in the form of heat, in a given way. It is admitted by all, that this heat could, a part of it, be made to do work by parting with some of it to a cooler body. The question is, whether this last part which has been imparted to the cooler body can be restored or transferred to the warmer body again without the expenditure of energy. Rankine evidently believed such a transfer possible, for in a paper on the "Reconcentration of the Mechanical Energy of the Universe,"* he has supposed it possible to reflect radiations in such a way as to give the universe such differences of temperature as to ensure it a new lease of life. Clausius, in his admirable paper on the "Concentration of Rays of Light and Heat,"† has shown the general impossibility of such a reconcentration as Rankine supposed, when the radiating bodies are at rest; nevertheless, no such impossibility may finally appear in case of the actual universe, which is a system of moving bodies.

The law of the dissipation of energy has been applied to the universe at large, and if the consequences which have been drawn from its supposed validity are to be regarded as no longer expressing a necessary law, then we are led to affirm that without change in the laws of nature as at present known to us, it is possible for increasing differences of temperature to be caused without the expenditure of energy, however improbable the supposition may be that such is the fact, and however improbable it may be that such differences are actually being caused on a scale sufficient to interfere in any practical way with the progress of the dissipation of energy as affirmed by Thomson, or check the increase of the entropy of the universe as stated by Clausius.

Still, it may be remarked, that a large part of the exchange of heat in the universe takes place in the radiant form; and it seems to me that it remains to be proved what the fact actually is, and consequently I must regard it as still an open question as to whether, on the whole, the available energy of the universe is being dissipated and its entropy increased or not.

Lest the foregoing remarks should be construed as in any sense undervaluing the splendid discoveries of Clausius, Thomson and Rankine in the

*Phil. Mag., Series iv, Vol. iv.

†Mech. Th. of Heat, Chapter xii.

domain of thermodynamics, let me disclaim such an interpretation entirely, and say that my only wish is to add, if possible, to the exactness and completeness of those theories, which are among the most important of modern physics.

Cincinnati, April 22d, 1882.

[NOTE.—Professor Willard Gibbs has suggested to me that we are not at liberty to assume that reflections or radiations taking place at moving surfaces, follow the same laws as from surfaces at rest; and that a perfect reflector moving in a medium through which luminous waves are being propagated, may suffer a resistance which would require the expenditure of as much energy as could be obtained by the proposed process. Admitting for the moment the justness of these observations respecting reflections and radiations from moving surfaces, I shall hope to show in the first place that the syren may be so adjusted that no such resistance need be encountered, and in the second place that it is possible so to modify the syren that no reflections or radiations need take place from moving surfaces.

In the discussion of the first point, let us consider the case of a ray falling perpendicularly upon a perfect reflector. The only numerical magnitudes susceptible of variation in this radiation are its wave length and amplitude, the velocity being assumed constant and dependent upon the elasticity of the medium. When the reflector moves in its own plane at right angles to the ray, it cannot, apparently, be seriously urged that the reflected ray will have either its wave length or its amplitude changed by the reflection. For, so far as can be seen, the wave length would suffer a change and be shortened only by giving the reflector a motion towards the approaching ray, thus crowding the waves together. Neither would the amplitude be changed, for to do this would require the moving plane to impart tangential impulses to the ether such as can be compounded with the transverse motions already existing. If such be the tangential action of the moving plane on the ether, we should be led to the apparently inadmissable result, that since a moving plane may impart tangential impulses to the lumniferous ether, a disk rotating with sufficient velocity in vacuo would become self-luminous. It would seem but reasonable in our present imperfect knowledge of the subject to conclude that the only resistance which a perfect reflector experiences, while moving against a ray, is normal to its surface, and to be represented by a normal pressure. Even if this view be not regarded as entirely correct, it may nevertheless be confidently affirmed that the tangential must be small compared with the normal resistance, just as the fractional resistance of a gas is small compared with that arising from direct pressure upon a body moving through it. Hence, it is seen, that in spite of friction it is possible to make a ray turn a mill whose vanes are perfect reflectors in the same manner as the wind turns a windmill; and the energy expended will in that case be withdrawn from the ray itself.

Now the rotating screen c of the syren may be regarded as such a mill, the surfaces of whose vanes may be so inclined as to return radiations coming from B partly to apertures in front of those from which they emanated and partly to those behind, so as to exert no force either to accelerate or retard c.

Should, however, energy be expended in moving c against the reflected ray, this energy must exist immediately after the reflection in the reflected ray and be transmitted by it to B. Hence we are led to the following remarkable result:—on the hypothesis that radiations cause pressure at surfaces at which they suffer total reflection, a part of the energy of the radiation may be expended in moving the reflector against a resistance while the remainder is all reflected to the body from which it emanated. It is to be noticed that this process of the *reflecting mill* or *mill* as it may be called for brevity, is, if possible, in more pronounced and unequivocal contradiction to the second law than that of the syren.

For the latter calls in question the accepted law of mutual exchanges and the second law as depending upon it, but the former applies to a single body alone as B, and a moving reflector. For example, let B have no radiations except those through the apertures b, then if that part of its radiations which are not expended in turning c are returned to it, it is possible for the mill c to be turned by radiations from B until the energy of B is all expended in performing work, thus withdrawing all heat from B while no heat has been transferred to any other body in the manner required by the second law, and this regardless of the temperature of surrounding objects. It therefore seems to me that the supposition of a pressure at reflecting surfaces is more directly opposed to the second law than that of no pressures.

In regard to the second point mentioned, it seems quite possible to construct a syren such that the reflections in it shall all take place from stationary surfaces, or from those whose velocity differs from zero by less than any assignable quantity. For let the mean velocity u of the screens be the same as before, but not continuous. Instead, let it consist of sudden steps forward, each of which is half the width of an aperture. The possibility of a mechanical arrangement which could effect this motion, without expenditure of energy, with the aid of perfect springs, fly-wheels, detents, etc., to any required degree of approximation will, I think, be admitted, certainly by any one who can admit that Maxwell's "sorting demon" expends no energy in opening and closing apertures.

It will be seen that the reflections all take place from screens at rest (or nearly so) in this modified syren, and that the same transmissions occur through its apertures as have heretofore been supposed to take place.

I am not inclined, however, to insist on the special kind of apparatus which I have proposed for rendering sensible the phenomenon which I believe to exist during the time in which the radiations are in process of becoming established, as contemplated in the ordinary law of thermal exchanges. The point to which I would emphatically direct attention is that since radiations are known to be moving in space apart from ponderable bodies and subject to reflections, it is possible so to deal with them as to completely alter their destination and successfully interfere with all results flowing from Prevost's law of exchanges. It also seems to me that the exactness of the second law of thermodynamics depends, as far as radiations are concerned, upon that of this law of exchanges.

Cincinnati, May 18th, 1882. H. T. E.]

Revision of the Dermestidæ of the United States. By Horace F. Jayne, M. D. *(With four Plates.)*

(Read before the American Philosophical Society, June 16th, 1882.)

Many years have elapsed since the small family of Dermestidæ, as represented in our fauna, has received careful study. The addition of new genera and species, and the confusion existing among those already well established, have suggested that a review of the entire field, in the light of modern entomological progress, would be useful to the student. In the following pages differences of structure have been recognized, as far as possible, as the only true and constant characters by which to separate species. The arrangement of genera is, substantially, that already well known, save only the necessary alterations incident to the introduction of two new genera. The specific classification is, almost entirely, original. Dr. LeConte, in addition to very many other favors, has kindly offered, in my absence, to read the proof of the following pages.

DERMESTIDÆ.

Head variable in size, deflexed; front variable in width, a single ocellus, or simple lens, at middle, except in Byturus and Dermestes; epistoma usually very short, coriaceous, on the same plane as the front except in Axinocerus, in which it is long and retracted; labrum distinct, mandibles short, simple, except in Byturus in which they are dentate, maxillæ with the base exposed, with two lobes of variable form, palpi small, slender, four-jointed; mentum quadrate, usually corneous; ligula simple, palpi three-jointed. Eyes usually prominent—exceedingly in Byturus—moderately coarsely granulated, rounded, entire, except in certain species of Trogoderma, Anthrenus and Orphilus, where they are more or less deeply emarginate in front.

Antennæ inserted in front of the eyes, usually eleven-jointed, variable in Anthrenus, nine-jointed in Dearthrus, ten-jointed in a foreign genus, Hadrotoma; terminated by a large club, which is quite strongly serrate in Acolpus and Trogoderma ; made up, usually, of three joints, of a variable number of joints, however, in Perimegatoma, Acolpus, Trogoderma, and Anthrenus, of two joints in Cryptorhopalum and some foreign genera, and of one, enormous, securiform joint in Axinocerus.

Prothorax short, with side pieces not separate, excavated beneath for the reception of the antennæ, except in Byturus, Attagenus, Dearthrus, Perimegatoma, Acolpus, and one foreign genus—Trinodes. In Anthrenus the antennal fossæ divide the anterior part of the lateral margin ; coxal cavities large, transverse, closed behind by the mesosternum, except in Byturus ; prosternum prolonged behind and usually lobed in front.

Mesosternum narrow and entire in Byturus and Dermestes ; narrow and emarginate in front, or entirely divided, in Dearthrus, Perimegatoma and two foreign genera—Megatoma and Hadrotoma ; wide and entire in Apsectus and Orphilus ; wide and deeply emarginate, or entirely divided in the remaining genera ; metasternum short, rounded or truncate in front or narrowly produced between the mesocoxæ ; side pieces wide, except in Byturus. Elytra covering the abdomen, not striate, except faintly in certain species of Dermestes. Sides more regularly oval in the females ; epipleuræ not extending beyond. Abdomen with five free ventral segments.

Anterior coxæ conical, prominent, with small trochanter ; middle coxæ oval, oblique, excavated externally, with large trochantin—usually distant, approximated in Byturus, Dermestes, Attagenus, Dearthrus, Perimegatoma and two foreign genera—Megatoma and Hadrotoma. Posterior coxæ slightly separated, transverse, not extending to the margins of the body, except in Orphilus, dilated into a plate partly protecting the thighs. This coxal plate shows a beautiful series of variations ; in Byturus it is almost obsolete ; in Dermestes and Attagenus very long, narrow, obliquely truncate externally ; covering only the basal half of the femur ; in genera from Dearthrus to Apsectus, inclusive, it is moderately long and wide, covering more than the basal half of the femur, not obliquely truncate externally, while in Orphilus it is short and wide, covering the anterior part of the femur for its entire length.

Legs short, somewhat contractile, tibiæ with distinct stout spurs ; tarsi five-jointed, pubescent, except in Byturus, where the second and third joints are lobed beneath, first joint either short or long, equaling the fifth, 2–3–4 always short, fifth always long, claws simple, except in Byturus, in which they are dentate.

Two sub-families may be thus separated :

Tarsi with second and third joints lobed beneath, claws strongly toothed at base, mandibles toothed. Anterior coxal cavities closed behind by the prosternum.................................. **BYTURIDÆ.**

Tarsi, claws, and mandibles simple. Anterior coxal cavities completed behind by the mesosternum... **DERMESTIDÆ.**

Sub-Family I.—Byturidæ.

BYTURUS, Latr.

Head very large, front as wide as long; no frontal ocellus. Mandibles furnished with several teeth; eyes very prominent, very large, coarsely granulated, round, entire; epistoma very short; antennæ 11-jointed, terminated by a three-jointed club. Thorax nearly as long as wide, anteriorly more than half as wide as at the base, which is somewhat bisinuate, disc convex; sides flattened, especially posteriorly, arcuate; hind angles rounded. Scutellum large, quadrate. Elytra three times as long as wide; sides sub-parallel, apical angles acute. Prosternum very short and wide, not lobed in front, tip narrowly and sharply produced; continuous around and behind anterior coxæ, enclosing them. Anterior coxæ prominent, slightly separated by the top of the prosternum. No antennal fossæ, spaces between prosternum and lateral margins broad, slightly concave. Mesosternum entire, broad and long, prolonged narrowly behind between the middle coxæ which are almost approximated. Metasternum short, side pieces wide (fig. 1).* Legs stout, femora attaining sides, slightly grooved beneath for the reception of the tibiæ, tibiæ stout, terminal spurs strong. First joint of tarsus triangular, 2–3 prolonged beneath into a membranous lobe, 4 small nearly concealed by 3, 5 as long as the four preceding together; the terminal claws are armed with a large basal tooth (fig. 3).

This genus, which is represented by two species—one from the Atlantic district and one from the Pacific—differs greatly from all the rest of genera in the family by the toothed mandibles, the absence of antennal fossæ; the anterior coxal cavities completed behind by the prosternum; the exceedingly large entire mesosternum, the feebly developed posterior coxal plates, the tarsus with second and third joints lobed beneath, and by the strong tooth of the ungues. There can be no doubt as to the position of this genus; its affinities with the rest of the Dermestidæ are marked. Erichson, however, placed it in the Melyridæ, DuVal among his Telmatophilidæ and Crotch in the Nitidulidæ. Redtenbacher and Lacordaire assign it to the present family.

Our two species may be distinguished as follows:—

Elytra uniformly light brown; antennal club compressed, second and third joints much wider than long; eyes very large and prominent; thorax coarsely punctate.......................... **unicolor.**

Elytra marked by three transverse black bands; antennal club elongate, second and third joints fully as long as wide; eyes smaller, less prominent; thorax finely punctate.................................. **grisescens.**

* The posterior coxæ are short and wide, but do not attain the sides, the coxal plates are very feebly developed, not covering the femora (fig. 2).

B. unicolor Say. Elongate, moderately convex, light brown, clothed with moderately long, semi-erect, yellow-cinereous pubescence; elytra uniformly light brown; head coarsely punctate, sparsely pubescent; eyes very large and prominent, black; antennæ nearly as long as the thorax, 11-jointed; first joint, large, round; second smaller; 3–8 decreasing gradually in size, wider than long; 9–10 subequal; 11 longer and rounded at tip; the last three joints forming a somewhat compressed club, which equals one-third the entire length of the antennæ; thorax brown, coarsely and densely punctate, pubescence long, dense at sides; scutellum glabrous; elytra uniformly brown, very coarsely and densely punctate, covered with moderately dense, long, semi-erect, yellow-cinereous hairs; body beneath also brown, pubescence short and recumbent; legs testaceous. (Figs. 1, 4.) Length 18 inches; 4.5mm. Habitat, Atlantic region.

B. grisescens Lec. Elongate, moderately convex, brown, covered with moderately dense, long, recumbent, yellowish-gray pubescence, antennæ, legs, and abdomen rufo-testaceous; elytra light brown marked with three broad transverse bands of black; head finely and sparsely punctate; eyes moderately large and prominent; antennal club elongate, second and third joints as long as wide; thorax finely and densely punctate; elytra moderately coarsely and densely punctate, brown, marked with three equally separated transverse black bands, of which the first is the faintest, and directed obliquely backward and outward, the second wider and darker, also directed backward and outward, but with a large sutural light brown spot; the third or apical band is distinct and directed forward and outward (Figs. 5, 6).

Length 12 inches; 3 mm. Habitat, California.

A smaller and darker species easily recognized by the characters already given.

Sub-Family II.—Dermestidæ (Genuini).

This sub-family, which is distinguished by the characters already given, is represented in our fauna by the following genera:

No frontal ocellus............................	**DERMESTES.**
Frontal ocellus distinct.	
Mesosternum narrow, middle coxæ not widely separated.	
Prosternum simple in front.	
Antennæ 11-jointed, mesosternum only deeply sulcate anteriorly, posterior coxal plate long, obliquely truncate externally	**ATTAGENUS.**
Antennæ 9-jointed, mesosternum narrowly divided, posterior coxal plate short, not obliquely truncate externally....	**DEARTHUS.**
Prosternum lobed in front.................	**PERIMEGATOMA.**

Mesosternum broad, emarginate in front or entirely divided, receiving the tip of the prosternum, middle coxæ widely separated.
  Mandibles and labrum not covered by the prosternum.
    No antennal fossæ........................ **ACOLPUS.**
    Antennal fossæ distinct.................. **TROGODERMA.**
  Mandibles covered, labrum not covered by the prosternum.
    Antennal fossæ under lateral margin of thorax. Body pubescent.
      Front rather flat, clypeus continuous on the same plane. Antennal club of at least two joints............. **CRYPTORHOPALUM.**
      Front convex between the eyes, clypeus forming an angle with the front, retracted. Antennal club of one large, broadly securiform joint..... **AXINOCERUS.**
    Antennal fossæ dividing the anterior part of the lateral margin of the thorax. Body clothed with scales............ **ANTHRENUS.**
Mesosternum broad, entire. Middle coxæ widely separated. Mouth parts covered by sternum, prosternum truncate behind. Posterior coxæ not prominent, not reaching the sides. Body covered with very long, erect hair........................ **APSECTUS.**
  Mouth parts covered by anterior legs, prosternum pointed behind. Posterior coxæ attain the sides. Body naked, shining.. **ORPHILUS.**

DERMESTES Linn.

The species grouped together in this genus are the largest and most conspicuous of the entire family. They are all elongate in form, black, more or less pubescent. The head is small and can be retracted within the thorax; the eyes large and, in all our species, entire. No frontal ocellus. The antennæ are 11-jointed, the last three joints being large, prolonged on their outer side, and forming an irregular club (fig. 7), which does not differ either in the species or sexes. The thorax in the first group —including six species—is very convex in front, and the anterior portion of the lateral margin cannot be seen from above, while in the second group—*pulcher, lardarius, cadaverinus* and *elongatus*—it is less convex, the entire lateral margin being visible. The base is broadly lobed; in the first group, impressed with a median fovea, conspicuous in *marmoratus*, hardly apparent in *fasciatus;* in the second group with two, widely separated, basal pits, thus linking this genus, and through it the entire family, with the *Mycetophagidæ.* The thorax is either covered with mixed brown, black and white pubescence, or is uniform in coloring; *mucoreus* and *vulpinus* have a large median triangular naked space on the upper surface. The scutellum is small, but distinctly visible. The elytra are elongate, sides slightly rounded, except in *elongatus*, where they are sub-parallel; pubescence quite dense, except in *pulcher* and *mucoreus*. The prosternum is very short, not lobed in front, prolonged behind into a short, acute point, not reaching beyond the anterior coxæ, which are large and almost contiguous. The antennal fossæ, moderately deep and well defined, are situated transversely in the anterior half of the spaces between the prosternum and lateral margins (fig. 8). The mesosternum is entire, narrow and short, not reaching beyond the middle of the meso-coxæ, which are not widely separated, the metasternum being prolonged anteriorly to meet it. The latter is short, the side pieces wide. The posterior coxæ do not attain the sides of the body, and the coxal plates are long and narrow, covering the basal half of femora, obliquely truncate externally (fig. 9). The abdomen is clothed with dense whitish pubescence (except in *pulcher*, *bicolor* and *cadaverinus*), and then bears a row of black spots on each side, except in *sobrinus*, which has two such series. The males have the third and fourth ventral segments marked by a small median pit, from which arises a bunch of brown, erect hairs. The male of *vulpinus* however, has only the fourth segment so characterized. The legs are stout, the femora, in the species of the first group already referred to, annulated at middle with white pubescence, but *mucoreus* has the basal half of thighs covered with white hairs. The first four joints of the tarsi are equal, the fifth as long as all the preceding taken together.

The species may be separated by means of the following table:

I. Males with third and fourth ventral segments each marked by a median pit from which arises a bunch of erect brown hairs.

Anterior portion of lateral margins of thorax not visible from above. Base with median puncture.

Femora annulated with white pubescence, thorax entirely pubescent.

Pubescence on upper surface variegated, a single series of lateral black spots on abdomen.

Elytra with broad basal band of yellowish cinereous pubescence.................................... **marmoratus.**

Elytra with broad sub-basal band of yellowish cinereous pubescence............................ **fasciatus.**

Elytra marmorate;

With yellowish cinereous and black pubescence. Scutellum not conspicuously lighter .... **murinus.**

With dark bluish cinereous, ochre and black pubescence. Scutellum conspicuously lighter... **talpinus.**

Pubescence on upper surface uniform, two series of lateral black spots on abdomen.................... **sobrinus.**

Femora with basal half clothed with white hairs. Elytra with broad basal rufous band, thorax with a large triangular naked spot at middle .... **mucoreus.**

Entire lateral margin of thorax visible from above. Base with two punctures. Legs not annulated.

Thorax and base of elytra red, covered with orange-red pubescence .... **pulcher.**

Basal portion of elytra rufous, bearing yellow pubescence, including three black spots......................... **lardarius.**

Thorax and elytra uniform in color, very elongate, striæ on elytra distinct, pubescence on abdomen cinereous, no series of lateral black spots...................... **elongatus.**

Not markedly elongate, striæ on elytra very faint, pubescence on abdomen white, and series of lateral black spots.. **cadaverinus.**

II. Male with the fourth ventral segment marked by a median pit. Anterior portion of lateral margins of thorax not visible from above. Color above uniform. Thorax with a large triangular naked spot at middle. One series of lateral black spots on abdomen. Legs not distinctly annulated.................................... **vulpinus.**

D. marmoratus Say. Oblong, convex, black, quite densely pubescent. Elytra black, mottled with ochre, black and cinereous pubescence, and bearing a large sub-quadrate spot just behind the base of cinereous. Head finely but densely punctate, pubescence semi-erect, dense, variegated, brown, black and white. Antennæ piceous, club fulvous. Thorax very convex anteriorly, basal half of lateral margin visible from above, sides suddenly narrowed at middle, finely and densely punctate, a deep fovea in middle of base, pubescence dense, variegated as on head, two lateral and a median small triangular white spots. Scutellum covered with sparse cinereous hairs. Elytra densely and finely punctate, faint striæ near apex, mottled with small transverse spots of fine recumbent brown, black and cinereous pubescence. A large irregularly quadrilateral cinereous spot on outer side just behind the base, the inner anterior angle of which is prolonged inward and forward to the scutellum. Body beneath black, clothed with long dense white recumbent hairs. Abdomen with a row of yellowish-black spots on either side. Last segment black, sparsely covered with fulvo-cinereous pubescence. Legs covered with dull brownish hairs, femora annulated at middle with white. Length .46 inch; 11.5 mm. (Fig. 10).

The largest species of the genus, and indeed of the entire family, which is found in our fauna. The large distinct basal, and the faint general cinereous spots on the elytra, the convex thorax, annulated femora, black spots on abdomen are the characters upon which to rely for a correct diagnosis. *Dermestes mannerheimi* Lec., appears to be only a variety in which the basal elytral spots are shorter and more confluent, while the transverse spots at middle and apex are wider and more distinct.

Occurs in the Western and Pacific States.

D. fasciatus Lec. Elongate, black, convex, quite densely clothed with black and cinereous pubescence. Elytra with a moderately broad sub-basal band, fine transverse mottlings of cinereous pubescence. Head moderately coarsely, densely punctate, pubescence semi-erect, dense, variegated fulvous and black. Antennæ piceous, club fuscous. Thorax very convex, lateral margins not visible from above, sides arcuate, densely and finely punctate, only a very slight depression at the middle of the base; pubescence dense, variegated, brown, black and cinereous. Scutellum covered with long, fulvo-cinereous, recumbent hairs. Elytra finely and densely punctate, striæ hardly apparent, pubescence black, marmorated with small, cinereous, transverse spots; a broad transverse band which does not reach the base also cinereous. Body beneath clothed with dense yellowish-white, recumbent pubescence, a single series of lateral black spots on abdomen, last segment black, except three white spots at base. Legs covered with dense brown hairs, femora annulated at middle. Length .32 inch; 8 mm. (Fig. 11.)

No difficulty will be encountered in recognizing this species; the broad, distinctly limited, transverse elytral cinereous band, which never attains the base, is characteristic.

Occurs in Colorado.

D. murinus Linn. Elongate, black, clothed with fine black and cinereous pubescence. Elytra black, covered with marmorate black and cinereous hairs. Head densely and moderately coarsely punctate, clothed with dense variegated hairs. Antennæ piceous, club fuscous. Thorax very convex in front, lateral margins not visible from above, sides arcuate; finely but densely punctate, a faint median basal depression, pubescence dense, variegated, a small white spot at middle. Scutellum clothed with cinerous hairs. Elytra black, densely and finely punctate, striæ indistinct, marmorate with fine sparse black, and coarser cinereous pubescence, the latter more dense at base. Body beneath black, clothed with long, dense, whitish yellow pubescence, abdomen with a row of black spots on each side, last segment black, marked with two white spots at base. Legs brown, femora annulated at middle with white. Length .22 inch; 8 mm. (Figs. 12, 13.)

This species is to be distinguished from the preceding by the irregularly mottled cinereous and black pubescence on the elytra, there being no distinct basal or sub-basal band. Two varieties can be recognized.

Variety a. In this the cinereous spots at the sides of the base of the elytra are confluent, the entire basal half appearing yellowish-white, except some black marking near the suture. (*Caninus* Germ.)

Variety b. The pubescence on the elytra is cinereous, faintly mottled with black. This form is smaller and more slender than the preceding, and was described by Dr. LeConte under the name *rattus*. I cannot, however, see anatomical characters by which it can be distinguished, the color of the pubescence not being sufficient, as all gradations through the first variety, up to a typical *murinus* are to be found.

Occurs in the Middle and Western States.

D. talpinus Mann. Elongate, convex, black, clothed with fine black recumbent hairs. Elytra black, covered with black pubescence, which is mottled with coarser ochre and gray. Head coarsely punctate, pubescence long, semi-erect, variegated. Antennæ fuscous. Thorax convex, anterior part of lateral margin not visible from above, sides arcuate; a not very distinct depression on base, finely and densely punctate, covered with bunches of variegated hairs. Scutellum clothed with coarse, recumbent, golden-yellow pubescence. Elytra black, densely and finely punctate, marked by a few faint striæ, pubescence black, marmorate with very small, transverse spots of ochre and gray. Body beneath clothed with long, recumbent, grayish-white pubescence, and a single series of lateral black spots on abdomen. Last segment entirely black, except two faint white spots, at base, on each side of median line. Legs clothed with brown pubescence; femora annulated at middle with white. Length .26 inch; 6.5 mm.

This species is to be distinguished from the foregoing mottled forms, by the almost black color of the pubescence on the elytra, and by the conspicuously yellow scutellum.

Occurs in the Pacific States.

D. sobrinus Lec. Elongate, convex, black, covered with short, sparse, fuscous pubescence. Elytra uniformly black, pubescent. Head moderately coarsely and densely punctate. Antennæ testaceous. Thorax convex, anterior part of lateral margin not visible from above, sides suddenly narrowed at middle, a very faint depression at middle of base, hind angles prominent, faintly and densely punctate, entirely pubescent. Scutellum densely punctate. Elytra finely and densely punctate, faint striæ just apparent, pubescence sparse and unicolored. Body beneath covered with long, dense, white, recumbent pubescence. Abdomen marked by two lateral and two sub-median longitudinal rows of spots of black pubescence. Legs clothed with dense brown hairs; femora annulated at middle with white. Length .32 inch; 8 mm.

The distinguishing characters of this species are found in the convex thorax, the uniform color of the pubescence on the upper surface, the four rows of abdominal spots and the annulated femora. Occurs in Texas—one specimen in Dr. LeConte's cabinet.

D. mucoreus Lec. Elongate, moderately convex, black, clothed with sparse black and cinereous pubescence. Elytra black, with a broad irregular basal band rufous, which bears sparse reddish-yellow hairs. Head moderately coarsely and densely punctate, pubescence cinereous and dense. Antennæ piceous; thorax very convex anteriorly, anterior two-thirds of lateral margin invisible from above, sides arcuate, basal fovea indistinct; finely and densely punctate, covered at sides, base and front with cinereous pubescence, leaving a large triangular spot at middle naked. Scutellum black, sparsely pubescent.

Elytra black, basal third rufous, bearing an irregular transverse band of yellowish hairs; pubescence black, with a transverse spot on each side of suture, at middle, and some faint mottlings; cinereous, under surface clothed with dense, white hairs. Lateral spots on abdomen distinct; last segment white, legs sparsely pubescent, except the basal half of femora which is covered with dense white hairs. Length .28 inch; 7 mm.

A number of specimens received by Dr. Horn from Texas, on comparison with the type in Dr. LeConte's cabinet, prove to be of this species. The original description was of an immature form from an uncertain locality. The characters to be relied upon are the convex, naked at middle, thorax, with uniformly cinereous pubescence, faint basal puncture; the elytral rufous band; and the femora white at base.

D. pulcher Lec. Elongate, moderately convex, red, covered with sparse, short, recumbent, golden pubescence. Elytra black, except a narrow basal band, which is red. Head finely and moderately densely punctate. Thorax only moderately convex, lateral margins entirely visible from above, gently arcuate, base broadly lobed, two distinct basal foveæ on each side of lobe, hind angles prominent; finely and densely punctate. Elytra densely, moderately coarsely punctate; a few faint striæ indicated near apex, black, covered with very sparse, fine, black pubescence, except the base which is red, clothed with golden hairs. Scutellum punctate. Entire under surface (also antennæ and legs) red, finely punctate, pubescence fine. Length 25 inch; 6.2 mm. (Fig. 16.)

No trouble will be found in distinguishing this species; the general red color, with the almost entirely black elytra, the flattened thorax, with two basal foveæ; the absence of abdominal spots and white rings on femora, furnish conclusive characters.

Occurs in the Southern, Middle and Western States.

D. lardarius Linn. Elongate, moderately convex, black or piceous, clothed with short black sparse recumbent pubescence. Elytra marked at base with a broad rufous space which is covered with cinereous yellow and three spots of black pubescence. Under surface and legs black with yellowish pubescence, without spots or rings. Head moderately coarsely but very densely punctate, antennæ rufous. Thorax moderately convex, lateral margins entirely visible from above, basal fovea not very deep; finely, but very densely punctate, pubescence black, scutellum covered with black pubescence. Elytra finely, but very densely, punctate, indistinct striæ near apex, black with a space at base rufous which bears yellow hairs and a transverse row of three black spots at the basal third. Length .24.–30 inch ; 6–15 mm. (Figs. 14, 15.)

The most common of all the species ; to be recognized by its more elongate form, basal band of cinereous pubescence on elytra, and the uniform color of the hair on the under surface. A rubbed specimen bears some resemblance to *mucoreus*, but the important characters on the thorax and under surface of the latter, already given, would separate it at once.

Dermestes signatus Lec. is a variety in which the thorax is covered with denser cinereous pubescence, marked by three small black spots on disc, and the elytra almost entirely piceous, the cinereous pubescence extending nearly to the apex. A well furnished cabinet exhibits a complete series of gradations from the typical *lardarius* down to the variety under consideration.

Occurs everywhere.

D. elongatus Lec. Elongate, cylindrical, black or piceous, covered with moderately long, dark brown, recumbent pubescence. Elytra uniform in color, arcuate, marked by striæ. Antennæ, legs and under surface piceous. Head moderately coarsely punctate. Thorax only moderately convex, sides gently arcuate, slightly margined, finely and densely punctate, two not very distinct basal foveæ. Elytra black, finely and densely punctate, eight or ten distinct striæ from base to apex, under surface and legs covered with uniform dark cinereous pubescence. Length .36 inch ; 9 mm. (Fig. 17.)

The most elongated of all the forms under consideration, with the striæ on the elytra more apparent. The uniform pubescence and absence of markings on legs and abdomen are important additional characters. This species may be identical with *bicolor*, but from the description the form seems less elongated and the striæ deeper in the latter. A comparison of types would alone settle the matter. I have preferred to keep them, temporarily, at least, separate.

Occurs in the Southern and Western States.

D. cadaverinus Fabr. Elongate, moderately convex, black or piceous, clothed with sparse, short, recumbent, cinereous pubescence. Elytra black. Under side, legs and antennæ piceous. Head black, densely and moderately coarsely punctate. Thorax black, lateral margins arcuate, entirely visible from above ; base lobed, with two very distinct basal foveæ, densely, moderately coarsely punctate, with faint striæ on apical portion. Body beneath more densely pubescent. Abdomen without black spots at sides ; legs not annulated. Length .27 inch ; 6.7 mm.

This species is to be distinguished by the uniform color of thorax and elytra and of their pubescence, by the deep thoracic foveæ and only faint apical striæ on elytra.

Occurs in Florida.

D. vulpinus. Elongate, black, convex, clothed with sparse cinereous pubescence. Elytra uniform in color. Head densely, moderately coarsely punctate. Antennæ rufous. Thorax very convex in front, lateral margin not visible from above, finely and densely punctate, no distinct basal foveæ, pubescent only at sides and front, leaving a large triangular median space, naked. Scutellum clothed with orange-yellow hairs. Elytra black, finely and densely punctate, hardly any appearance of striæ, covered with sparse, cinereous, semi-erect pubescence. Body beneath clothed with long dense white hairs, a row of black spots on each side of abdomen, the fourth segment alone marked by a median pit, which bears a bunch of brown hairs; last segment brown, except two white spots on either side of median line. Legs covered with brown hair. Femora not distinctly annulated. Basal half almost entirely yellowish-white. Length .36 inch; 9 mm.

The male of this species can be recognized at once by the single abdominal pit on the fourth segment; the female by the convex, naked at disc, thorax; the uniform color of the upper surface, and the abdominal spots and indistinct markings on femora, which are important characters, common to both sexes.

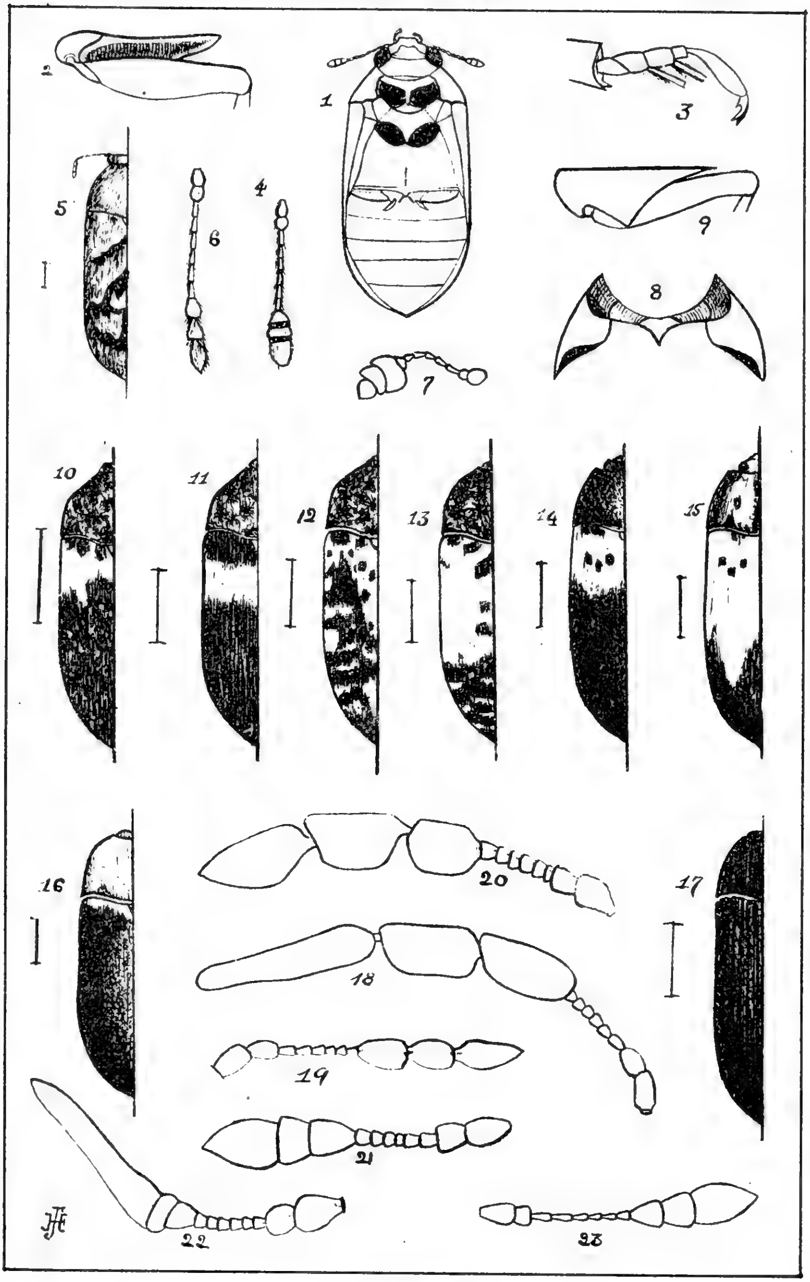
ATTAGENUS Latr.

Head small, front wide and flat, ocellus distinct. Epistoma short. Eyes round, entire, moderately prominent. Antennæ eleven-jointed, terminated by a three-jointed club, which varies greatly in the different species. Mouth parts not protected by prosternum, thorax convex, at base not quite twice as wide as long, apex half as wide as base, which is strongly bisinuate, sides arcuate, hind angles prominent. Scutellum small but distinct. Elytra elongate, moderately convex, apices hardly separately rounded. No antennal fossæ, prosternum not lobed in front, broad and moderately long, except in *varicolor*, in which it is narrow and short, prolonged behind into a tip which is acute, and extends slightly beyond the anterior coxæ. Mesosternum narrow, moderately long (very long in *Hornii*), sulcate anteriorly, mesocoxæ not widely separated. Posterior coxal plate very long, prominent, narrow, obliquely truncate externally. Legs stout, femora channeled beneath for tibiæ; first joint of tarsi very short, 2–5 successively larger.

The distinguishing characters of this genus are the narrow, emarginate mesosternum, prosternum simple in front, the 11-jointed antennæ and absence of antennal fossæ, and the long prominent hind coxal plate.

The following table is put forth to aid in separating our species:

Prosternum broad, moderately long.
  Elytra uniformly black or piceous. Last joint of male club four or five times as long as the preceding two united, which are very small.
    Pubescence on elytra uniformly dark and sparse.......... **piceus.**
    Pubescence on elytra dense and white on a smooth spot at middle, on each side of suture..................... **pellio.**



DERMESTIDÆ.

Elytra fulvous, with a black sub-basal spot and longitudinal broad band on either side of suture extending almost to the apex, pubescence uniformly cinereous. Last joint of male club as long as the preceding two united, which are very large and equal. .... **Hornii.**

Elytra black with a sub-basal sinuous transverse piceous band, which bears dense whitish pubescence, all three joints of male club very large and equal................**perplexus.**

Prosternum narrow and short.

Elytra black, with three, more or less confluent, broad piceous spots on either side of suture; whitish pubescence arranged in three distinct transverse fasciæ, all three joints of male antennæ club very large and equal. **varicolor.**

A. piceus Oliv. Elongate, convex, black, clothed with short, semi-erect, yellow pubescence. Head coarsely punctate, sparsely pubescent. Antennæ rufo-testaceous. Thorax black, coarsely punctate, pubescent at sides and base. Scutellum pubescent. Elytra black, or rufous, coarsely punctured, clothed with very sparse, brownish pubescence. Body beneath black, coarsely and densely punctate, clothed with semi-erect, yellow hairs. Prosternum long and wide. Legs rufous. Length .14–.20 inch; $3\frac{1}{2}$–5 mm. (Fig. 26.)

Male. Antennæ with first joint large, suboval; second smaller; joints 3–8 small; 9–11 forming the club, of which the first two joints are wide but very short, the last wide, extremely long, pointed at end—equaling all the preceding part of the organ. (Fig. 22.)

Female. Antennal club compact, not quite equal to all the preceding joints, made up of three joints of which 9–10 are equal; while the last equals the two united. (Fig. 23.)

Under this name I have included *rufipennis, dichrous, spurcus, megatoma,* as I can see no characters by which they can be separated. The sparsely pubescent uniformly colored elytra, the broad prosternum and the structure of the male antennæ are diagnostic.

Occurs everywhere.

A. pellio Linn. Elongate, convex, black, clothed with short, semi-erect, brown hairs; head coarsely punctate, pubescence sparse, brown and erect, antennæ rufo-testaceous, club cinereous. Thorax coarsely punctate, base and angles clothed with white pubescence; scutellum pubescent. Elytra black, sparsely pubescent, a small smooth spot on either side of suture is clothed with dense white hairs. Body beneath black, coarsely punctate, pubescence yellow, semi-erect. Prosternum wide, moderately long; abdominal segments rufous, margined with black, pubescent. Length .21 inch; 5.5 mm. (Figs. 29, 30.)

Male. Antennal club with joints 9–10 very small—last joint very large, as long as all the remaining portion of the antennæ.

Female. Antennal club compact, joints 9–10 wide, together equaling the last segment.

Distinguished by the elytral spots, uniform color, and the structure of the prosternum and male antennal club.

Occurs in New England.

A. Hornii, n.sp. Elongate, convex, black, clothed with dense, cinereous, semi-erect pubescence. Elytra fulvous with a broad longitudinal black band, interrupted obliquely at basal third, of black; head coarsely punctate, pubescent, antennæ testaceous; thorax coarsely punctate, densely pubescent. Elytra coarsely punctate, fulvous with a basal spot and longitudinal band rufous; entirely clothed with dense, cinereous recumbent pubescence. Body beneath rufo-piceous, moderately coarsely punctate, clothed with short cinereous hairs, prosternum moderately long, wide. Mesosternum twice as wide as long, sulcate in front, very prominent. Abdominal segments black with short cinereous hairs. Legs testaceous. Length .14 inch; 3.5 mm. (Figs. 24, 25.)

Male. Antennal club elongate, with joints 9–10 very large, equal, together as long as all the preceding joints, 11 elongate almost equal to 9 and 10 united. (Fig. 18.)

Female. Antennal club elongate, joints 9–10–11 equal. (Fig. 19.)

This species is easily separated from the rest, by the markings, and dense cinereous pubescence of the elytra and by the structure of the male antennal club. The mesosternum is long, less deeply sulcate and more prominent than in the other species.

It was recognized by Crotch as a new form and labeled in the collections with the above name, although no description has ever been published.

A. byturodes Cr. of the Check List is the female of this species. Occurs in the Pacific States.

A. perplexus n.sp. Elongate, convex, black, clothed with short, black, semi-erect pubescence. Elytra with broad sinuous basal and a few spots at middle and apex, of whitish pubescence. Head coarsely punctate, pubescence black and cinereous. Antennæ rufous. Thorax densely and coarsely punctate, disc sparsely, sides and base more densely clothed with long semi-erect yellow pubescence. Elytra black, with a piceous sinuous sub-basal band which bears whitish-yellow hairs. Body beneath black, coarsely punctate, pubescence short, semi-erect, yellowish-white. Prosternum wide, moderately long, abdominal segments black, finely punctate, pubescent, legs rufous. Length .16 inch; 4 mm.

Male. Antennal club with joints 9–10 equal; 11 slightly longer not equal to both the preceding united.

Female. Antennal club with the last joint equal to two preceding united.

This species is entirely different in appearance and in the structure of the male antennal club from all others in our fauna except *varicolor,* from which it can be easily distinguished by the narrow short prosternum and broad confluent piceous spots on the elytra of the latter.

Occurs in Nevada.

A. varicolor, n. sp. Elongate, convex, black, covered with whitish-yellow, semi-erect pubescence. Head and thorax coarsely punctate, pubescent. Antennæ rufous. Scutellum pubescent. Elytra black, clothed with black, semi-erect pubescence, marked by three irregular transverse confluent rufous spots, with three sinous transverse bands of white semi-erect pubescence. Body beneath black, punctate, covered with short, cinereous hairs. Prosternum very short and narrow. Legs rufo-testaceous. Length .16 inch ; 4 mm. (Figs. 20, 21, 27, 28.)

Male. Antennal club not quite twice as long as all the preceding portion, with joints 9–11 very large ; last joint only slightly longer.

Female. Antennal club small, equal to all the preceding joints united, last joint almost equal to the two others together.

The distinguishing characters of this species are the narrow prosternum; structure of male antennal club ; the elytra, black and piceous, bearing three distinct white fasciæ.

Occurs in the Pacific States.

DEARTHRUS Lec.

Head as wide as anterior border of thorax. Eyes round, large, very prominent, entire. Antennæ 9-jointed, terminated by a 3-jointed club (fig. 33). Thorax not twice as wide as long, slightly bisinuate at base. Elytra elongate, sides nearly parallel. Prosternum one-third as long as wide, tip sub-acute, not produced beyond anterior coxæ. No true antennal fossæ. Mesosternum narrowly divided. Mesocoxæ not widely separated (fig. 32). Metasternum short, side pieces wide. Posterior coxæ not reaching the sides of body. Coxal plates short and wide, covering more than basal half of femora. Legs slender, first four joints of tarsi subequal, last joint much longer, hardly equal to all the others taken together.

This genus, founded upon one species, has been merged into *Attagenus*, from which, however, it is undoubtedly distinct. The 9-jointed antennæ, the peculiar prosternum, the narrowly divided mesosternum, the short and wide posterior coxal plates like those of *Trogoderma* and allied genera, and finally, the entire facies of the insect, are characters too important to be overlooked or underestimated.

D. longulus Lec. Elongate, compressed, black, clothed with sparse yellow semi-erect pubescence. Head black, coarsely punctate, sparsely pubescent. Thorax coarsely punctate, sparsely pubescent. Elytra black or piceous, coarsely punctate, sparsely pubescent. Body beneath rufous, moderately coarsely punctate, clothed with sparse, cinereous pubescence. Abdominal segments rufous, margined with rufo-testaceous, punctate, pubescent. Legs rufous. (Fig. 31.)

Length .1 inch ; 2.5 mm.

Male. Antennæ of nine joints, first very large, sub-oval; second somewhat smaller; 3–6 small; 7–9 forming the club equal to all the preceding united, of which the first is very small; the second wider and longer; the last twice as wide as the second and almost three times as long as the two united, obtusely pointed at tip.

Female. Club of antennæ a little more than half as long as the preceding joints taken together; last joint as wide as, and little longer than the second; nearly truncate at tip.

Occurs in the Atlantic district.

PERIMEGATOMA Horn.

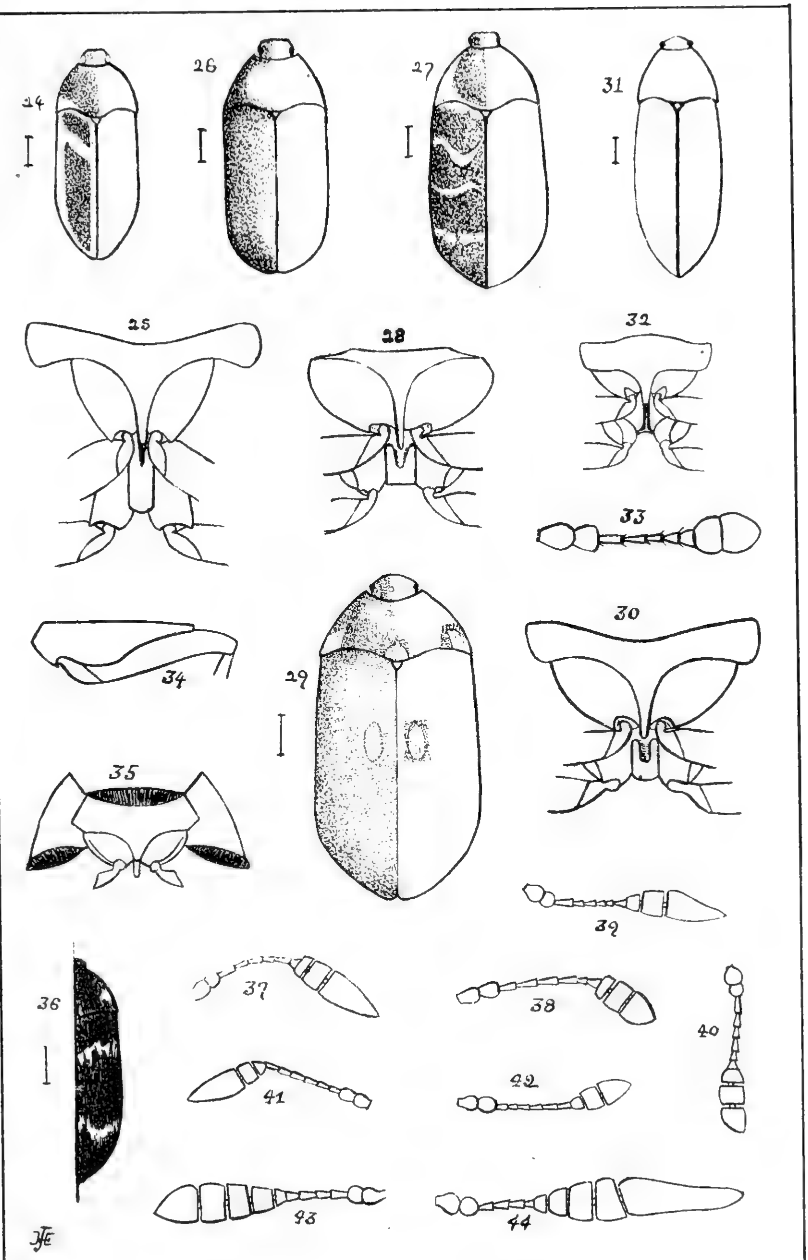
Form elongated, only moderately convex, body dark in color. Head moderately wide, front flat, epistoma moderately short; a distinct ocellus. Antennæ 11-jointed, club 3-jointed, except in *Belfragi,* where it is 5-jointed. Eyes large, round, prominent, and entire. Thorax twice as wide at base as at apex, and half as long as the greatest width, very convex and prominent in front, with a transverse depression across the base, which is slightly bisinuate. Sides arcuate, hind angles prominent, except in *Belfragi,* where they are somewhat retracted. Scutellum small, but distinct. Elytra long, sides nearly parallel, apices not separately rounded. Prosternum only moderately broad, and very long, lobed in front, covering all the mouth parts, except the labrum, produced behind into a short tip received into the mesosternum, which is narrow and deeply emarginate. No antennal fossæ, spaces between prosternum and lateral margins slightly concave (Fig. 35), metasternum short, side pieces wide. Legs stout. Posterior coxæ do not attain the sides; coxal plate short, moderately wide (Fig. 34); first joint of tarsus long, 2–3–4 successively shorter, 5 as long as first.

This genus was established for several species, occuring from Lake Superior to Texas, California and Sitka, which agree with *Megatoma* in all the characters except in the antennal fossæ, which are absent in this genus. The ornamentation, by the pubescence of the surface, resembles somewhat that of *Megatoma,* there being two transverse, undulating, cinereous bands, the one at the basal third, the other at the apical fourth.

The following is the arrangement of the species, proposed by Dr. Horn (Trans. Am. Ent. Soc. 1875, p. 135):

Antennal club 3-jointed.
- First joint of club in both sexes, very little smaller than the second joint.
  - Pubescence unicolored, grayish-white (.16 inch)....... **cylindricum.**
  - Pubescence bicolored (.20 inch)........................ **variegatum.**
- First joint of club extremely short.
  - Pubescence bicolored (.14)........................... **falsum.**

Antennal club 5-jointed.
  - Pubescence bicolored.................................. **Belfragi.**



DERMESTIDÆ.

P. cylindricum Kby. Oblong, oval, piceous, shining, sparsely clothed with moderately short, semi-erect, easily removed, cinereous pubescence. Elytra uniformly piceous or marked by two transverse rufous bands. Head coarsely and densely punctate, pubescence sparse. Antennæ rufous. Thorax very densely and coarsely punctate, moderately densely pubescent, especially at sides. Elytra less densely and coarsely punctate, either black and uniformly pubescent or marked by two piceous bands at apical and basal third, to which the pubescence is more closely adherent. Body beneath piceous, coarsely punctate, moderately densely pubescent. Legs piceous. Length .13–.16 inch ; 3.2–4 mm.

Male. First and second joints of antennæ large, sub-equal, 3–8 very small, 9–11 forming a club which is longer than all the preceding joints together, the first nearly as large as the second, and the last longer than the other two together, and pointed at tip. (Fig. 37.)

Female. Club of antennæ only half as long as the preceding joints together, last joint not much larger than second, obtusely pointed at tip. (Fig. 38.)

Occurs from Hudson Bay Territory to California.

Certain specimens from California, in Dr. LeConte's collections, differ somewhat in the ornamentation of the elytra. Dr. Horn describes them as follows :

Specimen a. Uniformly piceous, pubescence normal, slightly denser at the sides of the thorax *(angularis* Mann).

Specimen b. Similar to *a*, but with the pubescence adhering more closely, and forming a very indistinct sinuous band at basal and apical third.

Specimen c. Elytra with sinuous, transverse, rufo-piceous bands at apical and basal third, to which the pubescence is very closely adherent, causing the elytra to be conspicuously marked.

This species is easily recognized by the uniform color of the pubescence and by the antennal club.

P. falsum Horn. Form, color, and ornamentation as in *cylindricum, variety c.* The pubescence of the elytra is bicolored, composed of pale-brownish and grayish-white hairs intermixed, the former forming a narrow, transverse band in front of the rufous bands of the elytra. Length .14 inch ; $3\frac{1}{2}$ mm.

Male. Club of antennæ slightly longer than all the preceding joints together, first joint extremely short, but nearly as wide as the second, terminal joint more than twice as long as the two preceding together, and pointed at tip. (Fig. 41.)

Female. Club of antennæ not longer than the preceding joints taken together, first joint much shorter than the second, terminal joint slightly longer than the first two united, and but little longer than wide, oval at tip. (Fig. 42.)

Occurs in California, and is to be known by the short first joint of the antennal club.

P. variegatum Horn. Oblong-oval, piceous or piceo-rufous. Elytra with two sinuous transverse bands of rufous, with dense white pubescence. Head and thorax densely punctured, covered with intermixed pale-brown and white hairs. Elytra oblong-oval, sides sub-parallel, surface less densely punctured than the thorax. Color piceous, with a sinuous rufous band at basal and another at apical third, rather densely covered with white pubescence, the remainder of the surface with intermixed pale-brown and whitish hairs. Body beneath densely punctured, sparsely covered with cinereous hairs. Antennæ rufous or pale brown. Length .20–22 inch ; 5–5.5 mm. (Fig. 36.)

Male.—Club of antennæ not quite equal to the preceding joints united, first joint as large as second, terminal as long as the first and second together, and pointed at tip. (Fig. 39.)

Female. Club of antennæ not longer than preceding joints together, first two joints nearly equal, and the terminal shorter than the other two united, oval and slightly obliquely truncate on the inner side. (Fig. 40.)

Occurs in California and Oregon. This species is larger and broader than the two just considered. It may be recognized by the bicolored pubescence and the structure of the antennal club.

P. Belfragi Lec. Structure, color and ornamentation similar to the preceding species, but the form is decidedly more elongate. Length .22 inch ; 5.5 mm.

Male. Club of antennæ of five joints, twice as long as all the preceding joints united, first and second joints moderately wide, but short, subequal, third and fourth much wider, and twice as long, terminal as long as the four preceding together, and obtusely pointed at tip. (Fig. 43.)

Female. Club of antennæ of five joints, about equal to the preceding joints united ; terminal joint hardly equaling third and fourth, almost globular. (Fig. 44.)

Occurs in Texas.

ACOLPUS, n. g.

Head as wide as front margin of thorax. Frontal ocellus distinct. Eyes large, prominent, round and entire, moderately coarsely granulated, mouth parts free, antennæ 11-jointed, thorax about twice as wide at base as long, apex only one fourth as wide as base, sides arcuate, lateral margins somewhat flattened, hind angles prominent, base bisinuate. Scutellum small, nearly covered by the thorax ; elytra about twice as long as wide, sides subparallel, apices slightly separately rounded ; no antennal fossæ ; spaces between prosternum and lateral margin concave, coarsely punctate ; prosternum broad, moderately long, produced posteriorly into an acute long tip, completely dividing the mesosternum, which is wide. Mesocoxæ therefore widely separated. Mesosternum short, side pieces wide; hind coxæ moderately long, narrow, coxal plates only attaining side pieces. Legs stout, reaching sides of body; first joint of tarsus long, second shorter, third and fourth still smaller, the fifth equals the first.

This genus differs from *Trogoderma* by the absence of the antennal fossæ. There is but one species.

A. primus, n. sp. Elongate, moderately convex, black, clothed with very sparse, semi-erect, moderately long, cinereous pubescence. Elytra piceous, with a moderately broad transverse sinuous band on the basal third yellow, antennæ, abdomen and legs, piceous. Head densely and very coarsely punctate, antennæ 11-jointed; joints 1–2 large; 3–5 much smaller; 6–11 large and wide, forming an elongate serrated club. Thorax very densely and coarsely punctate, pubescent at sides. Elytra coarsely, much less densely punctate; a transverse depression across the base, piceous except a transverse sinuous yellow band at the junction of the basal and middle thirds, which is moderately broad and directed slightly forward, and somewhat more densely covered with lighter hair. Body beneath rufous, very coarsely punctate, pubescence shorter, more dense and recumbent. Length .08 inch; 2mm. (Fig. 45.)

Two specimens from Texas in Dr. LeConte's cabinet, from Mr. Belfrage.

The single light band on the elytra will serve as an additional character to separate this species from any of our known *Trogoderma.*

TROGODERMA Latr.

Oblong, convex, dark, elytra marked with sinuous rufous bands, bearing light pubescence. Head small, a distinct ocellus, front flat, clypeus short. Eyes prominent, moderately coarsely granulated, round, entire in *simplex, sternale* and *ornatum,* emarginate in front in *inclusum.* Thorax very convex, twice as wide at base as long, base three times as wide as apex, bisinuated, slightly produced sub-acutely in the median line, sides arcuate, hind angles moderately prominent. The antennæ are 11-jointed, terminated by a club which is 6-jointed and strongly serrate in the males of *sternale* and *ornatum,* 7-jointed, not pectinate in the males of *inclusum,* and 5-jointed in the females of *simplex,* and 4-jointed in the females of the other species. Scutellum moderately large, uncovered. Elytra with sides sub-parallel, apices separately rounded.

Antennal fossa occupying the entire space between the prosternum and lateral margin of thorax, except in *simplex,* where they are limited to the anterior part of the prosternal suture. Prosternum moderately broad and long, not lobed in front, produced behind into a long tip, which is broad, entirely dividing the mesosternum in *simplex, ornatum* and *inclusum,* acute in *sternale,* the mesosternum being only deeply emarginated. Mesocoxæ very widely separated. Posterior coxal plates moderately long and wide, not reaching the sides. Legs stout, femora grooved beneath to receive the tibiæ; first joint of tarsi long, second, third and fourth successively shorter, together equaling the fifth.

The elytra of all the species, in our fauna at least, are fasciate. The anatomical characters by which to recognize this genus are: the distinct antennal fossæ, characteristic antennæ, prosternum not lobed in front, the broad, deeply emarginate or entirely divided mesosternum, and the moderately wide and long posterior coxal plate.

Our species may be arranged as follows:

Eyes entire.
  Antennal fossa near prosternal suture.... .... **simplex.**
  Antennal fossa sub-marginal.
    Prosternal tip broad.
      Mesosternum broadly divided.......................... **ornatum.**
    Prosternal tip narrow.
      Mesosternum deeply emarginate .... **sternale.**
Eyes emarginate in front.................................. **inclusum.**

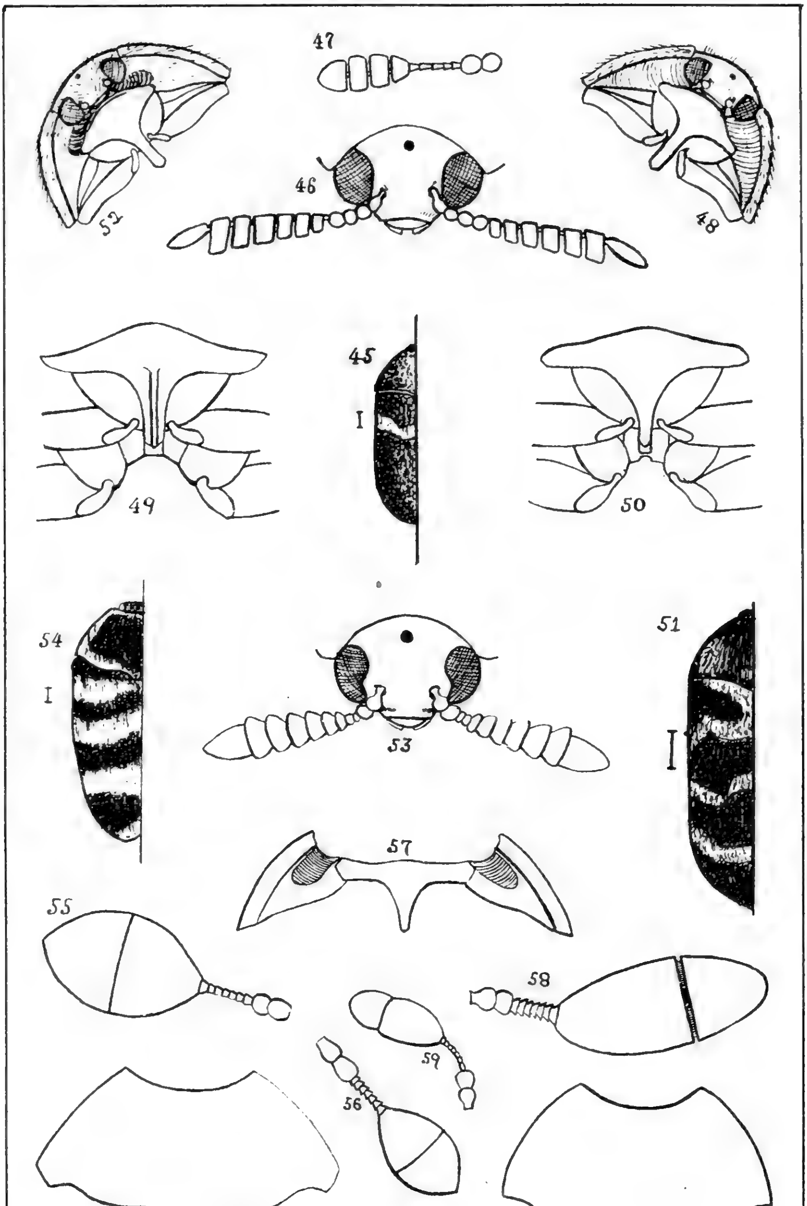
T. simplex, n. sp. Oblong, black, clothed with black semi-erect pubescence. Elytra black, with three sinuous bands and apical spot rufous with white pubescence. Head coarsely punctate, front covered with coarse yellow hair. Eyes entire, moderately prominent. Antennæ piceo-testaceous, joints 1 and 2 rufous. Thorax coarsely, not very densely, punctate, with whitish-yellow pubescence at sides and base, disc less pubescent. Scutellum pubescent. Elytra coarsely punctate, black, with three irregular bands of red, bearing semi-erect whitish pubescence. Body beneath black, coarsely punctured, clothed with short recumbent cinereous pubescence. Antennal fossa limited to a small space near prosternal suture. Prosternum long, moderately broad, tip prolonged, completely dividing the mesosternum. Abdominal segments black, margined with rufous, clothed with cinereous pubescence. Legs piceous, tibiæ and tarsi rufous. Length .20 inch; 5 mm. (Figs. 51, 52.)

Male unknown.

Female. Antennæ with joints 1 and 2 large, almost equal, 3–6 small, globular, 7–11 forming the club, which is fusiform.

The distinguishing characters of this species are the completely divided mesosternum, the entire eyes, and antennal fossæ limited to the prosternal sutures. It is of larger form than any of our known species. Found in the Western States.

T. ornatum Say. Oval, black, clothed with semi-erect, black pubescence. Elytra with three irregular confluent bands and apical and basal spots of gray pubescence. Head with front densely and coarsely punctate, clothed with erect black pubescence, eyes entire, moderately prominent. Antennæ testaceous. Thorax moderately sparsely punctate. Scutellum pubescent. Elytra coarsely, moderately sparsely punctate, black, clothed with black pubescence and with three irregular bands of red, bearing gray pubescence.



DERMESTIDÆ.

Body beneath black, clothed with cinereous pubescence, coarsely punctate. Antennal fossæ deep and large. Prosternum long and moderately broad, tip broad, sub-carinate. Mesosternum completely and broadly divided to receive prosternum. Abdominal segments black or rufous, coarsely punctate and pubescent. Legs rufous. Length .08–.20 inch; 2.5 mm. (Figs. 46, 47, 48.)

Male. Antennæ with joints 1–2 large and equal, globular, 3–5 small and globular, 6–11 strongly pectinate, forming the club.

Female. Antennæ with joints 1 and 2 almost equal, large, globular, 3–7 small, globular, 8–11 forming the club.

This species may be separated by its entire eyes, the character of the antennæ, the large antennal fossæ, the broad tip of the prosternum and the widely divided mesosternum. It is of moderate size.

Occurs everywhere.

T. sternale, n. sp. Oblong, black, clothed with sparse, black, semi-erect pubescence. Elytra black, with three irregular confluent bands and apical and basal spots of red, bearing whitish pubescence. Head coarsely punctate, sparsely pubescent. Eyes entire, moderately prominent. Antennæ rufo-testaceous. Thorax coarsely punctate, sides and base bearing whitish pubescence. Elytra black, with three variable rufo-testaceous bands, bearing white or gray pubescence, the rest sparsely clothed with black hairs. Body beneath piceous, coarsely punctate, with cinereous pubescence. Antennal fossa moderately deep, occupying all the space between prosternum and lateral margins. Prosternum short, moderately wide, tip convex and acute. Mesosternum deeply incised but not entirely divided. Abdominal segments piceous (variable to rufous), apical margins testaceous. Legs rufous. Length .08–.16 inch; 2–4 mm. (Fig. 50.)

Male. Antennæ with joints 1 and 2 large, 3–5 small and equal, 6–11 forming a deeply pectinate club; joints 10 and 11 are usually connate.

Female. Antennæ with joints 1 and 2 large, 4–7 small, 8–11 forming the club.

The distinctive characters of this species are the entire eyes; pectinate antennæ; large antennal fossæ; acute tip of prosternum and the mesosternum only deeply incised. It is the smallest form in the genus.

Occurs in California, New Mexico, Arizona, Texas, &c.

T. inclusum Lec. Oval, somewhat oblong, black, clothed with moderately long semi-erect black pubescence. Elytra with four sinuous confluent bands of red, bearing whitish pubescence. Head coarsely and densely punctured, quite sparsely pubescent. Eyes deeply emarginate in front, not very prominent. Antennæ testaceous. Thorax finely punctate, moderately sparsely pubescent. Elytra black, with four irregular bands of red, bearing grayish pubescence, the rest with sparse black pubescence, coarsely punctate. Body beneath piceous, coarsely punctate, with cinereous recumbent pubescence. Antennal fossa deep, occupying nearly all the space between the front and lateral margins. Prosternum short, moderately wide, tip wide, convex, not carinate. Abdominal segments rufous, apical margins paler, pubescent. Legs rufo-testaceous. Length .08–.16 inch ; 2–4 mm. (Fig. 53.)

Male. Antennal joints 1 and 2 large, 3–4 very small, 5–11 forming the club, which is not deeply pectinate.

Female. Antennal joints 1 and 2 large, 3–7 small, 8–11 forming the club.

This well known species possesses well marked characters by which it can be at once separated from the preceding forms. The emarginate eyes and non-pectinate antennæ united with large antennal fossæ, broad prosternal tip and completely divided mesosternum are conclusive. *T. tarsale* Mels. and *T. pallipes* Zieg. are identical with this species.

Occurs in Pennsylvania, Massachusetts and South Carolina.

CRYPTORHOPALUM Guér.

Head moderately large, front wide, with a prominent ocellus, the epistoma short and on the same plane with the front, eyes prominent, round, moderately coarsely granulated, entire. The antennæ are 11-jointed, terminated by a 2-jointed club, which is twice as long in the males as in the females, the joints being equal in *hemorrhoidale*, the terminal joint much shorter than the preceding in all the other species. The thorax at base is twice as wide as long, apex one half the width of the base ; the latter bisinuate, quite strong, lobed behind on the middle line, lobe truncate, partially overlapping the scutellum ; the sides are arcuate, somewhat dilated over the antennal fossæ in the males of all the species, very markedly so in *ruficorne ;* hind angles acute and prominent except in the male of *ruficorne*, where they are retracted. Scutellum distinct, triangular. Elytra widest at base, sides oval, apices separately rounded. Antennal fossæ distinct ; the mouth parts, except the labrum, are covered by the prosternum which is not lobed in front, but is wide, moderately long, the tip broadly produced, widely dividing the mesosternum and consequently causing the mesocoxæ to be widely separated. Metasternum short, side pieces wide. Hind coxal plates moderately long, wide, reaching the epimera of metathorax. Legs stout, femora grooved beneath for tibiæ, first and last joint of tarsi long, nearly equaling the small intermediate ones united.

The species of this genus are small, black or piceous, and moderately coarsely punctate, the elytra are sparsely pubescent except in *balteatum*, where the grayish hairs are arranged in fasciate form. The anatomical characters by which this genus is separated from the others, are the wide, short, flat front ; the 2-jointed club of the antennæ ; the submarginal antennal fossæ ; the prosternum covering all the mouth parts except the labrum ; its broad tip dividing widely the broad mesosternum ; and the wide, moderately long, posterior coxal plates.

The species can be tabulated as follows :—

Elytra with two sinuous transverse bands, humeral ring, and apical spot of yellowish white pubescence......	**balteatum.**
Elytra sparsely and uniformly pubescent.	
Posterior third distinctly lighter in color than the remainder. Both joints of the antennal club subequal; metasternum finely and sparsely punctate..	**hemorrhoidale.**
Apex only distinctly lighter than remainder.	
Last joint of antennal club much smaller than preceding. Metasternum coarsely and densely punctate,	**apicale.**
Elytra uniform in color. Last joint of antennal club smaller than preceding.	
Thorax finely and densely punctate; sides nearly arcuate and hind angles acute in the male.........	**triste.**
Thorax almost smooth; sides greatly dilated and hind angles retracted in the male.....................	**ruficorne.**

C. balteatum Lec. Oval, convex, piceous or fuscous, clothed with moderately long, yellowish, semi-erect pubescence. Elytra marked by two transverse sinuous bands, a humeral ring, and apical spot of longer whitish pubescence. Head coarsely punctate. Antennæ fuscous, terminated by a large 2-jointed club. Thorax convex, hind angles acute, moderately finely punctate, pubescence more dense at sides and base. Scutellum small, naked. Elytra coarsely punctate, piceous, sparsely clothed with semi-erect, yellow and black pubescence, with humeral ring, two transverse bands, and apical spot of dense whitish-yellow hairs. Body beneath black or piceous, coarsely punctate, covered with fine, long, semi-erect, yellowish-white pubescence. Metasternum moderately finely punctate. Abdomen fuscous, coarsely punctate, densely pubescent. Legs rufous.

Male. I have not been able to see any males of this species.

Female. Antennal club elongate, made up of two joints, nearly equal, about as wide as long, together equaling all the preceding joints. The club is received into a fossa which occupies only the anterior half of the space between the prosternum and lateral margin, is almost circular, and appears to lie transversely. Length .10 inch; 2.5 mm. (Fig. 44.)

The distinguishing characters of this species are the coarsely punctate, piceous, fasciate elytra, and the structure of the antennal club.

The banded elytra give the insect the appearance of a *Trogoderma*, but the generic characters, already given, serve to separate this species with certainty.

Occurs in the Pacific States.

C. hemorrhoidale Lec. Elongate-oval, moderately convex, reddish-brown, clothed with moderately long, yellow, semi-erect pubescence. Elytra reddish-brown, posterior third lighter. Head black, very coarsely and densely punctate, sparsely pubescent. Antennæ light brown. Thorax convex, moderately finely punctate, pubescence long and yellow. Scutellum naked and rough. Elytra black as far as the posterior third, which is piceous or rufous, very sparsely pubescent, coarsely and moderately densely punctate. Body beneath black, coarsely, except the metasternum, which is finely punctate ; pubescence long and yellow. Legs with thighs rufous, tibiæ and tarsi lighter. Length .09 inch ; 2.1 mm.

Male. Antennal club very large, composed of two sub-equal joints, almost disc-shaped, and twice as long as the preceding segments united. (Fig. 45.)

Female. Antennal club of two sub-equal joints, together only as long as all the other joints united. (Fig. 46.)

The important characters which enable us to separate this species are, the constant light color of the posterior third of the elytra, the oval antennal club of two sub-equal joints, and the finely punctate metasternum.

Occurs in the Southern and Western States.

C. apicale Mann. Elongate, convex, black, sparsely clothed with moderately long, yellowish, semi-erect pubescence. Head coarsely punctate, sparsely pubescent. Antennæ light brown. Thorax with hind angles acute, black, finely and densely punctate, pubescence sparse. Scutellum small, scabrous, naked. Elytra black, apex rufous, coarsely punctate, pubescence sparse, yellow and black ; apex usually clothed with dense yellow hairs. Body beneath black, moderately coarsely punctate, sparsely pubescent. Metasternum very coarsely punctured. Abdomen black or piceous. Legs rufous, tibiæ, etc., lighter. Length .11 inch ; 2.3 mm.

Male. Antennal club elongate, of two joints, the last of which is half as long as the preceding, together twice as long as all the others united. Club received into a fossa which extends almost to the posterior angle of lateral space. (Fig. 57.)

Female. Antennal club as in male, but only half as long ; the fossa occupies only the anterior half of the lateral space. (Figs. 58, 59.)

The prominent characters of this species, are found in the apical color of the elytra, the coarse puncturing of the metasternum and the elongate antennal club, composed of two unequal joints.

Occurs in California.

C. ruficorne Lec. Sub-oval, convex, black or piceous, clothed with yellowish semi-erect pubescence. Head coarsely punctate, pubescence sparse and yellow. Antennæ very light, almost testaceous. Thorax convex ; in the male the lateral margins are strongly dilated over the antennal fossæ and the hind angles are retracted, very finely and sparsely punctured, pubescent at sides. Scutellum naked, black. Elytra piceous, coarsely punctured, clothed with sparse yellow and black hairs. Body beneath almost black, coarsely punctured, sparsely pubescent. Metasternum very coarsely punctate. Legs rufous. Length .08 inch ; 2 mm. (Fig. 61.)

Male. Antennal club very broad—in other respects like the preceding species.

Female. Antennal club like the preceding species.

This form may be easily distinguished by the plain piceous elytra, the almost smooth thorax, which in the male has the margin dilated and convex where it forms a roof for the antennal fossa, and the hind angles retracted. The male club is very light in color and extremely broad.

Occurs in California.

C. triste Lec. Elongate-oval, black or piceous, convex, clothed with sparse, yellowish-red, semi-erect pubescence.

Head coarsely punctate, pubescence sparse and yellow. Antennæ light, last joint rufous or black. Thorax convex, hind angles acute in both sexes, finely but very densely punctured, sparsely pubescent at sides. Scutellum black, naked. Elytra entirely black, moderately coarsely punctate, pubescence very sparse, yellowish-red. Body beneath black, covered with sparse, fine, yellow, semi-erect, hairs. Metasternum very coarsely punctate. Legs entirely rufous. Length .08 inch; 2 mm. (Fig. 60.)

Male. Antennal club as in preceding species but more elongate and darker.

Female. Antennal club as in *ruficorne*, darker.

The distinguishing characters are, the plain dark colored elytra, the finely but very densely punctured thorax, and the elongate antennal club of two unequal joints.

I can see no valid difference between this species and *nigricorne* Lec. and *picicorne* Lec; *fusculum* Lec. appears to be only a smaller variety which is more pubescent.

Occurs everywhere, in the Atlantic region.

AXINOCERUS, n. g.

Head large, front convex between the eyes, clypeus forming an angle with the front, retracted (Fig. 64). Eyes large, globular, finely granulated, entire, a distinct ocellus. Antennæ inserted under the angle formed by the meeting of the clypeus and front, of eleven joints, bearing an enormous securiform club of one joint. (Fig. 63.) Thorax about twice as wide at base, as long; apex less than half the width of the base, margined; sides arcuate, slightly flattened, margined; posterior angles acute, base slightly bisinuate, broadly lobed at middle, lobe truncate. Scutellum small. Elytra with humeral angles not prominent, sides arcuate, apices separately rounded. Antennal fossa large, somewhat triangular, occupying the entire space between prosternum and lateral margin. Mouth parts, except labrum, covered by the prosternum, which is broad, moderately long, the anterior margin somewhat deflexed, the tip broadly produced posteriorly, dividing the mesosternum. Mesocoxæ widely separated. Metasternum broadly truncate in front. Hind coxæ, coxal plates and legs as in *Cryptorhopalum.*

The creation of this genus is made necessary by the discovery of a new species which cannot be relegated to any of the existing genera. It is closely allied to *Cryptorhopalum* from which it differs only by having a long, retracted clypeus and an antennal club unlike anything heretofore described as occurring in this family. The general form, moreover, is more broadly oval than in the preceding genus.

A. americanus, n. sp. Broadly oval, convex, black, shining, clothed with moderately long, semi-erect, brown pubescence. Elytra uniformly black. Abdomen, legs, and antennæ rufous. Head coarsely not densely punctate. Antennæ of eleven joints, of which 1 and 2 are moderately large, globular, sub-equal. 3–10 small, increasing in size as they recede from the head, to be joined to the basal portion of the upper edge of the large terminal joint, which is flat, broad at base, pointed at apex, three times as long as wide, a little more than twice as long as all the preceding joints taken together. Thorax sparsely and finely punctate at middle, more densely and coarsely at sides. Scutellum smooth and naked. Elytra rather coarsely, not densely punctate, black, side margins near apex rufous. Body beneath black, coarsely and moderately densely punctate, very sparsely pubescent. Length .08 inch; 2 mm. (Fig. 62.)

One specimen from Lavaca county, Texas, in Dr. LeConte's collection, collected by Mr. Schwarz.

ANTHRENUS Geof.

Ovate, convex, dark, covered with scales which are large and triangular in *scrophulariæ*, smaller in *museorum* and *claviger*, and very long and narrow in *varius*. Head small, a distinct ocellus, epistoma moderately long and flat, mouth parts entirely protected by the prosternum. Eyes moderately large, prominent, emarginate in *scrophulariæ*, entire in the rest of our species. Antennæ short, 11-jointed in *scrophulariæ* and *varius*, terminated by a 3-jointed club; 8-jointed in *museorum*, bearing a 2-jointed club, and 5-jointed in *claviger*, with a large club of one joint. Thorax very convex at base, more than twice as wide as long; base three or four times as wide as apex, bisinuate, lobed behind in the median line; lobe acute, covering almost the entire scutellum; lateral margins slightly expanded, arcuate; hind angles prominent. Elytra ovate, apices slightly separately rounded. Antennal fossa dividing the anterior part of the lateral margin of thorax. (Fig. 65.) Prosternum short and wide, lobed in front, covering all the mouth parts except the labrum, produced behind into a broad tip, which does not reach much beyond the anterior coxæ. Mesosternum very wide, completely and broadly divided. Mesocoxæ very widely separated. Metasternum short, side pieces wide. Posterior coxal plate moderately short, wide, but not reaching the sides. Femora stout, grooved beneath for the tibiæ, which are quite slender. First four joints of tarsi small, sub-equal, terminal joint nearly as long as the four united.

This genus possesses very distinct characters by which it may be separated from all others, viz: The short, broad form; the thorax, so wide at base and narrow in front, with the antennal fossæ dividing its lateral margin; the mouth parts covered, except the labrum, by the prosternum; the widely separated mesocoxæ, and finally the clothing, consisting of large or small variegated scales.

The following table will enable us to recognize the species:

Antennæ 11-jointed; club 3-jointed.

Eyes emarginate; scales coarse, large, triangular, as wide as long. Antennal club oval...................... **scrophulariæ.**

Eyes entire; scales fine, not triangular, three times as long as wide. Antennal club oblong.................... **varius.**

Antennæ 8-jointed; club 2-jointed.

Eyes entire, scales small, triangular...................... **museorum.**

Antennæ 5-jointed; club of a single very long joint.

Eyes entire, scales small, triangular...................... **claviger.**

A. scrophulariæ Linn. Ovate, moderately convex, black, clothed with large, triangular, black, white, and orange-red scales. Elytra marked by a sutural longitudinal band and apical spot of orange-red scales and two transverse bands and basal spots of white. Head black, coarsely punctate, thickly covered with black scales, a few orange-red scales around the eyes and on clypeus. Eyes emarginate in front, not very prominent. Antennæ black, 11-jointed, terminated by a broadly oval 3-jointed club, which is as long as all the preceding joints united. Thorax black, coarsely punctate, disc covered with black, sides and base with white and orange scales. Scutellum hardly visible. Elytra black, mostly covered with black scales, but the suture is broadly orange with three equi-distant lateral projections of the same color, the first two of which join sinuous white bands; the posterior is obscurely connected with an apical orange spot; usually a distinct basal white spot. Body beneath black, covered with white and orange scales. First abdominal segment with two naked hollows, on each side of base, to receive the posterior femora, last four with lateral black spots; terminal segment with a large median quadrilateral black space. Legs black or rufous, femora clothed sparsely with white and yellow scales. Length .09–.14 inch; 2.2–3.5 mm. (Figs. 66, 69.)

A common and widely distributed species, to be recognized by the emarginate eyes, large scales, and broadly oval antennal club. The ornamentation varies greatly in color and arrangement. The entire color of the upper surface may be altered, the orange in the sutural band may be replaced by white, and the transverse bands may become indistinct and small, or again large and confluent.

Two varieties dependent on these changes are to be found in our fauna.

Variety **flavipes** Lec. In this, yellow scales seem to have replaced the black, on the head, on the disc of the thorax, between the sinuous bands on the elytra, arranged in spots on the sides of the abdomen and in a quadrilateral space on the last segment. Only a faint trace of white on each side of anterior part of suture. The white bands are larger than in a typical *scrophulariæ,* two large white spots near the apex, represent the posterior lateral prolongation of the sutural orange, and the apical spot. (Fig. 67.)

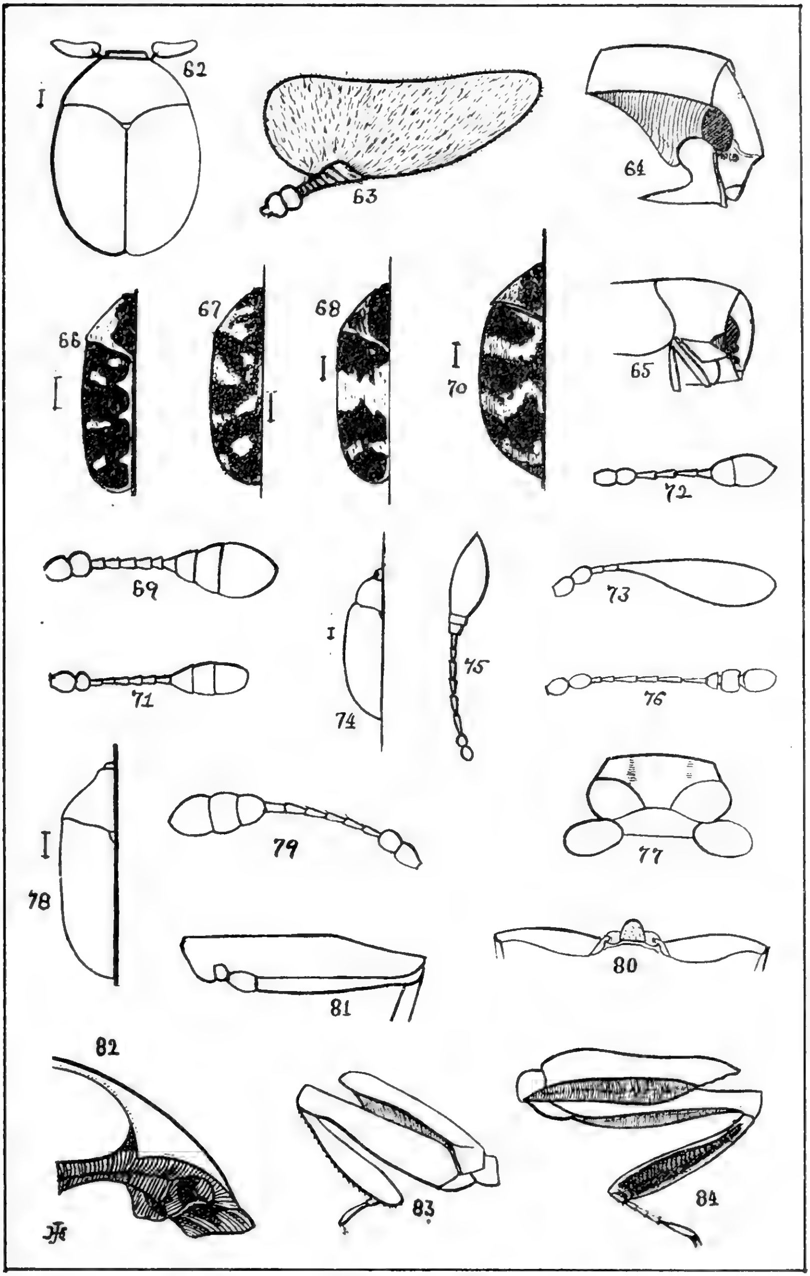
This variety I believe from the description given by Reitter to be the variety *albidus* of Brullé, but I have not had the opportunity for comparison.

Variety **thoracicus** Mels. The scales on the upper surface are black as in *scrophulariæ,* the orange suture may be present or replaced by white ; the first and second transverse bands are large, confluent at the sides only, or throughout their entire extent, forming a very wide sub-basal band. (Fig. 58.)

A. varius Fabr. Ovate convex, black, clothed with yellow, white, and black, fine, long scales. Elytra marked by a larger humeral ring, a transverse sinuous band, and an apical spot of mixed yellow and white scales. Head coarsely punctate, covered with fine yellow scales. Eyes quite prominent, entire ; antennæ black or rufous, 11-jointed, first and second joints large, globular, sub-equal ; 3–8 small, equal, compressed ; 9–11 form a club which equals the preceding part of the antennæ, the last joint decidedly larger than the other two. Thorax coarsely punctate, disc sparsely clothed with yellow, sides and lobe of base covered with white scales. Scutellum hardly discernible. Elytra black, coarsely punctate, covered with black scales and ornamented with a large basal ring, a transeverse median sinuous band, and an apical spot of mixed white and yellow. Body beneath black, clothed with fine, long, yellowish-gray scales, mixed at sides with yellow, first abdominal segment with a naked groove on each side of base to receive the posterior femora, last four marked with brownish-yellow spots at lateral margins ; only a faint spot of black in the middle of the last segment. Legs black, femora covered with scales. Length .07–.12 inch ; 1.7–3 mm. (Figs. 70, 71.)

The distinguishing characters of this species are the fine, narrow and long scales which clothe it ; the entire, prominent eyes, the 3-jointed elongate antennal club, and the almost uniform absence of a large black spot at the last ventral segment. The markings on the elytra vary considerably in different specimens, showing a series from a perfectly banded to an obscurely mottled form. The insects are widely distributed and in the larval stage are especially destructive to zoölogical collections.

A. museorum Linn. Oblong, brown, moderately convex, covered with black and yellowish-white, small, triangular scales. Elytra with black or brown scales sparsely mixed with white, three indefinite, irregular bands also white. Head covered with scales which are brown, around the eyes



DERMESTIDÆ.

whitish. Eyes very prominent, entire. Antennæ brown, 8-jointed; first joint is large, globular, 2–6 small, longer than wide, 7–8 forming the club, longer than wide, equal, together not making up quite one-half the entire antenna. Thorax covered with scales, brown at disc, yellow and white at the sides and base. Scutellum hardly seen. Elytra brown, covered, not densely, with brown and white scales, marked by three irregular indistinct sinuous bands and humeral spot of white. Body beneath brown, covered with small, triangular, cinereous scales, a row of black spots on each side of abdomen, no naked hollows on the first segment, and a faint median black spot on the last. Legs brown, femora clothed with whitish scales. Length .06–.10 inch; 1.5–2.5 mm. (Fig. 72.)

This species can be recognized by the entire eyes, the 8-jointed antennæ, and small triangular sparse scales.

A. claviger Er. Ovate, convex, black, clothed with black, moderately large, triangular scales. Elytra ornamented with three faint, sinuous bands and humeral spot of yellow scales. Head black, coarsely punctate, scales black and yellowish. Eyes prominent, entire. Antennæ 5-jointed; joints 1–2 large, globular, sub-equal, 3–4 very small and compressed, the last more than three times as long as the other joints united; rufous, last joint darker. Thorax coarsely punctate, scales black at middle, yellow at sides. Elytra black and piceous, very coarsely punctured, clothed with black scales and with three equally separated, indistinct, interrupted, sinuous bands, and humeral spot of small yellow scales. Body beneath black, covered with small sparse cinereous scales. Legs rufous. Length .07 inch; 3.7 mm. (Fig. 73.)

The smallest, darkest, and least conspicuously ornamented of any of our species. The distinguishing characters are the 5-jointed antennæ with its 1-jointed club, the entire eyes, the small sparse scales, and the almost uniform color of the elytra.

Occurs in Pennsylvania.

APSECTUS Lec.

The one species upon which this genus is established, is the smallest form found among our *Dermestidæ;* the head is wide, the epistoma short, the ocellus distinct, the mouth parts protected by the prosternum. Eyes very large, prominent, rounded, entire. Antennæ as long as the thorax, 11-jointed, terminated by a slender, elongated, 3-jointed club. Thorax twice as wide as long, sides flattened, lateral margins arcuate, hind angles prominent; base bisinuate, slightly lobed posteriorly at middle. Scutellum quite large. Elytra as wide as long, sides regularly oval, apical angles not separately rounded. Antennal fossæ not sharply defined, sub-marginal. Prosternum lobed in front, narrow, moderately long, produced behind between the anterior coxæ, separating them widely, but broadly truncate at tip, reaching the mesosternum which is short, three times as wide as long and rounded in front. Mesocoxæ very widely separated. Posterior coxal plate very short, moderately wide, but not attaining the sides. Legs moderately stout, last joint of tarsus as long as the four preceding taken together.

This genus closely resembles *Trinodes*, but the latter has the prosternum prolonged sub-acutely behind, entirely dividing the mesosternum, and the antennal cavities are wanting.

A. hispidus Mels. Sub-oval, convex, black, covered with sparse, very long, erect, brown hairs. Elytra brown or black. Head sparsely pubescent. Antennæ 11-jointed, testaceous, club 3-jointed, darker. Thorax sparsely punctured and pubescent. Scutellum naked. Elytra black or rufous, coarsely, moderately sparsely punctate, pubescence sparse, very long. Body beneath light brown, pubescent. Abdomen coarsely punctate, pubescence more dense. Length .05 inch ; 1.5 mm. (Figs. 74, 77.)

Male. Antennæ terminated by a 3-jointed club, of which the joints 1–2 are small, 3 half as long as the entire antenna. (Fig. 75.)

Female. Antennæ bearing a 3-jointed club, the last joint of which is equal to the two preceding taken together. (Fig. 76.)

In addition to the anatomical characters already given, we may recognize the insect by the small size and long erect pubescence.

Occurs in the Middle and Southern States.

ORPHILUS Erichs.

Head with small but distinct ocellus. Eyes moderately prominent, moderately coarsely granulated, emarginate in front. Antennæ 11-jointed, bearing a 3-jointed club. Thorax very convex, nearly as long as wide at base, apex only one fourth as wide as the base, which is bisinuate, sides arcuate, lateral margins nearly straight, only the posterior half can be seen from above. Hind angles moderately prominent. Scutellum distinct. Sides of elytra nearly parallel, antennal cavities not well defined, confined to the anterior half of spaces between prosternum and side margins, which space is marked just behind middle, with a deep pit to receive the knee of the anterior leg, behind which is the usual transverse fossa for the middle leg. (Fig. 82.) Prosternum small, declivous, produced behind but not passing the anterior coxæ, which are very large and approximated. Mouth parts and prosternum covered by the anterior legs. Mesosternum large, as broad as long, rounded in front, widely separating the mesocoxæ. (Fig. 80.) Hind coxæ short and wide, reaching the sides of the body. Coxal plates also wide, covering the anterior portion of the femur for its entire length. (Fig. 81.) Femora very stout, attaining the sides, punctured, channeled beneath for the tibiæ, anterior tibiæ very broad and flat, with a groove on the anterior surface to receive the tarsus. (Figs. 83, 84.) The middle and posterior tibiæ are more slender. Tarsis moderately slender, last joint equaling the four preceding added together.

The characters upon which to rely for a proper appreciation of this genus are, the insignificant prosternum ; large, entire mesosternum ; the large anterior legs protecting the mouth parts, the pits to receive the anterior knees, the character of hind coxal plates and the almost entire absence of pubescence.

O. glabratus Fabr. Ovate, black, moderately convex, shining, without pubescence. Elytra uniformly black. Head coarsely punctate. Antennæ rufous, 11-jointed, bearing a 3-jointed club which equals about one-half the preceding part of the organ. Joints 1–2 moderately large, 3–8 small, 9 twice as long as any of the preceding and as wide as long, equaling joint 10; the terminal joint is somewhat longer. Thorax coarsely punctate. Scutellum with a few fine punctures. Elytra entirely black, very coarsely punctured, with a transverse depression across the basal third and a faint vertical one on each side of the suture, on the apical half. Body beneath black, coarsely punctate, abdomen rufous, lighter at the edges of the segments. Legs rufous. Length .12 inch; 3 mm. (Figs. 79, 80.)

There is but one species in our fauna, but the punctures on the thorax vary considerably as to size and number, in the different specimens. When they are coarse and deep the insect is a true *glabratus;* when less coarse we may regard it as the variety *ater* Er., and when relatively fine as the variety *subnitidus* Lec. There are no characters of sufficient value to enable us to separate these forms into different species. The larger specimens, the second variety by the way, are from the Pacific, the smaller from the Middle States.

Synonymy and Bibliography.

DERMESTIDÆ.

SUB-FAMILY I; BYTURIDÆ.

BYTURUS.

Latr. Préc. car. Ins. 1796, p. 69.

unicolor Say. Journ. Acad. Phil., iii, p. 197.
americanus, Dej. Cat., 3d ed., p. 137.

grisescens Lec. New species, Col. 34, i, 1863.

SUB-FAMILY II; DERMESTIDÆ—(genuini.)

LeConte Synopsis, Proc. Acad. Phil., 1854, p. 106.

DERMESTES.

Linn. Syst. Nat. ii, 1767, p. 561.

marmoratus Say. Journ. Acad. Phil., iii, p. 197, Chevrol. Ann. Fr. 1863, p. 616.
var. Mannerheimi Lec., loc. cit., p. 107.

fasciatus Lec., loc. cit., p. 107.

murinus Linné, Faun. Suec., p. 144; Erich. Nat Ins., iii, p. 429.
caninus Germ., Ins., spec. nov., p. 84.
nubilus Say, Ins. of Louisana, 1832; Lec., loc. cit., p. 107.
dissector Kirby, Fauna. Bor. Am., iv, p. 115.
rattus Lec., loc. cit., p. 108.

talpinus Mann. Bull. Mosc., 1843, ii, p. 257.

sobrinus Lec., loc. cit., p. 108.
mucoreus Lec., loc. cit., p. 108.
pulcher Lec., loc. cit., p. 108.
lardarius Linn., Faun. Suec., p. 140.
var. signatus Lec., Trans. Amer. Ent. Soc., 1874, p. 50.
elongatus Lec., loc. cit., p. 109.
cadaverinus Fabr., Syst. Ent., p. 55; ibid. Ent. ii, 9, p. 7, t. 2, f. 9, a-b.
vulpinus Fab., Spec. Ins. i, p. 64.; Lec., loc. cit., p. 109.
lupinus Mann., Bull. Mosc., 1843, ii, p. 257.
maculatus DeGeer, Ins. iv, p. 223.

Attagenus.

* Latr. Gen. Crust. et Ins. ii, 1807, p. 32.

piceus Oliv., Ent. ii, 9, p. 10, t. 1, f. 4, a-b.
dichrous Lec., loc. cit., p. 110.
megatoma Fabr., Ent. Syst., Suppl., p. 71.
rufipennis Lec., Proc. Acad. Phil., 1859, p. 71.
spurcus Lec., Synop., loc. cit., p. 109.
pellio Linné, Fauna. Suec., p. 141.
bipunctatus Deg., Ins. iv, p. 197.
Hornii, n. sp.
perplexus, n. sp.
varicolor, n. sp.

Dearthrus.

LeConte, Class. Col., N. Am., 1, 1861, p. 108.

longulus Lec., New Spec. Col., i, 1863, p. 73.

Perimegatoma.

Horn, Trans. Amer. Ent. Soc., 1875, p. 135.

cylindricum Kby., Fauna Bor. Am., iv, p. 113, pl. 7, fig. 3; Horn, loc. cit., p. 136.
var. *angularis*, Mann. Bull. Mosc., 1853, iii, p. 216.
variegatum Horn, loc. cit., p. 136.
falsum Horn, loc. cit., p. 136.
Belfragei Lec., Trans. Amer. Ent. Soc., 1874, p. 49; Horn, loc. cit., p. 137.

Acolpus, n. g.

primus, n. sp.

Trogoderma.

Latr., Regn. Anim. Ed. 2, iv, 1829, p. 511.

simplex, n. sp.
sternale, n. sp.

ornatum Say., Journ. Acad Phil. v, p. 185.
pusillum Lec., Synop. loc. cit., p. 111.
inclusum Lec., loc. cit., p. 110.
pallipes Ziegl., Proc. Acad. Phil. ii., p. 269.
tarsale Mels., Proc. Acad. Phil. ii, p. 116.

CRYPTORHOPALUM.

Guér., Ic. Regn. Anim. Ins., 1838, p. 67.

balteatum Lec., Synop. loc. cit., p. 111.
hæmorrhoidale Lec., Ann. Lyc. 1, p. 170. t. 11, f. 4.
apicale Mann., Bull. Mosc., 1843, ii, p. 258.
ruficorne Lec., Synop. loc. cit., p. 111.
triste Lec., l. c., p. 111.
var. *fusculum* Lec., loc. cit., p. 111.
nigricorne Lec., Proc. Acad. Phil., 1861, p. 344.
picicorne Lec., Synop. loc. cit., p. 111.

AXINOCERUS, n. g.

americanus, n. sp.

ANTHRENUS.

Geoffroy, Inst. Envir. Par. i, 1764, p. 113.

scrophulariæ Linn., Syst. Nat. i, 2, p. 568.
var. *flavipes* Lec., Synop., p. 112.
var. *thoracicus* Mels., Proc. Acad. Phil. ii, p. 117.
lepidus Lec., Synop. loc. cit., p. 112.
varius Fabr., Syst. Ent., p. 60.
var. *destructor* Mels., loc. cit., p. 116.
museorum Linn., Fauna Suec., p. 145.
castaneæ Mels., loc. cit., p. 116.
claviger Er., Nat. Ins. iii, p. 458.

APSECTUS.

LeConte, Proc. Acad. Phil., 1854, p. 113.

hispidus Melsh., Proc. Acad. Phil. ii, p. 117; Lec., loc. cit.

ORPHILUS.

Erich., Nat. Ins. iii, 1846, p. 461.

glabratus Fabr., Syst. El. i, p. 109; Er., loc. cit., p. 462.
ater Erich., loc. cit., p. 463.
subnitidus Lec., Proc. Acad. Phil., 1861, p. 344.

Explanation of Plate.

Fig. 1. Underside of **Byturus unicolor** Say.
Fig. 2. Posterior coxal plate of **Byturus.**
Fig. 3. Tarsus of the same.
Fig. 4. Antenna of **Byturus unicolor** Say.
Fig. 5. **Byturus grisescens** Lec.
Fig. 6. Antenna of the same.
Fig. 7. Antenna of **Dermestes.**
Fig. 8. Underside of prothorax of the same.
Fig. 9. Posterior coxal plate of the same.
Fig. 10. **Dermestes marmoratus** Say
Fig. 11. " **fasciatus** Lec.
Fig. 12. " **murinus** Linn.
Fig. 13. " " var. **caninus?**
Fig. 14. " **lardarius** Linn.
Fig. 15. " " var. **signatus** Lec.
Fig. 16. " **pulcher** Lec.
Fig. 17. " **elongatus** Lec.
Fig. 18. Antenna of ♂ **Attagenus Hornii,** n. sp.
Fig. 19. " ♀ same.
Fig. 20. " ♂ **Attagenus varicolor,** n. sp.
Fig. 21. " ♀ same.
Fig. 22. " ♂ **Attagenus piceus** Oliv.
Fig. 23. " ♀ same.
Fig. 24. **Attagenus Hornii,** n. sp.
Fig. 25. Prosternum and mesosternum of the same.
Fig. 26. **Attagenus piceus** Oliv.
Fig. 27. " **varicolor,** n. sp.
Fig. 28. Prosternum and mesosternum of the same.
Fig. 29. **Attagenus pellio** Linn.
Fig. 30. Prosternum and mesosternum of the same.
Fig. 31. **Dearthrus longulus** Lec.
Fig. 32. Prosternum and mesosternum of the same.
Fig. 33. Antenna of ♀ of the same.
Fig. 34. Posterior coxal plate of **Perimegatoma.**
Fig. 35. Underside of prothorax of the same.
Fig. 36. Elytral markings of the same.
Fig. 37. Antenna of ♂ **Perimegatoma cylindricum** Kby.
Fig. 38. " ♀ same.
Fig. 39. " ♂ **Perimegatoma variegatum** Horn.
Fig. 40. " ♀ same.
Fig. 41. " ♂ **Perimegatoma falsum** Horn.
Fig. 42. " ♀ same.
Fig. 43. " ♂ **Perimegatoma Belfragei** Lec.
Fig. 44. " ♀ same.

Fig. 45. **Acolpus primus**, n. sp.
Fig. 46. Head and antennæ of ♂ **Trogoderma ornata** Say.
Fig. 47. Antenna of ♀ same.
Fig. 48. Underside of head and prothorax of the same.
Fig. 49. Prosternum and mesosternum of the same.
Fig. 50. " " " **Trogoderma sternale**, n. sp.
Fig. 51. **Trogoderma simplex**, n. sp.
Fig. 52. Underside of head and prothorax of the same.
Fig. 53. Head and antennæ of **Trogoderma inclusum** Lec.
Fig. 54. **Cryptorhopalum balteatum** Lec.
Fig. 55. Antenna of ♂ **Cryptorhopalum hæmorrhoidale** Lec.
Fig. 56. " ♀ same.
Fig. 57. Underside of prothorax of **C. apicale** Mann.
Fig. 58. Antenna of ♂ same.
Fig. 59. " ♀ same.
Fig. 60. Thorax of **Cryptorhopalum triste** Lec.
Fig. 61. Thorax of **Cryptorhopalum ruficorne** Lec.
Fig. 62. **Axinocerus americanus**, n. sp.
Fig. 63. Antenna of the same.
Fig. 64. Side view of the head and thorax of the same.
Fig. 65. " " " " **Anthrenus.**
Fig. 66. **Anthrenus scrophulariæ** Linn.
Fig. 67. " " var. **flavipes** Lec.
Fig. 68. " " var. **thoracicus** Mels.
Fig. 69. Antenna of the same.
Fig. 70. **Anthrenus varius** Fabr.
Fig. 71. Antenna of the same.
Fig. 72. " **Anthrenus museorum** Linn.
Fig. 73. " **Anthrenus claviger** Er.
Fig. 74. **Apsectus hispidus** Mels.
Fig. 75. Antenna of ♂ of the same.
Fig. 76. " ♀ of the same.
Fig. 77. Prosternum and mesosternum of the same.
Fig. 78. **Orphilus glabratus** Er.
Fig. 79. Antenna of the same.
Fig. 80. Mesosternum and femora of the same.
Fig. 81. Posterior coxal plate of the same.
Fig. 82. Half of the underside of thorax of the same.
Fig. 83. Anterior leg of the same, lower surface.
Fig. 84. " " " " upper "

Stated Meeting, July 21, 1882.

Present, 3 members.

Dr. Cresson, in the Chair.

Letters of acknowledgment were received from Dr. B. A. Gould of Cardova; the Musée Guimét; the Soc. Zoologique de France; Royal Irish Academy; and Adelaide Observatory.

A request from the Meteorological Society of London, 1838–40, was on motion granted.

On the President's recommendation it was ordered that the Leander McCormick Observatory of Virginia University be placed on the list of correspondents to receive the Proceedings.

A copy of Proceedings No. 111, just published, was laid on the table for inspection.

The copy of Dr. G. B. Wood's portrait in the University, by Miss M. W. Lesley, ordered by the Society, was exhibited.

Donations for the Library were received from the Asiatic Society of Japan; the Natural History Societies at Emden, Geneva and Bonn; the Academies at Brussels, Turin and Rome; Prof. E. Renevier, Lausanne; the Soc. de Geographie; Prof. Persifor Frazer; M. H. Brocard, of Paris; the Société Geographic Commerciale, Bordeaux; the Revista Euskara, Pamplona; Royal Astronomical Society, Journal of Forestry and Nature, and Messrs. William Tebb and G. J. Symons, of London; the Field Naturalist of Manchester; the Mitchell Library of Glasgow; the Literary and Historical Society of Quebec; the Observatory at Yale College and Prof. E. Loomis; Connecticut Academy; American Journal of Science; Essex Institute; Boston Society of Natural History; Prof. W. M. Davis; American Journal of Medical Sciences; Franklin Institute; Journal of Pharmacy, Library Company and Mercantile Library at Philadelphia; Prof. J. S. Newberry; U. S. National Museum; Chief of Engineers; Coast Survey; Edward C. Pickering; Historical and Geological Society at Wilkesbarre; Ohio Mechanics' Institute; Antiquarian and Oriental Journal; Minnesota Academy, and Adelaide Observatory.

Pending nominations Nos. 959 to 963 were read and balloted for and the following were declared duly elected members:

Prof. Léon de Rosny, of Paris.

Hon. Edward Sêve, Consul Gen. Belgium to U. S. A.

Mr. Joseph Snowden Bell, of Philadelphia.

M. Gaston Planté, of Paris.

Mr. Alexander Graham Bell, of Washington, D. C.

And the meeting was adjourned.

Stated Meeting, August 18, 1882.

Present, 3 members.

Curator, Mr. PHILLIPS, in the Chair.

Letters accepting membership were received from Mr. J. Snowden Bell, dated Philadelphia, 913 Walnut Street, July 26, 1882.

From Mr. Alexander Graham Bell, dated McCurdy Cottage, Newport, R. I., Aug. 7, 1882.

And from Mr. Léon de Rosny, dated Paris, No. 47 Avenue du Quêsne, Aug. 5, 1882.

Acknowledgments of the receipt of publications were received from the R. A. Amsterdam (105, 106, 107, 108, List, XV, iii); the Society at Würtemberg (107, 108, XV, iii); the Zoological Society in Amsterdam (109); the London Statistical Society (109); the Geological Survey of Canada (110, 111); the Maryland Historical Society (111); the Museum of Comp. Zoology (111) and Mr. A. Agassiz (111).

Envoy letters were received from the R. A. Amsterdam; the Bib. Nat. Vitt. Em. at Rome; and the Greenwich Observatory.

Donations to the Library were received from the Frankfort Zoological Garden; the Vienna Anthropological, Geological, Zoological and Meteorological Institutions; the Berlin Academy and Geological and Horticultural Societies; the Societies at Stuttgard and Göttingen; the two Academies in Rome, and the R. Geological Commission; the Paris Museum N. H., Bureau of Longitudes, Annales des Mines, Ethnological, Anthropological, Geographical and American Societies, Ecole Polytechnique, International Congress of Orientalists, M. C. Schnœbel, M. M. Loewy, and Revue Politique; the Guimét Museum at Lyons; the Geographical and Linnean Societies at Bordeaux; the Abbeville Society of Emulation; the Brussels Academy and Statistical Commission; the British Association, the London Astronomical, Meteorological, Geographical, Geological, Zoological, Asiatic and Antiquarian Societies; the Greenwich Observatory; the Edinburgh Royal Society; the Cornwall Polytechnic Society; the Melbourne Surveyors, and Inspectors of Mines; the Royal Society of Canada at Ottawa; the Essex Institute; Am. Antiquarian Society; Museum of C. Zoology; Am. Journal of Science; N. Y. Meteorological Observatory; Long Island Historical Society; Franklin Institute; Engineers' Club; Journal of Pharmacy; Academy of N. S. of Philadelphia; Johns Hopkins University; U. S. Signal Bureau; War Department; Census Bureau; National Museum and Fish Commission.

The death of Gouverneur K. Warren, Lieu.-Col. U. S. A., at Newport, R. I., Aug. 8, 1882, was announced.

The death of Viscount De Rougé (the announcement of which had been omitted) was ordered to be placed on record.

Dr. Genth read a paper entitled "Contributions from the Laboratory of the University of Pennsylvania. XX. Contributions to Mineralogy."

New nominations Nos. 964, 965, 966, 967, 968 were read; and the meeting was adjourned.

Contributions from the Laboratory of the University of Pennsylvania.

No. XX.

CONTRIBUTIONS TO MINERALOGY.

By F. A. Genth.

(*Read before the American Philosophical Society, August 18, 1882.*)

I. In a paper, read before the American Philosophical Society on September 19th, 1873, I communicated some observations on the occurrence of *Corundum,* and, especially, on its alteration into other minerals. Since then I had an opportunity to examine many beautiful specimens of the same kind, by which my views on the subject received the fullest confirmation. I was in hopes that I would be able to prepare a second edition of my paper, illustrated with carefully drawn figures of the most important and striking forms, but, finding that my time is too much taken up by other duties, I fear that I shall never accomplish my desire, and, for this reason, will place on record, as an appendix to my first paper, the description of a few very remarkable occurrences.*

* In his Handbuch der Mineralchemie, 2 Auflage, Leipzig, 1875, Prof. C. F. Rammelsberg repeatedly refers to the above investigation, but, unfortunately, gives me credit for statements which I never have made. As they are of too much importance to remain uncontradicted, I will briefly allude to the most striking.

On page 147 (Specieller Theil), he says that I came to the conclusion that "*at the time, when chrysolite changed into serpentine, corundum was formed, which, subsequently, was altered into other minerals,*" while I simply state the fact that the largest deposits of corundum occur in serpentine, or in chrysolite, or the rocks immediately adjoining the same, and I do not even intimate that they were formed at the time when the latter changed into the former, as they occur equally in both; that I do not suppose (as Prof. R. seems to believe) that the alumina was eliminated from rocks which do not contain any appreciable quantity of it, is, I should think, sufficiently indicated by my query, "*by what agencies such enormous quantities of alumina could have been precipitated to form corundum?*"

On page 137, in quoting some of my analyses of the black spinels (ceylanites), Prof. Rammelsberg remarks that *their purity was very doubtful*, and that *besides the 4.31 per cent. of corundum*, which were eliminated during the process of analysis, *it must contain 9.6 per cent. additional.* If Prof. Rammelsberg had read my paper with the least attention, he would have found that I come pretty nearly to the same conclusion, for I say: "*that the most carefully selected material still contained a mechanical admixture of 13.36 per cent. of corundum.*" How little Prof. Rammelsberg seems to appreciate the drift of the whole investigation, is proved by the fact that he attacks the purity of my mineral species, when I never intended to publish these analyses as those of typical specimens of spinel, but, on the contrary, as *mixtures*, still showing remnants of the original species, and I distinctly say: "*This analysis, however, establishes the very important fact of the mechanical admixture of corundum.*"

On page 182, Prof. Rammelsberg says: "*According to Hunt bauxite is changed into corundum by strong ignition, and* GENTH THINKS THAT THIS ALTERATION TAKES PLACE AT ORDINARY TEMPERATURE ALSO." Now, the second part of the sentence

1. Corundum, altered into Spinel.

a. At the Carter Mine, in Madison county, N. C., corundum is found in white and pink crystals, but mostly in irregular grayish-white or white cleavage masses, generally enveloping a variety of a delicate pink color. Where small cracks or fissures occur in the corundum, it can be observed, sometimes only by a small dark line, that a change has commenced which in many places extends through large masses, converting the corundum into a massive greenish-black spinel, with uneven fracture, and of a fine granular structure, rarely showing planes of octahedral crystals in the compact mass. It yields a grayish-green powder and has a specific gravity of 3.751. The spinel shows in many cases small scales of prochlorite, into which it finally passes.

With difficulty I have selected some which was free from prochlorite, but although the material appeared to be quite pure, it was found to contain a small quantity of unaltered corundum = 1.15%. The following are the results of my analysis (a), and after deducting silicic acid and corundum (b), calculated composition (c).

		a.		b.		c.		
Al_2O_3	=	66.02	—	66.74	—	$FeFe_2O_4$	=	1.94
Fe_2O_3	=	1.33	—	1.34		$FeAl_2O_4$	=	27.53
CuO	=	0.09	—	0.09		$CuAl_2O_4$	=	0.21
NiO	=	0.33	—	0.33		$ZnAl_2O_4$	=	0.50
ZnO	=	0.22	—	0.22		$NiAl_2O_4$	=	0.78
FeO	=	11.81	—	11.94		$MgAl_2O_4$	=	69.04
MgO	=	19.13	—	19.34				
SiO_2	=	0.24	—	—				
Corundum	=	1.15	—	—				
		100.32		100.00				100.00

b. At the meeting of the American Philosophical Society of March 17, 1882, Dr. Edgar F. Smith and Mr. N. Wiley Thomas described corundum from a locality, three-quarters of a mile north of Shimersville, in Lehigh county, where numerous crystals had been ploughed up. I am indebted to Dr. Smith for a variety of specimens. The crystals are mostly rough, and show the hexagonal prism and pyramid and basal planes. Many of them have some feldspar and mica attached, showing that they probably come from a granitic gangue. The color of the crystals is generally gray, a few, however, show a reddish or a pink color. Disseminated through all the crystals and frequently accumulating on the surface, are minute, very brilliant crystals of a highly titaniferous menaccanite; these are *not*

which he saddles on me, is Dr. Hunt's. I positively deny the possibility of such a change in the following language: "*I do not know of a single instance in which corundum could have eliminated under such circumstances from the hydrate; on the contrary, the presence of grains of corundum in the bauxite proves pretty conclusively that the latter results from the hydration of corundum, and that the grains which have been found are remnants, not yet converted.*"

magnetic. It appears that this corundum has not been altered to a very great extent, only a few specimens of black spinel in irregular masses or rounded, pyramidal forms have been found, besides these only very thin yellowish or greenish, soft coatings, in very minute quantity, which may be a potassium mica. I could not get enough for examination. The spinel has an iron-black color, and is slightly magnetic. Its specific gravity is = 4.056.

Mr. George M. Lawrence has made an analysis of it in the Laboratory of the University of Pennsylvania, and found, after deducting 1.47% of silicic acid as follows (a); the calculated composition (b).

		a.	b.		
Al_2O_3	=	56.42	$MgAl_2O_4$	=	25.40
Fe_2O_3	=	13.17	$FeAl_2O_4$	=	48.51
FeO	=	22.95	$FeFe_2O_4$	=	26.09
MgO	=	4.94			
TiO_2	=	2.62			100.00
		100.10			

The titanic acid is present evidently as a mechanical admixture of menaccanite $FeTiO_3$; deducting this and 24.16% of corundum, the composition of the pure spinel is given under (b). I do not consider the $FeFe_2O_4$ a mechanical admixture of magnetite, as it cannot be dissolved out by hydrochloric acid.

2. *Corundum, altered into Zoisite.*

This is one of the rarer forms into which corundum is altered. I will add, therefore, Towns county, Georgia, as a new locality, where it occurs in small quantity.

The corundum is of a beautiful pink color, surrounded by greenish-white, cleavable zoisite.

3. *Corundum, altered into Feldspar and Mica (Damourite).*

When my first observations on the alterations of corundum were published, I expressed some doubt about the feldspar, as having been the results of such a change, because I had then not seen any specimens which gave positive evidence of it, although even at that time there was a great probability that a substance which, beyond any question, was found to be altered into fibrolite, cyanite, mica, zoisite, &c., could also, without difficulty, be converted into feldspars. Since then I have seen many specimens which remove my last doubts and prove that most of the occurrences, referred to in my paper, are the results of alteration. In addition to those already mentioned, I will give a few data which may be of interest:

a. I had mentioned a granular, yellowish or brownish-white oligoclase from Unionville, as the probable result of such a change. At the same locality we find occurring in small quantities, remnants of crystals of gray corundum, generally surrounded by a little silvery mica in fine scales, in brownish-white or light brown cleavable feldspar, in masses sometimes from 25 to 30^{mm} in diameter. The feldspar shows distinct triclinic striation. The corundum, where it is in contact with the feldspar or the micaceous coating, has a corroded appearance. The analysis gave :

SiO_2	=	62.62	contains oxygen	33.36	
Al_2O_3	=	22.59	" "	10.55	} = 3.6
Fe_2O_3	=	0.22	" "	0.06	
MnO	=	trace			
MgO	=	0.18	" "	0.07	} = 2.89
CaO	=	1.94	" "	0.56	
Na_2O	=	7.41	" "	1.91	
K_2O	=	2.52	" "	0.35	
Ignition	=	2.45			
		99.93			

This feldspar, after its fine powder had been dried over sulphuric acid for several days, gave on ignition 2.45 % of water and, in another sample, 2.55 %. As there is not a sufficient amount of bases R_2O and RO present for oligoclase, may not a portion of this water be basic water?

b. Another interesting occurrence of the alteration of corundum into a feldspar, is that at the "Black Horse" tavern, near Media, in Delaware county. The corundum, of a dark gray color in rough crystals, generally coated with a film of fine scaly mica, is imbedded in a finely granular brownish-white feldspar, which has probably resulted from its alteration. It has a specific gravity of 2.611, and the mean of two closely agreeing analyses, is as follows :

SiO_2	=	58.42	contains oxygen	31.16	
Al_2O_3	=	23.14	" "	10.82	} = 10.87
Fe_2O_3	=	0.18	" "	0.05	
MnO	=	trace			
MgO	=	0.35	" "	0.14	} = 3.45
CaO	=	3.13	" "	0.89	
SrO	=	trace			
BaO	=	2.56	" "	0.27	
Na_2O	=	3.68	" "	0.95	
K_2O	=	7.06	" "	1.20	
Ignition	=	1.54			
		100.06			

The constituents of $R_2O(RO)$: R_2O_3 : SiO_2 are in the ratio of 3.45 : 10.87 : 31.16, which is = 1 : 3.1 : 9, or almost exactly that of oligoclase.

It is an interesting fact that a part of the calcium oxide is replaced by barium oxide.

c. The Presley Mine in Haywood county, N. C., has furnished some very remarkable specimens of corundum, altered into feldspar as well as mica (muscovite).

α. The corundum at that Mine is generally of a grayish-blue color, sometimes in large crystals, more or less altered into the two minerals mentioned. Frequently in the interior of the crystals, when the altering agents had access by fissures or otherwise, small patches of white, cleavable feldspar may be seen, often, but not always, surrounded by mica. In other specimens, very little of the original mineral is left, and the grayish blue, deeply striated nucleus of corundum is surrounded by an aureole of exceedingly delicate, subfibrous mica (damourite) variable in thickness from 1 to over 20^{mm} in diameter. When in immediate contact with the corundum the altered mineral is generally almost compact and scarcely presents a crystalline structure, farther away from it, it becomes more scaly, the scales increasing in quantity and size; often large plates are mixed with very fine scales of mica. The color of the compact and subfibrous mica is generally of a very delicate pink, but sometimes also white with silky lustre; the scales are mostly white with a yellowish or silver-gray tint. Masses of such, partly altered corundum, of over 150^{mm} in diameter have been found, containing nuclei of nearly unaltered corundum of from 10 to 100^{mm} in diameter, sometimes showing the beginning of a change into mica and albite, where the alteration has been facilitated by fissures.

β. A very remarkable specimen from the same mine is an imperfect crystal of muscovite with plates of 35^{mm} in diameter, showing three or four sides of a six-sided prism. The upper and lower part of the original crystal are broken off, but it is still over 50^{mm} in height. It has an eminently basal cleavage, easily splits into thin elastic laminæ and has a brownish-gray color. In the center of the crystal and also in the lower part are remnants of smooth, bluish-gray cleavable corundum from 8 to 10^{mm} in diameter. On the exterior portion of the muscovite are small quantities of albite.

γ. The alteration of corundum into muscovite and albite is perhaps still better represented by a specimen, consisting of an imperfect crystal of muscovite of a brownish-gray color, of over 80^{mm} in diameter and a thickness of 40^{mm}, to which is attached, especially on one side, white, cleavable albite. The whole specimen is over 150^{mm} long, about 85^{mm} broad and 45^{mm} thick. Disseminated through the mass, both the mica and the feldspar, are remnants of crystals of grayish-blue corundum. Generally there is a thin seam of mica between the corundum and feldspar, but, in many places, the latter is in immediate contact with the corundum. The corundum shows distinctly the action of dissolving agents, it is rounded, smooth, as, if waterworn, sometimes corrugated, etc.

The whole mass has the appearance of a coarse granite, in which the quartz is replaced by corundum.

The corundum closely resembles the coarse crystals which are associated with mica and feldspar at Ilmensk and the River Barsovka in the Ural.

The analysis of the broadly foliated muscovite (c 1), that of the albite (c 2).

d. Very interesting varieties of altered corundum have been discovered by Mr. J. A. D. Stephenson of Statesville, N. C., at Belt's Bridge, Iredell county, N. C. The corundum has a gray and grayish-white color, and occurs in masses, sometimes over a foot in diameter, but generally smaller; they are irregular in form, always more or less rounded, sometimes globular, egg-shaped, rarely pyramidal and showing yet the crystalline form of corundum, but of the original mineral, many of the globular masses do not contain a trace, others contain small particles, disseminated through the mass, or a nucleus in the center. The altered mineral is mostly mica (damourite) some of the specimens also contain black tourmaline in radiating crystalline masses, which sometimes start from the corundum nucleus, but not always. The mica is either compact, of a grayish-white color or subfibrous (analysis (d1) by Miss Mary T. Lewis, after deducting 3.51 of corundum), and very fine scaly with pearly lustre, the scales rarely assume a size of more than 2^{mm} in diameter. In one of the specimens in which all the corundum has disappeared, I noticed minute cavities, containing fragments of a vitreous mineral which appears to be quartz, but the quantity was too small for further examination.

In connection with this, I will mention a specimen from the same locality, received by Col. Joseph Willcox. It appears to be a fragment of an irregular hexagonal prism, a little over 100^{mm} high, and somewhat less broad. The original form is scarcely perceptible, the sides being rounded and rough. There is a core of unaltered gray corundum of 65 $\times$ 55^{mm} surrounded with subfibrous, and on the outside with scaly mica, inclosing bunches of radiating, black tourmaline; disseminated through the unaltered corundum are many rounded masses of a brownish-red garnet from 4 to 6^{mm} in diameter, an association which I never before have observed. The analysis of the subfibrous mica, surrounding this corundum, which has been made by Mr. Frank Prince shows that a portion of the alkalies has been replaced by lime (d2).

e. In 1876 corundum was discovered in the micaceous schists near Bradford, Coosa county, Alabama, of which numerous specimens have been kindly presented to me by Dr. Eugene A. Smith, State Geologist of Alabama.

It is usually found in hexagonal prisms, but also in pyramidal form, apparently $\frac{4}{3}$–2, always, however, very rough and altered.

The corundum itself is of a brown and bronze color; sometimes exhibiting a star of six rays. Amongst the large number of specimens which I have examined, I have never seen one which was free from an admixture of grains of menaccanite ; in some of the crystals there were only a few small ones, rarely over one millimetre in size, in others, the quantity, disseminated through the corundum, is very large, and a great portion, probably in the act of crystallization, has been pushed to the outside of the corundum crystals, and gives them a coating of menaccanite, which sometimes reaches a thickness of 5^{mm}. The menaccanite grains have no distinct form, they have an iron-black color, and, on a fracture, submetallic lustre, they are not magnetic, and gave the following composition :

TiO_2	=	17.62
Fe_2O_3	=	67.36
Al_2O_3	=	3.73
FeO	=	11.14
MgO	=	0.27
SiO_2	=	0.41
		100.53

The only alteration of this corundum which I have noticed, is that into mica and small quantities of tourmaline, but the specimens which have been obtained from this locality are the most beautiful and of great scientific interest.

The brown corundum is surrounded with greenish-white subfibrous mica, showing under a good magnifier a very fine scaly structure ; this mica is sometimes only a very thin coating, but frequently from 2 to 5^{mm} in thickness, surrounded by fine scaly mica, much of which has changed to brown scales with submetallic lustre, which largely exfoliate when heated, like jefferisite or maconite. In some specimens the subfibrous mica peels off and then shows the edges of the corundum rounded, and the whole surfaces acted upon, as if by a solvent ; other specimens contain a core of brown corundum with the star of six rays ; the corundum still shows the *rounded* hexagonal form, but the subfibrous greenish-white mica forms a ring around it with *perfect hexagonal sides* and sharp edges (analysis e), the whole being imbedded in fine scaly mica schist. Where many of such partly altered corundum crystals are crowded together in the mica schist, the appearance reminds one of plum pudding.

Many of the corundum crystals are almost completely changed into mica. Then they are often flattened out, and form irregular nodules in the mica schist, having a whitish or greenish-white color, are fine scaly on the surface (sometimes imbedding small slender crystals of black tourmaline), but compact or very fine granular in the interior. On breaking, some show yet minute traces of unaltered corundum ; others have not a trace of it left, and have not the remotest resemblance to mica, but more the appearance of a grayish white compact limestone. Analysis of the compact mica (e2).

The menaccanite which was in the original mineral is also present in the altered.

The analyses gave :

	c 1	c 2	d 1	d 2	e 1	e 2
Spec. Grav. =	2.640	—	—	—	—	—
SiO_2 =	65.52	45.26	45.96	44.03	44.54	45.00
Al_2O_3 =	22.25	36.33	38.22	40.16	36.52	36.08
Fe_2O_3 =	trace	1.96	0.61	trace	3.26	2.73
MgO =	—	0.14	—	—	0.37	0.72
CaO =	1.96	0.35	0.37	3.14	0.23	1.01
Li_2O =	—	—	trace	trace	trace	trace
Na_2O =	9.54	0.48	0.74	1.42	0.65	1.35
K_2O =	0.53	11.09	9.21	6.66	10.38	7.79
Ignition, =	0.22	4.50	4.89	5.04	4.65	4.68
	100.02	100.11	100.00	100.45	100.60	99.36

f. Another locality which furnishes flattened nodules of mica, with a nucleus of corundum, is the Haskett mine in Macon county, N. C. They are mostly small, rarely over 10^{mm} in diameter, and contain a grayish-white corundum, surrounded by a subfibrous or fine scaly mica.

There are many other localities in which corundum altered into mica have been observed since the publication of my paper, but the specimens from them do not present any other than ordinary interest, I will therefore mention only a few localities : Franklin, Sussex county, N. J. (rare), Hogback, Jackson county, N. C., Cheohee, S. C., and also corundum from gravel beds, at the Placer mines at Gainesville, Ga., Brindetown and elsewhere in Burke county, McDowell county, etc., N. C.

4. Corundum, altered into Margarite.

The change of corundum into potassium mica is far more common than that into calcium mica or margarite.

a. One of the first observed in this State was brought to our notice by Prof. B. Silliman, in 1849, who published a description of that, found near Village Green (Am. Journ. of Sc. [2] viii, 378), of which he gives several analyses by Mr. W. J. Craw. When I published my paper on corundum, I did not notice this occurrence, as I had, at that time, not been able to examine any specimens. The corundum is of a dark brown color, showing sometimes, especially when wet, beautiful reflections of a rich bronze color and submetallic lustre. It is mostly in remnants of imperfect crystals imbedded in the altered mineral in scales of a silver white color and pearly lustre. I have also some specimens which are imperfect crystals having a core of unaltered corundum, surrounded with subfibrous and fine scaly margarite.

I will mention that the locality formerly known as Village Green is *now* Samuel Smith's farm (formerly Isaac Morgan's), Aston township, Delaware county, Pa.

b. At the Hogback Mine, Jackson county, N. C., most of the corundum which is altered changes into muscovite, but margarite also occurs. It is found with corundum, associated with an earthy yellowish mineral, like that of Gainesville, Ga., mentioned in my first paper, in which it is imbedded in small white pearly scales, often fan-shaped and radiating from a center. I had only a small quantity of not quite pure material, of which I have made a partial analysis (b).

c. I have analyzed a specimen from Unionville, Pa., which is quite interesting :—

The mass consists of a greenish-white, compact mineral, showing only very slightly a fine granular structure. Interlaminated are very thin micaceous strata, separating the compact mineral into layers ; the whole inclosing a nucleus of unaltered gray corundum. The outside of the mass is coated with a scaly mica, the individual scales varying from 1 to 2^{mm} in size, which is evidently the result of an alteration, showing in the first place the change of corundum into compact margarite, and secondly, the change of the latter into muscovite.

The analysis of the margarite, as pure as can be selected, is given below (c 1), but also a partial analysis of the resulting muscovite, but of material, containing an admixture of margarite (c 2).

d. Very remarkable specimens of corundum, usually surrounded by margarite have been found at Hendrick's farm, Iredell county, N. C. The corundum occurs in hexagonal crystals, sometimes tapering, as if they were very acute hexagonal pyramids, with basal plane. They are very perfect and from 50 to 125^{mm} in length, of a pale brownish or grayish-white color. Many of the specimens contain numerous cavities which in most cases are small and indistinct, so that it is difficult, if not impossible, to suggest, what may have produced them, others show a hexagonal form, but in one specimen, which contains larger cavities, some from 10 to 15^{mm} in size, very little doubt is left that the mineral which previously occupied them was corundum in crystals showing a hexagonal pyramid and prism.

The corundum from Hendrick's farm is always altered on the surface, which is enveloped by a coating of margarite, from 1 to 6^{mm} in thickness. It is rarely subfibrous and fine scaly, but mostly compact and more or less porous. It has some black tourmaline in small crystals or crystalline groups imbedded in it, and on its surface it is beginning to change into muscovite. Where the margarite is in contact with the corundum, the latter has become rough and eaten. The analysis of the purest from this locality gave me the results (d 1), a less pure specimen was analyzed in the Laboratory of the University of Pennsylvania by Mr. Frank Julian (d 2).

	b	c 1	c 2	d 1	d 2
Specific Gravity	—	2.997	——	3.004	——
SiO_2	29.07	34.10	——	32.55	33.10
Al_2O_3	50.44	47.38	——	48.87	52.20
Fe_2O_3	trace	0.34	——	0.60	trace
MgO	——	0.17	——	0.23	——
CaO	11.63	9.20	——	10.48	8.44
Li_2O	——	trace	——	trace	trace
Na_2O	——	1.14	0.80	2.38	2.59
K_2O	——	2.34	8.80	0.43	——
Ignition	6.63	4.43	4.15	4.34	4.85
Corundum	——	0.54	——	——	——
		99.64		99.88	101.18

5. *Corundum, altered into Fibrolite.*

a. In my previous paper I mention an observation by Prof. C. U. Shepard that at the Falls of the Yantic near Norwich, Conn., small crystals of sapphire are completely surrounded by fibrolite. Since then, Prof. George J. Brush has kindly presented to me a specimen which is quite interesting. It is a fibrolite of a brownish-white color, and shows, if examined with a strong lens, disseminated through the mass, numerous particles or remnants of grayish-blue corundum from which the fibrolite was formed ; but besides, there is implanted in the fibrolite, a small hexagonal crystal of brown corundum 5^{mm} long and 1.5^{mm} thick, which must have crystallized at the time when the fibrolite was formed.

b. Recently this rare alteration of corundum into fibrolite has been found in numerous specimens at Shoup's Ford, Burke Co., N. C.

The corundum occurs in a mica schist in crystals, varying generally between 20 and 75^{mm} in length and from 10 to 45^{mm} in thickness, it has a brown or a bronze color and many crystals exhibit a star of six rays. The crystals are frequently flattened, always altered on the surface, rarely to a depth of 5^{mm}. The alteration consists of an aureole of very fine fibrous and radiating white fibrolite.

It seems that subsequently the fibrolite underwent a partial alteration into mica, as the mica schist in which the crystals are imbedded contains still a large admixture of fibrolite.

c. I have very little doubt that the alteration, described by Sillem (Jahrb. für Mineralogie, 1851, 385), of corundum into *quartz* from Barsovka in the Ural is really that into *fibrolite.*

The altered mineral surrounds a core of unchanged corundum from which it radiates.

My opinion is supported by the fact that Sillem's description of this alteration is identical with mine of corundum into fibrolite ; then, that quartz very rarely assumes a radiating structure ; that fibrolite has nearly the hardness of quartz ; and finally that his statement is not supported by an analysis.

6. Corundum, altered into Cyanite.

a. In the gravel, two miles West of Statesville, Iredell Co., N. C., an interesting specimen has been found, consisting of a nucleus of pink colored corundum, around which is crystallized pale blue cyanite which latter has evidently resulted from the alteration of corundum.

b. In some specimens which I have received since the publication of my first paper on corundum, I have observed that the coarsely-bladed crystalline masses of cyanite from Wilkes county, N. C., resulting from the alteration of corundum, are further changed into micaceous minerals. They are very finely granular, scaly, and show the bladed structure and cleavage of the original cyanite, and between the laminæ minute scales of mica and a little quartz.

They have a grayish to brownish-white color, faint pearly lustre. H = 2.5. sp. gr. = 2.920. The purest material has been analyzed by my son, Mr. F. A. Genth, Jr., who found :

SiO_2	=	35.58
Al_2O_3	=	49.42
Fe_2O_3	=	trace
MgO	=	trace
CaO	=	6.34
Na_2O	=	2.11
K_2O	=	3.01
H_2O	=	4.12
		100.58

This analysis would correspond to about 59 % of calcium-sodium-mica (margarite), 29 % of potassium mica (muscovite), 9.7 % of unaltered cyanite and about 2.6 % of quartz.

7. When were the Corundum Alterations formed?

In many of the gravel beds in the Southern States, especially in North Carolina and Georgia, corundum is frequently met with, very rarely associated with diamonds, but generally with gold, zircon, monazite, xenotime, brookite, octahedrite, rutile, menaccanite, chromite, magnetite, cyanite, garnet, epidote, &c.

The corundum is sometimes, but rarely found in crystals of the usual form, mostly in fragments and cleavage pieces with very sharp edges and angles, which hardly ever are water-worn. These fragments show that the minerals have been broken by a very great force which had acted upon them very rapidly. Many of these fragments give evidence that, at the time when the corundum was broken up, a great portion of it had already undergone an alteration into other minerals. The most frequent are muscovite, mostly in fine scales, sometimes in subfibrous coatings ; some also show feldspar, margarite, black spinel and tourmaline, and very rarely cyanite, usually containing a nucleus of corundum. The altered minerals, according to their hardness are more or less water-worn and rounded, whilst the corundum which they enclose is quite sharp and angular, which fact proves that, *since the great gravel deposits were formed no alteration of the corundum has taken place in these deposits.*

II. Alteration of Orthoclase into Albite.

Orthoclase changed into albite is undoubtedly one of the most interesting alteration of one mineral into another. Numerous occurrences of it have been observed in Europe, but I am not aware that it ever was noticed in this country ; I will therefore give the description of an occurrence from the neighborhood of Philadelphia.

At the gneiss quarries of Upper Avondale, in Delaware county, Pa., druses have some time ago been found, which are lined with crystals of albite, associated with those of muscovite, and rarely with beautiful, but very minute, crystals of white beryl in hexagonal prisms and many pyramids, small crystals and groups of black tourmaline and calcite in cleavage masses and small scalenohedra, 1^3, and thin hexagonal plates, which had so much the form of muscovite crystals that, at first, they were thought to be pseudomorphs. Mr. Lewis Palmer, of Media, presented me with a number of specimens.

The albite appears in short, stout colorless or white crystals, mostly in twins, showing principally the planes $I.\ O.\ i\text{-}\breve{i}.\ 2\text{-}\breve{i}.\ i\text{-}\breve{3}$ and $1\text{-}\bar{i}.$ and 1; the latter plane very small and indistinct. Many of the crystals are very small and imperfect, and form a crystalline coating upon the cleavage masses, either directly upon a flesh-colored orthoclase or a grayish-white plagioclase intervening. I have analyzed perfectly colorless crystals (1).

Some of the specimens show conclusively that the albite is more recent than the orthoclase, and results from the decomposition of the latter, sometimes with the intermediate development of a plagioclase, and that the crystals and crystalline masses of muscovite have resulted at the same time, and contain the potassium oxide of the former orthoclase. The orthoclase which is associated with these albite crystals forms flesh-colored cleavage masses, which on the cleavage planes are bright and lustrous. The purest which with a strong lens appeared to be without admixture, was examined by my son, Mr. F. A. Genth, Jr. In their sections under the microscope it shows the rectangular reticulation characteristic of orthoclase, but disseminated through it, minute particles of plagioclase, giving proof of an incipient alteration (2).

One specimen, particularly is quite interesting. It is a mass of coarse cleavage particles of flesh-colored and white feldspars, with colorless albite crystals in cavities and crystals and scaly aggregations of muscovite and a little quartz. A cleavage crystal of flesh-colored orthoclase, especially on one side shows a rotten appearance, as if in part eaten away and one of the edges and planes is replaced by a lining of albite in the form of an imperfect crystal made up by an aggregation of many small individuals, joined together. In other places the albite gradually pushes itself, as it were, into the orthoclase, leaving in many instances only a small nucleus of the flesh-colored feldspar in the white.

In other instances there is between the orthoclase and the crystals of albite a grayish or grayish-white cleavable feldspar with deep striation. The analysis (3) shows it to be a mixture of albite with oligoclase, the oxygen ratio between R_2O (RO) : Al_2O_3 : SiO_2 being = 1 : 3.1 : 10.6.

Although not in connection with the alteration of orthoclase into albite and muscovite, I will mention that at the same locality orthoclase has also been found in colorless crystals (4), and white cleavage masses (5) associated with imperfect crystal of muscovite.

The analyses gave the following results :

	1 Crystals of albite	2 Orthoclase, flesh-red cleavage mass	3 Albite and oligoclase, cleavage mass.	4 Crystals of orthoclase, colorless.	5 Orthoclase, white cleavage mass.
Spec. Grav.	2.604	2.555	2.620	2.595	2.572
Si_2O	68.52	64.53	65.22	65.84	65.03
P_2O_5	—	—	—	—	0.08
Al_2O_3	19.44	19.64	21.44	19.50	19.22
Fe_2O_3	—	trace	0.20	—	—
MnO	—	—	trace	—	trace
MgO	—	0.25	—	—	—
CaO	—	0.16	2.07	trace	0.32
BaO	—	—	—	0.08	—
Na_2O	11.42	1.77	9.36	3.93	1.71
K_2O	0.65	13.62	1.16	10.69	14.18
Ignition	—	0.71	0.58	0.22	0.13
	100.03	100.68	100.03	100.26	100.67

Such alterations of orthoclase into albite occur not only in the quarries of Upper Avondale ; in the lower quarries at Leiperville similar facts can be observed, although not so striking, many of the large orthoclase crystals showing small patches of a thin coating of a white feldspar, albite or oligoclase, in many places penetrating into the orthoclase to a considerable extent.

Oligoclase is very common in our gneissic rocks, often associated with orthoclase, and very probably it is the result of the alteration of the latter.

III. Alteration of Talc into Anthophyllite.

The suggestion which I made over 20 years ago (Am. Journ. Sc. [2] xxx, 200), that the chrome and nickel-bearing serpentines have resulted from the alteration of chrysolite, is, at present, I believe, generally admitted, since the numerous investigations of Tschermak, von Drasche, Groth, Sandberger, and others, have established beyond doubt that this change from the one mineral into the other is almost universal.

At that time I have also shown that at Webster, Jackson county, N. C., a foliated talc has in a similar manner resulted from the alteration of chrysolite. The latter alteration has since been observed in most of the localities in the Southern States, where corundum deposits are found associated with chrysolite rocks.

In Pennsylvania, where the unaltered chrysolite rock has never been observed, a rock has been found which is its representative and contains the same constituents, only in different proportions. In North Carolina the granular chrysolite always contains small quantities of enstatite (bronzite), in Pennsylvania on the contrary we have an enstatite (bronzite) rock, containing small grains (from 5 to 10%) of chrysolite. It is best developed at Castle Rock, Delaware county, also near Wood's Chrome Mine in Lancaster county.

In all the chrysolite rocks small grains or crystals of chromite are disseminated through the mass of the rock; in the serpentine, which has resulted from the alteration of the chrysolite, these crystals or grains are still present and give evidence of the original mineral. This is also the case with a peculiar variety of talc, the so-called "indurated talc," which occurs a few hundred yards south-south-west from Castle Rock, Delaware county, Pa. It is compact, with a strong lens shows a cryptocrystalline, slightly scaly structure, and an impure grayish-olive green color. $H = 2$. Sp. Gr. $= 2.789$. Fracture splintery to subconchoidal; dull.

The analysis gave:

			Calculated:
SiO_2	=	62.48	61.92
TiO_2	=	trace	
Chromite	=	0.20	
Cr_2O_3	=	0.13	
Al_2O_3	=	0.59	
NiO	=	0.16	
FeO	=	4.95	5.57
MgO	=	27.60	27.86
Ignition	=	4.81	4.65
		100.92	100.00

This is a talc, in which about one tenth of the magnesia is replaced by ferrous oxide $= H_2 (Mg_{\frac{9}{10}} Fe_{\frac{1}{10}})_3 Si_4 O_{12}$, represented by the calculated analysis above given.

Talc is generally one of the *final* products of the alteration of other rocks and minerals, but in this case, it has suffered a very remarkable change into anthophyllite. It is enveloped by an aureole of a white or grayish-white mineral, radiating from the nucleus of talc, having a thickness of from a few to over 15^{mm}. The mineral is fibrous, of silky lustre and shows a large cleavage angle, similar to amphibole ; the terminal planes are either not developed or broken off. It incloses, like the original talc, grains of chromite. Its Spec. gravity was found to be 2.983. Besides my analysis (a) I will give, for comparison, the analysis by Dr. A. Brezina of the anthophyllite from Hermannschlag in Moravia (Tschermak's Mineral. Mitth., 1874, 247).

		Castle Rock.		Hermannschlag.
SiO_2	=	56.88	—	57.39
Al_2O_3	=	2.45	—	2.04
Cr_2O_3	=	trace	—	——
Fe_2O_3	=	——	—	0.42
FeO	=	9.20	—	6.53
MnO	=	0.28	—	——
NiO	=	0.17	—	——
MgO	=	28.50	—	29.08
CaO	=	——	—	0.69
Na_2O	=	0.18	—	——
K_2O	=	0.03	—	——
Ignition	=	2.28	—	2.56
		99.97		98.71

From the description of the mica globules from Hermannschlag, by Director G. Tschermak (Tschermak's Min. Mitth., 1872, 264) we learn that next to the anthophyllite-stratum and between it and the nucleus of biotite, is a stratum which has a seladon-green color, and appears to be a mixture of talc and chlorite, strongly altered. This observation is of very great interest in connection with the evident alteration of talc into anthophyllite, above described.

There is also an observation of Dr. F. Becke (Tschermak's Min. Mitth. [Neue Folge] iv, 450) who noticed the alteration of olivin into anthophyllite between the gabbro locality "Vier Linden" and the R. R. Station Rosswein in Saxony. The olivin shows in many places a commencing alteration into serpentine (*or talc?*), and is surrounded by a stratum of anthophyllite of from 5–6^{mm} in thickness. This seems to be an analogous case, first, the olivin altered into serpentine (*or talc*), and this subsequently changed into anthophyllite.

IV. Talc, pseudomorphous after Magnetite.

In the vicinity of Dublin in Harford county, Md., is a series of rocks, consisting principally of gneiss and micaceous schists. They are underlaid by a bed of talcose slate, changing in some places into a very superior quality of massive soapstone, from 12 to 15 feet in thickness. Immediately adjoining, and under the talcose slates and soapstone, and in most cases separated from them by seams of chlorite or chlorite slate, lies a very large bed of a beautiful variety of green serpentine, mottled and of darker and paler green colors, of about 500 feet in thickness, and under this, a bed of mottled black serpentine of about 800 feet, and frequently imbedded in the latter, masses of the same dark green serpentine. This immense bed of serpentine, in its two varieties, rests upon chloritic slates, with numerous crystals of magnetite in octahedra and twins, so called hemitropes, and talc slates, and below these again occurs another, but smaller bed of green serpentine of about 180 feet in thickness, which like the other is underlaid by chloritic and talcose slates, followed by a third bed of green serpentine.

A titaniferous variety of magnetite is found in lenticular masses of various sizes, intercalated between the green serpentine and is frequently bounded on the hanging wall by chloritic slates.

The green serpentine is quarried for ornamental purposes as it admits of a very fine polish and can be obtained in many beautiful shades of light and dark green.

The chloritic slate is generally of a very fine scaly structure, sometimes the scales become larger, from 0.5 to 1^{mm} in diameter on an average, but rarely reaching 3^{mm}.

At one locality in this large belt, a coarse scaly chlorite, immediately in contact with talc slate, has disseminated through it numerous small octahedra of talc, pseudomorphous after magnetite, an alteration, which, if I am correct, has never been observed before. These crystals from 1 to 2^{mm} in diameter are of a silvery-white color and pearly lustre, the scales are arranged parallel to the octahedral planes, in the center is occasionally a small nucleus of magnetite, sometimes associated with pulverulent limonite.

This alteration of magnetite crystals into talc is of importance in connection with the steatite bed of 12 to 15 feet in thickness, to which I have above referred, because it shows that no good reason can be given to contradict the proposition that an entire magnetite bed has disappeared and has been replaced by steatite. This opinion is proved by the following observations.

The steatite is of a white or greenish-white color, it has mostly an uneven fracture, some seams in it, however, graduate into a slaty structure. Cryptocrystalline, and showing, when powdered, to be composed of an aggregate of exceedingly fine scales. *Disseminated through the whole mass are dark spots, from 0.1 to 10^{mm} in diameter.* Especially the larger ones sometimes have *a definite shape of squares or rhombs, or other forms, representing sections of magnetite crystals.* These dark spots of a dark gray or iron-black color, are quite soft and can be reduced to a powder by the nail of a finger, and consist of fine scaly talc, *colored by remnants of the original magnetite,* which frequently can be separated by a magnet, or dissolved out by hydrochloric acid. That only a small number of the dark spots show the form of sections of magnetite, whilst most of them are without definite shape, shows that the original magnetite in the bed was granular or compact, but had, as is very common, *crystals* of magnetite disseminated through the whole mass.

V. Gahnite.

a. Already in 1876, at the Centennial Exhibition, I observed, amongst minerals from Western North Carolina, a specimen which was so unlike any species with which I was familiar, that I was in doubt about its nature. A little fragment of it which I afterwards received I put provisionally under gahnite. About a year ago I recognized the same mineral again amongst others which Mr. W. E. Hidden had collected in North Carolina, who very kindly gave me some fragments for investigation, which proved it to be gahnite.

Apparently without form, a fracture between splintery and conchoidal, and of a very rich, dark green color, which can best be observed by transmitted light. H = 7.5. Sp. Gr. = 4.576. The analysis is given below (a), after deducting 0.09% SiO_2 and (a 2) the calculated results.

It occurs rarely at the Deake Mica Mine, Mitchell Co., N. C. The specimen at the Centennial Exhibition was about 4^{cm} long and 3^{cm} broad and, with an exception of thin micaceous coatings between fractures, was free from admixtures; Mr. Hidden's specimen was about 2 to 2.5^{cm} in size, and was surrounded by a thin coating of about 1^{mm} in thickness, consisting of yellowish-white fine scaly muscovite, evidently the result of alteration.

b. Last summer Mr. Charles E. Hall, of the Geological Survey of Pennsylvania, brought me for determination a number of specimens from the Cotopaxi Mine, Chaffee county, Colorado, which were found to be gahnite.

It occurs in large rough crystals, principally octahedra, some of the crystals show also the dodecahedral plane; the largest crystal which I have seen has an octahedral edge of 9^{cm} in length; the crystals are often distorted and flattened out by the enlargement of two opposite octahedral planes. Besides containing inclosures of galenite, and, in smaller quantity of chalcopyrite and pyrite, they are very much altered.

When in a pure state it has a dark blackish-green color, and an uneven to subconchoidal fracture. The material for the analysis was very carefully selected, and first treated with sulphuric acid to remove the impurities, resulting from its alteration. Mr. Harry F. Keller has analyzed it in the Laboratory of the University of Pennsylvania, and obtained the results (b), after deducting 1.85 per cent. of silica; (b 1) are the results calculated from the analysis:

	a	b		a 1	b 1
Al_2O_3	= 54.86	— 60.76	— $CuAl_2O_4$	= 0.69	— ——
Fe_2O_3	= 4.50	— 0.58	— $ZnAl_2O_4$	= 86.34	— 53.94
FeO	= 1.14	— 4.56	— $FeAl_2O_4$	= ——	— 10.44
MnO	= 0.29	— ——	— $MnAl_2O_4$	= 0.71	— ——
CuO	= 0.30	— ——	— $MgAl_2O_4$	= 1.07	— 36.88
ZnO	= 38.05	— 23.77	— $MgFe_2O_4$	= 2.46	— ——
MgO	= 0.79	— 10.33	— $FeFe_2O_4$	= 3.67	— 0.84
			— Al_2O_3	= 4.99	— ——
	99.93	100.00		99.93	102.10

The analysis *a* shows an excess of nearly 5 per cent. of alumina, which is remarkable, as the separations in the analysis were most perfect. This gahnite does not come from a corundum locality, and it is therefore improbable that any has been inclosed in it.

In Mr. Keller's analysis, 2.10 per cent. of alumina are wanting to form spinel, RR_2O_4.

c. Alterations of the Gahnite from Cotopaxi.

Even the best and purest specimens from this locality, which appear to be quite fresh, show innumerable cracks, breaking them up into small angular fragments.

a. In most instances these are coated with a white earthy mineral, which dissolves in strong boiling hydrochloric acid. A qualitative analysis shows this coating to be a hydrous silicate of alumina and magnesia, and it is probably the same substance which in thicker coatings, has a finely fibrous structure, a white or greenish-white color and silky lustre. The thickest were not over 3^{mm} in thickness, and were very much mixed with ferric oxide, and other impurities, some of them carbonates, as dilute hydrochloric acid liberates carbon dioxide. Does not exfoliate on ignition. The ignited mineral is readily decomposed by sulphuric acid.

The best material which I could obtain for analysis, although still very impure, was sufficiently pure to determine the position in the system where the mineral belongs. It was decomposed by sulphuric acid after ignition, then the silica extracted by sodium hydrate, and separated from this solution. About 6 per cent., insoluble in sulphuric acid and sodium hydrate, mostly gahnite, were deducted, and the following results obtained :

Ignition	=	13.82
SiO_2	=	28.08
Al_2O_3	=	18.20
Fe_2O_3	=	4.32
CuO	=	0.82
PbO	=	1.80
ZnO	=	1.75
MgO	=	29.85
		98.64

Lead and zinc are probably present as carbonates, the ferric oxide as such, if I therefore deduct these as impurities, the following composition, which places this mineral near ripidolite, will probably not be far from the truth.

SiO_2	=	31.68
Al_2O_3	=	20.54
MgO	=	33.68
H_2O	=	14.10
		100.00

β. Another alteration, shown by many of the crystals, is that into a micaceous, chloritic mineral. It either forms a coating parallel with the octahedral planes or penetrates the crystals irregularly in every direction.

It has a white, grayish- or greenish-white color, is sectile and very little elastic. On ignition it does not exfoliate, but turns silver-white. The ignited mineral is easily decomposed by sulphuric acid. 0.2747 grms. although not quite, but nearly pure, was all that I could obtain for analysis, from which 0.0140 grms. insoluble in sulphuric acid and, subsequently, in sodium hydrate was deducted as impurity. The results were:

					Calculated:
SiO_2	=	31.15			32.58
Al_2O_3	=	13.12			13.95
FeO	=	10.74			11.40
CuO	=	0.77			——
ZnO	=	0.39			——
MgO	=	29.23			29.86
Ignition	=	11.78	H_2O	=	12.21
Alkalies		?			——
		97.18			100.00

These results show the mineral to belong to the chlorite group, closely agreeing with the formula $H_{30}\ [Fe_{\frac{35}{200}}Mg_{\frac{165}{200}}]_{20}\ Al_6\ Si_{12}\ O_{68}$, for which I give calculated percentage above. It must remain undecided whether or not this is a new species, until larger quantities of pure material can be obtained for a fuller investigation.

VI. Rutile and Zircon from the Itacolumite of Edge Hill, Bucks County, Pa.

In the examination of a series of "Edge Hill rocks" which, according to Mr. Charles E. Hall (Report C6., of the 2d Geological Survey of Pennsylvania), are Potsdam sandstone, I have made a few observations which should be placed on record.

The rocks are generally thinly laminated quartzites which contain yellowish-white scales of muscovite in larger or smaller quantity, and are identical in appearance with the large mass of the "itacolumite" rocks of the Southern States, which do not show any flexibility.

Especially in Neeley's Quarry, but also in smaller quantity in many others, the rock contains exceedingly minute, yellowish, orange or brownish-yellow grains, they are smaller than 0.25^{mm}. By powdering and levigation I have obtained a considerable quantity of the same.

Under the microscope they appear as irregular, sharp, angular fragments, showing now and then a very smooth plane, but no distinct crystalline form. They have a honey-yellow color. B. B. they gave the reaction of titanic oxide, and a very minute trace of tin.

Associated with the yellow grains are small crystals of a dark brown almost black tourmaline, small crystalline plates of menaccanite and colorless or slightly yellowish and brownish-white zircons, the latter more or less water-worn, but showing the planes of the prism *I*, the pyramid 1 and also less distinct, the planes of the pyramids *ii*, and 33.

As it is an impossibility to pick out enough of the pure yellow grains for analysis, I made several unsuccessful attempts to analyze the mixture, and obtained by Pisani's method 79.07% of titanic oxide.

I had, at the expense of one week's labor, picked out a little over two milligrams of *perfectly pure yellow grains*, which Dr. G. A. Koenig had the kindness to test by his colorimetric method, and pronounced to be *almost pure titanic oxide*, the yellow grains are therefore probably a variety of rutile.

In the rock itself the yellow grains show the same sharp angular forms above mentioned, whilst the zircons are water-worn. It appears from this that the rutile, tourmaline, mica and menaccanite crystallized or rather separated when or after the itacolumite was deposited, whilst the zircons, together with the quartz, are remnants of decomposed rocks, probably coming from granulites. In those of the South mountains, I have frequently observed microscopic zircons, very similar in form to those in the Edge Hill rocks. I may mention that Prof. Zirkel (Jahrb. f. Mineralogie, 1876, 90), has also detected microscopic zircons in the granulites of Saxony.

Artificial Rutile and Octahedrite.

Whilst decomposing some of the mixed yellow sands, containing about 80 % of rutile, by fusion with a rather small quantity of potassium hydrogen sulphate, I was interrupted in my work for several hours, so that the greater portion of the potassium hydrogen sulphate was converted into potassium sulphate. By dissolving in cold water most of the titanic oxide went into solution, but I noticed a pale brownish, heavy, sandy substance, which, under the microscope, appeared in very brilliant crystals of the usual form of rutile *I* and *ii*, and pyramids 1 and 1*i*. One or two of the crystals were twins. There were, perhaps, several hundred of rutile crystals. Amongst these I observed *two* crystals of *octahedrite* which had the acute pyramid 1 and a decided *blue* color.

Experiments which I subsequently made for the purpose of making these artificial rutile crystals from pure titanic oxide were not very successful; although I have repeatedly obtained microscopic quadratic forms, I never could get any distinct brilliant crystals.

VII. Sphalerite and Prehnite, from Cornwall, Lebanon Co., Pa.

a. Sphalerite.

About two years ago small crystals of a greenish mineral were discovered by Mr. E. E. Craumer, of Lebanon, Pa., associated with a white crystalline coating upon the magnetite of the great Cornwall Ore Bank.

Lebanon county, Pa. I am indebted to him and also to Mr. J. Taylor Boyd, the General Superintendent of the Cornwall Ore Bank, for about a dozen of these *exceedingly rare crystals*, which I have found to be *sphalerite*. Only two or three distinct crystals were obtained, which were octahedra in hemitrope twins. Most of the crystals are very much distorted or imperfect for want of space for their development.

In color, they are between asparagus-green, brownish-green and light brown. Spec. grav. = 4.033.

The largest crystals are between 4 and 5^{mm} in size. They occur in cavities of magnetite and are associated with a peculiar variety of prehnite, which sometimes envelops the sphalerite, magnetite, pyrite and crystallized chlorite, in small scales, frequently altered into a mineral resembling leidyite, which also envelops the magnetite crystals. There is too little of the latter for further examination.

The analyses of the sphalerite crystals gave the following results:

		1.	2.
S	=	32.69	33.06
Zn	=	66.47	} 66.96
Co	=	0.34	
Fe	=	0.38	
		99.88	100.02

b. Prehnite.

This occurs in crystalline incrustations upon magnetite, or as lining the cavities of the same. They consist of minute crystals and groups of crystals showing the planes *I, O,* and *ii*, forming frequently small globular, coxcomb and fan-shaped aggregations, colorless, white, yellowish and brownish-white. Sp. gr. = 3.042. The prehnite is the most recent formation, its incrustations covering magnetite, sphalerite, pyrite, chlorite and leidyite. The analysis of a carefully selected specimen gave:

SiO_2	=	42.40
Al_2O_3	=	20.88
Fe_2O_3	=	5.54
CaO	=	27.02
H_2O	=	4.01
Alkalies and MgO	=	traces
		99.85

VIII. Pyrophyllite in Anthracite.

At the meeting of the American Philosophical Society, of July 18th, 1879, I mentioned the very interesting occurrence of pyrophyllite in delicately fibrous incrustations from the Buck Mountain seam near Mahanoy City, Schuylkill county, Pa.

Identical in appearance and association it has lately been observed by

Mr. Oswald J. Heinrich, near Drifton, Luzerne county, in the Tomhicken Basin, which lies 75 feet above the Buck Mountain seam.

Another variety of pyrophyllite, which has the appearance of kaolinite, has also been found by Mr. Heinrich, near Drifton and Gowen, in the Buck Mountain seam. He has favored me with the following data, relative to its occurrence.

It is found principally in the upper bank of the seam which has a thickness of 5 to 6 feet and does not only occur in the planes of stratification and fissures, but even in the most compact anthracite. It has accumulated especially in layers or lenticular patches of from one-half to over one inch in thickness in the slate bank which divides the upper from the lower bank, and which has a thickness of from 8 to 15 inches, sometimes inclosing a few inches of anthracite. It is white or yellowish-white, compact, cryptocrystalline, slightly soils the fingers. Soft. Does not in the least exfoliate or expand on strong ignition. Sp. gr. = 2.812.

Not decomposed by sulphuric acid. The analysis of that from Cross Creek Colliery, near Drifton, Luzerne county, gave :

SiO_2	=	65.77
Al_2O_3	=	29.36
Fe_2O_3	=	0.12
H_2O	=	4.85
		100.10

IX. Beryl from Alexander Co., N. C.

Many beautiful varieties of beryl have lately been found in Alexander county, N. C., and Mr. Wm. Earl Hidden especially has brought to light many of the most interesting specimens. To him I am indebted for a fragment of a rounded pebble which has a slightly leek-green color, turning brown by oxidation. It has a pretty distinct cleavage in one direction. Its specific gravity was found to be = 2.703. The analysis proved it to be beryl. It contained :

SiO_2	=	66.28
Al_2O_3	=	18.60
Be_2O_3	=	13.61
FeO	=	0.22
Ignition,	=	0.83
		99.54

X. Allanite.

Mr. W. E. Hidden found in the "Hiddenite" vein, Alexander county, N. C., associated with quartz, white orthoclase and little mica, small brownish-red, brownish-yellow or light brown crystals, which have the appearance of a partial decomposition or hydration, and a resinous lustre.

Their analysis proved them to be allanite. Sp. gr. = 3.005. As the quantity for examination was very small the cerium oxides were not separated.

For comparison I give the analysis of a variety of allanite from the Mica Mine of Balsam Gap in Buncombe Co., N. C., where it occurs in jet black or brownish-black slender crystals, sometimes from six to twelve inches in length (Minerals, &c. of North Carolina, Raleigh, 1881). Spec. grav. = 3.400.—

		Alexander Co.		Balsam Gap.
SiO_2	=	32.05	—	32.79
Al_2O_3	=	22.93	—	18.16
Fe_2O_3	=	11.04	—	1.64
FeO	=	——	—	10.08
MnO	=	1.99	—	1.23
Ce_2O_3 }	=	14.81	—	6.07
$(DiLa)_2O_3$ }			—	14.40
Y_2O_3	=	0.85	—	1.84
MgO	=	1.28	—	0.15
CaO	=	9.43	—	10.95
Na_2O	=	0.54	—	0.33
K_2O	=	0.20	—	0.12
Ignition	=	3.64	—	1.89
		98.76		99.65

XI. Niccolite from Colorado.

In the American Journal of Science [3] xxiii, 380, Mr. Malvern W. Iles mentions the occurrence of smaltite near Gothic, Gunnison Co., Colorado, and gives an analysis of the same. He states that the Gem and other mines near Silver Cliff, Colorado, contain a number of nickeliferous minerals and a small amount of cobalt.

About two years ago I received fragments of niccolite from Colorado from some of my students, and about a year ago Mr. Henry A. Vezin sent me a specimen from Silver Cliff, which was pure enough for examination.

It occurs in rounded or nodular masses disseminated through a granular limestone, which has the appearance of dolomite, but contains only a very small percentage of magnesia. In dissolving the limestone, the niccolite remains in small irregular masses, partly made up by globular and botryoidal aggregations with a crystalline black surface, showing the crystals of niccolite to be exceedingly small and indistinct; I have not seen any in which the form could be made out. It has a very pale copper-red color with a grayish tint. Sp. gr. = 7.314.

Associated with it in druses of the limestone are globular crystalline groups of an apple-green mineral, which is probably an arseniate of nickel but which has not the appearance or annabergite.

The analysis of the niccolite gave :

As	=	46.81
Sb	=	2.24
S	=	2.52
Cu	=	1.59
Ni	=	44.76
Co	=	1.70
Fe	=	0.60
		100.22

This is a niccolite in which a small portion of the arsenic is replaced by antimony and sulphur.

XII. Artificial Alisonite (?).

About a year ago Mr. R. Pearce, Metallurgist of the Works of the Boston and Colorado Smelting Co., at Argo, Colorado, kindly sent me some very interesting crystals from furnace bottoms, which he had never before observed.

They were octahedral crystals, some showed cubical planes and slight indications of the dodecahedron ; they were mostly distorted, cavernous, and many of them rounded, iron-black, and of metallic lustre. Spec. gr. = 5.545. Crystallized upon a plate of copper matte, containing a large percentage of metallic copper.

The analysis gave :

				Calculated.
S	=	15.23	—	17.61
Ag	=	2.16	—	——
Cu	=	51.33	—	49.84
Pb	=	31.15	—	32.55
Fe	=	trace	—	——
				100.00
		99.87		

The composition is similar to alisonite or nearer $2PbS, 5Cu_2S$ in which part of the copper is replaced by silver. The small percentage of sulphur can be accounted for from a small admixture of metallic copper, with which some of the crystals were contaminated.

UNIVERSITY OF PENNSYLVANIA, August 17, 1882.

Stated Meeting, September 15, 1882.

Present, 4 members.

Vice-President, Dr. LE CONTE, in the Chair.

M. Woldemar Kowalevski, member of the I. Academy of St. Petersburg, was introduced.

M. Edward Sêve de Bar, accepted membership by letter, dated Philadelphia, August 31, 1882.

The death of M. Liouville, at Paris, Sept. 9, was announced.

Acknowledgments of the receipt of publications were received from the Ast. Gesell., Leipsig (109); the Cincinnati Observatory (109, 111); the Leop. Car. Gesell. Halle am Saale (109); and the Free Public Library of New Bedford (111).

Requests for missing numbers were received from the Leop. Car. Gesell. Halle am Saale (108, and pp. 483–498 of —-); and from the Paris Geographical Society (XIV, ii, and 62).

Donations for the Library were received from the Revista Euskara; Academy of St. Petersburg; Ant. and Hist. Society at Copenhagen; Academies at Amsterdam, Leiden, Harlem, Batavia, Brussels and Munich; Geographical Societies at Paris and Bordeaux; London Antiquarian Society and Nature; Cambridge University Library; Hist. Societies of New York and New Jersey; James Hall; Franklin Institute, Journal of Pharmacy and Dr. J. B. Roberts; U. S. National Museum, Fish Commission, Census Bureau and Coast Survey; Am. Chem. Journal, and Johns Hopkins University; Ohio Mechanics Institute, and Davenport Academy of Sciences.

Mr. Cope exhibited and described some remarkable new fossil forms from the Permian rocks of Texas, and communicated a "Third contribution to the history of the Vertebrata of the Permian formation in Texas."

The reading of nominations being dispensed with, the meeting was adjourned.

Photodynamic Notes, VI. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, October 6, 1882.)

242. *Stability of Harmonies.*

In Note 220, I presented several reasons for believing that the mean periods of planetary rotation are stable. They are all dependent upon more general principles which regulate the harmony of persistent oscillations in elastic media, and consequently furnish strong *a priori* presumptions against all hypotheses which seem, in any way, to conflict with harmonic tendencies. The certainty (Note 213), which Proctor admits, of Earth's having a pulsation period, with which its rotation must once have begun to approach to synchronism, springs from a like source with the harmonic tendencies in Jupiter's satellite system, and Laplace's reasoning is equally applicable to both cases. The "pulsation period" which is due to luminous vibration is constant, and if it should ever be suddenly or greatly disturbed, rotation would immediately begin again to approach to its normal synchronism. After the synchronism is once reached, all the influences from which it originated continue to contribute towards its perpetual maintenance.

243. *Improbability of Delaunay's Hypothesis.*

Newcomb and Holden (*Astronomy*, p. 148) close their note on the secular acceleration of the Moon, as follows :—"The present theory of acceleration is, therefore, that the Moon is really accelerated about six seconds in a century, and that the motion of the Earth on its axis is gradually diminishing at such a rate as to produce an apparent additional acceleration which may range from two to six seconds." The former portion is known to be cyclical, to be followed, after a long interval, by a corresponding retardation ; there is not a particle of evidence to discredit the probability that the latter portion is also cyclical. Neither is there a particle of evidence that there is any tidal friction except at the shores of the ocean, where any accelerating tendencies at one period are counterbalanced by retarding tendencies at another. The frictional hypothesis was a gratuitous assumption, to explain a doubtful phenomenon, and although the explanation would be satisfactory if the frictional retardation could be proven, the assumption violates the ordinary rules of framing scientific hypotheses so completely, that its chief claim for consideration rests upon the reputation of its originator. On the other hand, the harmonic hypothesis makes no assumption ; starting from acknowledged facts and principles, it asks what results may be reasonably anticipated, and there are few, if any, modern researches, in which the anticipations have been so abundantly verified. Even if we grant frictional retardation, there is "no way of determining the amount of this retardation unless we assume that it causes the observed discrepancy between the theoretical and observed accelerations of the Moon" (*op. cit.* p. 147).

244. *Scientific Skepticism.*

Hesitation in the acceptance of alleged results, in any new line of scientific research, is an obvious duty on the part of those who are fitted and expected to be on the watch against the promulgation of hasty generalizations which would needlessly cumber the field of knowledge. There is danger, however, that even faithful watchmen may sometimes hinder scientific progress by failing to keep their skepticism within proper bounds. The fact of harmony, and especially of coördinated harmony, transcends all mathematical tests of probability. It would be a tedious, but not a difficult task, to find in how many ways the letters of the Iliad could be arranged, and it is often wrongly assumed* that in a purely accidental arrangement of the letters, the faultless one would be as likely to take place as any other. It would be no more absurd to inquire whether the music of an orchestra might not be accidental, than to make a like inquiry as to the rhythm of atoms and waves and spheres. When mathematical tests confirm the probability that special forms of harmony are due to special laws, as in phyllotactic, thermodynamic and fundamental atomicities, they are useful ; but when they fail to give any reason for obvious accordances, as in Schuster's first examination of spectral lines (Note 141), they are utterly worthless unless they awaken further inquiries which lead to satisfactory results, as in Schuster's final conclusions.

245. *Centre of Dawning Condensation in the Terrestrial Belt.*

The intrinsic probability that the major axis of the Moon's orbit is invariable, is greatly enhanced by the following proportion :

$$r_3 : l_3 : : R_3 : L_3$$

Substituting the several known values, we have : $r_3 =$ Earth's equatorial semi-diameter $= 3962.8$ miles ; $l_3 =$ Laplace's terrestrial limit $= \left(\frac{86164.1}{5073.6}\right)^{\frac{2}{3}} r_3$; $R_3 =$ Moon's semi-axis major $= 60.2778\, r_3$; $L_3 =$ limit of incipient belt-condensation $= R_3 l_3 \div r_3 = 1{,}578{,}217$ miles. The oscillatory value of Sun's mass (Note 23, etc.,) gives, for the ratio of Earth's subsidence from the centre of the belt of greatest condensation, $L_3 \div \rho_3 = 1{,}578{,}217 \div 92{,}785{,}700 = .0170093$, and for the dawning central locus of the belt of greatest condensation, $1.0170093\, \rho_3$. The arithmetical mean between Stockwell's estimates of Mercury's secular perihelion and the secular aphelion of Mars is $(.2974008 + 1.736478) \div 2 = 1.0169394\, \rho_3$. The difference between the two estimates is less than $\frac{1}{142}$ of one per cent

* See Note 252.

246. *Pendulum Estimate of Moon's Mass.*

In Note 8, I anticipated slight modifications of my first estimate of Moon's mass, as likely to be required by subsequent investigations. If we apply the principles which are involved in the coefficient of solar torsion, Note 162, to the determination of the length of Earth's theoretical pendulum, we find

$$l = g\left(\frac{t}{\pi}\right)^2 = \frac{32.088}{5280} \times (43082.05)^2 \div \pi^2 = 1,142,882 \text{ miles.}$$

From this equation we deduce the relative value of Moon's mass, μ, by the proportion,

$$\rho_3 : l :: m_3 : \mu$$

$$92,785,700 : 1,142,882 :: 81.1857 : 1$$

This estimate differs from the one in Note 8 by less than $\frac{1}{51}$ of one per cent.

247. *Rotation Estimate of Moon's Mass.*

The conviction, which I have often expressed (Note 220, etc.), that rotation is only modified revolution, is further strengthened by the following considerations. The orbital velocity (v_a) which the combined energies of Earth and Moon tend to give to an equatorial particle which is nearest to the Moon, is about 2.18 times as great as the velocity (v_β) which they tend to give to the mean centre of gravity of Earth's oscillating particles. The preponderating attraction of Earth prevents the action of these tendencies, in any other way than as accelerating disturbances on the several particles whose retarded and constrained revolution leads to axial rotation. The greater acceleration, acting for a half-monthly oscillation (t_a), gives the mean orbital velocity of the system (v_o), while the smaller acceleration, acting for a half-daily oscillation, gives Earth's equatorial velocity of rotation (v_r), as is shown by the proportion

$$v_o : v_r :: v_a t_a : v_\beta t_\beta$$

$$18.4735 : .288183 :: 14.7652942\, v_a : \tfrac{1}{2}\, v_\beta$$

$$v_a = 2.1798\, v_\beta.$$

If we designate the distances of the respective particles from the centre of gravity of the system by d_a and d_β, we have $d_\beta\, v_\beta^2 = d_a\, v_a^2$; $d_\beta = 4.7514\, d_a$. The theoretical mean intersections of d_a with Earth's surface should be on the equator, and those of d_β should be on meridians, but want of exact homogeneity, as well as orbital inclinations, may be presumed slightly to modify their respective loci. The mean centre of gravity of Earth's oscillatory particles is at the distance r from the surface, but they are all also affected by wave-lengths equivalent to d_a, so that we have $d_\beta = d_a + r = 4.7514\, d_a$. Hence $r = 3.7514\, d_a$; $d_a = .26657\, r = 1056.35$ miles; $d_\beta = 5019.15$ m.; $r - d_a = 2906.45$ m.; $m_3 + \mu = (238,869 \div 2906.45)\, \mu = 82.1858\, \mu$; $m_3 = 81.1858\, \mu$, a value which corresponds exactly with the one in the foregoing note.

248. *Harmonics of Central Condensation.*

The superficial intersections of d_a, in the foregoing note, describe circles about the poles, which have diametrical arcs of 5° 10′ 40″, which differs by only 2′ from the inclination of the Moon's orbit. If we take $1 \times 2 \times 3 \times 5$, the product of the first four phyllotactic numbers, as a divisor of Earth's diameter, calling the quotient a, we have the following approximate accordances :

Harmonic.		Observed,	
$4\,a = 1056.748$	miles.	$d_a = 1056.35$	miles.
$11\,a = 2906.057$	"	$r - d_a = 2906.45$	"
$15\,a = 3962.805$	"	$r = 3962.8$	"
$19\,a = 5019.553$	"	$d_\beta = 5019.15$	"
$7\,a = 1849.309$	"	$r - 2\,d_a = 1850.10$	"

The coefficients of nodal division in the radius which is nearest the Moon, (4, 11), are the second and fourth of the secondary phyllotactic numbers. The coefficients in the remote radius, (8, 7), are the third phyllotactic numbers in the primary and secondary series, or the artiad and perissad divisors (Notes 201–2,). It may be interesting to inquire whether the frequency and locality of earthquakes are affected by these nodal influences.

249. *Pendulum Estimate of Earth's Oblateness.*

The ratio of Earth's equatorial semi-diameter to its theoretical equatorial pendulum, or the corresponding ratio of v_0^2 to v_r^2, (square of limiting orbital velocity to square of equatorial rotation-velocity), represents a centrifugal force which would tend to produce oblateness in a liquid globe, to maintain oblateness in a solidified globe, or to exert a constant pressure for restoring oblateness, should it be temporarily disturbed in any way. From the estimate of the theoretical pendulum in Note 246 we get

$$3962.8 : 1,142,882 :: 1 : 288.40$$

Bessels' estimate was 298.1528 ; Clarke's two estimates 291.36, 293.76 : Listing's (1878, cited by Newcomb and Holden, p. 202), 288.5. This accordance furnishes additional reasons for believing that Earth's rotation and Moon's mean distance are as invariable as planetary major axes.

250. *Oscillatory Relations of Venus.*

The masses of Venus and Earth are more nearly alike than those of Jupiter and Saturn. This is perhaps owing to their comparatively central position in the belt of greatest condensation. The reasonable expectation that their mutual actions and reactions should be rhythmical is strengthened by many harmonic relations, among which are the following :

1. If we divide Venus's mean locus of subsidence (mean aphelion) by the product of the first four phyllotactic numbers, $1 \times 2 \times 3 \times 5 = 30$,

and call the quotient a, we obtain an approximate harmonic divisor for six cardinal nodes :

Harmonic.		Observed.		
27 a	.6740	Venus,	s. p.	.6722
28 a	.6990	"	m. p.	.6978
29 a	.7239	"	m.	.7233
30 a	.7489	"	m. a.	.7489
31 a	.7739	"	s. a.	.7744
40 a	.9985	Earth,	m.	1.0000

2. Venus's incipient locus of subsidence (secular aphelion) is near the second centre of linear oscillation of the incipient locus of subsidence of Mars.

$$(\tfrac{2}{3} \text{ of } \tfrac{2}{3} = \tfrac{4}{9}) \text{ of } 1.7365 = .7718.$$

Harmonic.	Observed.
.7718	.7744

3. The photodynamic origin of Venus's orbital period (224.701 days) is indicated by the proportion,

$$\rho_3 : l_\lambda : : t_e : t_v$$

The length (l_λ) of a theoretical pendulum at Sun's equator, which would oscillate once while a wave of light traverses the solar modulus of light, is $l_\lambda = 224.261\ \rho_3$; t_e and t_v are respectively Earth's day and Venus's year.

4. Moon's semi-axis major is a mean proportional between Earth's semi-diameter (r_3) and Venus's nearest approach to Earth. Venus's secular aphelion $= .7744234\ \rho_3$; Earth's secular perihelion $= .9322648\ \rho_3$; difference, $.1578414\ \rho_3 = 3695.725\ r_3$; $\sqrt{3695.725} = 60.792$.

5. Earth's oscillatory influence on Venus's mean subsidence is indicated by the proportion

$$r_3 : l_3 : : \rho_m : \rho_s$$

$$3962.8 : 1,142,882 : : 60.2778 : 17384.276$$

Stockwell's estimate for Venus's mean locus of subsidence is $.748878\ \rho_3 = 17534.36\ r_3$.

6. All the orbital loci of Venus are midway between Sun and orbital loci of Mars.

7. Venus's incipient rupturing locus (secular perihelion $= .672\rho_3$) is near Earth's linear centre of oscillation ($\tfrac{2}{3}$ of ρ_3.)

8. Venus's mass indicates Earth's harmonic influence at her incipient locus of subsidence (ρ_s).

$$m_3 : m_2 : : \rho_3 : \rho_s$$

$$428,417 : 331,776 : : 1 : .7744234$$

Hill's estimate for $m_0 \div m_2$ is 427,240, which differs from the harmonic estimate by less than $\tfrac{3}{10}$ of one per cent.

251. *Oscillatory Relations of Mercury.*

The cardinal loci of Mercury show the following among other harmonic relations :

1. The locus of Mercury's semi-axis major (.3871) is the rupturing locus for Venus's locus of incipient subsidence : ($\frac{1}{2}$ of .7744 = .3872).

2. Mercury's incipient rupturing locus (.2974) indicates phyllotactic influence at Venus's locus of incipient subsidence (.7744)

$$.2977 : .7741 : : 5 : 13.$$

3. Mercury's incipient rupturing locus (.2974) is also near the extremity of the linear pendulum, which has Mars's incipient subsidence locus (1.7365) for its point of suspension, and Venus's incipient subsidence locus (.7744) for its centre of oscillation :

$$(3 \times .7744 - 1.7365) \div 2 = .2934.$$

4. If we divide Earth's semi-axis major by the phyllotactic product $2 \times 3 \times 3 \times 13$, we find approximate indications of Earth's harmonic influence on Mercury's cardinal loci.

70 *a*	.298	Mercury	s. p.	.297
75 *a*	.320	"	m. p.	.319
91 *a*	.388	"	m.	.387
107 *a*	.456	"	m. a.	.455
112 *a*	.477	"	s. a.	.477
234 *a*	.997	Earth		1.000

252. *Improbability of Accidental Harmonies.*

Schuster's harmonic investigation (Note 141) appears to have been grounded on the hypothesis, which others have also entertained, that harmonies such as are found in spectral lines and planetary positions may be accidental. In note 244, I spoke of such an hypothesis as "wrongly assumed," and I believe that it is only calculated to hinder scientific progress. Professor Peirce, in the Howland will case, showed that the relation of each individual position to all the possible positions which it might assume, as well as the relative positions of the lines among themselves, should be considered in calculations of mathematical probability. In the Iliad problem, the bare improbability of the accidental arrangement of the letters in their orderly sequence is a^n, a representing the number of letters in the alphabet and n the number of letters in the poem. Let p be the number of readily distinguishable positions which each letter can assume, and the adverse probability against the accidental occurrence of the actual positions would be $(ap)^n$. The improbability would be likewise increased by considerations of the spaces between the letters, the word spaces, the orderly arrangement of lines and pages, the probable frequency of errors, and countless other particulars which are indicative of plan and purpose. Finally, the adequate explanation which is furnished by the simple hypothesis of human contrivance, wholly removes the question from the realm of chance, and makes the improbability infinite.

253. *Probability of Anticipated Results.*

It is not likely that any one would ever think of attributing the angles of crystals to accident, although it would not be so unreasonable to do so as it would be to account for much closer harmonies in that way. The laws of crystallization are obscure and almost wholly unknown, and yet we are not slow in believing that there are such laws, in spite of the irregularities which were pointed out in Note 232. The laws of elasticity, which lead to nodal action, are as well understood as any of the fundamental truths of physical science, yet there are many who fail to recognize them, and who seem to think that no explanation is needed of the harmonies which thrust themselves upon us on every hand. I am not aware that any attempt has ever been made, by any one who believes in the possibility that connected harmonies may be merely accidental, to confirm his belief by framing a series of such harmonies. In ordinary investigations, the discovery of a single fact, through anticipations which are grounded upon theoretical assumptions, is hailed as a wonderful scientific achievement. In the study of rhythmic elasticity such successful anticipations may be endlessly multiplied before their importance becomes generally understood. And yet each one of those verified anticipations lends a confirmation to the photodynamic hypothesis which is little, if any, short of absolute certainty, and which cannot be measured by any ordinary test of mathematical probability.

254. *A Photodynamic "Problem of Three Bodies."*

We have now gathered, by strictly Baconian methods, all the facts which are needed for framing and solving the following problem: To find simple stellar, planetary and satellite relations of mass, position and æthereal density, that will satisfy tendencies to the formation of three primary harmonic nodes, in an elastic medium which propagates undulations with the velocity of light.

1. Nodal tendencies presuppose some deviations from absolute homogeneity, which lead to differences of direction and velocity in the subsiding particles, thus giving rise to oscillations which continually incline to take some form of synchronism. As long as there is any liberty of motion among the particles, those which are at the boundary line, between the constraining inertia of central stellar nucleation and æthereal impulse, will oscillate with the greatest rapidity, tending to assume paths which will alternately receive and exhaust the projectile energies of the æthereal medium. Those energies cannot be completely exhausted until enough time has elapsed to communicate the velocity of light (v_λ), to an æthereal particle which is at rest at the beginning of the oscillation. The central inertia makes the oscillations circular, changing free elliptic revolution into constrained axial rotation, each oscillation of half-rotation occupying a time (t) which gives $gt = v_\lambda$; $gt_2 =$ modulus of light $= M$; $M \div \pi^2 =$

length of a theoretical pendulum, at the stellar equatorial surface, which would swing synchronously with the rotary oscillations ; $g = \frac{v_\lambda}{t} = \frac{m}{r^2}$. The value of g determines the mean orbital velocity, $\sqrt{gr_n}$, for any semi-axis major, r_n.

2. The actions and reactions, between the stellar centre and the primary centre of planetary condensation (Note 23), involve tendencies towards the linear centre of gravity ($\frac{1}{2}$), the centre of linear oscillation ($\frac{1}{3}$), the centre of conical oscillation, ($\frac{1}{4}$), and centripetal accelerations which vary as the fourth power of the velocity of circular orbital revolution. These tendencies may all be satisfied by a stellar mass which is $(2 \times 3 \times 4)^4 = 331$-776 times the mass of primary condensation.

3. The orbital control of the stellar centre is exercised on the planet and satellite alike, at the mean distance ρ_3. If the planet transfers to the satellite a projectile *vis viva*, (l), corresponding to its superficial energy of rotation (Note 246), the relative masses of the planet and satellite, which satisfy their joint oscillatory relations and Sun's projectile energy, may be represented by the proportion :

$$\rho_3 : l : : m_3 : \mu.$$

255. *Subordinate Tendencies.*

There are other harmonic tendencies which seem likely to have been less permanent and more open to modification. The following instances of primitive tendency may be given as interesting:

4. The radii of static equlibrium are inversely as the masses ; rupturing *vis viva* is acquired by subsidence through $\frac{1}{2}$ radius ; if the rupturing locus of simple subsidence becomes a centre of linear oscillation for satellite semi-axis major, ρ_μ, we have

$$\rho_\mu : r_3 : : \tfrac{3}{2}\, m_3 : 2\, \mu.$$

5. The relations of æthereal density are found by the method of Note 240.

Notes 162, 23, and 246 give the following mass values which *precisely* satisfy the first three of these requirements, viz : $m_0 = 331{,}776\ m_3$; $m_3 = 81.186\ \mu$. The fourth requirement points to the value, $m_3 = 80.372\ \mu$. This slight discrepancy may, perhaps, be partly owing to the fact that Earth's oscillation is mainly rotational while Moon's is nearly that of a circular pendulum.

256. *Other Approximations to Moon's Mass.*

a. The formula, $mt^2 \propto \rho^3$, gives the following approximations to the value of μ : (1 year ÷ 1 lunar mo.)$^2 = 178.724$; $(\rho_3 \div \rho_\mu)^3 = 58{,}609{,}000$; $(m_0 + m_3) = 327{,}930\ (m_3 + \mu) = 331{,}777\ m_3$; $m_3 = 86.241\ \mu$.

b. A close harmonic approximation is given by the proportion :

$$m_3 : \mu : : 6\, t_3 : t_\mu : : 2191.54 \text{ dy} : 27.32166 \text{ dy} : : 80.214 : 1.$$

c. The coefficient of t, in the above approximation, is the phyllotactic product, $1 \times 2 \times 3$. It is also very nearly equivalent to the square root of the quotient of Laplace's solar limit by Sun's semi-diameter, which would give, $m_3 = 80.619 \mu$.

d. The mass of Mars is very nearly a mean proportional between the masses of Earth and Moon; $(3,093,500 \div 331,776)^2 = 86.938$.

e. An approximation similar to *b* is given by the proportion:

$$\text{month} : \text{day} : : m_3 : 3 \mu : : 81.965 : 3.$$

f. Moon's locus of subsidence, or aphelion (s), and the mass of Venus (m_2), furnish the following approximation:

$$m_2 : \mu : : s : r_3 : : 63.593 : 1.$$

Substituting the observed basis of the second approximation to m_2 in Note 250, this gives, $m_2 = 82.119 \mu$.

Many other approximations might doubtless be found which would represent obvious harmonic tendencies within the belt of greatest condensation.

257. *Simplicity and Conciseness of Harmonic Calculus.*

The range of estimates in the foregoing note is about $8\frac{3}{8}$ per cent., and the mean of all the estimates is about 2 per cent. greater than the most recent astronomical estimates. These deviations are four times as great as in my extreme estimates of solar distance, and twelve times as great as in the estimates which have been based upon the latest determinations of the harmonic elements. If these approximations are compared with those which had been made by astronomers, a hundred years after Newton had published the laws of gravitation, the indications of superiority in the harmonic methods become very striking. The difficulty of finding the harmonic influences which are most important, is incomparably less than that of determining the corresponding gravitating influences, and the saving of labor is obvious to every one who has ever solved astronomical problems by the ordinary processes of mathematical analysis. Doubts as to the degree of certainty which attaches to purely harmonic results will naturally arise, in the minds of those who have never carefully inquired into the necessity of elastic rhythm, but I believe that such doubts will gradually yield to the fast accumulating evidences of its universal sway. Astronomical, chemical and mechanical science may all be challenged to produce a series of connected fundamental determinations that are comparable, in precision and in intrinsic mathematical probability, with those which are embodied in Note 168 and in the three solutions of Note 254.

258. *Needless Obscurity.*

In Sir John Leslie's Dissertation on the Progress of Mathematical and Physical Science (*Encyc. Brit.*, 8th. Ed., i, 732), after referring to the "maze of intricate and abstruse *formulæ*" in which Laplace had involved the phenomena of capillary attraction, the following reflections of Dr.

Thomas Young are quoted :—"It must be confessed that, in this country, the cultivation of the higher branches of the Mathematics, and the invention of new methods of calculation, cannot be too much recommended to the generality of those who apply themselves to Natural Philosophy ; but it is equally true, on the other hand, that the first mathematicians on the Continent have exerted great ingenuity in involving the plainest truths of mechanics in the intricacies of Algebraical formulas, and in some instances have even lost sight of the real state of an investigation, by attending only to the symbols, which they have employed for expressing its steps." After this quotation Leslie proceeds as follows :—"Laplace's intricate formula has been since unraveled by the acute discrimination of Mr. Ivory, who disjoined it into two separate portions ; the one depending on the adhesion of the watery film to the inside of the tube, and the other resulting from half the cohesion of the particles of the liquid to each other. But our ingenious countryman deduced these elements of the complete force from the simplest physical principles, availing himself of the property of equable diffusion of pressure through the mass of a fluid. The same investigation gave the measure and limits of depression observed in mercury and some other liquids."

259. *Coöperative Methods.*

Since the invention of Hamilton's quaternions and Peirce's linear associative algebras, the temptation for mathematicians to involve "the plainest truths of mechanics in the intricacies of algebraical formulas" has greatly increased. The higher the algebra, the smaller is the number who are able to understand it. While it may be no part of an investigator's duty to "popularize" science, no result can be rightly regarded as belonging to the dominion of science until it has been so far popularized as to be brought within the grasp of the majority of scientific men who are willing to follow the several steps of the original investigation. Labor which is expended on intricate solutions of problems which can be simply deduced from "the property of equable diffusion of pressure through the mass of a fluid," or from other properties of elastic media, is either labor wholly wasted, or, at best, an exercise of ingenuity which serves as a harmless recreation. On the other hand, the use of well-known physical relations as clews for the discovery of coördinate relations, alternating with analytical solutions of problems which are suggested by such discoveries, combines the advantages of theory and observation in ways which are most helpful to scientific progress. Whenever any given result may be reached by two or more different methods, the shortest and simplest is always most commendable.

260. *Lunar Magnetic Polarization.*

The relations between magnetic fluctuations and gravitating tendencies to the restoration of equilibrium in disturbed atmospheric or æthereal currents

(Notes 116–122), are, as might reasonably have been foreseen, greatly modified by Sun's thermal activity. The moon, acting on the currents which originate in Sun's thermal disturbance, shows accordances both in time and magnitude (Note 121), which point strongly, if not conclusively, to an absolute identity between lunar disturbances of terrestrial magnetism and of terrestrial gravitation. These pointings are confirmed by the identity of velocity, in the electro-magnetic "ratio," in the pendulum-oscillations of solar rotation, and in the transmission of luminous undulations. The symmetrical arrangement of æthereal particles which most simply represents the results of elastic pressure (*Proc. Amer. Phil. Soc.*, xii, 408), the spiral tendencies of division in extreme and mean ratio, the rotation which helps to maintain equilibrium between conflicting forces (Note 212), the differences of centrifugal and centripetal energy which result from rotation, all contribute towards an axial polarity which should modify all forms of chemical and mechanical aggregation. To these elements of cyclical rhythm Moon adds her orbital disturbance of Earth's rotation (Notes 247–8), which is so modified by orbital inclination as to produce a magnetic nutation. If we add to these considerations the oscillations of Earth's crust, and other influences which lead to variations in the relative positions of areas of greatest heat and cold, we find data for many interesting problems in mathematical analysis, the solution of which may throw much light both on the normal and abnormal phenomena of terrestrial magnetism.

261. *Gravitating Modulus of Planetary Revolution.*

The hypothesis that stellar rotation is merely retarded revolution, and the exact correspondence between the time of rotary oscillation and the time in which maximum gravitating acceleration would communicate the velocity of light to an æthereal particle, suggest the likelihood of other moduli, which may be intimately connected with the solar-equatorial modulus of light, and which may help us towards a fuller understanding of fundamental kinetic relations. As the rotary oscillations are circular, the simplest and most natural comparison would refer them to circular revolutions of uniform velocity; as all orbital times and velocities are functions of mass and distance, it seems right to begin by examining the greatest possible limit of circular-orbital velocity ($\sqrt{g_o r_o}$), and the least possible limit of circular-orbital oscillatory time $\left(\frac{1}{2} t \text{ of revolution} = \pi\sqrt{\frac{r_o}{g_o}}\right)$. The British Nautical Almanac value of n, Note 75, gives $t = \frac{1}{2} t_o = 5024.5$ sec.; $g_o t = \pi\sqrt{g_o r_o} = .0019643 \, r_o$; $g_o t^2 = \pi^2 l = \pi^2 r_o$. The photodynamic relations of this fundamental gravitating modulus, to the two chief planetary loci, are shown by the approximate identity of t with the time in which a luminous ray would traverse Jupiter's orbit or Saturn's mean aphelion radius vector. Neptune's gravitating modulus, $\pi^2 \rho_8$, represents the second supra-Neptunian locus which I indicated in 1873, and which Forbes found to represent a group of cometary aphelion distances (Note 32).

262. *Photodynamic Modulus of Planetary Revolution.*

A mathematical friend, in whose judgment I place great confidence, admits the conclusiveness of the evidence in favor of paraboloidal harmony in rupturing planetary loci (Note 46, etc.), but he thinks that the approximation to the locus of *Alpha Centauri* may be accidental. I am well aware of the difficulty, which every one naturally finds, in believing that the seemingly quiet undulations of light should have any influence on the relative positions of stellar systems. The remembrance that the *vis viva* of action or reaction, for any given mass, varies as the square of oscillating velocity, would show that if there is any physical influence which controls interstellar arrangements, it should be the one which has the greatest normal velocity. The parabolic energy which is manifested within the solar system, both in approaching and in leaving the sun, must be indefinitely extended, and the luminous undulations which it indicates are equally extensive. The symmetry of the three-fold division in the paraboloid, together with the fact that the uncertainty of stellar distance is of the same order of magnitude as planetary eccentricities, excludes any probable attribution of the stellar accordance to accidental coincidence. The foregoing note furnishes additional grounds for accepting all the harmonic relations of the photodynamic paraboloid as effective. Since $L_o \propto r^2$ (Note 75), and L_o at $r_o = \pi^2 l_o^3$, at the gravitating modulus $\pi^2 r_o$, the photodynamic modulus would be $\pi^6 l^3_o$, its logarithm being $6 \times .4971499 + 3 \times 1.5606934 = 7.6649796$. This is only .0013506 less than the logarithm for the locus of *α Centauri,* as deduced from the corona line and the British estimate of Sun's semi-diameter, indicating a difference of less than $\frac{5}{16}$ of one per cent. It is, therefore, *certain* that the photodynamic modulus of Sun's gravitating modulus is in the *neighborhood,* if not in the actual locus, of the nearest known star.

263. *A Chain of Photodynamic Harmonies.*

If we designate the planetary locus which corresponds to the corona line (Note 45) by x; Jupiter's greatest eccentricity by y; and the theoretical locus of *α Centauri* by z, the following connected equations can all be deduced from simple and obvious forms of elastic rhythm :

1.	$y = 1 - (1048.875 \div 5.202798\, n) = .06055$	Note 3
2.	$m_o = (2 \times 3 \times 4)^4\, m_3 = 331776\, m_3$	" 23
3.	$x = \pi^{\frac{2}{3}}\, nr_o = 460.61\, r_o$	" 45
4.	$z : x :: m_5^2 : m_3^2 \quad z = 461746300\, r_o$	" 46
5.	$v_o = 2\pi\, r_o\, n^{\frac{3}{2}} \div 1 \text{ year} = .0006265013\, r_o$	" 75
6.	$V_o = \pi\, v_o\, (l_o \div r_o)^{\frac{3}{2}} = .4313442\, r_o$	" 75
7.	$V_o = nr_o \div 497.827 \quad n = 214.735$	" 75

8. $z = \pi^6 \, l_o^{\,3} \div r_o^{\,2} \quad l_o = 36.3497 \, r_o$ Note 261

9. $r_a = \rho \div n = 960''.556$ " 75

10. $r_o = (m_o \div m_3)^{\frac{1}{3}} \times (1 \text{ yr.} \div t_3)^{\frac{2}{3}} \times r_3 \div n = 432094$ miles " 75

11. $p_o = r_3 \, r_a \div r_o = 8''.8094$ " 75

12. $t_o = 1 \text{ yr.} \div n^{\frac{3}{2}} = 10029$ sec. " 75

13. $d_o \div d_3 = (t_3 \div t_o)^2 = .255927$ " 75

14. $L_o = (V_o \div v_o)^2 \, r_o = 474028 \, r_o$ " 75

15. Corona line $= 7612 \times \log. 30.037 \, n \div \log. x = 5321.7$ " 45

16. $\rho_3 = n r_o = 92{,}785{,}700$ miles " 75

The values of y, m_o, x, z, l_o, L_o, and the corona line, all represent photodynamic considerations; the other values are readily deduced from them by simple radiodynamic relations. Stockwell's estimate of y is .06083; the value of n is intermediate between those of the British and the American Nautical Almanacs; the value of the corona line corresponds *precisely* with the geometrical wave-length in Note 41; all the other values are within the astronomical limits of probable error.

264. *Further Oscillatory Relations of Venus.*

It seems not unlikely that the position of Venus, in the belt of greatest condensation, may have nearly as many suggestive relations as that of Earth. To the eight indications of Note 250, the following may be added:

9. All the orbital loci of Venus are between a primary and a secondary centre of linear oscillation for Earth's semi-axis major ($\frac{2}{3}$, and $\frac{2}{3} + \frac{1}{3}$ of $\frac{1}{3} = \frac{7}{9}$). Stockwell's estimates are, secular perihelion, .6722; secular aphelion, .7744.

10. The secular aphelion of Venus is nearly a mean proportional between Earth's second reciprocal centre of oscillation ($\frac{1}{3}$ of $\frac{1}{3}$), and Jupiter's secular aphelion; $\sqrt{\frac{1}{9} \times 5.42735} = .7766$.

11. The major-axis of the nebular ellipse which marks the incipient separation of Venus from Earth, 1.7744, is indicative of a successive nucleation for Earth's semi-axis major; $\frac{4}{3} \times \frac{4}{3} = 1.7778$.

12. The mass harmony (8), introduces the principle of virtual velocities into the foregoing nebular ellipse, at the beginning of subsidence for Venus.

265. *Tidal Harmony.*

The tidal disturbance of Earth by Sun, during a semi-annual orbital oscillation, is sufficient to give orbital velocity to all the particles which are disturbed both by Sun and by Moon. Orbital velocity would be communicated in $\frac{1}{\pi}$ of an oscillation, to the particles which are disturbed by Sun's tidal action. During the remainder of the oscillation a like velocity would be communicated to $\pi - 1$ times as many particles. If we designate Moon's mass and semi-axis major by m_a and ρ_a, this approximation gives us the following proportion :

$$m_a : \rho_a^3 : : (\pi - 1)\, m_0 : \rho_3^3.$$

Substituting $m_0 = 331776\, m_3$, $\rho_3 = 92785700$ miles, $\rho_a = 238869$ miles, we get, $m_3 = 82.486\, m_a$. The values which were found in Notes 8 and 246 seem likely to be subject to fewer modifications than this, but every additional indication of approximation to anticipated harmonies lends new interest to the discussion of elastic influence and furnishes new material for future analytic research.

266. *Harmonic Tidal Cycles.*

The tendency of the solar and lunar tidal disturbances to cyclic harmony, is shown by the approximate equality of the solar disturbance, during the interval which would give terrestrial particles orbital velocity, to the lunar disturbance, during a sidereal revolution about the Earth. The approximation may be expressed by the equation :

$$\frac{m_0}{\rho_3^3} \times \frac{1\ yr}{2\pi} \doteq \frac{m_a}{\rho_a^3} \times 1\ mo.$$

Substituting the same values as in the foregoing note for m_0, ρ_3 and ρ_a, we get the approximate value, $m_3 = 83.025 m_a$. The closeness of these various approximations may be attributed, with great likelihood, to original influences of central-belt condensation, aided by the natural stability of harmonic oscillations which have once been set up. The slight discrepancies between different estimates are probably owing to subordinate rhythmic disturbances, such as nutation, precession, and other oscillations, the exact influence of which we may reasonably hope to understand when we have a fuller knowledge of æthereal elasticity.

267. *Subterranean Tides.*

My views regarding the influence of elasticity upon tidal adjustments, (*Proc. Amer. Ph. Soc.*, ix–xiv ; xvi, sq.; *Phot. Notes* 215–8), are confirmed by the subterranean tides in the flooded mines at Dux, in Bohemia. In a communication to *Ciel et Terre* (copied in *Ann. de Chim. et de Phys.*, xxv, 533–46), M. C. Lagrange cites the discussion, by Grablowitz (*Boll. della Soc. Adr. di Sci. Nat. in Trieste*, vol. vi, fasc. I, 1880), of Klönne's observations. The observations seem to show conclusively that the ebb and flow in the mines is due to combined solar and lunar action, but that it can be satisfactorily explained only by the direct attraction of the two bodies upon the solid mass of the Earth. Lagrange refers to previous investigations, by himself and by George H. Darwin, which go to show that if cosmical bodies have any elasticity, they must undergo continual and periodic changes of form. Grablowitz infers that those changes should lead to oscillations of various intensity, so as to produce mechanical effects which differ according to the nature and degree of local elasticity, but subjected to invariable laws which are regulated by the relative movements of the disturbing bodies. Naumann's tables (*Handbuch der Chemie*, 1877, pp. 346–59), show that if the whole Earth was a solid diamond, or if it was composed of rocks which are least expansible, the greatest quarter-daily tidal deformations would not involve an amount of work equivalent to $\frac{1}{2}$° C. The spring tidal stress during six hours is $\left(\frac{m_o}{\rho_o^3} + \frac{m_a}{\rho_a^3}\right)\frac{gt^2}{2} \doteq 619$ ft., which is enough to furnish many times the available force requisite for all the adjustments of æthereal elasticity, freely moving particles, and internal work in the solid rocks.

268. "*Conservation of Solar Energy.*"

The views of Dr. C. William Siemens suggest a consideration of the influence of solar rotation upon the æthereal atmosphere, at various distances from Sun's centre. Laplace's limit, according to the data in Note 263, is at 36.35 r_o. The centrifugal force of rotation at that limit would be $36.35^2 = 1321.3$ times as great as at Sun's surface, while the centripetal force of gavitation is only $\frac{1}{1321.3}$ times as great. The photographs of the solar eclipse which have been lately published (*Nature*, April 20th, 1882), indicate an atmospheric oblateness which may be due to the equilibrating tendencies of these two opposing forces. If the æthereal disturbances which result from this source are not sufficient to account for luminous and thermal vibrations, we may look still further to the velocity which the subsiding particles would acquire in falling from the equatorial limit to the poles. If there was no resistance, this velocity would be $\left(\frac{35.35}{36.35} \times 2gr\right)^{\frac{1}{2}} = 376.8$ miles per second. Any diminution of this velocity by resistance would be converted into heat. If the mean limit between the centrifugal and centripetal tendencies is in latitude 30°, the mean diminution of velocity when the particles reach the polar zone, would be .982 of $376.8 = 370$ miles. If the mean time of accomplishing the centrifugal and centripetal cycles is the same as the time of half-rotary oscillation, the formula of torsional elasticity (Note 162) provides for radiations with the oscillatory velocity of light, and the general tendency of nebulæ to a discoid or flattened form gains a new significance.

269. *Another Test of Atomic Divisors.*

In order to avoid all questions of absolute probability, in Notes 171, 201, 202, etc., I have computed $(n\ D - O) \div D$ for all the elements in Clarke's table except H, using $D_1 = 7$ for the perissads, $D_2 = 8$ for the artiads, $D_3 = 1$ for the hydrogen divisor. Adding the logarithms of $(n\ D - O) \div D$, I find for the perissads,

Σ (for D_1) = A	$\overline{20}.4692966$
Σ (for D_3) = B	$\overline{22}.9326580$
A — B	1.5366386

The aggregate probability of the hydrogen divisor is, therefore, 34.406 times as great as that of the general perissad divisor, 7.

For the artiads

Σ (for D_2) = C	$\overline{45}.3906748$
Σ (for D_3) = D	$\overline{38}.1502848$
D — C	6.7596100

The aggregate probability of the general artiad divisor, 8, is therefore 5749234 times as great as that of the hydrogen divisor.

For all the elements,

Σ (for D_1 and D_2) = E	$\overline{65}.8599714$
Σ (for D_3) = F	$\overline{59}.0829428$
F — E	5.2229714

The aggregate probability of the atmospheric divisors is, therefore, 167098 times as great as that of the hydrogen divisor.

Dividing the sums of the perissad, artiad and total logarithms by 20, 44, 64, respectively, we get for the mean values of (n D — O) ÷ D, and for the mean relative probability of phyllotactic influence,

		Log.	Antilog.	Probability.
Perissad,	D_1	$\overline{1}.0234648$	.10555	2.145
	D_3	$\overline{2}.9466329$	.08844	3.223
Artiad,	D_2	$\overline{2}.9861517$	.09686	2.124
	D_3	$\overline{1}.1397792$	.13797	1.491
Total,	D_1, D_2	$\overline{2}.9978121$	.09950	2.009
	D_3	$\overline{1}.0794210$	.12007	1.664

The relative probability is found by dividing the mean accidental ratios for 20, 44, and 64 numbers, with differences equally distributed, by the antilogarithms, or observed ratios. The accidental ratios are .22607 for the perissads, .20578 for the artiads, .19985 for the whole list of elements.

Some criticisms have been made upon my previous estimates of probability, which overlooked my demonstration that ordinary tests fail to show probabilities which are known to exist (Notes 145, 149), and my introduction of "the *a priori* probability of tendency to division in extreme and mean ratio" (Note 171). As my object is to show the *relative* probability of different divisors, and as it is impossible to know what weight should be given to *a priori* considerations, the present method may be acceptable.

270. *Fundamental Centrifugal and Centripetal Mass-Relations.*

The influence of cardinal loci upon the relative masses at the chief centre of nucleation and at the chief centre of condensation, is shown by the equation :

$$\frac{m_3}{m_0} \cdot \frac{l^4}{r_0^4} = \frac{\rho_5}{\rho_3}. \qquad (1)$$

In this equation, ρ_3 = Earth's semi-axis major = 1 ; ρ_5 = Jupiter's semi-axis major = 5.202798 ; r_0 = Sun's semi-diameter ; l = Laplace's solar limit = 36.3658 r_0 (See Note 75). This gives for Sun's mass, m_0 =

336,153 m_3, which is 1.32 per cent. greater than the estimate which is based on requirements of oscillation and subsidence (Notes 5, 23, etc.). If f_o, f_1 designate the centrifugal force of rotation at r_o, l, respectively, and g_o, g_1 represent the corresponding centripetal accelerations of gravity, equation (1) may assume the form :

$$\frac{m_3}{m_o} \cdot \frac{f_1}{g_1} = \frac{\rho_5}{\rho_3} \cdot \frac{f_o}{g_o} \qquad (2)$$

Equation (1) is especially interesting for its bearing on the conservation of solar energy (Note 268); equations (1) and (2) represent the equal ratios of action and reaction between centripetal and centrifugal tendencies, all the numerators having a centrifugal origin, while all the denominators are centripetal. Combining these equations with the equation of Earth's photodynamic *vis viva* (Note 91), we get

$$\frac{m_5}{m_3} \cdot \frac{l^4}{r^4} = \left(\frac{v_\lambda}{r_n}\right)^2 \cdot \frac{\rho_5}{\rho_3} \qquad (3)$$

Here also we have centrifugal numerators and centripetal denominators, together with photodynamic orbital relations of mass, distance, velocity, rotation, revolution and condensation, which are very suggestive.

271. *Perissad Relations of Nitrogen.*

If we take the continued product, for all the elements, of the percentages of D which represent $(n\ D - O) \div D$, the hydrogen product is 69.208 times as great as for Gerber's empirical divisors, and 18178.47 times as great as that for my phyllotactic factors (Note 136). While this is sufficient to show the influence of phyllotactic tendencies, my comparisons of relative probability have led me to the discovery of important modifications of these tendencies by the abundant gases, H, N, O; H being a representative factor of the monatomic elements, $\frac{1}{9}$ N for the tri and pentavalent, 8 H for the di- and tetratomic, $\frac{1}{16}$ O = .998 for the remaining metallic elements. The effect of a slight difference in the divisor upon the residuals, as well as my method of operation, may be illustrated by testing Gerber's divisor ($D_1 = 1.559$) and my own ($D_2 = \frac{1}{9} N = 1.558$) on the tri- and pentavalent elements:

	Clarke.		R₁.		R₂.	Log. R₁.	Log. R₂.
N	14.021	=	9 D_1 — 10	=	9 D_2 — 1	1.0000000	.0000000
P	30.958	=	20 D_1 — 222	=	20 D_2 — 202	2.3463530	2.3053514
As	74.918	=	48 D_1 + 86	=	48 D_2 + 134	1.9344984	2.1271048
Sb	119.955	=	77 D_1 — 88	=	77 D_2 — 11	1.9444827	1.0413927
Bi	207.523	=	133 D_1 + 176	=	133 D_2 + 309	2.2455127	2.4899585
Au	196.155	=	126 D_1 — 279	=	126 D_2 — 153	2.4456042	2.1846914
Bo	10.941	=	7 D_1 + 28	=	7 D_2 + 35	1.4471580	1.5440680
Ta	182.144	=	117 D_1 — 259	=	117 D_2 — 142	2.4132998	2.1522883
V	51.256	=	33 D_1 — 191	=	33 D_2 — 158	2.2810334	2.1986571
Σ log. R						18.0579422	16.0435122
9 × log. D						28.7356149	28.7331075
Σ log. (R ÷ D) = log. P						$\overline{11}.3223273$	$\overline{13}.3104047$
Mean log. = $\frac{1}{9}$ Σ log. = log. *p*						$\overline{2}.8135919$	$\overline{2}.5900450$

The logarithm of aggregate relative probability is $\overline{11}.3223273 - \overline{13}.3104047 = 2.0119226$; the log. of mean relative probability is $\overline{2}.8135919 - \overline{2}.5900450 = .2235469$. Hence the aggregate relative probability of the nitrogen divisor, $P_2 \div P_1 = 102.783$; the mean relative probability, $p_2 \div p_1 = 1.6732$.

272. *Aggregate and Mean Ratio of Residuals to Atomic Divisors.*

In the following table the logarithms for each group are computed after the method of the foregoing note. The divisor for the first surd, S_1, is $\frac{1}{2}(3-\sqrt{5}) = .382$; for the second surd, S_2, $\frac{1}{2}(\sqrt{5}-1) = .618$; for hydrogen, H = 1; for Gerber and Chase I, see Note 136; for Chase II, see Note 269; for Chase III, see Note 271.

Group.	S_2.	S_1.	H.	Gerber.	Chase I.	Chase II.	Chase III.
Monat.	$\overline{8}.3393239$	$\overline{8}.5143370$	$\overline{12}.2138579$	$\overline{11}.7186094$	$\overline{11}.6283038$	$\overline{11}.4019386$	$\overline{12}.2138579$
3 and 5.	$\overline{7}.4310096$	$\overline{8}.7210766$	$\overline{10}.7187995$	$\overline{11}.3223273$	$\overline{11}.3223273$	$\overline{9}.0673580$	$\overline{13}.3104047$
2 and 4.	$\overline{11}.7492826$	$\overline{14}.6963491$	$\overline{16}.5909435$	$\overline{23}.8649303$	$\overline{23}.6476134$	$\overline{23}.3406987$	$\overline{23}.3406987$
Metal.	$\overline{18}.5073145$	$\overline{19}.1410255$	$\overline{23}.5593397$	$\overline{18}.3369171$	$\overline{20}.2251388$	$\overline{22}.0499751$	$\overline{32}.5388218$
Periss.	$\overline{15}.7703335$	$\overline{15}.2354136$	$\overline{22}.9326574$	$\overline{21}.0409367$	$\overline{22}.9506311$	$\overline{20}.4692966$	$\overline{25}.5212626$
Artiad.	$\overline{28}.2565971$	$\overline{33}.8373746$	$\overline{38}.1502832$	$\overline{40}.2018474$	$\overline{43}.8727522$	$\overline{45}.3906738$	$\overline{55}.8795205$
Aggreg.	$\overline{42}.0269306$	$\overline{47}.0727882$	$\overline{59}.0829406$	$\overline{61}.2427841$	$\overline{64}.8233833$	$\overline{65}.8599704$	$\overline{79}.4037831$
Mean.	$\overline{1}.3441708$	$\overline{1}.2667623$	$\overline{1}.0794209$	$\overline{1}.0506685$	$\overline{1}.0128654$	$\overline{2}.9978120$	$\overline{2}.7719341$
Rel. Ag.	.0000000	4.9541424	16.9439900	18.7841465	21.2035473	22.1669602	36.6231475
Rel. M.	.0000000	.0774085	.2647499	.2935023	.3313054	.3463588	.5722367

The aggregate residual ratio for S_2 is more than 87,900,000,000,000,000 times as great as for hydrogen, and more than 4,199,000,000,000,000,000,000,000,000,000,000,000 times as great as for the relations to H, N, O; the mean ratio is 1.8397 times as great as for H, and 3.7345 times as great as for my second group of divisors. The aggregate hydrogen ratio is more than 47,770,000,000,000,000,000 times as great as for my third group, the mean ratio being 2.0299 times as great.

273. *Comparison of Geometric and Arithmetic Residual Means.*

The logarithms of the geometric mean residual ratios, for the several groups, may be found by dividing the monatomic logarithms by 11, the tri- and pentatomic by 9, the di- and tetratomic by 17, the metallic by 27. Some questions of relative probability may be tested more readily by arithmetical means, and for this reason as well as in order to preserve additional evidence of phyllotactic influence, the following table is given. All of my divisors were deduced from phyllotactic considerations; the first set shows the great superiority of my phyllotactic over Gerber's approximately phyllotactic divisors; the second set introduces corresponding terms of two phyllotactic series; the third set has two divisors which are simply phyllotactic (1, 8) and two which are products of phyllotactic ratios ($\frac{1}{16} = \frac{1}{2} \times \frac{1}{8}$; $\frac{1}{9} = \frac{1}{3} \times \frac{1}{3}$).

Group.	Arithmetical. S_2.	S_1.	H.	G.	C_1.	C_2.	C_3.	Geometrical. S_2.	S_1.	H.	G.	C_1.	C_2.	C_3.
Monat.	.237	.232	.215	.195	.171	.205	.215	.201	.209	.085	.116	.114	.109	.085
3 and 5.	.218	.225	.142	.096	.096	.186	.082	.186	.155	.093	.065	.065	.102	.039
2 and 4.	.288	.221	.214	.144	.145	.137	.137	.249	.165	.124	.050	.048	.046	.046
Metal.	.268	.279	.225	.246	.240	.227	.127	.225	.200	.148	.222	.185	.154	.068
Periss.	.229	.228	.182	.150	.137	.172	.155	.194	.183	.088	.090	.089	.106	.060
Artiad.	.276	.245	.220	.207	.203	.192	.131	.234	.186	.138	.125	.110	.097	.059
Aggreg.	.261	.240	.209	.189	.183	.186	.139	.237	.185	.120	.112	.103	.099	.059

274. *Some Consequences of the Identity of Luminous and Gravitating Oscillation.*

The ethereal particles, which are repelled from Sun's equator by the centrifugal force of rotation, "subside" spirally towards the poles, giving rise to Ampérian currents which account for Maxwell's identification of luminous and electromagnetic waves and yielding a mechanical equivalent of 76,000,000 J for every pound of subsiding matter; the axial core of the spirals is the rod of the virtual solar pendulum (Note 162) of which the length and the radius of torsion are both determined by the solar modulus of light; the continual succession of spiral impulsions substitutes uniform rotation for reciprocal oscillation; the *precise* accordance between the time of rotary oscillation and the time of acquiring or losing the velocity of luminous projection, shows the equally precise agreement between centrifugal ethereal action and centripetal gravitating reaction; the combination of axial rotation with orbital revolution produces continual shiftings of inertial resistance which must be followed by continual renewals of ethereal disturbance; the perpetual maintenance of luminous oscillation by influx, as well as by an equivalent efflux, removes "the reproach of Thermodynamics."

Such are a few of the obvious considerations which are suggested by the identity of luminous and gravitating oscillatory velocity at the centre of the solar system. In subjecting them to the tests of mathematical analysis, the equilibrating tendencies of centrifugal and centripetal action should be studied with especial reference to three oblate spheroids, all of which have the same poles as the Sun. Their equatorial loci are respectively coincident with Laplace's limit ($36.35 r_0$), the virtual radius of solar torsion ($688.95 r_0$), and the solar modulus of light ($474657 r_0$).

275. *Consideration of Some Objections.*

Professor Geo. Fras. FitzGerald (*Nature*, xxvi, 80) presents four questions in the way of objection to the hypothesis of the conservation of solar energy by an average influx which is exactly equivalent to the average efflux. The reply of Dr. Siemens may be supplemented by some additional considerations. "1. How the interplanetary gases near the Sun acquire a sufficient radial velocity to prevent their becoming a dense atmosphere around him?" The proportionality of centrifugal force to mass would combine with the tendencies of gaseous diffusion and with the increased molecular velocity of gaseous condensation, to maintain a constant circulation of all the constituents of the solar atmosphere. "2. Why enormous atmospheres have not long ago become attached to the planets, notably to the Moon?" The reported discovery of a lunar atmosphere by Trépied and Thollon, during the late solar eclipse, which is announced in the same number as the question, gives an apt and timely confirmation of Wollaston's views, which are cited by Siemens. "3. Why the earth has not long ago been deluged when a constant stream of aqueous vapor that would produce a rain of more than 30 inches per annum all over the earth, must annually pass out past the earth in order to supply fuel to be dissociated by the heat that annually passes the earth?" The average annual rainfall of the whole globe is not accurately known, but there is good reason to believe that it is very nearly, if not precisely, such as would be required by the hypothesis. "4. Why we can see the stars although most of the solar radiations are absorbed within some reasonable distance of the Sun?" The prevalent thermodynamic hypotheses suppose an unlimited power of absorbing radiant *vis viva*, without any tangible evidence of such absorption. All that needs to be explained is the maintenance of a uniform amount of æthereal oscillations in the universe. If the centrifugal and centripetal alternations of less elastic particles are linked with like alternations of more elastic particles, the actions and reactions of elasticity and inertia may account for the operation and stability of all physical laws.

276. *Influence of Explosive Oscillations on Radiant Energy.*

The relations which I have pointed out between explosive oscillations and planetary positions (*Proc. Amer. Phil. Soc.*, xii, 392–417, *et seq.*), should also influence the centrifugal and centripetal alternations within Sun's photosphere. I have often shown that the photodynamic equality of luminous and gravitating oscillations tends to drive all of Sun's particles towards the limit between aggregation and dissociation, so that a slight external disturbance may turn the unstable equilibrium in either direction. Berthelot's investigations (C. R. xciii. 613–9) of explosions in gaseous compounds by detonating agents, have indicated the existence of explosive waves which are quite distinct from simple waves of sound, and have shown that compounds and explosive mixtures generally become more sensitive to shocks as they near the temperature at which they begin to decompose. Hence a meteor, or even a single molecule, which has acquired a sufficient velocity of subsidence in its sunward fall, may explode a gaseous compound which is in or near the nascent state, and the explosion may react upon the falling mass or molecule so as to leave it in an unstable equilibrium which is ready for explosion by the next like subsidence. The locus of the virtual radius of solar torsion (ar_0, Note 162) in the asteroidal belt, makes the minor planets important outposts of explosive oscillation in the second of the oblate spheroids to which I called attention in Note 274, and opens a wide field for analytical research respecting the equilibrating tendencies between centripetal and centrifugal energy. The stability of major axes, in orbital revolution, is no more necessary than the reciprocal equality of radiodynamic action and reaction in elastic media.

277. *Relations of Earth to the Asteroids.*

Different portions of the asteroidal belt are so related to Earth's varying positions as to share the influence, either directly or through the conversion of oscillatory *vis viva* into projectile *vis viva*, of linear, spherical and explosive centres of oscillation. One of these relations, which seems specially important and significant in connection with the maintenance of solar energy, is found by dividing the virtual radius of solar torsion ($ar_0 = 688.95r_0$) by Earth's mean radius vector ($\rho_3 = 214.45r_0$). This gives a relative distance of 1 ÷ 3.2134, and a relative orbital velocity of $(3.2134 \div 1)^{\frac{1}{2}} = 1.7926 \div 1$ at the chief centre of condensation in the solar system, as compared with the orbital velocity at the extremity of the radius of torsion. This is within about $\frac{5}{12}$ of one per cent. of the ratio (1.8) of the *vis viva* of oscillating particles to the *vis viva* of wave propagation, which was indicated by me in 1872 (*Proc. Am. Phil. Soc.*, xii, 394), and by Maxwell in 1877 (*Phil. Mag.* [5] iii., 453, iv. 209). A portion of this trifling difference may be explained by the gradual diminution of æthereal density upon receding from stellar centres (Note 240).

278. *Collateral Hypotheses.*

In investigating the relations of centripetal and centrifugal action and reaction, it seems desirable to consider and compare the following hypotheses and conclusions :

1. Laplace's estimate that the velocity of transmission, in gravitating acceleration, is at least 100,000,000 times as great as that of light.

2. LeSage's hypothesis that gravitation and luminous undulation represent equal actions and reactions.

3. Faraday's fruitless search for a gravitating constant which would satisfy his interpretation of the doctrine of conservation of energy.

4. Herschel's comparison of the mean *vis viva* of light, with that of sound.

5. Weber's identification of the velocity of light (v_λ), with the "electro-magnetic ratio" (v_ε).

6. Berthelot's "explosive waves," and their action upon sound waves.

7. The inquiries of Siemens into the combined influence of rotation, centrifugal action, gravitating force, and chemical affinity.

8. The various attempts of Thomson, Rankine, Maxwell, Eddy, and others, to escape the apparent consequences of the second law of thermodynamics.

279. *Cosmical and Molecular Constant.*

If there is a natural unit of force we may look for a natural unit of velocity. The hypothesis that all the particles of bodies are in constant motion, involves oscillation of various kinds, orbital, pendulous, or wave. Different transformations of similar oscillations are harmonic. Rotation may be regarded as a pendulous oscillation due to retarded and modified revolution. The resemblance of LeSage's theory to the kinetic theory of gases points to a probability that the natural unit of velocity is oscillatory. This probability is strengthened if we assume the existence of molecular and intermolecular elasticity. In looking to the activities of the principal mass in our system for indications of a natural unit of velocity, we find that gravitating velocities may be represented by gt. In order that gt may be constant, t must vary inversely as g and, therefore, directly as r^2. This variation is found in the rotation of a nebulous sphere, where it holds good for all stages of expansion or contraction which are not affected by external influence. Gravitating acceleration should do its whole work in stellar rotation, as well as in planetary revolution. Particles exposed to solar superficial gravitating acceleration, during a single oscillation of half-rotation, would acquire a constant velocity ($gt = v_\gamma$) which is equivalent to the velocity of light. In other words, the unit of velocity which is indicated by the combined constant of solar gravitation and rotation is the same as is indicated by light and by electricity.

280. *Harmonious Development.*

The velocity of light, like the velocity of sound, represents an elastic atmosphere whose height, if homogeneous, would be twice the virtual fall which would give the velocity in question. The analogy is enhanced by the fact that the hypothetical elasticity of the luminiferous æther is in harmonic accordance with solar rotation and planetary revolution. The identity of velocity

$$v_\lambda = v_\varepsilon = v_\gamma$$

represents three simple relations of light, electricity and gravitation. Interpret this fact as we may, it is strongly suggestive of some interplay between sun and matter outside of it, which has determined solar constants. The invariability of v_γ by nebular contraction indicates the same determination for the present and for all future time. If Sun's mass and magnitude are determined by cosmic causes, so that the solar system can always be considered as undergoing a process of harmonious development, the mass, rotation and other solar elements seem likely to be connected by numerical relations, either with other bodies of the system or with cosmical or physical data.

281. *A Fundamental Time-Integral.*

Thomson and Tait (*Nat. Phil.*, i, § 52) speak of the principle of harmonic motion as one of "immense use, not only in ordinary kinetics, but in the theories of sound, light, heat, etc." Nearly all the results of my physical investigations go to confirm the truth of this statement. The velocity which is involved in the time-integral of projection against a constant gravitating retardation, is measured by gt. The theory of the ballistic pendulum assumes (*op. cit.*, § 298) "that the ball and pendulum are moving on as one mass *before the pendulum has been sensibly deflected from the vertical.* This is the essential peculiarity of the apparatus. A sufficiently great force might move it far from the vertical in a small fraction of its time of vibration. But in order that the time-integral may have its simplest application to such a case, the direction of the force would have continually to change so as to be always the same as that of the motion of the block."

This is precisely the case in the identity of the foregoing note, according to LeSage's hypothesis. The doctrine of correlation of force leads us to look for the simplest forms of harmonic motion at the centres of stellar systems. The simplest value of t, in a harmony of luminous undulation and stellar rotation, is that of a single oscillation of half-rotation. We have no means of knowing whether the identity, $v\lambda = v_{\Xi} = v_{\gamma}$, holds for any system except our own, but its verification by our sun and the variety of ways in which photodynamic harmonies are deduced are very significant.

282. *A Secondary Time-Integral.*

The harmony between Sun's constrained rotation and luminous undulation warrants an expectation of subordinate harmonies between solar and planetary motions. We may naturally look for the simplest relation in some harmonic motions of Sun and Jupiter. Jupiter is at the nebular centre of the system, on a diameter which is bounded by mean loci of Neptune and Uranus, and the velocity which is involved in its time-integral of rotary oscillation, (gt), is nearly, and perhaps exactly, the same as the limit of planetary velocity in a circular orbit ($\sqrt{gr}$ at Sun's surface). Although planetary revolution at Sun's surface is impossible, the influences which tend to produce it are continuous, and any wave motion which may be thus produced is propagated with uniform velocity through the medium in which the waves originate. The uncertainties in regard to the exact values of Earth's semiaxis major and the apparent semidiameter of Sun and Jupiter, introduce a range of uncertainty into the velocity of Jupiter's time integral, which amounts to about five per cent. Values may be taken which are very near the mean values and which make the accordance exact. This accordance may, perhaps, lead to a special extension and modification of George H. Darwin's beautiful investigations.

283. *A Third Time-Integral.*

The centre which seems to hold the third rank in point of cosmical importance, in the solar system, is the centre of the belt of greatest condensation, which is represented by Earth's orbit. The velocity which is involved in its time-integral of rotary oscillation is slightly less than Jupiter's corresponding velocity, being almost, or quite identical with planetary velocity at the mean centre of gravity of Sun and Jupiter. These successive accordances furnish data for a second "photodynamic problem of three bodies," which is, perhaps, even more remarkable than the one given in Note 254. The importance of the combined harmonies may be shown by a simple recapitulation of the several harmonic velocities, viz.: 1. The identity of Note 280; 2. The velocities which correspond with the respective time-integrals of rotary oscillation for the chief centre of nucleation (Sun), the centre of nebulosity (Jupiter), and the chief centre of condensation (Earth); 3. The limiting velocity of circular orbital revolution in the system; 4. The velocity of circular orbital revolution at the centre of gravity of Sun and Jupiter.

284. *Instantaneous Action.*

The case of gravitating action and re-action between Moon and Earth (*Thomson and Tait*, § 276), is the one which led Laplace to his highest estimate of the velocity of gravitating transmission and to suppose that the transmission might be absolutely instantaneous. It is also the case which led Adams (*Ib.* § 830) to the discovery of Laplace's error respecting the theoretical invariability of the mean sidereal day and to the subsequent discussions of tidal friction and retardation. That there is such a thing as instantaneous action is so generally believed that it seems desirable that attempts should be made to furnish some physical representation of its possibility and to demonstrate its influence upon adjustments of equilibrium in cosmical actions and reactions. If frictional accelerations in one portion of a rotating globe can be compensated by frictional retardations in another, or if elasticity (Note 217) aids tidal tendency and wave propagation in making the instantaneous changes which are required by tidal action, our tidal theories need careful revision. The *facts* of harmonic relation which are found on all sides, indicate activities which have been at work in all time, and they should not be ignored for any merely theoretical considerations.

285. "*Harmonic Analysis of Tidal Observations.*"

At the last meeting of the British Association, a special grant of £50 was made to Mr. George H. Darwin, for a Harmonic Analysis of Tidal Observations. Mr. Darwin's success in developing Sir William Thomson's views upon cosmical viscosity, and the beauty of many of his results, give assurance of valuable additions to human knowledge from any work that he may undertake. The accuracy of the conclusions which he has already drawn from Delaunay's hypothesis, is unquestionable. My criticisms (Notes 215–225) upon Prof. Ball's use of those conclusions, were based upon the fact that they did not adequately represent all the elements of the questions which were involved, the laws of intermolecular elasticity and harmonic motion having been almost entirely overlooked. In the absence of any positive evidence of tidal retardation, we have no right to jump at the conclusion that it is established by the second law of thermo-dynamics. The "reproach" which that law involves is increasingly felt by able investigators (Note 278, 8), and even if it should at last be unanimously admitted that the reproach is unavoidable, it is more satisfactory to suppose a continual restoration of energy by divine supervision, than to believe in the spasmodic alternations of rest and activity, which are taught in the Hindoo mythology.

286. *Refraction of Energy.*

The important cosmical time-integrals and the triple identity of fundamental velocities (Notes, 280–3), seem to be indicative of a continual equivalence of centripetal and centrifugal activities, such as LeSage made the basis of his hypothesis ; the rotation of stellar centres serving both to maintain the active energies of the universe and to provide cyclical adjustments of equilibrium. The apparent requirements of thermo-dynamics may, perhaps, be partially satisfied by the probability that the æthereal atmosphere of every star has a relatively hot and a relatively cold hemisphere. It seems possible that all radiations, luminous, thermal, electrical, or kinetic in any other form, may be so refracted, in their passage through the various stellar atmospheres, as to be either reflected from star to star, or transiently absorbed by media which can speedily be enabled, by stellar rotation, to give them out again.

287. *Another Phyllotactic Atomic Divisor.*

The di- and tetratomic group of chemical elements can be more nearly represented by the phyllotactic divisor $\frac{2}{3}$ C = 7.9824, than by 8 H (Notes, 271–2).

		T.	O.	T ∽ O.	(Log. T ∽ O.)
O	2 D	15.9648	15.9633	.0015	$\bar{3}.17609$
S	4 D	31.9296	31.984	.0544	$\bar{2}.73560$
Se	10 D	79.8240	78,797	1.027	0.01157
Te	16 D	127.7184	127.960	.2416	$\bar{1}.38310$
Mg	3 D	23.9472	23.959	.0118	$\bar{2}.07188$
Ca	5 D	39.9120	39.990	.078	$\bar{2}.89209$
Sr	11 D	87.8064	87.374	.4324	$\bar{1}.63589$
Ba	17 D	135.7008	136.763	1.0622	0.02620
C	2 D	15.9648	11.9736	3.9912	0.60110
Si	4 D	31.9296	28.195	3.7346	0.57224
Ti	6 D	47.8944	49.846	1.9516	0.29039
Zr	11 D	87.8064	89.367	1.5606	0.19329
Sn	15 D	119.7360	117.698	2.038	0.30920
Hg	25 D	199.5600	199.712	.152	$\bar{1}.18184$
Mo	12 D	95.7888	95.527	.2618	$\bar{1}.41797$
W	23 D	183.5952	183.610	.0148	$\bar{2}.17026$
U	30 D	239.4720	238.482	.99	$\bar{1}.99564$

$\overline{10}.66435$

17 (log. D = .90213) 15.33621

17) $\overline{25}.32814$

Logarithm of mean residual, $\bar{2}.54871$

288. *Another Basis for Estimates of Probability.*

The substitution of $\frac{2}{3}$ C for $\frac{1}{2}$ O or 8 H, in Notes 271–2, not only introduces another evidence of phyllotactic influence upon atomicity, but it also shows that the organic elements, C, H, O, N, stand in important phyllotactic relations to four fundamental groups of elements. If we omit C from the comparison, the remaining elements of the di- and tetratomic group give $\bar{2}.47682$ for their logarithm of mean residual. The respective residuals themselves are $.03538D$ and $.02998D$. I have already considered various probabilities, which were based on Schuster's estimates, as well as relative probabilities which are independent of any absolute estimates. Another satisfactory basis of comparison may be found in the mean limiting value of the residual, $a - nD = \frac{D}{5.43654} (2\pi D)^{\frac{1}{2D}}$, when the possible residuals are taken in arithmetical progression. If all possible values are thus taken, in other words, if the number of terms is infinite, the second factor becomes unity and the limiting value is $\frac{D}{5.43654} = .18394D$. This is 5.2 times as great as the first of the above mean residuals, or 6.135 times as great as the second.

289. *Resumé of Phyllotactic Atomicity.*

The most satisfactory phyllotactic divisors for the four elementary groups, as indicated by the foregoing notes, are the following: α, for the monatomic group, $H = 1 \doteq \frac{1}{2}.\frac{1}{8}\ O$; β, for the tri- and pentavalent group, $\frac{1}{3}.\frac{1}{3}$ N $= 1.558$; γ, for the di- and tetratomic group, $\frac{2}{3}\ C \doteq \frac{1}{2}$ O $\doteq 8\ H =$ 7.9824; δ, for the residuary metallic group, $\frac{1}{2}.\frac{1}{8}\ O \doteq \frac{1}{8}\gamma = .998$. The comparative residual percentages, as deduced from Note 272, and from these divisors are given in the table below:

	S_2.	S_1.	H.	Gerber.	Chase.
Monat.	.20117	.20868	.08483	.11623	.08483
3 and 5	.18626	.15532	.09306	.06510	.06499
2 and 4	.24947	.16498	.12405	.04988	.02998
Metal.	.22497	.20023	.14752	.22172	.06882
Periss.	.19432	.18271	.08344	.08955	.07525
Artiad.	.23414	.18584	.13797	.12460	.04965
Mean	.22089	.18483	.12007	.11237	.05654

290. *Comparative Probabilities.*

The following tables give the comparative probabilities for the several divisors: 1st, if the hydrogen unit; 2d, if $.18394D$ is taken as the unit of probability.

	S_2	S_1	H.	Gerber.	Chase.
Monat.	.4217	.4065	1.0000	.7298	1.0000
3 and 5	.4996	.5991	1.0000	1.4295	1.4318
2 and 4	.4972	.7519	1.0000	2.4868	4.1377
Metal.	.6558	.7368	1.0000	.6653	2.1625
Perissad.	.4551	.4840	1.0000	.9876	1.1753
Artiad.	.5893	.7424	1.0000	1.1073	2.7787
Mean	.5436	.6496	1.0000	1.0684	2.1235

Aggregate, S_2 .000000000000000114; S_1 .00000000000102; H 1; G 69.019; C 853,782,000,000,000,000,000.

Monat.	.9143	.8814	2.1685	1.5825	2.1685
3 and 5	.9876	1.1843	1.9766	2.8255	2.8302
2 and 4	.7373	1.1149	1.4829	3.6876	6.1356
Metal.	.8176	.9187	1.2469	.8296	2.6964
Perissad.	.9466	1.0067	2.0799	2.0541	2.4445
Artiad.	.7856	.9898	1.3332	1.4763	3.7046
Mean.	.8327	.9952	1.5320	1.6369	3.2533

Aggregate, S_2 .00000815; S_1 .735; H 718,725,600,000; G 49,821,227,000,-000; C 614,812,000,000,000,000,000,000,000,000,000.

291. *Another Comparative Basis.*

In the above comparisons it seemed best to exclude the elements that were *exactly* phyllotactic multiples of the assumed divisors (H in the 3d and 5th columns; N and C in the 5th). If those elements were considered as uncertain to the amount of .001 H, the results would be modified, by introducing all the elements, as follows: residuals; H, monatomic, .05859, perissad, .07144, mean, .11154; Chase, monatomic, .05859, tri- and pentatomic, .03891, di- and tetratomic, .03538, perissad, .04916, artiad, .05293, mean, .05168. The comparative mean probabilities would be as follows: S_2 .5050, S_1 .6035, H 1.0000, Gerber .9926, Chase 2.1581. The mean probability of the hydrogen unit, as deduced from the mean accidental residual, would be, 1.9286; of the phyllotactic divisors, 3.5589. That the test of the mean accidental residual is sufficiently severe is evident from the probabilities which it indicates for the surd divisors, S_1 and S_2.

292. *Objection Answered.*

The uncertainity, even of Clarke's recomputation of atomic weights, has been urged as an objection to the acceptance of any apparent probabilities which may be inferred from their examination. If our conclusions were absolute, the objection would be valid, and it must be admitted that even the comparative probabilities will doubtless be greatly modified by the more accurate determination of doubtful atomicities. The modifications, however, would be quite as likely to increase the evidences of phyllotactic influence as to diminish them, if there were no reason to look for such influence. The *a priori* grounds for expecting proof of harmonic action in some shape or other (Note 281), together with the various physical tendencies to division in extreme and mean ratio (Notes 135, etc.), which make phyllotaxy a simple form of harmony, seem likely to turn the scale largely on the side of its present leaning, so as to make the fact of atomic phyllotaxy more and more evident with each successive increase of precision in atomic measurements. While the mean probability of the hydrogen unit, under the most favorable aspect, is 1.93 times as great as that of any divisor taken at random, the mean probability of the phyllotactic divisors, under the least favorable aspect, is 1.845 times as great as that of hydrogen. If my divisors, like Gerber's, had been purely empirical, there would have been more reason to think that they might lose credit with increased precision of determination, but even then it would be strange if so large a relative advantage were entirely overcome. The successive discoveries that Gerber's divisors are approximately phyllotactic, that their significance is increased by making them exactly phyllotactic, and that the most satisfactory divisors which have yet been found stand in simple phyllotactic relations to the four fundamental organic elements, furnish no ground for expecting any future reversal or weakening of the harmonic indications which I have already set forth.

293. *Photodynamic Precession.*

To the many harmonic evidences of photodynamic action and reaction between the chief centres of nucleation and of condensation, Sun and Earth, may be added one which serves to illustrate and extend the principles that are involved in my first "photodynamic problem of three bodies" (Note 254). If we suppose the photodynamic rotating influence on the æthereal sphere, at the equatorial locus of Sun's modulus of light ($474028r_0$; Note 263), to be such as would give planetary velocity at the same locus, the time of rotation would be $(474028 \div 214.73)^{\frac{3}{2}} = 103721$ years. If nebular condensation were to begin at that locus and proceed until the primitive velocity of the locus would tend, through viscosity, to become parabolic, the nucleal radius would be reduced to one-half and the time of rotation to one-fourth of the primitive values. The period, or "great year," which is thus indicated (25930.25 years), is virtually identical with a complete revolution of the equinoxes, which Herschel estimates at 25,868 years; Stockwell at 25,694 8 ± 281.2 years;* Newcomb and Holden "about 25,800 years." This accordance furnishes another reason for believing, with Laplace, in the stability of the physical universe, rather than in the ultimate stagnation which seems to be indicated by the questionable second law of thermodynamics.

294. *Harmonic Rotation of Earth and Moon.*

The improbability of Delaunay's hypothesis is further increased by harmonies of rotation which involve the conjoint action of Sun, Earth and Moon.

* The differences from the mean value being due to secular inequalities.

By taking the rotating locus of the linear centre of oscillation, for Laplace's terrestrial limit, l, we find that the velocity of rotation at $\frac{1}{3}\,l$ is virtually identical with Moon's mean velocity of revolution. Let $l = nr_3$;

then $t_\alpha = 2\pi\sqrt{\frac{n^3 r_3}{g_3}} = 86164.1$ seconds; $n = 6.60704$; $\frac{1}{3}\,l = 2.20235 r_3$; velocity of rotation at $\frac{1}{3}\,l = 4.40469\ \pi r_3$ per sidereal day, or $4.41675\ \pi r_3$ per mean solar day. If this is Moon's mean orbital velocity, the circumference of her orbit is $(27.321661 \times 4.41675 = 120.673)\ \pi r_3$. Moon's orbital eccentricity being .0549081, her orbit is $.999246 \times 2\pi a$ and $a = 60.382\ r_3$. Proctor's estimate is $60.263\ r_3$; Littrow's, $60.278\ r_3$; Newcomb's $60.639\ r_3$. See, also, Note 296.

295. *Spectrum of Comet Wells.*

Huggins (*Nature*, June 22, 1882, p. 179) gives a band spectrum, with measured wave-lengths for the brightest portions. Its harmonics are shown in the following comparisons:

	Huggins.	Divisors.	Harmonic.
α	4769	1	4769
β	4634	$1 + a$	4634.2
γ	4507	$1 + 2a$	4507.2
δ	4412	$1 + 2b$	4412.1
ε	4253	$1 + 3b$	4252.9

$$\beta-\gamma : \gamma-\varepsilon :: 1 : 2$$
$$\gamma-\varepsilon : \beta-\varepsilon :: 2 : 3$$

In other words, γ is the centre of linear oscillation between ε and β.

Other phyllotactic approximations are indicated by the proportions:

$$\delta-\varepsilon : \gamma-\varepsilon :: 5 : 8 \text{ nearly.}$$
$$\gamma-\varepsilon : \alpha-\varepsilon :: 1 : 2 \quad \text{“}$$

These several relations show a primitive phyllotactic tendency, which is controlled and modified by γ and the harmonic divisors. The following values would *exactly* satisfy all the phyllotactic harmonics: 4760.71, 4633.86, 4507, 4411.86, 4253.29.

296. *Harmonic Nebular Time-Integrals.*

The second "photodynamic problem of three bodies," which is specially implied in my three primitive time integrals (Notes 281–3), may be associated with the first through a harmonic relation which involves Moon's orbital time (t_β), Earth's rotation (t_α), Earth's superficial gravitating acceleration (g_3), and Sun's gravitating acceleration at the perihelion centre of gravity of Sun and Jupiter (g_0). The relation is expressed by the proportion.

$$t_\beta : t_\alpha :: g_0 : g_3$$

The resulting equation, $g_3 t_\beta = g_0 t_\alpha$, indicates two important harmonic time-integrals, which seem much more likely to be permanent, than to be disturbed and even overthrown by tidal friction and retardation. Since g is taken at the present locus of Jupiter's orbital projection, it seems possible that the lunar disturbance, which Delaunay referred to tidal friction, may have a secular period, which represents some function of Jupiter's secular variations of eccentricity. If we take Leverrier's estimate of Jupiter's present eccentricity, .0482388, and Stockwell's estimate of its secular variation, .0608274, Sun's superficial gravitating acceleration is 1.027 $g_0 =$ $1.027 \times 27.321661 = 28.059$. This gives $\rho_3 = 92,409,000$ miles, if we take the oscillatory estimate of Solar mass, and the British Nautical Almanac estimate of Sun's apparent semi-diameter ($m_0 = 331,776\ m_3$; $\rho_3 =$ $214.45\rho_0$). Compare Note 256, *e*.

297. *Two Tidal Questions.*

No physical question can be regarded as satisfactorily settled, until all the known facts which are likely to have any bearing on its solution have been duly considered. Provisional hypotheses may be very properly adopted as occasional and temporary expedients, in order to fix new points of departure, and facilitate the progress of investigation, but even they are defective whenever they are obviously limited and partial. The cosmical importance of harmonic motion, which Laplace demonstrated in his discussions of Jupiter's satellite system, as well as the further evidences of its general physical importance which have been brought forward by Lagrange, Fourier and Thomson, cannot be wisely set aside, even in a provisional hypothesis, through any dogmatic assertion of a thermodynamic requirement, which, if it is not compensated in some way, may possibly lengthen the terrestrial day by a minute interval, which has been variously estimated, from $\frac{1}{80000}$ to $\frac{11}{50}$ of a second in a year. Even if the requirement was universally admitted, the relations of photodynamic precession (Note 293), indicate a possible harmonic acceleration which is manifoldly greater than this problematical retardation. Before making any admission which would call for a careful study of this possible acceleration, two questions should be satisfactorily answered: 1. Are the tidal tendencies instantaneously adjusted? 2. Are the local tidal frictions limited to mere terrestrial action, so that the conversion of motion into heat, at one point, is compensated by a conversion of heat into motion at another?

298. *Explosive Waves.*

Berthelot's discovery has already been suggested (Note 278, 6) as one of the important topics for consideration in the study of æthereal correlations. The velocity, $\sqrt{gh}$, which is indicated by the explosive energy of H_2O (Note 16), is $(32.088 \times 68878.2 \times 1389.6 \div 9)^{\frac{1}{2}} = 18473$ ft. $= 3.49865$ miles per second. This velocity is sufficient, under the normal atmospheric pressure at Earth's surface, to produce æthereal waves which are manifested by light, heat and chemical combination. We may accordingly look for like phenomena whenever "subsiding" particles penetrate the nebulous region of the zodiacal light with a corresponding *vis viva*. Subsidence from Laplace's solar limit (Notes 268, 274), would give a *vis viva* which is more than 10000 times as great, in their passage through the solar atmosphere. These facts should be carefully considered in any investigations which are suggested by the hypothesis of Dr. Siemens. The explosive velocity being acquired long before the subsiding matter reaches Sun's surface, the compounded and condensed particles continue sunward into the region of dissociation and centrifugal projection. No sufficient reason has yet been given, for doubting the adequacy of the fundamental time-integral (Notes 280–1) to keep up this circulation indefinitely. Important harmonic analogies are suggested by Neptune's projectile orbital velocity at secular perihelion, and by Jupiter's mean locus of subsidence. According to Stockwell's estimates of the planetary elements, Neptune's secular perihelion velocity is 3.42 miles per second and Jupiter's mean aphelion is 5.4274 ρ_3; the mean proportional between Earth's semi-axis major and Neptune's secular perihelion being 5.4404 ρ_3.

299. *Alternations of Energy.*

All the ordinary assumptions of dissipation of energy take it for granted that the universal æther is able to absorb heat indefinitely, without imparting it again to more condensed matter. If this were the case, why should not the heat be absorbed in its passage from star to star? Judging from atmospheric analogies, we may infer the existence of æthereal convection currents and a greater manifestation of heat with increasing density. If æthereal density varies with pressure, as I have supposed in Notes 35, 236–240, etc., the kinetic theory of gases would imply a constant mean molecular velocity. The tangential character of luminous undulations implies a polarity which would tend to the formation of æthereal spheroids about stellar centres, and if those centres have an orbital motion which is combined with an axial rotation of their respective orbs, the continual changes of relative position would favor a transfer of energy from star to star which, with reflection and refraction (Note 286), might maintain perpetual tendencies to an equilibrium which would never be reached. It seems not unlikely that the thermal relations of every star to its æthereal spheroid may be so adjusted that there is a transfer of heat from the æther to the nucleus during one-half of each rotation, and from the nucleus to the æther during the other half. Such a hypothesis lends a meaning to the fundamental kinetic identity (Note 280), which is in thorough accordance with Laplace's belief in the stability of the solar system.

300. *Actions and Reactions in Moving Radiations.*

Prof. H. T. Eddy (*Sci. Proc.* of the *Ohio Mech. Inst.*, July, *1882*) describes a method for the distribution of heat in a way which conflicts with the second law of thermodynamics. He objects to the so-called axioms of Clausius and Thomson, on the ground of their implicit assumption that heat is radiated with infinite velocity, inasmuch as they take no account of the states of relative rest or motion of the bodies between which the heat passes. He cites the statement of Kirchhoff, "that the second law cannot be (at present) proved ; but it, so far, has never been found in disagreement with experience;" the view of Maxwell and Boltzmann (*Wien Sitzb.*, Bände, lxxvi, lxxviii), that it should be regarded "as merely the mean result flowing from the laws of probability ;" Rankine's paper (*Phil., Mag*, [4] iv, 358), in which "he has supposed it possible to reflect radiations in such a way as to give the universe such differences of temperature as to insure it a new lease of life ;" and the paper of Clausius (*Mech. Theory of Heat*, chap. xii), showing the general impossibility of such a reconcentration as Rankine supposed, when the radiating bodies are at rest ; nevertheless, no such impossibility may finally appear in case of the actual universe which is a system of moving bodies." He closes his discussion with the following sentences: "The point to which I would emphatically direct attention is, that since radiations are known to be moving in space, apart from ponderable bodies, and subject to reflections, it is possible so to deal with them as to completely alter their destination, and successfully interfere with all results flowing from Prevost's law of exchanges. It also seems to me that the exactness of the second law of thermodynamics depends, as far as radiations are concerned, upon that of this law of exchanges." In addition to the reflections to which moving radiations are subject, I have also called attention to their refraction (Note 286), and I have endeavored to co-ordinate all my discussions, through the fundamental identity (Note 280), which implies an equivalent motion of reaction for every radiant action. Moreover, the moving particles in each radiant undulation are all subject to cosmical attractions and perturbations, which have not yet been considered in investigations of the seeming dissipation of energy.

301. *Thrust of Polar Ice-Caps.*

Geologists who believe that the northern hemisphere was once largely covered with ice, have usually attributed the thrust to the simple gravitating pressure of the accumulation at the pole. The position of many of the boulders, and of the supposed terminal moraines, seems to indicate a greater propelling force than many investigators are willing to attribute to the combined action of polar centripetal and equatorial centrifugal energy. Perhaps the unwillingness may be removed by making proper allowance for "the flow of solids," an element of the problem which does not seem to have received any consideration beyond the simple plasticity and regelation which have been studied in connection with the movements of ordinary glaciers. The photodynamic hypothesis of an all-pervading and universally active æther involves the requirement of perpetual tendencies toward equilibrium, and the evidence of such tendencies which is given by Earth's oblateness (Notes 246, 249) furnishes an adequate explanation for many of the glacial phenomena which have hitherto seemed paradoxical. Bessel's estimate of the oblateness is slightly less than would result from Tresca's "flow;" Clarke's two estimates accord more nearly with the theoretical value; while Listing's, which is the latest of all, gives an agreement which is virtually exact. If we start from his estimate (1 : 288.4), we get $g = \frac{4\pi^2 \times 288.4}{(86164.1)^2} r = 32.086$ ft. Ganot's value is 32.088 ft. It can hardly be believed that such a coincidence is merely accidental. If it is indicative, as I have supposed, of inter-molecular ætheреal action, it has an important bearing on tidal equilibrium, and it shows that Earth's shape and rigidity were not fixed in any past age, but are at all times adjusted to the requirements of internal elasticity and external attractions. Any arguments which may be adduced in favor of such an adjustment may be urged, *a fortiori*, in support of the flow and thrust of a plastic material like ice. The velocity of terrestrial rotation, in the mean latitude which Prof. H. C. Lewis has indicated for the terminal moraine in Pennsylvania, is more than 1000 feet per second. The centrifugal force consequent upon such a velocity, together with the thrust of an ice-cap which extended to the pole, must greatly facilitate glacial flow. The equilibrating forces would work upon local glaciers, in the same way as upon a general ice-cap.

The Classification of the Ungulate Mammalia. By E. D. Cope.

(Read before the American Philosophical Society, May 19, 1882.)

In the present essay the osseous system is chiefly considered, and of this, the structure of the feet more than of any other part of the skeleton. The ungulata are here understood to be the hoofed placental Mammalia with enamel covered teeth, as distinguished from the unguiculate or clawed, and the mutilate or flipper limbed, and the edentate or enamelless, groups. The exact circumscription and definition is not here attempted, though probably the brain furnishes an additional basis of it in the absence of the crucial, parietoöccipital, calcarine fissures, etc. Suffice it to say that it is on the whole a rather homogeneous body of mammalia, especially distinguished as to its economy by the absence of forms accustomed to an insectivorous and carnivorous diet, and embracing the great majority of the herbivorous types of the world.

The internal relations of this vast division are readily determined by reference to the characters of the teeth and feet, as well as other less important points. I have always insisted that the place of first importance should be given to the feet, and the discovery of various extinct types has justified this view. The predominant significance of this part of the skeleton was first appreciated by Owen, who defined the orders *Perisso-*

dactyla and *Artiodactyla*. Professor Gill* has also used these characters to a large extent, but without giving them the exclusive weight that appears to me to belong to them. Other authors have either passed them by unnoticed, or have correlated them or subordinated them to other characters in a way which has left the question of true affinity and therefore of phylogeny, in a very unsatisfactory condition. Much light having been thrown on these points by recent discoveries in paleontology, the results, as they appear to me, are here given.

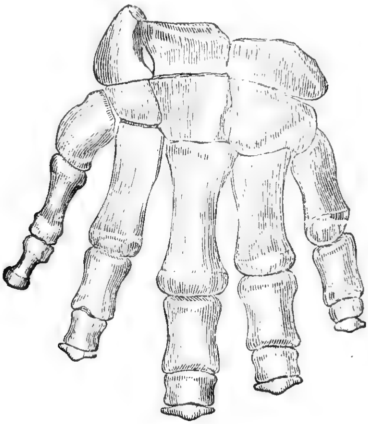


FIG. 1.

FIG. 1.—Left anterior foot of *Elephas africanus* (from De Blainville).

Carpus.—It is well known that in the *Perissodactyla* and *Artiodactyla*, the bones of the two rows of the carpus alternate with each other; that the lunar for instance rests on the unciform, and to a varying degree on the magnum, and that the scaphoides rests on the magnum and to some degree on the trapezoides and trapezium. It is also known that in the *Proboscidea*, another state of affairs exists; *i. e.*, that the bones of the two rows do not alternate, but that the scaphoides, lunar and cuneiform, rest directly on the trapezium and trapezoides, the magnum, and the unciform respectively. The preceding characters are sometimes included in the definitions of the respective orders. Further than this they have not been used in a systematic sense.

Professor Gill says of the carpus of the *Hyracoidea*, "carpal bones in two interlocking rows; cuneiform extending inwards (and articulating with magnum); * * * unciform and lunar separated by the interposition of the cuneiform and magnum." Professor Flower† gives a figure which justifies these statements, but neither the one nor the other agree with my

* Arrangement of the families of Mammals prepared for the Smithsonian Institution. Miscellaneous Collections 230. Nov., 1872.

† Osteology of the Mammalia, p. 266; fig. 92.

specimens. In the manus of a *Hyrax capensis* (from Verreaux, Paris), I find the following condition of the carpus. The bones of the two series are articulated consecutively, and not alternately; they do not interlock, but inasmuch as the magnum is a little narrower than the lunar, the latter is just in contact (anteriorly) with the trapezoides (centrale) on the one side, and the unciform on the other. My specimen agrees with Cuvier's figure of *Hyrax capensis* in all respects. It is probable that Professor

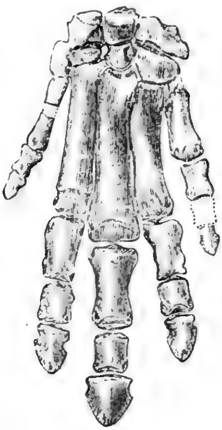


Fig. 2.

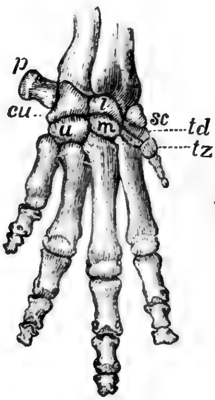


Fig. 3.

Fig. 2.—Left anterior foot of *Phenacodus primævus*, one-third natural size (original).

Fig. 3.—Right anterior foot of *Hyrax capensis*; (from Cuvier). *Sc.* scapuloid bone; *l.* lunar; *cu.* cuneïform; *p.* pisiform; *tz.* trapezium; *td.* trapezoides; *m.* magnum; *u.* unciform.

Flower has figured some other species under that name, which besides its peculiarities, is of smaller size than the *H. capensis* (see Fig. 3).

In April, 1875* I described the manus of *Coryphodon* (Bathmodon), showing that the lunar was supported below by the magnum and by parts of the unciform. This carpus has the characters of that of *Hyrax capensis*, with the last named articulation more extensive. This was the first description of the carpus of the *Amblypoda*. In February, 1876,† Professor Marsh described the carpus of *Uintatherium* (*Dinoceras*), and asserted that the bones "form interlocking series." He however states that "the magnum is supported by the lunar and not at all by the scaphoid," a state of things which does not belong to the interlocking carpus. The trapezoides does not join the lunar, but the unciform does so, as in *Coryphodon*. Professor Marsh's figure as to the articu-

* Systematic Catalogue of the vertebrata of the Eocene of New Mexico, p. 24 (U. S. Geol. Survey W. of 100th Mer.).

† Amer. Journal Sci. Arts. xi, p. 167; pl. vi., fig. 2.

lations of the magnum does not agree with his description, as it makes that bone articulate with the scaphoid. The second description is however correct, and the carpus is identical with that of *Coryphodon*. (Fig. 4.)

In the *American Naturalist*, June, 1882,* I have shown that the carpus of the *Condylarthra* is essentially like that of the *Hyracoidea*. (Fig. 2.)

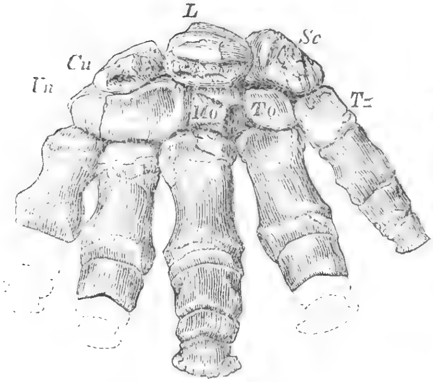


FIG. 4.

FIG. 5.

FIG. 4.—Manus of *Coryphodon* (original). The cuneïform is imperfect.

FIG. 5.—Left posterior foot of *Elephas indicus*; (from Cuvier). *ca.* calcaneum: *a.* astragalus; *n.* navicular; *cu.* cuboid; *ec.* ectocuneïform; *mc.* mesocuneïform.

Tarsus.—In the tarsus of the *Perissodactyla* and *Artiodactyla* it is well understood that the cuboid extends inwards so as to articulate with the astragalus, giving the latter a double distal facet. It is also well known that the astragalus of the *Proboscidea* has but a single distal articulation, that with the navicular. It is, however, true that the cuboid is extended inwards, but that it articulates with the distal extremity of the navicular instead of that of the astragalus. It was shown by Cuvier that the astragalus of the *Hyracoidea* articulates with the navicular only, and that the cuboid is not extended inwards so as to overlap the latter. In 1873 Marsh† stated that the astragalus of the *Amblypoda* articulates with both cuboid and navicular. Finally I discovered in 1881,‡ that the astragalus of the *Condylarthra* articulates with the navicular only and that the cuboid articulates with

* Page 522.

† American Journal Science and Art, January, 1873.

‡ American Naturalist, 1881, p. 1017.

the calcaneum only. In the tarsus then there are four types of articula-

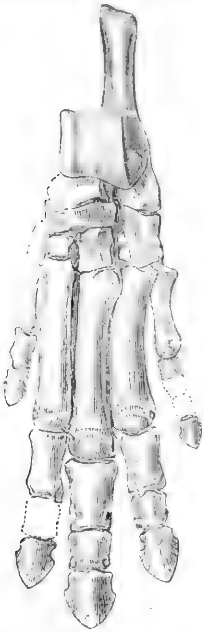


FIG. 6.

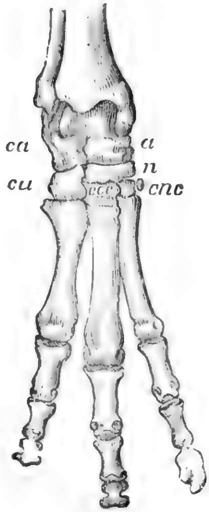


FIG. 7.

FIG. 6.—Left posterior foot of *Phenacodus primævus*, one-third natural size (original).
FIG. 7.—Right posterior foot of *Hyrax capensis* (from Cuvier). *Ca.* calcaneum; *a.* astragalus; *n.* navicular; *cu.* cuboid; *ecc.* ectocuneiform; *mc.* mesocuneiform; *enc.* entocuneïform.

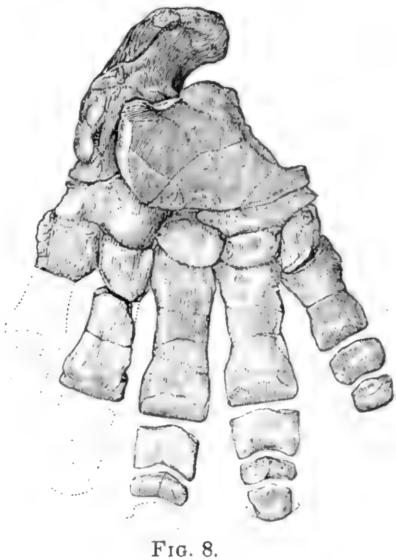


FIG. 8.

FIG. 8.—Posterior foot of *Coryphodon* (original).

tion, which are typified in the *Condylarthra*, the *Proboscidea*, the *Amblypoda* and the *Artiodactyla* respectively. (Figs. 5–9.)

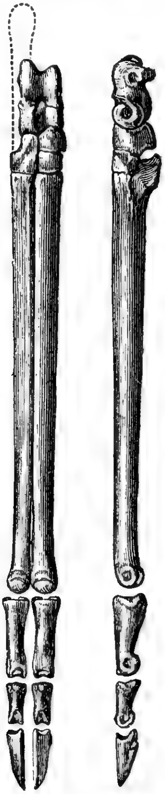


Fig. 9.

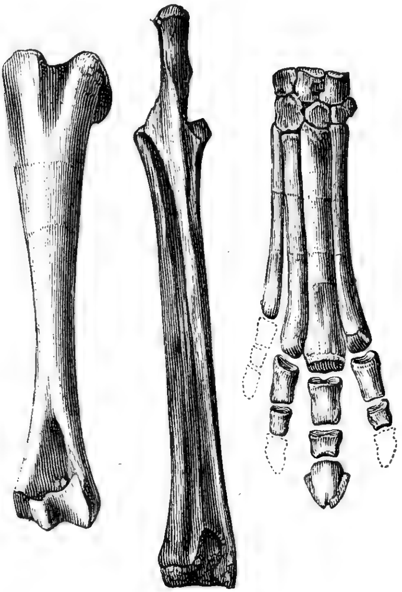


Fig. 10.

Fig. 9.—Hind foot of *Poëbrotherium labiatum* (original).
Fig. 10.—Fore leg and foot of *Hyracotherium venticolum* (original).

Orders.—From the preceding considerations we derive the following definitions of the primary divisions of the Ungulata, which should be called orders. In the first place I find the diversity in the structure of the carpus to be greater in the relations of the magnum and scaphoides, than in the relations between the unciform and the lunar. In other words the trapezoides and magnum are more variable in their proportions than is the unciform. This is directly due to the fact that the reduction of the inner two digits is more usual than the reduction of the external two. I therefore view the relations of these bones as more characteristic. In the tarsus the really variable bone is the cuboid. It is by its extension inwards that the additional facet of the astragalus is produced. Its relations will therefore be considered rather than those of the astragalus in framing the following definitions :

Order I. Scaphoides supported by trapezoides and not by magnum, which supports lunar. Cuboid articulating proximally with calcaneum only.......... .... *Taxeopoda.*

Order II. Scaphoides supported by trapezoides, and not by magnum, which supports lunar. Cuboid extended inwards and articulating with the distal face of the navicular.......................................*Proboscidea.*

Order III. Scaphoides supported by trapezoides and not by magnum, which with unciform, supports the lunar. Cuboid extended inwards and articulating with astragalus...............................*Amblypoda.*

Order IV. Scaphoides supported by magnum, which with the unciform also supports the lunar. Cuboid extended inwards so as to articulate with the astragalus...*Diplarthra.*

The sub-orders are defined as follows :

I. TAXEOPODA.

There are two, perhaps three sub-orders of the *Taxeopoda;* the *Hyracoidea*, the *Condylarthra*, and perhaps the *Toxodontia*.* The *Toxodontia* are however not sufficiently known for final reference.† The sub-orders are defined as follows :

A postglenoid process ; no fibular facet of calcaneum, but an interlocking articulation between fibula and astragalus ; ungual phalanges truncate...*Hyracoidea.*

A postglenoid process ; no fibular facets on either calcaneum or astragalus ; a third trochanter of the femur ; ungual phalanges acuminate........ *Condylarthra.*

There are a good many other subordinate characters which distinguish the *Condylarthra*, which will be given in my forthcoming volume iv of the Hayden Survey, on the Tertiary Vertebrata of Western America.

II. PROBOSCIDEA.

There may be two sub-orders of this order, the *Proboscidea* and the *Toxodontia*. I do not know the Carpus of *Toxodon*, but if it does not differ more from that of the elephants than the tarsus does; it is not entitled to subordinal distinction from the Proboscidea. The sub-order of *Proboscidea* is defined as follows :

A fibular articulation of the calcaneum ; no postglenoid process ; no third trochanter of femur.......................... ....*Proboscidea.*

* See my remarks on Toxodon, Proceedings Amer. Philosoph. Society, 1881, p. 402.

† The considerable resemblance between the dentition of *Toxodon* and *Hyrax* must not be overlooked.

III. AMBLYPODA.

The sub-orders of this order, as I pointed out in 1873, are two, defined as follows:

Superior incisor teeth; no ali-sphenoid canal; a third trochanter of femur; *Pantodonta.*

No superior incisors, nor ali-sphenoid canal, nor third trochanter of femur; *Dinocerata.*

The difference between the *Proboscidea* and the *Amblypoda* consists chiefly in that the navicular of the latter is shortened externally so as to permit the cuboid to articulate with the astragalus. The cuboid has the same form in both. The peculiar character of the navicular gives the astragalus a different form.

IV. DIPLARTHRA.

This order is called by some authors the Ungulata, but that name is also used in the larger sense in which it is here employed. This appears to be its legitimate application, as the name should, if possible, be used for hoofed Mammalia in general, as its meaning implies. The two well known sub-orders are the following:

Astragalus truncate distally; number of toes odd, the median one the largest.... .... *Perissodactyla.*

Astragalus with a distal ginglymus; number of toes even, the median two largest.. *Artiodactyla.*

Phylogeny.—The serial arrangement of the bones of the carpus and tarsus seen in the *Taxeopoda,* is probably the primitive one, and we may expect numerous accessions to that order on further exploration of the early Eocene epochs. The modification seen in the more modern orders of *Perissodactyla* and *Artiodactyla,* may be regarded as a rotation to the inner side, of the bones of the second carpal row, on those of the first. This rotation is probably nearly coincident with the loss of the pollex, as it throws the weight one digit outwards, that is on the third and fourth digits, rendering the first functionally useless to a foot constructed solely for sustaining a weight in motion. The alternation of the two rows of carpals clearly gives greater strength to the foot than their serial arrangement, and this may probably account for the survival of the type possessing it, and the extinction of nearly all the species of the type which does not possess it. Here is applied again the principle first observed by Kowalevsky in the proximal metapodial articulations. This author shows that the types in which the metapodials articulate with two carpal or tarsal bones, have survived, while those in which the articulation is made with a single carpal or tarsal have become extinct. The double articulation is, of course, mechanically the more secure against dislocation or fracture.

As regards the inner part of the manus I know of no genus which presents a type of carpus intermediate between that of the *Taxeopoda* and

Amblypoda on the one hand, and the *Perissodactyla* and *Artiodactyla* on the other. Such will however probably be discovered. But the earliest *Perissodactyla*, as for instance *Hyracotherium*, *Hyrachyus* and *Triplopus*, possess the carpus of the later forms, *Rhinocerus* and *Tapirus*. The order *Amblypoda* occupies an interesting position between the two groups, for while it has the carpus of the primitive type, it has the tarsus of the later orders. The bones of the tarsus alternate, thus showing a decided advance on the *Taxeopoda*. This order is then less primitive than the latter, although in the form of its astragalus it no doubt retains some primitive peculiarities which none of the known *Taxeopoda* possess. I refer to the absence of trochlea, a character which will yet be discovered in the *Taxeopoda*, I have no doubt.

The *Taxeopoda* approach remarkably near the *Bunotheria*, and the unguiculate and ungulate orders are brought into the closest approximation in these representatives. In fact I know of nothing to distinguish the *Condylarthra* from the *Mesodonta*, but the ungulate and unguiculate characters of the two divisions. In the *Creodonta* this distinction is reduced to very small proportions, since the claws of *Mesonyx* are almost hoofs. Some of the genera of the *Periptychidæ* present resemblances to the *Creodonta* in their dentition also.

The facts already adduced throw much light on the genealogy of the Ungulate Mammalia. The entire series has not yet been discovered, but we can with great probability supply the missing links. In 1874 I pointed* out the existence of a yet undiscovered type of Ungulata, which was ancestral to the *Amblypoda*, *Proboscidea*, *Perissodactyla* and *Artiodactyla*, indicating it by a star only in a genealogical table. This form was discovered in 1881, seven years later, in the *Condylarthra*. It was not until later† that I assumed that the *Diplarthra* are descendants of the *Amblypoda*, although not of either of the known orders, but of a theoretical division with bunodont teeth.‡ That such a group has existed is rendered extremely probable in view of the existence of the bunodont *Proboscidea* and *Condylarthra*. That the *Taxeopoda* was the ancestor of this hypothetical group as well as of the *Proboscidea*, is extremely probable. But here again neither of the sub-orders of this group represent exactly the ancestors of the known *Amblypoda*, which have an especially primitive form of the astragalus not found in the former. In the absence of an ankle-joint, the *Amblypoda* are more primitive than any other division of the Ungulata, and their ancestors are not likely to have been more specialized than they. It is probable that a third sub-order of *Taxeopoda* has existed which had no trochlea of the astragalus, which I call provisionally by the name of *Platyarthra*.

* Homologies and Origin of Teeth, etc., Journal Academy Nat. Science, Philada., 1874, p. 20.

† Report U. S. Geol. Survey W. of 100th Mer., p. 282, 1877.

‡ This hypothetical sub-order is called in the appended scheme, *Amblypoda Hyodonta*.

The preceding paragraphs were written in May of the present year. On my return home, September 1st, after an absence of three months, I find that various parts of the skeleton of *Periptychus** have reached my museum. On examination, I find that the astragalus of that genus fulfils the anticipation above expressed. *It is without trochlea,* and nearly resembles that of *Elephas.* As it agrees nearly with that of *Phenacodus* in other respects I only separate it as a family from the *Phenacodontidæ.* One other type remains to be discovered which shall connect the *Periptychidæ* and the hypothetical *Hyodonta,* and that is a Taxeopod without a head to the astragalus,—unless, indeed, the "*Hyodonta*" should prove to have such a head. I think the latter the less probable hypothesis, and hence retain the term *Platyarthra* for the hypothetical Taxeopod without trochlea or head of the astragalus.

These relations may be rendered clearer by the following diagram :

TAXEOPODA.

Condylarthra. Platyarthra.††

Hyracoidea.

PROBOSCIDEA. AMBLYPODA.

Hyodonta.†† Pantodonta.

Dinocerata.

DIPLARTHRA.

Perissodactyla. Artiodactyla.

Third contribution to the History of the Vertebrata of the Permian formation of Texas. By E. D. Cope.

(*Read before the American Philosophical Society, September 15, 1882.*)

Since the publication of my second contribution to this subject,‡ I have described four additional species. These are, in Bulletin of the U. S. Geological Survey of the Territories ;§ *Pantylus cordatus* and *Dimetrodon semiradicatus;* in the American Naturalist,‖ *Eryops reticulatus* and *Za-*

* See American Naturalist, October, 1882.

†† Hypothetical.

‡ Paleontological Bulletin, No. 32, Proceedings American Philosophical Society, 1880; the plates, 1881.

§ Vol. vi, 1881, p. 79.

‖ 1881, p. 1020.

trachys apicalis. The last two were not included in my catalogue of the Permian Vertebrata published previously* in the same year. The present paper adds some important points to this remarkable fauna, and explains the hitherto obscure relations of several genera.

DIADECTIDÆ.

The pelvis and sacrum of a species of this group are preserved in my collection, and they indicate further peculiarities of this group,

The sacrum consists of two vertebræ only, and is thoroughly united with the pelvis by its transverse processes. The latter are decurved on the inner side of the iliac bones, and the sutures which distinguish them from the latter and from each other, are not serrate. The inferior arch is robust, but very narrow anteroposteriorly. The acetabulum is entire in every respect, so that it is probable that both pubis and ischium are united undistinguishably in the arch. The pubis is perforated by the usual internal femoral foramen. The posterior edge is grooved, and it might be suspected that this marks the articulation of an ischium. The anterior edge is however grooved in the same way, so that the appearance is rather the position of muscular insertion. The spines of the sacral vertebræ are distinct, and have the usual form seen in *Diadectes.*

The two sacral vertebræ and the absence of obturator foramen, are characters of the suborder *Pelycosauria* in which the latter differs from the *Dicynodontia.* I am still inclined to question whether the extraordinary characters of the cranio-vertebral articulation I have described, justify the separation of the *Diadectidæ* as a third sub-order of the *Theromorpha,* which I have called the *Cotylosauria,*† or whether they are not due to the loss of a loosely articulated basioccipital bone.

EDAPHOSAURUS Cope, genus novum.

Apparently allied to *Pantylus.* Temporal fossæ not overroofed; surfaces of cranial bones not sculptured. Mandibular and maxillary teeth subequal. Posterior half of the mandibular ramus expanded inwards and supporting numerous closely arranged teeth. Pterygoid, or perhaps an internal expansion of the malar bones, supporting a dense body of teeth, corresponding to those of the lower jaw. Teeth subconical.

The single species of this genus in my possession shows the following characters of systematic importance. An arch extends from the parietal plane posteriorly and downwards to the external base of the quadrate. The specimen is not yet in a condition to show how much of this is parietal, and how much squamosal or opisthotic. The proximal half of the posterior part of this arch is a distinct element, perhaps a transverse process of the supraöccipital. A distinct element connects the basioccipital on each side with the quadrate. The articular extremity of the latter has

* American Naturalist Feb., 1881.

† American Naturalist, 1880, p. 304.

a deep anteroposterior concave emargination. There is a flat bone extending from it anteriorly which is apparently pterygoid rather than quadratojugal. The tooth bearing portion terminates opposite the middle of the basisphenoid.

The occipital condyle is undivided, and the basisphenoid presents the usual two divaricating protuberances to the basioccipital.

EDAPHOSAURUS POGONIAS, sp. nov.

Represented by the followsng portions of a skull; basis cranii with portion posterior to the middle of the parietal bone; left maxillary with dental plate, left mandibular ramus entire; various flat bones undetermined. There is also a body which may be the atlas with its arch somewhat dislocated. These pieces are in part covered with a thin layer of the red deposit of the Permian bed in which they occur.

The facial plate of the *os maxillare* is subvertical, so that the orbit is lateral. The latter is rather small. The malar bone is narrow, and is continuous with the dentigerous bone of the palate. The latter has a thickened posterior edge, which commences below the anterior part of the orbit, and extends posteriorly to the middle of the basisphenoid. Thence the border turns forwards. Its anterior edge is below the anterior border of the orbit, and the general form is a longitudinal oval. The maxillary teeth are somewhat weathered, and obscured by a thin layer of matrix. The posterior ones are compressed-conic; the premaxillaries are four in number on one side, and are more nearly conic, and have incurved apices. The median premaxillary suture is, however, not clearly defined, so that the number of premaxillaries remains uncertain. The centre of the probable nostril measures one-third the distance from the premaxillary border to the anterior edge of the orbit. There are eight rows of (?) pterygoid teeth at the posterior fourth of the series. The teeth are subequal and obtuse, increasing a little anteriorly.

The mandibular ramus is robust, and the external face slopes inwardly and downwards. The external border rises a little above a few of the posterior teeth, but it is injured at the posterior of the coronoid process, so that its existence cannot be ascertained. The border then descends and turns inwards to the articulation, which is condyloid at its internal extremity. The inferior edge of the anterior part of the ramus becomes a median ridge below the condyloid region, and terminates in a short, compressed angular process. The symphysis is not coössified, and is convex downwards and forwards. The inferior part is subhorizontal, and forms the edge of a transverse plate which is separated from the vertical part of the ramus by a deep groove. The inner vertical face of the ramus is strongly convex, as is the corresponding edge of the symphyseal suture. The apices of the teeth are worn, but they were probably conic, the posterior gradually smaller and more obtuse. The interior face of packed teeth begins at the posterior two-fifths of the external series, and expands inwards posteriorly. It contains six longitudinal rows opposite the antepenultimate dentary tooth.

All the bony surfaces are smooth.

Measurements.	M.
Length of mandibular ramus (straight)	.162
" symphysis of do. (straight)	.038
" external dental series	.077
Width of ramus at dental pavement	.040
" skull at ends of OO. quadrata	.138
" extremity of O. quadratum	.024
" occipital condyle	.018
Length of superior dental pavement	.065
Width of basisphenoid posteriorly	.029

The supposed axis vertebra is longer than wide, and the centrum is deeply excavated posteriorly. Anteriorly it appears to have lost a piece—the centrum of the atlas, which, while fitting it closely, was not co-ossified with it. There is a flat horizontal convex ala in the place of a diapophysis, and an obtuse median hypapophysial angle. The neural spine is compressed, except posteriorly, where it is transversely expanded, terminating above in a short obtusely accuminate apex. From this apex an obtuse rib passes down the median line, and disappears above the neural arch, where the spine is somewhat narrower. The postzygapophyses are well developed and look downward.

Measurements of axis.	M.
Length of centrum below	.020
Width, including diapophyses	.035
Elevation of spine from postzygapophysis	.038
Width of do., posteriorly	.020

Remarks.—This interesting form is probably allied to *Pantylus*, which I have hitherto regarded as a Batrachian. The two genera may be placed in a special family of the Pelycosauria, to be called the *Edaphosauridæ*. This family will be distinguished from the *Clepsydropidæ* by the presence of more than one series of teeth on parts of the jaws. It is possible that *Helodectes* must be placed in it.

ECTOCYNODON Cope.

Paleontological Bulletin No. 29, p. 508.

A species now before me resembles in generic characters the type of this genus, *E. ordinatus*. That species was described as having the canine tooth near the middle of the maxillary bone, while in the present one it is near the anterior part of it, as in some other genera. In the typical species, as in the species to be described, the cranial bones are sculptured, and the temporal fossæ are overroofed. The sculptured surface as well as the canine teeth distinguish *Ectocynodon* from *Pariotichus* Cope and *Procolophon* Owen, which genera are otherwise related.

ECTOCYNODON AGUTI, sp. nov.

This reptile is much larger than the *Pariotichus brachyops*, and the anterior part of the cranium has a different form. The general shape of the head is much like that of a rodent mammal of the genus *Dasyprocta*. It is rather wide at the temporal regions, flat above, and narrowed and compressed anterior to the orbits. The muzzle is narrowed and obtuse, and the nostrils are terminal, and are lateral and a little anterior in direction. The maxillary alveolar edge is nearly straight, but the premaxillary edge, beginning below the posterior border of the nares, descends forward at an angle of 45°. Viewed from the front, the premaxillary border is a festoon, strongly convex downwards, and below the anterior part of the nostril. The suture separating the premaxillaries is distinct. The orbits are of moderate size, as in an aguti, and invade the superior frontal plane in a slight degree. The frontoparietal fontanelle is rather large.

The mandible is robust, and presents a short angle. It closes up behind the premaxillary lobate edge. Its teeth are concealed in the specimen. The maxillary teeth increase rapidly in size forwards. The premaxillaries commence smaller next the maxillaries, and increase in size to the first, which is a little larger than the anterior maxillary. The crowns are weathered away. The sculpture on the maxillary and malar bones consists of closely placed shallow fossæ. On the posterior part of the frontals there are strong ridges radiating posteriorly, and situated close together.

Measurements.	M.
Length of skull to end of angle of lower jaw	.090
" " frontoparietal fontanelle	.056
" " orbit, above	.026
" ramus mandibuli	.082
Depth of skull at orbit	.033
" ramus "	.019
Width of skull posteriorly	.068
" " between orbits	.017
" " between external nares	.0105
Diameter of first premaxillary tooth	.003
" second maxillary tooth	.003
Six fossæ of the malar bone	.005
Seven grooves of the frontal bone	.005

This species is much larger than the *Ectocynodon ordinatus* Cope, and the canine tooth has a more anterior position.

Discovered by W. F. Cummins.

DIPLOCAULUS Cope.

Paleontological Bulletin No. 26, p. 187, Nov. 21st, 1877. Proceedings American Philos. Society, 1877, p. 187.

This genus was characterized by me at the places cited, as follows: "Vertebral centra elongate, contracted medially, and perforated by the foramen chordæ dorsalis, coössified with the neural arch, and supporting transverse processes. Two rib articulations, one below the other, generally both at the extremities of processes, but the inferior sometimes sessile. No neural spine nor diapophysis ; the zygapophysis normal and well developed."

This diagnosis was derived from the vertebræ of a single species from the Clepsydrops shale of Illinois, the *D. salamandroides*, and since that description was written, no additional specimens have come under my observation. In the Catalogue of the Vertebrata of the Permian I placed the genus as the type of a family, the *Diplocaulidæ*, among the Pelycosauria. I am now, however, through the energy of Mr. W. F. Cummins, in possession of specimens of a number of individuals of a second species of *Diplocaulus*, found by him in the Permian beds of Texas. From them I derive that the genus and family must be referred to the Stegocephalous Batrachia. It is, however, exceptional among these in the fauna of which it is a member, in not belonging either to the Rhachitomi* or to the Embolomera, since the vertebral centra are not segmented, nor are the intercentra present in any form. Under these definitions it must be referred to the suborder which includes *Oëstocephalus*, *Ceraterpeton*, etc., for which I have adopted Dawson's name Microsauria. The division includes genera with simple amphicœlous vertebral centra, and teeth without inflections of the dentine. The following characters must be added to *Diplocaulus :*

Vertebræ with a more or less perfect zygosphen articulation ; centra shorter in the anterior than in the median part of the column ; axis and atlas solidly united by a long zygosphen, which is not roofed over by the zygantrum. Neural arch continued as a short tube into the foramen magnum. Atlas unsegmented, and, like the axis, without free hypapophysis. Cervical vertebræ not distinguished from dorsals, and with two-headed ribs.

Orbit separated from the maxillary bone by the union of the lachrymal and malar. Either the malar, or more probably the quadratojugal, extends much posterior to the quadrate bone. It is bounded above by the squamosal, which extends anteriorly to the distinct postfrontal, thus covering over the temporal fossa. Posteriorly it extends into a long, free process, like the operculum of *Polyodon* ossified. This horn does not appear to consist of the epiotic as appears to be the case in *Ceraterpteon.* The quadrate bone is extended very obliquely forwards and its extremity is divided into an hourglass-shaped condyle. In other words the condyle consists of two cones with apices continuous. The internal cone is the smaller, and its base is overlapped from before by a flat bone, probably the pterygoid. The cotyli of the mandible correspond. Mandible without angle ; symphysis short.

The teeth are of about equal size, and are rather slender and with conical apex. Their surface is not inflected at any point. The superior series is

* American Naturalist, 1882, p. 334.

double, forming two lines between which the mandibular teeth close. This superior series stands near the external edge of the vomer, palatine and pterygoid bones successively. I have not been able to find any larger teeth in the jaws in this genus. Some fragments mingled with those here described, display such teeth, but I think they pertain to a species of another genus. I know nothing of the limbs of this genus.

DIPLOCAULUS MAGNICORNIS, sp. nov.

The species is indicated by fragments of a number of crania, and portions of several vertebral columns. These were collected at two different localities by Mr. W. F. Cummins.

The skull is very peculiar in the great extent of the parts posterior to the orbits as compared with the portion anterior to them. The posterior border not being complete, the proportions cannot be exactly given, but the part anterior to the orbits is two-thirds the length of the part extending from their posterior border to near the base of the lateral horn, and one-fifth the distance from the orbit to the extremity of the horn. The part of the border of the orbit preserved indicates that the latter is of fair size. It is separated from the maxillary border by at least its own diameter. The external nares are peculiarly situated. They are nearer the orbit than the end of the muzzle, and are close to the maxillary border, being separated from the mouth by a narrow strip of bone only. They are round, open nearly laterally, and are removed from the edge of the orbits by the diameter of the latter.

The malar or quadratojugal bone is protuberant at the canthus oris and projects laterally beyond the mandible at its posterior part. It also projects beyond the extremity of the quadrate bone. This border is continued as that of the external base of the horn, but the portion which belongs to this element is soon distinguished from the superior element (squamosal) which composes the horn, by a groove. This groove is decurved, and bounds the apex of the element, which is a decurved, low tuberosity. The horn is produced backwards in a horizontal plane, forming a long flat triangle which contracts gradually with straight sides. The apex is narrowed, obtuse, and a little incurved. Near and at the extremity the horn is flat above and convex below.

The mandibular quadrate cotylus consists of two fossæ, which together form an approximate figure ∞, of which the internal fossa is the smaller, and opens internally. The external one is nearly transverse. The superior border of the ramus posteriorly is straight. The greater part of the superior aspect is occupied by a huge fossa which opens upwards.

It is uncertain whether the horns meet at an entering angle on the middle line posteriorly or not, but the width of the base of the horn indicates that such is the case. The extremity of the muzzle is depressed, and is broadly rounded.

The external surface of the skull is sculptured in the form of fossæ so distributed that the narrow ridges separating them do not form straight lines, except in a few places on the superior face of the horn. This sculpture is strongly impressed, and is of medium coarseness. It extends on the inferior face of the quadratojugal (?) posterior to the quadrate, and on the inferior side of the horn at the edges. It is most extended below from the interior edge, and for the terminal inch of the horn, is as well marked as on the superior face. Elsewhere the sculpture of the inferior side passes into punctæ before disappearing. A groove marks the superior boundary of the maxillary bone, which divides when it reaches the superior surface. One branch descends behind the nostril, the other passes transversely across the lachrymal bone and shallows out before reaching the middle line of the muzzle. The mandible is even rougher than the superior surfaces, and has a longitudinal groove below the dental line, to near the symphysis, where it runs out on the alveolar edge. The internal and external sides of the mandible posteriorly, are smooth. On the malar and other facial bones there are four fossæ in 9 or 10 mm.

The atlas is peculiarly flattened above, the neural arch being a tube, without neural spine. Its anterior tubular prolongation is not long, and is deeply notched below. The condyloid fossæ are widely spread transversely and nearly flat, except that their surface is carried forwards on the neural tube. They are well separated below. There is a strong hypapophysial keel, which diminishes and runs out anteriorly. There are prezygapophysial facets, but the postzygapophyses exist. Their superior edge is however carried posteriorly to form the sides of the huge embracing zygantrum. These side processes, which I will call zygantropophyses, extend as far posteriorly as above the posterior end of the centrum of the axis, embracing almost the whole of the neural arch. There is another short median superior process, which notches the extremity of the zygosphen. The side of the atlas between the postzygapophysis and the condyloid facet is wrinkled, and the inferior face finely punctate.

In the axis, the hypopophysis is a large ridge with a horizontal truncate edge. The costal heads of the diapophysis are not split to the base of the latter and the superior is the more robust (extremities broken off). Centrum concave posteriorly, and on each side of hypopophysis with reticulate surface. A short zygantropophysis ; zygantrum not large. Exposed summit of zygosphen (nearly equal neural arch) without neural spine. In both the axis and other cervical vertebræ, the superior diapophysis is connected with the zygapophyses fore and aft, in accord with the shortness of the centra. In the more posterior vertebræ they become separated on account of the increasing length of the centrum.

The third vertebra is like the axis, except in having a keel-shaped neural spine, and a short obtuse zygosphen continued from its base anteriorly. With increasing length of centrum the diapophysis becomes longer, and the hypopophysial ridge becomes wider, and coëxtensive with the inferior face of the centrum. It is separated by an angle from the sides in the longer vertebræ ; in those of intermediate length, the inferior face is convex. All of them retain the delicate lines and punctæ of the inferior surface. The neural spine on the more elongate vertebræ is a rather elevated keel, with horizontal superior edge. Its posterior extremity forms a wedge-like zygosphen. The zygantrum is a deep V-shaped cavity, opening posteriorly and not roofed over at any point unless for a small part of its fundus. The zygapophyses are well spread, and have horizontal faces. Each of the columns of the diapophysis sends a ridge forwards, which enclose a groove between them.

Measurements of vertebræ.		M.
Length of atlas below		.015
" " at zygantropophyses		.029
Expanse " " condyloid facets		.034
" of centrum atlas behind		.0145
Depth of atlas at middle		.019
Length of axis below		.015
" " at zygantropophyses		.016
Width of zygosphen above		.011
Expanse of postzygapophyses		.024
Width of centrum posteriorly		.012
Depth " "		
Length of centrum of another (No. III)		.018
" " " (No. IV)		.022
Expanse of postzygapophyses of do		.018
Length of centrum of No. V		.022
Diameters centrum V anteriorly	vertical	.013
	transverse	.012
Expanse prezygapophyses		.021
Elevation of neural spine from centrum		.011
Diameters centrum No. VI	anteroposterior	.023
	vertical	.011
	transverse	.013

The vertebræ of this species are very much larger than those of the *D. salamandroides*, and the diapophyses do not originate so low down on the centrum. Otherwise they are much alike. The cranium of the Illinois species is yet undetermined.

The *D. magnicornis* was discovered by W. F. Cummins.

ACHELOMA. Cope, genus novum.

Order Rhachitomi; family Eryopidæ,* differing from *Eryops* in the absence of notch of the posterior border of the skull between the epiotic and quadrate or squamosal bones, and in the absence of condyles of the humerus.

Mandible without angular process. Teeth of the jaws subequal, rather larger anteriorly; some large ones on the *os palatinum* at different points

* American Naturalist, 1882, p. 335.

along the external margin. Pterygoid bone ending in a free decurved edge anterior to the quadrate bone. Palatines and pterygoids narrow, leaving a wide palatal foramen. Vertebræ in their principal features as in *Eryops*. The humerus is unlike any of those enumerated in my synopsis of Permian humeri,* but resembles the one figured by Gaudry as belonging to *Actinodon*, except that in *Acheloma* there are no condyles, and there is an epicondylar foramen. This is the first time I have observed the foramen in a Batrachian, though it is universal, so far as known, in the Pelycosauria. As in *Actinodon*, there is a short process above the external epicondylar angle.

The absence of humeral condyles in this genus is paralleled by the same feature in *Clepsydrops natalis*. It looks as though the animal were young, and had not yet attained to the coössification of epiphyses. This theory may account for the condition of the humeri in the two species mentioned. It occurs equally in the *Trimerorhachis insignis*. As all these species show every other indication of maturity, and as I have never yet observed free epiphyses in any of my numerous Texan collections, I am disposed to look on this condition of the humeri as a case of permanent incompleteness, of which the Batrachia present so many instances.

ACHELOMA CUMMINSI, sp. nov.

This animal is represented by a greater part of a skull and vertebral column, with both humeri and scapulæ and various other bones of the limbs, including phalanges. All of these remains look a good deal like *Eryops megacephalus*, and they might be supposed on hasty examination to belong to the young of that species. On a full investigation the following differences appear, besides those already mentioned in the generic diagnosis.

The muzzle is relatively much shorter, and the extremity is less depressed; the length from the supraöccipital forwards, is a little less than the total width at the same point. In agreement with this, the mandibular rami, after diverging strongly from the symphysis, are strongly incurved to the quadrate, a form not found in *E. megacephalus*. The sculpture is more sharply defined in the present species. In the vertebræ, although the intercentra have the same degree of ossification as in the *E. megacephalus*, the neural spines have not the expanded head of those of the larger species, but look as though they had lost an epiphysis, as in the case of the humeri. They are erect, with subquadrate section, and not oblique and grooved as *Trimerorhachis insignis*. The diapophyses are more elongate than in *E. megacephalus*, and their extremities frequently have a subround or suboval section, and but few have the narrow surface seen in *E. megacephalus*. The ribs are short and flat, and have the distal extremities expanded paddle-shape. Laid backwards such a rib reaches to the posterior edge of the third diapophysis posterior to the one to which it is attached.

* Proceedings American Philos. Soc., 1878, p. 528.

The form of the skull is triangular, with rounded apex or muzzle, and a slight contraction behind the nostrils. The latter are near the edge of the jaw and open equally laterally and superiorly. The orbits are of medium size, and are as far from the edge of the jaw as the width of the interorbital space, which is about as wide as the diameter of an orbit. The posterior "table" is flat with decurved lateral edges, which rest in a squamosal suture on the squamosal or quadratojugal and quadrate bones. Its posterior angle is produced downwards and backwards to near the distal extremity of the quadrate. The latter slopes posteriorly and downwards. The quatratojugal region is strongly convex in vertical section. The mandibular ramus is strongly incurved posteriorly, from a point opposite the free extremity of the pterygoid. The symphysis mandibuli is short.

The sculpture is distinct on all the superior surfaces of the skull, and consists of fossæ of medium size, bounded by irregular narrow ridges. There are three fossæ in 10 mm. The fossæ are obsolete on the extremity of the muzzle and on the anterior part of both jaws.

The teeth are a little longer on the premaxillary than on the maxillary bone. There are five on each, or six, if the tooth below the nostril belongs to the premaxillary bone, The palatine teeth are much larger. The first, perhaps standing on the external edge of the vomer, is a little posterior to the line of the external nostril. The second is half way between the nostril and orbit, and the third is alongside of and just posterior to it. The fourth is opposite a point a little posterior to the middle of the orbit. Their surface is as yet obscured by a thin layer of fine indurated mud, which in some instances cannot be removed without destruction of the tooth surface.

The intercentra of the vertebræ are, as in *Eryops megacephalus*, ossified so as to nearly cut off the chorda dorsalis, but unlike that species they are not notched on one side of their lateral apices. The extremities of the neural spines are subquadrate, rounded behind, and flattened anteriorly. The edges of the postzygapophyses are prominent and flared upwards.

The scapula is robust and flat, having the posterior-external border longest, and concave, and the superior-posterior, convex. In my specimens the thin anterior edge is broken. The coracoid appears to be coössified with the proximal external edge of the scapula, and is directed downwards and backwards. Its extension is small, and terminates in an apex posteriorly, and a thick double edge inferiorly. The glenoid cavity borders this edge, and is small. The epicoracoid if it existed, is lost. The thick inferior edge of the coracoid and scapula, is similar to those of the humerus and vertebral processes, which suggest a cartilaginous cap. The position of the scapula and coracoid is peculiar. If the glenoid cavity is directed outwards, the ribs adherent to them fit their extremities, from which they have been broken, which adhere to the vertebræ. This is probably the natural position. When thus placed, the plate of the scapula is horizontal transversely, and inclined upwards and posteriorly at 30°. The coracoid is vertical. When in place, there is a large tuberosity above and anterior to the glenoid fossa, immediately behind which is a wide shallow fossa.

The curve of the proximal extremity of the humerus is a semicircle. That of the distal end is less convex, being flattened at the middle. Viewed proximally the proximal end is a little concave on one side, and one extremity of the articular surface is expanded and rounded. Viewed distally, the distal extremity is angulate concave, the middle portion being straight and the extremities bent in the same direction, one being longer than the other, and neither expanded. The entire extremity makes an angle of 90° with the plane of the proximal end. The epitrochlear foramen is protected by a strong bridge.

Measurements.

Skull.	M.
Length to line of angles of mandible	.188
" posterior edge of supraöccipital	.168
" line of posterior edge of orbit	.121
" " anterior edge nares	.017
" " extremity of pterygoid	.142
Width of skull at angles of mandible	.134
" " " greatest	.158
" " just behind nares	.051
" " at nares	.054
" of cranial table at middle	.086
" between orbits	.030
Length of a premaxillary tooth	.011
Diameter of base of do	.004
Length of a median maxillary tooth	.007
Diameter of base of do	.004
Length of a median palatine tooth	.021
Diameter of same at base	.009
Depth of ramus mandibuli at angle	.015

Vertebræ and Ribs.

Diameters of intercentrum { transverse	.018
Diameters of intercentrum { antroposterior	.010
Total elevation of same vertebra	.027
Elevation of neural spine above postzygapophysis	.005
Total expanse of diapophyses of same	.027
Length of diapophysis from postzygapophysis	.0095
Diameter of end of { neural spine	.206
Diameter of end of { diapophysis { transverse	.004
Diameter of end of { diapophysis { vertical	.006
Length of rib of 5th vertebra in advance of the vertebra measured	.038
Width of rib distally	.027

Scapular arch.	M.
Length of scapula on anterior face	.069
Width do. at antero-internal distal angle, transversely.	.032
" of coracoid and epicoracoid at glenoid cavity, from edge of scapula	.023
Length of epicoracoid and coracoid	.037
" humerus	.064
Width of shaft at middle	.016
Diameters proximal end { long	.039
Diameters proximal end { short at middle	.010
Diameters distal end { long	.039
Diameters distal end { short at middle	.010
Length ungual phalange	.004
" second "	.0075
" first "	.0135
Width do. { proximally	.010
Width do. { distally	.008

This species was discovered by Mr. W. F. Cummins, to whom I dedicate it with much pleasure.

ANISODEXIS Cope, genus novum.

Class Batrachia; order Rhachitomi; family Eryopidæ. Teeth on premaxillary, maxillary, and dentary bones of unequal lengths, some very large, others very small. Dentinal inflections straight, nearly reaching the pulp cavity. Cranial surfaces sculptured.

This genus differs from all the others of the *Eryopidæ,* in the great and abrupt inequality of the teeth of the external series of the mouth, resembling in this respect some of the Saurians of this deposit, rather than the batrachia. Whether it possesses long palatine or pterygoid teeth such as most of the latter exhibit, is not rendered clear by the specimens, but appearances indicate the presence of one near the anterior part of the maxillary. Mandibular series simple.

ANISODEXIS IMBRICARIUS Cope, sp. nov.

Founded on numerous fragments of the skull with jaws, and a vertebral arch and spine found in connection with the remains of the *Diplocaulus magnicornis.* These pieces indicate a larger species than the latter, and are nearly equal to the *Eryops megacephalus.* The jaws are not preserved entire, but portions from different parts of the length display the dental characters.

The sculpture of such parts of the superior surface of the skull is a coarse reticulation, coarser than in any other species known to me. Near the edges, some of the bones become smoother, and the ridges flatten into overlapping laminæ. The entire sculpture of the dentary bone is of this imbricate character, the apparent overlapping being from before backwards, and below upwards. This is totally different from what is observed in the other known species of *Eryopidæ*, *Trimerorhachidæ*, and *Diplocaulidæ*. The teeth are round in section, but become lenticular near the apex, developing low cutting edges. The basal grooves are fine, but distinct, and extend half way to the apex, or farther. One large, and one medium sized teeth stand on each dentary bone near the symphysis, and there are two similar ones at a point further back on the same bone. Near the anterior part of the maxillary, below the ? nostrils, is a huge tooth, with a graduated series of small teeth posterior to it, and a very small one anterior to it.

The neural arch of a vertebra has a well developed vertical spine. Its neurapophysis rested in an oval fossa of the centrum which probably was divided into pleurocentra. The prezygapophyses are very small, and look directly upwards. The postzygapophyses are much larger, and look obliquely outwards and backwards. The spine is not expanded at the summit, and is granular, as though it was protected by a cartilaginous cap. Its section is anteroposteriorly lenticular, with acute edge (angle) posteriorly, and a very narrow truncate edge anteriorly. The latter is bounded below just above the root of the neural arch by two little fossæ. The posterior keel is bounded below by a corresponding single fossa. The posterior acute edge of the spine is dentate, and the surface on each side of it, is beveled with rabbeted surfaces as though for a coarse squamosal suture. But the appearance of suture is fallacious, and is simply due to contraction of the transverse diameter of the spine. The neurapophysis is much narrower anteroposteriorly than the neural spine.

Measurements.	M.
Depth of maxillary bone at large anterior tooth	.037
" dentary at symphysis	.025
" " near middle	.021
Width " " "	.015
Diameter of base of large maxillary tooth	.010
" " small maxillary tooth	.0035
Length " " " "	.008
" of large mandibular tooth near symphysis	.016
Diameter of base of crown of do	.006
Elevation of neural arch	.037
Diameters neural spine { vertical	.029
Diameters neural spine { at apex { anteroposterior	.019
Diameters neural spine { at apex { transverse	.012
Width neurapophysis anteroposteriorly	.010

From Mr. W. F. Cummins' collections.

I had thought at one time that this species might be referable to the genus *Leptophractus* of the Coal Measures. No trace of the vertebræ of the Rhachitomous order has yet been found in that formation in this country, nor have any of the Coal Measure genera of Batrachia yet been found in the Permian of the United States.* It is not improbable that such occurrence of genera may yet be substantiated, but the identification of an order hitherto unknown in a formation, on uncertain characters, is not a safe proceeding. The vertebræ of *Leptophractus* although not certainly known, are supposed to be of the Labyrinthodont type. The teeth are much more compressed and trenchant than in the present species, nor do there appear to be any long ones near the symphysis mandibuli. I consider the question of reference to Leptophractus to be still an open one.

The family *Eryopidæ*, though abundant in individuals, is not represented by many species. They are presumably as follows:

Anisodexis imbricarius Cope.
Acheloma cumminsi Cope.
Eryops reticulatus Cope.
Eryops ferricolus Cope (*Parioxys olim*).
Eryops megacephalus Cope.
Actinodon frossardi Gaudry.
Zatrachys serratus Cope.
Zatrachys apicalis Cope.

But the occipital condyles are unknown in *Acheloma* and *Zatrachys*.

I may add here that through the courtesy of Messrs. Scott and Osborne, I have seen, in the Museum of Princeton College, vertebræ of some species of the Rhachitomi from Saarbrücken, along with *Archegosaurus*, with entire centra, from the same locality.

Synopsis of the Vertebrata of the Puerco Eocene epoch. By E. D. Cope.

(*Read before the American Philosophical Society, October 20, 1882.*)

REPTILIA.

CROCODILIA.

Crocodilus sp.
Crocodilus sp.
Crocodilus sp.

TESTUDINATA.

Plastomenus ? communis Cope.
Dermatemys sp.
Compsemys sp.
Emys sp.

* *Peplorhina arctata* Cope, from the Illinois Permian, is not a *Peplorhina*, but a Theromorph Saurian.

CHORISTODERA.

Champsosaurus australis Cope, American Naturalist, 1881, p. 690.

Champsosaurus puercensis Cope, Proceedings American Philosophical Society, 1881, p. 195.

Champsosaurus saponensis Cope, Loc. cit. 1881, p. 196.

MAMMALIA.

MARSUPIALIA.

Ptilodus mediaevus Cope, American Naturalist, 1881, p. 922.

Ptilodus trovessartianus Cope, loc. cit. 1882, p. 686.

Catopsalis foliatus Cope, loc. cit. 1882, p. 416.

Catopsalis pollux Cope, loc. cit. 1882, p. 685.

Polymastodon taöensis Cope, loc. cit. 1882, p. 684.

BUNOTHERIA.

Taeniodonta.

Hemiganus vultuosus Cope, loc. cit. 1882, p. 831.

Tæniolabis scalper Cope, loc. cit. 1882, p. 604.

Tillodonta.

Psittacotherium multifragum Cope, l. c., 1882 p. 156.

Psittacotherium aspasiæ Cope, Proceed. Amer. Philosophical Society, 1882, p. 192, (1882).

Mesodonta.

Pelycodus pelvidens Cope, Proceeds. Amer. Philos. Soc. 1881, (1882) p. 151. *Lipodectes pelvidens* Cope, American Naturalist. 1881, p. 1019.

Hyopsodus acolytus Cope, sp. nov.

This the least species of the genus, is also the oldest, being derived from the Puerco horizon. Parts of two individuals furnish the characters of the inferior and superior true molars, and the fourth superior premolars. The species differs from those hitherto described in other characters than the minute size. One of these is the absence of posterior interior cusp, the heels of the first and second true inferior molars being bounded by a ridge only at this point, as in most of the species of *Pelycodus*. The last inferior molar is not smaller than the second, nor longer. The anterior cusps of all the molars are robust, so that on the first and second true molars they are separated by a shallow notch only. There is a rudiment of the anterior inner cusp on the first true molar but none on the second and third. The posterior external is obtuse and has a triangular section on all the molars; a crest is continued from the heel of the third molar on the inner side of the crown half way to the anterior inner cusp.

The *Microsyops spierianus* differs from this species in its smaller size (true molars .008) and in the presence of posterior internal cusps of the true molars.

The *Hyopsodus acolytus* was found by Mr. D. Baldwin, in New Mexico.

CREODONTA.

Sarcothraustes antiquus Cope, Proceeds. Amer. Philos. Soc. 1881 (1882), p. 193.

Dissacus carnifex Cope, Amer. Natst. Oct. 1882 (Sept.), p. 834.

Dissacus navajovius Cope, loc. cit. 1881, p. 1019. *Mesonyx navajovius* Cope, Proceeds. Amer. Philos. Society, 1881, p. 484.

Triisodon quivirensis Cope Amer. Nat. 1881, p. 667.

Triisodon heilprinianus Cope, Proceeds. Amer. Philos. Soc. 1881 (1882), p. 193.

Deltatherium fundaminis Cope, Amer. Nat. 1881, p. 237; 1881, p. 337. *Lipodectes penetrans*, loc. cit. 1881, p. 1019.

Deltatherium baldwini Cope.

This Creodont is known only from a portion of a right mandibular ramus which supports the two last premolars, and the first true molar with part of the second. It differs from the *D. fundaminis* in its materially smaller size, and in the forms of the teeth. The first true molar is a more robust tooth, and the basis of the posterior or heel crest is more rounded, and less angulate. The anterior inner cusp projects less anteriorly. The fourth premolar has a distinct anterior basal lobe which is wanting in the *D. fundaminis.* Its heel is short and wide, and the posterior face of the principal cusp is flat, and there is a rudiment of an internal tubercle on its side. The second premolar is elevated and acute, has no anterior basal lobe, and has a very short wide heel, enamel slightly roughened. The animal was rather aged.

Measurements.		M.
Length of P-m. ii and iii and M. ii		.0160
Diameters M. i	anteroposterior	.0058
	transverse	.0040
Elevation of crown of P-m. iii		.0052
Depth of mandible at M. i		.0180

From the Puerco beds of N. W. New Mexico. Dedicated to Mr. D. Baldwin, the discoverer of the Mammalian Fauna of the Puerco beds, which is one of the most important in the history of American Palæontology.

Deltatherium interruptum Cope.

The smallest species of *Deltatherium* is, like the *D. baldwini*, only represented by the anterior part of a right mandibular ramus, which supports the last premolar and the first true molar, with the bases of the other premolars and part of the canine. The canine is small and the first premolar in accordance with the generic character, is wanting. The second premolar is two-rooted The fourth has an elevated principal cusp, and a narrow heel on the inner side of the posterior base; anterior base injured. The first true molar has very little sectorial character, and resembles the corresponding tooth of a *Pelycodus.* It differs entirely from that of the *D. fundaminis* in the possession of a well marked posterior internal cusp, which is connected by a ridge with the large internal lateral cusp of the heel. The anterior cusps of opposite sides sub-equal. A weak external basal cingulum on the anterior half of the crown; no internal cingulum. Enamel of the tooth wrinkled.

Measurements.		M.
Length of premolar series		.0140
Elevation of P-m. iv		.0040
Diameters of M. i	antero posterior	.0055
	transverse	.0042
Depth of ramus at P-m. i		.0090
" " M.		.0113

On comparison with the *D. fundaminis,* the first molar tooth has the same dimensions, but the premolars are considerably smaller. The ramus is also shallower. Found by Mr. Baldwin in the Puerco beds of Northwest New Mexico.

Didymictis haydenianus, sp. nov.

This creodont is represented by parts of the maxillary and mandibular bones of the left side, the former supporting the four, and the latter supporting the three last molars. The arrangement of the superior molars is much as in *D. protenus,* the fourth premolar being a true sectorial. The third premolar has no internal lobe, although the section of the base of the crown is narrowly triangular. It has anterior and posterior basal lobes, and a posterior lobe on the cutting edge. In the sectorial the median lobe is a good deal more produced than the posterior, though the two form together the usual blade. The anterior basal lobe is distinct; and the internal is larger and is conic. The first true molar has the anterior external base of the crown produced. Its two external cusps are conic and distinct. The internal part of the crown is rounded and supports a conic internal tubercle, which is separated from the external cones by two small concentric tubercles. The second true molar is considerably smaller, and is transverse, its external border being very oblique. It has an acute internal lobe.

The character of the species is well-marked in the inferior true molars. The first has the form seen in other species of *Didymictis.* The heel is large, and with a median basin between lateral cutting edges. The two anterior inner cusps are of equal elevation and are near together; the external is much larger. The last molar is elongate, but reduced in size. Its anterior three cusps, rudimental in other species, are here elevated, forming the triangular mass seen in the first true molar. They are not so elevated, however, as in that tooth, and thus not so much developed as in *Oxyæna*, *Stypolophus*, etc. The fourth premolar has a median cutting edge on the short heel.

Measurements.		M.
Length last four superior molars		.022
" P-m. iii		.0065
" " iv		.0085
Width " "		.0050
Diameters M. i	anteroposterior	.0055
	transverse	.0088
	oblique external	.0072
Diameters M. ii	anteroposterior	.0027
	transverse	.0055
Diameters inferior M. I	anteroposterior	.007
	transverse	.005
Diameters inferior M. II	anteroposterior	.0055
	transverse	.003
Depth of ramus at M. II, (squeezed)		.010

The peculiar characters of the last inferior molar distinguish this species from its congeners. The last superior molar is relatively smaller than in the *D. protenus.* In size this species is superior to the *D. dawkinsianus*, and is smaller than the *D. leptomylus*. It is dedicated to the distinguished geologist, Dr. F. V. Hayden.

New Mexico, D. Baldwin.

TAXEOPODA.

CONDYLARTHRA.

Periptychidæ.

Periptychus rhabdodon Cope. *Catathlæus rhabdodon*, American Naturalist, 1881, 829.

Periptychus carinidens Cope, loc. cit. 1881, p. 337.

Periptychus ditrigonus Cope, sp. nov.

This rare species is known from a right mandibular ramus, which exhibits part of the symphyseal suture, with the alveoli of the molar teeth, except the first. The only well preserved crown is that of the second true molar.

The second true molar presents very peculiar characters, and the mandibular ramus is shallower and thicker than in the two other species of *Periptychus*. The former has a wide external cingulum which is not present in the other species, and there are only six cusps instead of seven. These are peculiarly arranged. The anterior three are much as in *P. rhabdodon*, the anterior being not quite so far internal as the posterior inner, close to it, and as large as the anterior external. The posterior three, are a posterior inner and posterior median as in *P. rhabdodon*, and a peculiarly placed posterior external. This is not opposite the posterior inner, but is anterior to such a position and intermediate between the latter point, and the one occupied by the median tubercle in *P. rhabdodon.* It is as large as the anterior external tubercle. All these tubercles are conical, and not connected by angles or ridges. The posterior external cusp leaves the cingulum wide posteriorly, and its edge develops some small tubercles. There are also some small tubercles at other points on the edge of the crown, but no other cingula. The enamel is not regularly ridged as in *P. rhabdodon,* but has a rather coarse obsolete wrinkling.

Measurements.	M.
Length from P-m. ii to M ii inclusive	.052
Diameters of M. ii { anteroposterior	.011
Diameters of M. ii { transverse	.010
Depth of ramus at M. ii	.022
Width of " "	.016
Depth of " " P-m. ii	.019

From the Puerco formation of New Mexico, D. Baldwin, discoverer.

Haploconus lineatus Cope, Amer. Nat. 1882, p. 417.

Haploconus angustus Cope, Loc. cit. 1882, p. 418. *Mioclænus angustus* Cope, loc. cit. 1881, p. 831.

Haploconus xiphodon, sp. nov.

This species is represented by a mandibular ramus, and perhaps by three rami. The one on which the species rests contains five molars, the middle one of the series broken, so that its form cannot be positively ascertained. It is probable that it is the first true molar, so that the animal exhibits the last true molar not entirely protruded, and is therefore nearly adult, but there are some reasons for suspecting it to be young. Thus the last inferior molar does not exhibit more of a heel than the second usually does, and the third supposed premolar is smaller than that tooth is in the other species, having nearly the proportions of the second premolar. The teeth present may then be supposed to be the molars from the second to the sixth inclusive. But opposed to this view is the fact that the supposed third premolar has more the structure of that tooth in details, than that of the second, and the specimens accompanying, which have the temporary dentition apparently of the same species, present premolar teeth of a very different character. In any case the present specimen represents a third species of the genus, and I describe it at present as an adult.

The third premolar has a simple compressed crown, about as high as the length of its base, and without anterior basal tubercle. It has a narrow triangular posterior face which is concave, and truncated by a cingulum below; no heel proper, nor lateral cingula. The fourth premolar is an elongate tooth consisting of a compressed principal median lobe, an anterior lobe connected with it, and a heel. The latter has elevated posterior and interior borders. A rudiment of an exterior border is seen in a narrow ridge on the external side of the posterior face of the principal lobe of the tooth.

The sides of the premolars present rather distinct ridges, as in *Periptychus carinidens.* The second true molar has two anterior and three posterior tubercles ; the latter close together, pointed and of about equal size. Of the anterior tubercles, the external is much the larger and more elevated. It is compressed and has a curved subacute anterior edge, which extends much in front of the internal tubercle. There is no anterior inner tubercle, nor are there any cingula. The enamel of the sides of the crown presents a few vertical ridges. The last inferior molar only differs from the second, in the greater size of the median posterior lobe, which is nevertheless smaller than in the two other species of *Haploconus.*

There is a mental foramen below the posterior edge of the second inferior premolar.

Measurements.	M.
Length of last five inferior molars	.0250
" third premolar	.0050
" fourth premolar	.0066
" second true molar	.0050
Width of second true molar	.0032
Length of third true molar	.0050
Depth of ramus at P-m. iii	.0095
" " M. iii	.0130

The two rami with the temporary premolars, exhibit the last true molar enclosed in the jaw. The third and fourth premolars are much like the fourth premolar of the specimen above described, but the fourth is a little more robust than that of the latter, which is very much like the third of the deciduous series. The space occupied by the supposed first premolar of the type specimen is too short for the fourth premolar of the deciduous series, otherwise it might be supposed to have occupied that position. The two true molars resemble those of the type, excepting that the last one does not extend so far into the base of the coronoid process, and is in accordance with the position as number two in the series.

The specimens were procured by Mr. D. Baldwin in the Puerco beds of New Mexico.

Haploconus entoconus Cope, loc. cit. 1882, p. 686.

Anisonchus coniferus Cope, loc. cit. 1882, October (September), p. 832.

Anisonchus gillianus Cope. *Haploconus gillianus* Cope, loc. cit., 1882, p. 686.

Anisonchus sectorius Cope, Proc. Amer. Philos. Soc. 1881, p. 488, *Mioclaenus sectorius,* Amer. Nat. 1881, p. 831.

Hemithlæus kowalevskianus Cope, Amer. Nat. 1882, p. 832.

Hemithlæus opisthacus Cope. *Mioclænus opisthacus,* 1 c. 1882, p. 833.

Conoryctes comma Cope American Naturalist, 1881, p. 829.

Conoryctes crassicuspis Cope.

The posterior part of a mandibular ramus supporting the last two molar teeth indicates a second and larger species of the genus. The ramus is one-half deeper than that of the *C. comma.* and the second true molar is much larger than in that species. The last true molar is much smaller than the the penultimate, and consists of three anterior cusps and a longer heel. The former are obtuse, the external the longer, the internal equal, the anterior on the inner edge of the crown. The heel sustains a low conic tubercle.

From the Puerco beds of N. W. New Mexico.

Phenacodontidæ.

Protogonia plicifera Cope, Amer. Nat. 1882, Oct. (Sept.), p. 833.

Protogonia subquadrata Cope, Proceedings Amer. Philos. Soc. 1881, p. 492

Phenacodus puercensis Cope, Proc. Amer. Philos. Soc. 1881, p. 492.

Phenacodus zuniënsis Cope, loc. cit. p. 492 ; loc. cit. 1881 (1882), p. 180.

Pantolambda bathmodon Cope, Amer. Nat. 1882, p. 418.

Mioclænus turgidus Cope, Amer. Nat. 1881, p. 830.

Mioclænus minimus, sp. nov.

This is one of the least mammalia of the Puerco fauna, exceeding by a little the *Hyopsodus acolytus.* It is represented by parts of two mandibles, which display all the true molars. As there are no premolars preserved, its reference to the genus *Mioclænus* is provisional only, but its true molars have the peculiar characteristics of those of the *M. turgidus*.

The two anterior cusps of the true molars are higher than the heel, and they are united together to a point above the level of the heel. The section of both those of the M. ii is round ; that of the external one of the first is cresentic ; of the inner cusp, round. The heel is wide, and supports a cusp at the posterior external angle. It is bounded posteriorly, and on the inner side by a raised ridge, which gives with the cusp, on wearing a comma-shaped surface. A transverse ridge closely appressed to the anterior cusps connects them anteriorly. In one of the specimens there is a cingulum on the external side of the second inferior molar ; on the other specimen it is wanting. Enamel smooth.

The mandibular ramus is rather deep and compressed, and displays an external ridge on the anterior border of the coronoid, which is not continued downwards.

Measurements (No. 2).		M.
Length of basis of true molars		.0125
Diameters M. ii	anteroposterior	.0040
	transverse	.0035
Depth of ramus at M. ii		.0073

From the Puerco beds of New Mexico. D. Baldwin.

Mioclænus subtrigonus Cope, Amer. Nat. 1881, p. 490, 491.

Mioclænus protogonioides Cope, loc. cit. 1882, Oct. (Sept.), p. 833.

Mioclænus mandibularis Cope, Amer. Nat. 1881, p. 830.

Mioclænus baldwini Cope, loc. cit. 1882, Oct. p. 833.

GENERAL REMARKS.

The preceding list of fifty-six species is doubtless sufficiently characteristic to enable us to form a pretty good idea of the Puerco fauna. Omitting six undetermined species of reptiles, we find the following peculiarities in the remaining forms. As already pointed out the three determined species of reptiles belong to a suborder, which has thus far been only found in the Laramie formation, or Cretaceous No. 6. This gives the Puerco at once a position below all the other tertiaries. The mutilate orders of mammals may be dismissed as being not likely to occur in a lacustrine formation. The orders of land Mammals are represented as follows:

Monotremata		0
Marsupialia		5
Rodentia		0
Chiroptera		0
Edentata		0
Bunotheria		15
Tæniodonta	2	
Tillodonta	2	
Insectivora	0	
Mesodonta	2	
Lemuroidea	0	
Creodonta	9	
Taxeopoda		25
Hyracoidea	0	
Condylarthra	25	
Proboscidea		0
Amblypoda		0
Diplarthra		0
Carnivora		0
Quadrumana		0
Total		45

The above list renders the peculiar facies of this fauna at once apparent. It is the only Tertiary fauna known, from which Perissodactyla are absent. The absence of Amblypoda, one of the oldest types, is unexpected. The lack of Rodentia is remarkable, and perhaps only due to failure of discovery; but if yet to be found, they must be very rare, and their absence is consistent with their small representation in the Wasatch beds above them. In the large number of Bunotheria, the Puerco agrees with the later Eocenes, but the order is here characterized by the small number of Mesodonta; and the Lemuroidea are apparently absent. An especial feature of the fauna is the presence of five undoubted species of Marsupialia of the family Plagiaulacidae, which has its origin in the Jurassic period, and extended through the Cretaceous. It is represented in the latter period in the Laramie by the genus *Meniscoëssus.**

In the absence of a number of the existing orders of placental Mammalia, the Puerco agrees with other Eocene faunæ. In the absence of all of the placental orders with convoluted cerebral hemispheres, this fauna is more primitive than any other Eocene fauna. The absence of all ungulata excepting Taxeopoda, which have the most primitive foot structure, is further evidence of its primitive character. This is further increased by the presence of the Marsupialia above mentioned. The general result is a mixture of Marsupial, and semi-marsupial forms, with half lemurs, and a great expansion of the Hyracoid type.

In more detail, the genera of Bunotheria may be compared with those of the period immediately following; viz.: The Wasatch. One genus only of the Creodonta is common to the two epochs (*Didymictis*). Five of the species remaining are much like oppossums, and may be Marsupialia. The two genera (*Deltatherium* and *Triisodon*) to which they belong, do not occur in the Wasatch. The remaining two genera, (three species) are peculiar to the Puerco, but represent a family (Mesonychidæ) which occurs throughout our Eocenes. The two species of Mesodonta belong to genera of the Wasatch, one of them at least extending into the Bridger. The genera of Tæniodonta and Tillodonta are distinct from those of any of the later Eocenes, so far as known.

Supplement on a new Meniscotherium from the Wasatch epoch.

Meniscotherium tapiacitis, sp. nov.

The species now to be described is a good deal smaller than *M. chamense*, and, *a fortiori*, than the *M. terrærubræ*. It is known to me from the nearly entire rami of a single mandible. These support the last five molars of one side or the other, and alveoli of two others and of the canine tooth.

Two characters besides the small size, are observable in this jaw. First, the symphysis has not the shallow convex inferior outline in transverse section; but is on the contrary angular, having subvertical sides separated from a convex middle by a rounded angle. The symphysis is thus deeper than in *M. terrærubræ*. Second, the crown of the third inferior molar tooth has partly the form of that of the second of the *M. terrærubræ*. It is anteroposteriorly short, and has a short heel and no anterior basal lobe; the section of the principal lobe is lenticular, and profile subconic. In *M. terrærubræ* this tooth is elongate, with well developed heel and anterior lobe. The alveolus of the canine is relatively larger than that of the *M. terrærubræ*. The coronoid process does not rise so close to the last molar tooth, nor so steeply, as in the latter species. The posterior recurvature of the internal extremity of the anterior limb of the posterior V of the true molars is but little marked.

* American Naturalist, 1882, p 830, Sept, 28th.

Measurements.	M.
Length of true molars on base	.018
Diameters M. ii { anteroposterior	.006
Diameters M. ii { transverse	.0044
Diameters M. iii { anteroposterior	.0065
Diameters M. iii { transverse	.0038
Diameters P-m. iii { vertical	.0045
Diameters P-m. iii { anteroposterior	.004
Width of inferior face of symphysis	.008
Depth ramus at P-m. iii	.009
" " " M. iii	.0103

This species was obtained by Mr. D. Baldwin from beds of probably lowest Wasatch age, in New Mexico.

On the Systematic Relations of the Carnivora Fissipedia. By E. D. Cope.

(*Read before the American Philosophical Society, October 20, 1882.*)

This order embraces the clawed mammalia with transverse glenoid cavity of the squamosal bone, confluent scaphoid and lunar bones of the carpus, and well developed cerebral hemispheres. It is well distinguished from all others at present known, but such definition is likely to be invalidated by future discovery. Some of the Insectivora possess a united scapholunar bone, but the reduction of the cerebral hemispheres of such forms distinguishes them. The presence of the crucial fissure of the hemispheres is present under various modifications in all *Carnivora*, while the parietooccipital and calcarine fissures are absent.

The many types of existing carnivora fall into natural groups, which are of the grade termed family in zoölogy. But the distinction of these from each other is not easily accompanished, nor is it easy to express their relations in a satisfactory manner. The primary suborders of pinnipedia and fissipedia are easily defined. Various characters have been considered in ascertaining the taxonomy of the more numerous fissiped division. The characters of the teeth, especially the sectorials, are important, as is also the number of the digits. Turner* has added important characters derived from the foramina at the base of the skull, and the otic bulla, which Flower† has extended. Garrod‡ has pointed out the significance of the number of convolutions of the middle and posterior part of the hemispheres. I have added some characters derived from the foramina of the posterior and lateral walls of the skull.§ Mr. Turner also defines the families by the form and relations of the paroccipital process.

* Proceedings Zoological Soc., London, 1848, p. 63.

† Loc. cit., 1869, p. 5. ‡ Loc. cit., 1878, p. 377.

§ Proceedings Amer. Philosophical Society, 1880, p.

In studying the extinct carnivora of the Tertiary period, it has become necessary to examine into the above definitions, in order to determine the affinities of the numerous genera which have been discovered. To take them up in order, I begin with the foramina at the base of the skull. The result of my study of these has been, that their importance was not overrated by Mr. Turner, and that the divisions of secondary rank indicated by them are well founded. Secondly, as to the form and structure of the auditory bulla. Although the degree and form of inflation are characteristic of various groups of Carnivora, they cannot be used in a systematic sense, because like all characters of proportion merely, there is no way of expressing them in a tangible form. For, if the forms in question pass into each other, the gradations are *insensible*, and not sensible, as is the case with an organ composed of distinct parts. The same objection does not apply so much to the arrangement of the septa of the bulla. The septum is absent in the Arctoidea of Flower (*Ursidæ* of Turner), small in the Cynoidea (Flower, *Canidæ* Turner), and generally large in the Æluroidea (Flower, *Felidæ* Turner). But here occurs the serious discrepancy, that in the Hyænidæ, otherwise so nearly allied to the Felidæ, the septum of the bulla is wanting. Nevertheless, the serial arrangement of the order indicated by Flower, viz.: commenc ing with the Arctoidea, following with the Cynoidea, and ending with the Æluroidea, is generally sustained by the structure of the auditory bulla, and by the characters of the feet and dentition, as well as of the cranial foramina. Turner's arrangement in the order, Ursidæ, Felidæ and Canidæ, is not sustained by his own characters, and its only support is derived from Flower's observations on the external or sylvian convolution of the hemisphere of the brain.* There are three simple longitudinal convolutions in the raccoons ; in the civets and cats the inferior convolution is fissured at the extremities, while in the dogs it is entirely divided, so that there are four longitudinal convolutions between the sylvian and median fissures.

An important set of characters hitherto overlooked, confirms Flower's order. I refer to those derived from the turbinal bones. In the ursine and canine forms generally, the maxilloturbinal is largely developed, and excludes the two ethmoturbinals from the anterior nareal opening. In the Feline group, as arranged by Turner, the inferior ethmoturbinal is developed at the expense of the maxilloturbinal, and occupies a part of the anterior nareal opening. These modifications are not, so far as my experience has gone, subject to the exceptions seen in the development of the otic septa and molar teeth, while they coincide with their indications. The seals possess the character of the inferior group, or Ursidæ, in a high degree.

The characters derived from the paroccipital process are of limited application, as the study of the extinct forms shows.

* Proceedings Zoological Society, London, 1869, p. 482.

I would then divide the fissiped carnivora into two tribes as follows :

External nostril occupied by the complex maxilloturbinal bone ; ethmoturbinals confined to the posterior part of the nasal fossa ; the inferior ethmoturbinal of reduced size.........................HYPOMYCTERI.
External nostril occupied by the inferior ethmoturbinal and the reduced maxilloturbinal............................. ....EPIMYCTERI.

While no doubt transitional forms will be discovered, the types at present known fall very distinctly into one or the other of these divisions. The characters are readily preceived on looking into the nares of well cleaned specimens. The *Hypomycteri* stand next to the *Pinnipedia,* since the maxilloturbinal bone has the same anterior development in that group.

In searching for definitions of the families, it is necessary to be precise as to the definition of terms. The meaning of the word sectorial is in this connection important, sinee there are so many transitional forms between the sectorial and tubercular tooth. A sectorial tooth then of the upper jaw, is one which has at least two external tubercles, which are the the homologues of the median and posterior lobes of the sectorial of the cat. By the flattening and emargination of their continuous edges, the sectorial blade is formed. One or two interior, and an anterior lobe, may or may not exist. In the genera of the *Procyonidæ,* except in *Bassaris,* the two external tubercles do not form a blade. The inferior sectorial tooth differs from the tubercular only in having an anterior lobe or cusp, which belongs primitively to the interior side. The inferior sectorial teeth with large heels, as in Viverridæ and Canidæ, I have called tubercular-sectorials. The sectorial blade is formed by the union and emargination of the edges of the anterior and the principal external cusp. This blade is not well developed in the genus *Cynogale* and still less in the *Procyonidæ* and *Ursidæ.* The families are then defined as follows.

HYPOMYCTERI.

I. No sectorial teeth in either jaw.

Toes 5–5................................. ....*Cercoleptidæ.*

II. Sectorial teeth in both jaws.

a. Toes 5–5

β. No alisphenoid canal.

True molars $\frac{2}{2}$.......................................*Procyonidæ.*
" " $\frac{1}{2}$.......................................*Mustelidæ.*

ββ. An alisphenoid canal.

Molars quadrate, $\frac{2}{2}$....................................*Aeluridæ.*
Molars longitudinal, $\frac{2}{3}$.................................*Ursidæ.*

aa. Toes 5–4 or 4–4.

Sectorials well developed, an alisphenoid canal ....*Canidæ.*

EPIMYCTERI.

I. Molars haplodont.

Toes 5–4 ; no alisphenoid canal.............................. *Protelidæ.*

II. Molars bunodont, no sectorials.

Toes 5–5 ; an alisphenoid canal.............................. *Arctictidæ.*

III. Molars bunodont, with sectorials.

α. Otic bulla with septum.

β. Alisphenoid canal and postglenoid foramen, present.

γ. True molars well developed.

Toes 5–5.. *Viverridæ.*

Toes 5–4.. *Cynictidæ.*

Toes 4–4.. *Suricatidæ.*

γγ. True molars much reduced.

Toes 5–5.. *Cryptoproctidæ.*

Toes 5–4.. *Nimravidæ.*

ββ. No alisphenoid canal; post glenoid foramen rudimental or wanting.

Toes 5–4.. *Felidæ.*

αα Otic bulla without septum.

No alisphenoid canal, nor post glenoid foramen : Toes 4–4...... *Hyænidæ.*

The genera of these families are the following :

CERCOLEPTIDÆ ; *Cercoleptes* Neotropical.

PROCYONIDÆ ; *Procyon,* Bassaricyon, Bassaris ;* Neartic and Neotropical.

MUSTELIDÆ ; Melinæ (two tubercles of internal side of superior sectorial) ; *Taxidea, Meles.* Mustelinæ, (one internal tubercle of superior sectorials) ; *Enhydris, Pteronura, Lutra, Aonyx, Barangia ; Helictis, Zorilla, Mephitis, Conepatus ; Mellivora ; Gulo, Galictis, Putorius, Mustela.*

ÆLURIDÆ ; *Aelurus ; Æluropoda ? Hyænarctos.*

URSIDÆ ; *Helarctos ; Arctotherium ; Ursus ; Melursus.*

CANIDÆ ; *Megalotis*† ; *Amphicyon ; Thous, Palæocyon, Temnocyon, Galecynus, Canis, Vulpes, Enhydrocyon, Hyænocyon, Brachycyon, Tomarctus, Speothus, Synagodus, Dysodus, Oligobunis, Icticyon, Lycaon.*

PROTELIDÆ ; *Proteles.* Ethiopian.

ARCTICTIDÆ ; *Arctictis.* Indian.

VIVERRIDÆ ; *Cynogale, Arctogale, Paguma, Paradoxurus, Nandinia, Hemigale, Galidia, Prionodon, Genetta, Viverricula, Viverra, Galidictis, Herpestes, Athylax, Calogale, Ichneumia, Bdeogale, Urva, Tæniogale, Onychogale, Helogale, Rhinogale, Mungos, Crossarchus, Eupleres.*

CYNICTIDÆ ; *Cynictis, ? Ictitherium.*

SURICATIDÆ ; *Suricata ;* Ethiopia.

CRYPTOPROCTIDÆ ; *Proælurus ; Cryptoprocta.*

NIMRAVIDÆ ; *Archælurus, Nimravus, Ælurogale ; Dinictis, Pogonodon, Hoplophoneus.*

* Including *Nasua*, which is not distinct.

† This genus cannot be made the type of a family as is done by Dr. Gray.

FELIDÆ; Machærodontinæ; *Machærodus, Smilodon;* Felinæ; *Plethælurus* (g. n.)*, *Catolynx; Felis; Neofelis; Uncia,*† *Lynx, Cynælurus.*
HYÆNIDÆ, *Hyænictis, Hyæna, Crocuta.*

Stated Meeting, Oct. 6th, 1882.

Present, 12 members.

Dr. CRESSON in the Chair.

Letters of acknowledgment were received from the Royal Society, Tasmania (90, 91), and the Surgeon General's Office, Washington (110, 111).

Letters of envoy were received from the Meteorological Office, London; and the University Library, Cambridge, England.

A request for missing numbers in the set of the American Philosophical Society Transactions and Proceedings in the library of the Geological Survey of Canada, was referred to the Librarian to report at the next meeting.

Donations for the Library were received from the Academies at St. Petersburg, Amsterdam, Turin, and Rome; Swedish Bureau of Statistics; Christiania University; Royal Danish Society; Royal Observatory, Turin; Zoologischer Anzeiger, Leipsig; Revue Politique, Paris; Meteorological Council, and Nature, London; Geological Society, Glasgow; M. Douw Lightfall, Montreal; Natural History Society, Boston; American Antiquarian Society, Worcester; American Philological Association; Free Public Library, New Bedford; American Journal, New Haven; N. Y. Meteorological Observatory; Buffalo Society of Natural Sciences; E. M. Museum of Geology and Archæology, Princeton; Franklin Institute, College of Pharmacy, Pennsylvania Museum of Industrial Art, and E. A.

* Type, *Felis planiceps* vig. Horsf. Char. Second (first) superior premolar two rooted; orbit closed behind; pupil round.

† Mr. Wortman has called my attention to a character of this genus which confirms its separation from Felis, as I proposed in 1879. The maxilloturbinal bone is less complex in the genus Uncia, than in Felis, consistently with a less nocturnal habit, and less necessity for acute smell.

Barber, Philadelphia; Delaware Historical Society; U. S. Naval Observatory, Census Bureau, U. S. National Museum and Fish Commission, Washington, D. C.

The death of S. F. Haven, at Worcester, Mass., in Sept. 1881, was ordered to be placed on record.

The death of Robert Briggs, at Dedham, Mass., July 25, 1882, aged about 55, was ordered to be placed on record.

Mr. Lewis read a paper on the Terminal Moraine in Pennsylvania.

Mr. Chase communicated a sixth series of Photodynamic notes.

Mr. Cope described a new synthetic form of Laramie Cretaceous mammal, *Meniscoëssus conquistus*, the first mammal species discovered in the Cretaceous.

Nominations 964–968 were read, and the meeting was adjourned.

Stated Meeting, Oct. 20th, 1882.

Present, 12 members.

Mr. Fraley, President, in the Chair.

Rev. Dr. Robbins was introduced to the presiding officer and took his seat.

Letters of envoy were received from the New Zealand Museum, Howard Coll. Observatory, the N. H. S. at Bamberg, and the Dept. Int. U. S.

A letter acknowledging Proc. No. 109, was received from the Danish S. of Sciences.

A letter from Mr. Jos. D. Weeks, of the Census office, Washington, requesting No. 87, was received.

A letter from Mr. A. Ramsay, office of the Scientific Roll, 7 Red Lion Court, Fleet street, London, requesting exchanges was received, dated Oct. 5th, 1882.

A letter from the "American" was read.

A letter from the Department of the Interior was received, respecting spare copies of the Census Reports of 1860 and 1870.

Donations for the Library were announced from the New Zealand Institute; Sydney Department of Mines; M. Barrande; Aug. Tischner; L. Rütimeyer; the N. H. S., Bamberg; the Gazetta Numismatica, at Como; Revue Politique; Revista Euskara; London Nature, C. W. King and C. Piazzi Smyth; the Massachusetts Historical Society; Harvard College Observatory; N. J. Historical Society; Pennsylvania Historical Society; Journal Medical Sciences; Smithsonian Institution; U. S. Geological and Geographical Survey, Signal Service and Census Bureaus, and Surgeon General's office; University of Virginia; American Journal of Forestry at Cincinnati; American Antiquarian at Chicago; Mexican National Observatory, and a copy of Herrera in four volumes from the library of the late Dr. Allen Voorhees Lesley, of New Castle, Del.

The death of Mr. John Downes at Washington, Sept. 27th, aged 84, was announced by the Secretary.

The death of Dr. Friédrich Wöhler, of Göttingen, Sept. 23d, aged 82, was announced by letter.

Dr. Horatio C. Wood offered for publication in the Transactions a memoir, entitled "On the nature of Diphtheria, a clinical and experimental research, by Drs. H. C. Wood and H. F. Forncad."

On motion it was referred for examination to a committee consisting of Drs. Horn, Ruschenberger and Henry Hartshorne.

Commodore E. Y. McCauley offered for publication in the Transactions a Dictionary of the Egyptian language.

On motion it was referred for examination to a committee consisting of Mr. Lesley, Dr. LeConte, Dr. Robbins and Mr. Phillips.

Prof. I. C. White's communication on the Geology of the Cheat river, in West Virginia, was read by the Secretary.

Prof. C. W. Claypole's notes on the Commingling of fossil forms, the discovery of *Holoptychius Americanus* low in the Chemung, at Leroy, in Bradford Co., Pa., and on a mistake in the Geological map of Bradford Co., were read by the Secretary.

Mr. Lesley described some recent observations of the amount of ice erosion along the crest of the Kittatinny mountain, west of the Delaware Water Gap, by Prof. H. C. Lewis.

Prof. Cope communicated a catalogue of twenty-eight new species entitled "Synopsis of the Vertebrata of the Puerco Eocene epoch," and a paper "On the systematic relations of the Carnivora."

On motion the deficiencies in the set of American Philosophical Society in the library of the Geological Survey of Canada were ordered to be supplied.

On motion of Mr. Phillips the President was requested to prepare a minute of the Bi-Centennial Celebration of the settlement of Pennsylvania, to be embodied in the records of the Society.

Pending nominations Nos. 964 to 968 were read and balloted for, and new nomination No. 968 was read.

On examination of the ballot boxes by the presiding officer, the following were declared duly elected members of the Society:

Charles Rau, M. D., Curator U. S. Museum, Washington.

Garrick Mallery, Lieutenant-Colonel U. S. A.

Hermann Kopp, of Heidelberg University.

Reinhardt Blum, of Heidelberg University.

Gustaf Tschermak, Director Geol. Reichsanstalt, Vienna.

And the meeting was adjourned.

Notes on the Geology of West Virginia. By I. C. White.

(Read before the American Philosophical Society, October 20, 1882.)

The Geology of the Cheat river Cañon along its course through Laurel Hill and Chestnut Ridge, between Albright (near Kingwood), in Preston county, and Ice's Ferry, in Monongalia county.

The material for the present paper has been gradually accumulated on class excursions from the University during the last five years.

Cheat river takes its rise on the summit of that great plateau, near the Randolph-Pocahontas line, from which so many large streams radiate to every point of the compass, the Elk, Greenbrier, James, Potomac, Monongahela and Cheat, all having the source of their principal branches on this plateau at an altitude of more than 3000 feet above the sea.

From this elevated divide, several branches—Dry, Laurel, Globe and Shaver's—flow northward in narrow, parallel valleys, into the southern portion of Tucker county, where meeting Black Fork from the north-east, they unite to form the main Cheat river which with many windings continues its general course almost due north to Albright, the south-eastern limit of the district under examination. Here, however, it veers to the north-west and maintains that general direction for the next twenty-five miles to Ice's Ferry, in Monongalia county, where it again veers north and unites with the Monongahela river just north from the W. Va.-Penna. line.

At Albright, the channel of the river is in the bottom of the syncline between the Viaduct and Laurel Hill axes, and its north-west course for twenty-five miles carries it squarely through Laurel Hill, Chestnut Ridge and the great synclinal plateau between them. Throughout this twenty miles (about twenty-five by the river), Cheat river flows in a wild cañon cut down 1000′–1500′ below the summits of the bordering mountains whose slopes are so rocky and precipitous that but a single human dwelling is in sight along the river, from where one enters the cañon below Albright, until he emerges from it near Ice's Ferry.

The Great Conglomerate, or No. XII, carrying the *Lower Coal Measures* on its top, crowns the steepest portion of the cañon throughout its entire length, and its immense boulders constantly block the narrow channel of the river, thus giving a wildness and grandeur to the scenery unsurpassed anywhere along the course of this famous stream.

But unrivaled as is the scenic beauty of this cañon, it presents still greater attractions for the geologist in the splendid natural exposures of the *Great Conglomerate* and *Sub-carboniferous* rocks that it affords; for under the arches of Laurel and Chestnut Ridges one may find many almost clean exposures from the top of No. XII down nearly to the base of No. X. To place some of these magnificent sections before those interested in Carboniferous geology is the principal object of this paper, and in order to accomplish this systematically we shall begin with the section at Ice's Ferry, and pass south-eastward up the Cheat river to Albright.

At this ferry, the road leading from Morgantown, W. Va., to Uniontown, Pa., crosses the river which, emerging from the cañon of No. XII, one mile above, now flows between low hills of the *Barren measures* with the *Mahoning sandstone* making bold cliffs along the immediate banks

About one-fourth mile above the ferry, a small stream puts into the west bank of Cheat over the Mahoning sandstone cliffs, and descending it from the Morgantown road near Mr. Bayles, the following succession may be seen, Sec. 1:

1.	*Coal (crinoidal)*	1′
2.	Shales, gray	10′
3.	*Shales, red*	25′
4.	Shales and concealed	45′
5.	Shales, brown, sandy	10′
6.	*Coal, Bakerstown*	2′½
7.	Sandy shales and shaly sandstone	50′
8.	*Upper Mahoning sandstone*, very massive and pebbly	30′
9.	Shaly sandstone, intermingled with *slaty coal* and representing *Brush creek coal* of Pennsylvania	3′
10.	Sandy Shales	7′
11.	*Lower Mahoning sandstone*, visible	85′
12.	Concealed to level of Cheat river	10′

No. 1 is the coal which so frequently occurs directly under the *Green Crinoidal limestone* in south-west Pennsylvania and the adjoining regions in West Virginia. It is quite impure and is well exposed at the roadside, some distance north-west from Mr. Bayles'.

No. 3 is the very persistent bed of red, marly shales which so constantly underlie the *Crinoidal limestone* in Pennsylvania and West Virginia, even retaining their place unfailingly in the series when the latter disappears.

The Bakerstown coal, No. 6, occurs along the Morgantown road near the toll-gate at Mr. Bayles', and is of fair quality. I have identified it with the coal bed occurring 100′ below the *Crinoidal limestone,* described as the *Bakerstown coal* in my Report Q, on North Allegheny county, Pennsylvania. These coals of the *Barrens* are of course sporadic and irregular in distribution, and their identification over wide areas would seem at first thought hazardous in the extreme, but as the principal beds always come in at certain well defined stratigraphical horizons there can be less objection to such identification than to a constant multiplication of local names to represent the same geological horizon, hence as the coal in question comes about 100′ below the *Crinoidal limestone,* I have thought it preferable to use the *Bakerstown* name even though the coal marshes in which each was formed may never have been connected with one another.

The Upper Mahoning sandstone, No. 8, is very conglomeratic at this locality, so much so that it was once extensively quarried for mill stones on the opposite side of the river.

The Brush creek coal is feebly represented in the section by a bed of black *coal slate* interstratified with thin layers of sandstone, immediately under the *Upper Mahoning sandstone.*

The Lower Mahoning Sandstone is not pebbly at this locality, and is rather inclined to be flaggy, though some portions of it are quite massive.

The Upper Freeport coal lies about 10′ below the level of Cheat river at the mouth of Bayles' run, where our section ends. On the east bank of the stream, it rises above drainage and was once mined as fuel for the Laurel Iron Works, situated one-half mile below. The coal is reported four feet thick and of good quality.

In passing up the river south-eastward from the ferry, the rocks rise very rapidly toward the *Chestnut Ridge axis,* and the top of No. XII makes its appearance above river level in a massive dam-like wall, just below Mr. Ley's, and not quite a mile above the ferry.

The intervening *Lower Coal Measures* are not well exposed, being concealed by the immense heaps of talus under the cliffs of Mahoning sandstone, but a vertical measurement from the outcrop of the *Upper Freeport coal* where seen along the Bruceton turnpike opposite Mr. Ley's, down to the top of the No. XII Conglomerate makes their thickness 250′. The only *coals* in these measures here are the *Upper Freeport,* and one that comes about 160′ below it, being $1\frac{1}{2}$′–2′ thick, and very excellent coal. It is either the *Middle* or *Lower Kittanning,* most probably the latter.

Continuing on up the river above Mr. Ley's, the rocks rise about 400′–450′ to the mile, and bring the top of the *Mauch Chunk shales* (No. XI) above river level at the mouth of Quarry run, a small stream that empties into the east bank of Cheat, one mile and a half above Ice's Ferry. It cuts a fine exposure through No. XII and in descending to the river along its right bank this section was got, Sec. 2:

1.	Sandstone, massive, *Homewood,* top of XII	25′	Pottsville conglomerate. 177′
2.	Concealed	40′	
3.	Very massive pebbly sandstone	75′	
4.	*Coal* { coal 0′ 10″, sandstone 0′ 3″, coal 0′ 3″ } *Quakertown coal?*	1′ 4″	
5.	Black, slaty shale	10′	
6.	Sandstone, gray, massive	20′	
7.	*Shale with streaks of coal*	1′	
8.	Sandstone, grayish-white, massive, base of No. XII	15′	
9.	Shales, green, containing I. O., top of No. XI	20′	Mauch Chunk Shales. 30′
10.	*Red shales*	10′	
11.	Greenish sandy shales and flaggy sandstone	60′	
12.	Concealed to mouth of old oil well boring	25′	
13.	Flaggy sandstone and shales (Mr. Ley's authority) in oil boring	185′	
14.	*Limestone, Umbral, Mountain, &c*	85′	
15.	Sandstone, (*Vespertine,* No. X) to bottom of hole	700′	

The section of No. XII, obtained at this locality, is quite interesting from the fact that it reveals this series much thinner than it had always been estimated on Cheat river. Owing to the difficulty of finding exposures at the immediate base of No. XII, much of the underlying massive rock in the Mauch Chunk shales has heretofore been included in No. XII on Cheat river, thus giving it a thickness of 300′–350′. The above section shows the true base of No. XII in an unmistakable manner, and shows that this series has a thickness of only 180′ at the locality in question.

The uppermost member, No. I, which corresponds to the *Homewood SS.* of the Penna. Survey reports, is a very massive, grayish-white rock, making a bold cliff around the mountain side, 20 to 30 yards back from No. 3, from which it is separated by a concealed interval of 40′ at this locality. This No. 2 is probably a shale or flaggy sandstone interval and may possibly contain a small coal bed, since the *Mercer series* of Penna. is due in this horizon.

No. 3 is the conglomerate portion of No. XII and is seen in one immense overhanging cliff along the right bank of Quarry run. It is a grayish-white rock, often exhibiting a buffish tinge, and contains many quartz pebbles scattered in layers throughout its mass, being largest and most numerous in the uppermost 25′. None were seen larger than chestnuts.

This stratum would seem to harmonize with the *Upper Connoquenessing sandstone* of the *Conglomerate series* in western Pennsylvania. It is the great cliff rock along the Cheat river cañon.

Immediately below this last stratum, there comes a very interesting little *bed of coal* which is quite persistent for many miles along Cheat river, being generally separated into two layers by a thin sandstone or shale as shown in the section, and always underlain by a thick bed of black, fissile slate. The bed is fully exposed for a distance of 200 yards at the base of the great cliff along Quarry run, and its variations are there beautifully shown. Occasionally the sandstone comes down and cuts it out entirely for a few feet, but it suddenly comes in again at the same horizon. It never gets thicker than 2′ and seems to be quite pure, simulating the "block" coals in physical aspect. Since it appears to come at the same geological horizon as the *Quakertown coal* of Lawrence Co., Pennsylvania. I have doubtfully referred it to that bed.

A diligent search was made in the *black shale,* No. 5, for *fossil plants,* but as yet none have been found except some macerated fragments of *Cordaites.*

Nos. 6–8 seem to represent the *Lower Cornnoquenessing SS.* of Penna.; the older, *Sharon conglomerate,* being in my opinion unrepresented in the section.

In passing from No. XII to the rocks of XI, there is a wonderful change in the lithology of the rocks, the massive, coarse, grayish white beds of

XII being replaced by a green sandy shale which the geologist instantly recognizes as belonging in the subcarboniferous beds. The junction of XII and XI is finely exposed for several rods at this locality, and the former seems to rest with a *slight unconformity* on No. XI. In the top of No. XI, at the horizon of No. 9, occur valuable deposits of *iron ore* all along the Cheat river mountains on each side of Chestnut Ridge, and they were formerly extensively mined and used at the Henry Clay, Laurel, Green Spring and other furnaces. It is known as the "*Swisher*," and "*Mountain*" *ore*, and was mined by both drifting and stripping, the bed sometimes attaining a thickness of 2 feet.

Were there any doubt about No. 9's being the top of XI, No. 10 would resolve it, for *red shale* is a factor unknown in No. XII. This *red bed* seems to hold a constant place in the *Mauch Chunk series* along Cheat river, having been seen at this same horizon in many localities. The section from No. 13 down, was given me by Mr. Ley, who assisted in drilling a well for oil near the mouth of Quarry run. As will be seen from the section, it makes the *Mauch Chunk shale* 300′ thick, and the Mountain Limestone 85′.

No. 15, is very probably not all No. X, but the lower portion doubtless penetrates the *Catskill*, or *Chemung*, if the former be absent as Prof. Stevenson claims.

In passing up Cheat river from the mouth of Quarry run, the rocks rise quite rapidly, and at one-half mile south-east from the locality of the last section, all of the *Mauch Chunk shale*, and nearly half of the *Mountain Limestone* have appeared above water-level, where on the left bank of Cheat, they reveal this succession (Sec. 3):

1. Sandstone, current-bedded	10′	Mauch Chunk Shale.
2. Concealed	15′	
3. Red shale	10′	
4. *Limestone*, fossiliferous, impure	8′	
5. Shales, red and green	15′	
6. Shales, marly	5′	
7. Limestone, grayish-white, massive	25′	Mountain Limestone.
8. Shale, calcareous, very fossiliferous	1′	
9. Limestone, massive, gray, to level of Cheat river (850′ A. T. by Bar)	15′	

This little section is interesting from the fact that it exhibits a structure in the basal portion of the *Mauch Chunk shale*, which is quite common in Fayette and Westmoreland counties. In those counties Prof. Stevenson (see Repts. KK, and KKK 2d Geol. Survey of Pa.), finds *one* and sometimes *two thin limestones* several feet above the base of the *Mauch Chunk shale*, and the same feature is present all along the Cheat river Cañon, as far up as Rowlesburg at least, where I find *three thin limestones* within an interval of 70′ *above the Mountain Limestone*. (See The Virginias for July, 1882.)

The *limestone*, No. 4, of the above section, is quite impure, having a brecciated appearance, and is fossiliferous, *Spirifers* and *Producti* being especially numerous. No. 7 was once extensively quarried at this locality, and used for flux at the old charcoal furnaces near Ice's Ferry. It is quite pure, making a beautiful white lime much valued for plastering purposes. It is possible that some portions of the stone might be successfully employed as a flux in the manufacture of glass.

The thin calcareous shale, No. 8, is a perfect mass of fossils, among which *Allorisma clavata, Hemipronites crassus, Athyris subtilita, A. subquadrata, Spirifer Keokuk, Productus cora,* and *Crinoidal fragments* are most numerous.

Continuing south-eastwards up the river, the rocks still rise with great rapidity, and at one mile and a half above the last locality, only 2½ miles from where the top of No. XII first emerges from the bed of Cheat, we get the following succession in descending the almost vertical wall on the right bank of the river (Sec. 4):

1.	Very massive pebbly sandstone	20′	No. XII. 165′
2.	Concealed	80′	
3.	Sandstone, massive, coarse	20′	
4.	Concealed	45′	
5.	Shales and concealed	20′	Mauch Chunk shale. 295′
6.	*Red shale*	10′	
7.	Sandstone, greenish, current-bedded	165′	
8.	*Red,* and green shales and concealed	50′	
9.	*Limestone,* impure	10′	
10.	Shales, green and red	25′	
11.	Flaggy sandstone and shales	15′	
12.	*Mountain limestone,* in layers 1′–10′ thick separated by thin calcareous shales	95′	
13.	Sandstone, finely laminated, and containing *pebbles of limestone*	10′	No. X. 305′
14.	"Silicious limestone," grayish-white	5′	
15.	Sandstone, flaggy	10′	
16.	Sandstone, massive, pebbly, current-bedded	80′	
17.	Concealed to level of Cheat river (875 A. T.)	200′	

I have placed the base of No. XII in this section, 45′ below the top of the concealed interval, since the band of *red shale,* No. 6, is evidently identical with the one in Sec. 2, which comes 20′ below the base of XII. This gives a thickness of 165′ for the latter at this locality, and since 10′–15′ have been eroded from its top, the group when complete would have about the same thickness as found in Sec. 2 (177′).

The *Mauch Chunk shale* foots up a thickness of 295′ at this locality, which is so near that given by the combined section and boring in Sec. 2 (300′), that the latter figure may be taken as the average thickness of these beds along the Cheat river cañon through Chestnut Ridge and Laurel Hill.

The sandstone in No. 7 gets quite massive at times, and this portion of the column makes a great bluff along either bank of the river, from which the descent to the stream is almost vertical in many places.

As will be seen by comparing the sections, the interval between the *Mountain limestone* and the *10′ impure limestone* above, is in this section just double that in Sec. 3, showing that it is quite variable.

The *Mountain limestone*, No. 12, juts out of the bluff in a great cliff at this point, and was once quarried for flux for the old Henry Clay furnace, situated near the head of Quarry run.

No. 14 seems to be identical with the "Silicious limestone" of Stevenson in Fayette and Westmoreland counties, and is here clearly a portion of No. X, since 10′ of *Pocono* or *Vespertine sandstone* comes above it.

No. 16 is a massive, hard, gray sandstone, containing streaks ot small quartz pebbles, and forming an immense cliff along the mountain side.

About one-fourth mile above the last locality, another section taken on the same (east) bank of Cheat river reveals the following structure (Sec. 5):

1.	Massive sandstone, and conglomerate, making lower half of No. XII	100′	
2.	Concealed	50′	Mauch Chunk shale. 292′
3.	Sandstone, flaggy, and current-bedded	160′	
4.	Layer of breccia	2′	
5.	Concealed and red shale	40′	
6.	*Limestone*, impure	5′	
7.	*Red shale*, and concealed	35′	
8.	*Mountain limestone*, visible	85′	
9.	Concealed	25′	
10.	"*Silicious limestone*,"	10′	No. X 435′
11.	Sandstone, massive, pebbly	100′	
12.	Concealed with flaggy sandstone at base	175′	
13.	Concealed to Cheat river (885′ A. T.)	150′	

This section is but a repetition of the preceding one, with slight variations, the *Silicious limestone* being here 10′ thick instead of 5′. It is a light gray rock, containing possibly 40–50 per cent. of lime, and would make as good pavement blocks as that from Westmoreland Co., so extensively used in Pittsburgh and vicinity.

No. 4 is a curious layer of shale, iron ore, and sandstone pebbles cemented into a matrix of impure limestone.

The rocks still rise quite rapidly south-eastward as we approach the *Chestnut Ridge axis* which crosses Cheat river about one mile and a quarter above the locality of Sec. 5.

About one-half mile south-east from the locality of the last section, a small rivulet falls over the base of No. XII, and completely exposes the beds at the junction of No. XI, with the former, exhibiting the following in descending the steep east bluff of the river (Sec. 6) :

1.	Conglomerate, very massive	100′	No. XII. 180′
2.	Sandstone, coarse, few pebbles	50′	
3.	Shales, sandy, buff, containing some I. O.	20′	
4.	Sandstone, massive, buff	10′	
5.	Shales, yellow, and green, containing I. O.	30′	Mauch Chunk shale. 293′
6.	Sandstone, greenish, somewhat flaggy	140′	
7.	*Layer of breccia,* calcareous	2′	
8.	Sandstone, green, flaggy	20′	
9.	*Layer of breccia,* calcareous	1′	
10.	Shales, red and green	45′	
11.	*Limestone,* impure	10′	
12.	*Red shales,* and flaggy sandstone	45′	
13.	*Mountain limestone*	100′	
14.	"*Silicious limestone,*" and Pocono sandstone	125′	No. X 575′
15.	Concealed to level of Cheat river	450′	

I was at first disposed to place the line between Nos. XII and XI at the base of No. 2 in the above section, but the massive yellowish sandstone, No. 4, so unlike anything usually found in No. XI, determined its base as the true dividing horizon between the two series. This is also confirmed by the thicknesses which result from placing it there, viz.: 180′ for XII and 293′ for XI shales, which are almost exactly the same as found for each in Sec. 2.

The "*Silicious limestone*" is 10′–15′ thick at this locality and as usual passes insensibly into the great sandstone deposit below.

A few rods further south from the last locality another measurement of the beds gave this result (Sec. 7) :

1.	Massive, pebbly sandstone	150′	No. XII. 185′.
2.	Shales and shaly sandstone, buff	35′	
3.	Shales, greenish, sandy	30′	Mauch Chunk Shale. 299′
4.	Sandstone, greenish-gray, flaggy	90′	
5.	*Red and green shales*	12′	
6.	Sandstone, greenish, massive at top, flaggy and shaly below	65′	
7.	*Brecciated limestone*	2′	
8.	*Red and green shales*	25′	
9.	Blue sandy shales, and green flaggy SS.	25′	
10.	*Limestone,* impure, fossiliferous	10′	
11.	Red and green shales and sandstone	40′	
12.	*Mountain Limestone*		

(*a*.) Massive limestone in layers 1′—5′ thick, sparingly fossiliferous	25′	}	110′
(*b*). Shaly limestone and calcareous shales, very fossiliferous, especially rich in *Productus, Spirifer, Athyris, Lophophyllum and Crinoidal columns*	5′		
(*c*). *Limestone*, gray, good, few fossils	45′		
(*d*). Shales and limestone	35′		
13. "*Silicious limestone*," passing gradually into sandstone below	30′	}	No. X. 605.
14. Sandstone, massive, pebbly, current-bedded, making cliffs	100′		
15. Concealed to level of Cheat river	475′		

Here the "*Silicious limestone*" runs down into the underlying sandstone to a depth of 30′ and finally fades into sandstone so imperceptibly that it is impossible to fix the line between the two.

Just above this locality, about one-fourth mile, the *Chestnut Ridge axis* crosses Cheat river, four and a half miles from Ice's Ferry. At the latter locality the top of No XII. is 300′ under the river, while here at the axis its top comes about 1300′ above Cheat river, or 1400′ higher than at Ice's Ferry, since the stream falls nearly 100′ between the two points.

Here, at the crest of the axis, the Great Conglomerate makes a broad and gentle arch, being almost horizontal for nearly a mile and a half. Its outcrop is traversed as usual by great intersecting fissures which are often 3′—4′ wide, and separate the stratum into immense blocks, some of which 50′ on a side, have toppled over into the steeply sloping edge of the cañon, and look from a distance as though a slight push would dislodge them into the great chasm beneath.

The scenery along the crest of this great arch is the grandest and most picturesque to be found on this river, famous for its wildness for a distance of nearly 200 miles. There are two points from which the outlook is especially fine, one of these known as *Hanging Cliff View* is on the east side of the river and about one mile above the locality of the last section. Here the river bends sharply westward and a long, narrow ledge of No. XII. sandstone, extends in a bold cliff far out into the main course of the cañon. From this elevated point, the eye takes in a radius of 25 to 30 miles for nearly three-quarters of the horizon ; to the south-east one looks up through the great gorges carved by the river out of Laurel Hill and Briery mountain, to the vicinity of Rowlesburg (30 miles distant), where on a clear day, the white puffs of steam and smoke from the B. & O. R. R. engines may be distinctly seen, as the heavily laden trains wind up the steep slopes of the Alleghanies to Cranberry Summit, the lofty peaks of whose surrounding mountains loom proudly against the horizon ; to the west and north, the eye has an unobstructed view down the cañon and out over its fast receding walls, to the great plateau of the

Coal Measures, which sculptured into endless forms of hill and dale stretches away to the limit of vision, in delightful contrast to the rugged mountains on the east. Add to this the wild dash of the river as it rushes along over its rocky bed, more than a thousand feet almost vertically below, disappearing in a silver thread far up and down the cañon, and we have a picture enchanting in the extreme.

The other point is Brock's View, named in honor of the late Dr. H. W. Brock, of the W. Va. University, who first discovered the beauties of this portion of the cañon. It is on the opposite side of the river from the Hanging Cliff, nearly one mile below, and is scarcely inferior in grandeur to the latter.

In descending from Hanging Cliff View to the river the following structure is visible (Sec. 8):

1.	Massive conglomerate	75′	No. XII 185′
2.	Concealed to base of XII	110′	
3.	Concealed	190′	Mauch Chunk 300′ Shale.
4.	Shales, red, green, &c., containing an impure limestone just below the centre	100′	
5.	Sandstone, greenish-gray, current-bedded	10′	
6.	*Mountain Limestone*	95′	
7.	Concealed, with occasional showing of limestone and shales	60′	
8.	Concealed to level of Cheat river	425′	

In descending from the same Hanging Cliff to a point one-half mile further up the river, and just below the "Beaver Hole," the following succession was observed (Sec. 9):

1.	Massive conglomerate, visible	65′	No. XII 185′
2.	Concealed to base of No XII	120′	
3.	Concealed	60′	Mauch Chunk 295′ Shale.
4.	Sandstone, green, flaggy	25′	
5.	Concealed, but showing frequent outcrops of green, flaggy sandstone	195′	
6.	Sandstone, green, massive, visible	5′	
7.	Concealed	10′	
8.	*Mountain Limestone*	120′	
9.	"*Silicious Limestone*"	30′	
10.	*Pocono sandstone*, massive and pebbly at top, hard and flaggy below to the level of Cheat river	425′	

The *Mountain Limestone* contains some extensive caverns along Cheat river, and one not far from the locality of this section has been named the *Eagle Cave*, from the fancied resemblance of one of its stalagmitic accumulations to the outspread figure of an eagle. It has been followed into the mountain side for several hundred yards, and those who have explored it, report some extensive rooms in this cavern.

The "Beaver Hole" mentioned above is a locality just above the Hanging Cliff View, where the current of the stream flows around the circumference of a circle about 150 yards in diameter, and is six miles above Ice's Ferry by the river, but probably not more than five in a direct line.

Continuing up the river from this point toward the south-east, the rocks dip rapidly down, and when we come to the mouth of Sandy creek, four miles above the Beaver Hole, the top of No. XII is only 400′ above the level of the stream, instead of 1300′, at the crest of the Chestnut Ridge axis. Here at the mouth of Sandy creek we are in the centre of the great trough or syncline between the Chestnut Ridge and Laurel Hill axes. This syncline enters Preston county from Fayette county, Pa., and extends in a south-west course entirely across Preston. The trough is about seven miles wide (from Chestnut Ridge axis to Laurel Hill axis) on Cheat river, but opens out rapidly south-westward from the dying down of its western rim (Chestnut Ridge axis), so that at the B. & O. R.R., near Independence, its breadth is not far from 12 miles.

The *Lower Coal Measures* shoot into the air on Chestnut ridge, but arching over, come down into this Preston county syncline, with 200 to 300 feet of the *Barrens* on top of them, so that at the mouth of Sandy creek, the *Upper Freeport Coal* comes into the immediate river hills. Sandy creek flows down the centre of the syncline from the east, removing a large portion of the *Barrens*, and near its mouth cutting a wide gap in the *Lower Coal Measures*, and a narrow gorge through No. XII.

In the same way, Bull run flows down the central line of the syncline from the west, emptying into Cheat one-half mile below the mouth of Sandy. It, too, has eroded a large hole from the *Lower Coal Measures*, but on cutting down to No. XII is suddenly arrested, and flows along on its top for nearly a mile until approaching the river, it cuts through the massive beds of that series, in several great cascades, giving splendid exposures of the rocks.

In descending the mountain from Mrs. Spurgeon's (opposite the mouth of Sandy creek), to Bull run, and thence down that stream to Cheat river, the following section (10) was constructed :

1. Upper Mahoning Sandstone, massive, visible..		20′	
2. Concealed (spring at 50′)...................		90′	
3. *Upper Freeport Coal*	coal, slaty.... 1′ 0″	7′	Lower Coal Measures 264′
	coal, good ... 2′ 0″		
	shale......... 0′ 3″		
	coal .... 1′ 6″		
	shale .... 1′ 0″		
	coal, good.... 1′ 6″		
4. Concealed..................................		10′	
5. *Upper Freeport limestone*....................		12′	
6. Concealed..................................		75′	
7. Sandstone, massive, visible (Freeport)........		10′	
8, Concealed..................................		90′	
9. *Coal blossom* (Kittanning Lower).............		—	
10. Shales, containing "kidney" I. O		10′	
11. Concealed and sandy shales..................		50′	

12.	Sandstone, flaggy and massive	30′	No. XII. 194′
13.	Massive sandstone, pebbly	60′	
14.	Very pebbly bed	5′	
15.	Massive sandstone, scattering pebbles	65′	
16.	Shale, dark, containing fossil plants	10′	
17.	*Coal, Quakertown?* { coal 10″, shale 3″, coal 5″ }	1′ 6″	
18.	Fire clay	7′	
19.	Black, fissile slate	15′	
20.	Concealed	90′	
21.	Shales, reddish	35′	
22.	Sandstone, rather massive, greenish	35′	
23.	Concealed, with occasional outcrop of green, flaggy sandstone to level of Cheat river at mouth of Bull run (960 A. T. Bar)	65′	

The structure of the Upper *Freeport coal* and *limestone* as given above. was obtained at a new opening on the road which crosses Bull run above Swindler's mill, and leads southward. The coal has been mined on the land of Mrs. Spurgeon in the immediate line of the section, but the opening had fallen in when I visited the locality, and the coal could not be seen. The coal is pitchy black with resinous lustre, is rather free from pyrite, and has every physical appearance of a good coking coal. The central bench just below the 3″ shale, is not so good as the rest of the bed, being somewhat slaty on the outcrop.

The Upper Freeport limestone is fully exposed in the ravine below the coal, and seems quite pure throughout, being light gray, very compact, and breaking with a sharp clean fracture. It contains a minute, *univalve fossil.*

The basal portion only of the Freeport sandstone (No. 7) is visible; it is a coarse, grayish-white, micaceous sand rock, specked with ferric oxide, and very much resembles the same bed in western Pennsylvania.

The great sand-rocks of No. XII are completely exposed at this locality, and as will be seen from the section contain *no coal* until we come down to the *Quakertown horizon*, the *Homewood sandstone* having merged with the underlying beds, thus shutting out the *Mercer coal and shale series* at this locality, and giving us 160′ of rock in one solid mass.

The little coal bed, No. 17, is identical with that given in Sec. 2, at the mouth of Quarry run, and here, as there, is also double, and underlain by a large bed of *black slate.* The coal is quite pure, and contains much *mineral charcoal.* In the dark shales above it, were seen some fragments of *Cordaites* and *leaves of Lepidodendron.*

In the section at Quarry run, 35′ more of No. XII, principally massive grayish-white sandstones, occur below this coal, but here, on Bull run, everything is concealed at this horizon, and the character of the interven ing rocks can only be conjectured. The topography would make them *shales*, and hence I think it probable that the sand rocks seen at Quarry run are absent here, and that the *black slate*, No. 19, rests immediately upon the *Mauch Chunk beds*, but should it prove otherwise, the base of No. XII would then be found about 30′ below the top of No. 20, thus making the entire thickness of this series 225′ instead of 194′, as given in the section.

The top of the *Mountain Limestone* must lie about 100′ below the level of Cheat river at this locality, where the centre of the syncline crosses.

At the mouth of Sandy creek, a massive, buffish-gray sandstone makes a bold cliff along the water's edge at 975′ A. T. (B), and 220′ below the base of No. XII.

As we pass up the river south-eastwards from the mouth of Sandy, the rocks begin to rise in that direction, and at one mile and a half above, the *Mountain Limestone* has completely emerged from the bed of the river, revealing the following structure along a steep ravine which puts into the west bank of Cheat (Sec. 11):

1.	Gray sandstone, somewhat massive	20′	Mauch Chunk. 220′
2.	Flaggy sandstone and sandy shales	150′	
3.	*Limestone*, impure	10′	
4.	Concealed and green sandy shales	30′	
5.	*Red shale*	10′	
6.	*Limestone*, massive, gray	40′	Mountain Limestone 94
7.	Blue shale and impure limestone	4′	
8.	Shaly *limestone*	5′	
9.	Gray, calcareous shale	2′	
10.	*Limestone* in massive beds, 1′–5′ thick	40′	
11.	Green shale	1′	
12.	Red shale	2′	
13.	*Silicious Limestone.* sandy limestone	2′	8′
	blue limestone, rather pure	4′	
	silicious limestone, passing gradually into sandstone below	2′	
14.	Gray sandstone (Pocono) to level of Cheat	10′	

This section is valuable, because it gives the first complete exposure that we have had between the *Mountain Limestone* and the "*Silicious*" beds, showing them separated here by 3′ of red and green shales, and thus allying the "*Silicious limestone*" more closely with the Pocono SS. into which it passes by insensible gradations.

In continuing on up the river from this locality, the rocks still rise to the southeast, though not much faster than the bed of Cheat, since its fall is very rapid over this portion of its course.

In the vicinity of the "Great Falls," four miles above the mouth of Sandy creek, the west wall of the cañon, capped at top by the sandstone of XII, becomes almost vertical, and give a very complete exposure of the rocks as shown in the following section (No. 12) obtained there :

1.	Flaggy sandstone and concealed	25′	
2.	Massive sandstone, top of *Homewood*	25′	No. XII, 220′
3.	Concealed	90′	
4.	Sandstone, very massive, pebbly	50′	
5.	Sandstone, grayish white, somewhat flaggy	55′	
6.	Green shales	15′	Mauch 295′ Chunk.
7.	Concealed, with blossom of *coal*	10′	
8.	Green shales and sandstone	130′	
9.	Sandstone, somewhat massive	25′	
10.	Greenish, flaggy sandstones	135′	
11.	Limestone and red shale	25′	Mountain 120′ Limestone
12.	Limestone	65′	
13.	Limestone, interstratified with red shale	20′	
14.	Red shale	10′	
15.	"Silicious limestone"	35′	
16.	Sandstone, massive, *Pocono*, to level of Cheat river, at Great Falls (1055′ A. T. Bar)	50′	

No. XII is here 220′ thick, or nearly 50′ greater than at Quarry run in Sec. 2, and it is possible that it should also include the 25′ of flaggy sandstone at the top of the section.

Small chunks of *coal* were seen mingled with other debris in the concealed interval, No. 7, and if they belong there, the bed would be in the *Mauch Chunk shale*, for No. 6, above, is unquestionably Subcarboniferous.

The "*Silicious limestone*" attains a thickness of 35′ at this locality, and even then it is doubtful, if I have carried it down far enough, since 10′–15′ more of the underlying *sandstone* possesses a very *limy* aspect in the great cliff which rises perpendicularly from the river at the Falls. The whole stratum is one solid mass from the top of No. 15 down to river level, the *Silicious limestone*, as well as the sandstone below exhibiting current bedding.

The "Falls" at this locality is a very rapid descent of the river for several rods over the massive portion of the *Pocono sandstone*, the stream descending about 10′ in as many rods.

The following section (13) was obtained about 300 yards above the Falls, in descending a timber chute where the logs in their rapid descent have removed the surface debris from several localities on the west bank of the river :

1.	*Upper Freeport Coal*, reported	7′	
2.	Concealed	200′	
4.	Sandstone, massive, top of XII	50′	No. XII. 225′
5.	Concealed	175′	
6.	*Red shale*	10′	
7.	Sandstone, flaggy greenish	40′	
8.	Sandstone, coarse, buff	3′	
9.	*Red shale with I. O. nodules*	10′	
10.	Sandstone, green, flaggy, visible	50′	
11.	Concealed to level of Cheat river	320′	

The Upper Freeport coal given in this section, has been opened along the road on the land of Mr. Graham, about one mile south-west from the top of the river bluff at No. 3, so that the interval of 200′ between the coal and No. XII, given by the barometer, should very probably be increased by 50′–75′, since the beds decline in that direction (S. W).

As we pass on south-eastward up Cheat river from the Falls, the rocks still continue rising gently for about two miles, when they turn over in the broad arch of Laurel Hill, and descend, carrying the limestones and shales of No. XI below river level, and finally submerging No. XII itself at Albright, in the centre of the trough, where the western bluff of the river reveals the following section (14) of the *Lower Coal measures:*

1.	Sandstone, somewhat massive, Mahoning?	30′
2.	Concealed	55′
3.	Shale, drab	15′
4.	Sandstone	2′
5.	Shale and fireclay	8′
6.	Shale, green, sandy	10′
7.	Sandstone, gray, massive, *Freeport*	30′
8.	Shale, drab	15′
9.	" dark blue	8′
10.	*Coal, Middle Kittanning (Darlington)*	2′-3′
11.	Concealed	5′
12.	Limestone, nodular, (*Johnstown cement bed*)	2′
13.	Concealed	23′
14.	Sandy shale	7′
15.	Sandstone, greenish	13′
16.	Shale, visible	5′
17.	Concealed to level of Cheat river at Albright bridge (1200′ A. T. Bar), and to top of No. XII, here in bed of river	25′
	Total height of section	255

From the thickness of the measures in the above section, it would seem that the *Upper Freeport coal* should be looked for immediately under the base of No. 1, which according to this identification would be the *Lower Mahoning sandstone,* but still it is possible that the *Lower coal measures* are here thicker than usual on Cheat river, and in that event the *Upper Freeport coal* would overshoot the top of this section.

No. 7 is undoubtedly the representative of the *Freeport sandstone* of Pennsylvania, while the coal, No. 10, would seem to be the *Middle Kittanning,* or *Darlington bed* of Western Pennsylvania, if Mr. Franklin Platt's identification of the latter with the coal overlying the *Johnstown cement bed* be correct; for the coal in question is here underlain by a grayish, nodular limestone that would well represent the "*cement bed.*"

The coal is quite good and has been gouged out of the hill to the depth of a few feet for more than one-half mile in the vicinity of Albright's bridge, its rapid dip into the hill preventing systematic mining.

Just above the bridge, the *Homewood sandstone* rises from the bed of the river and makes a bold cliff along its north-eastern bank, revealing under it a small *coal bed* beneath a few feet of shales.

On above this to the south-east, the other members of No. XII. come up, and make the steep north-west slope of Briery mountain.

I shall close this paper with a single suggestion in regard to the parallelism of the beds along the Cheat river that I have included under the name *Mauch Chunk shale.*

A review of the sections will show that this interval, extending from the base of XII down to the top of the *Mountain Limestone,* has a thickness of about 300′, and can be subdivided into three well marked groups: 1st, at top, a *shale interval* often containing *iron ore* and one or more thin *red beds,* thickness 30′—50′; 2d, a series of flaggy, green sandstones, often having a quite massive bed near the top, and sometimes containing *calcareous bands* 1′–2′ thick, thickness 165′; 3d, a series of red and green shales in which usually occur one or more thin beds of impure limestone, thickness down to the main mass of *Mountain Limestone,* 80′–100′.

Those who have read my summary of the Geology of Crawford and Erie counties, Pa., in Report Q[4], will recall that I there show the "Cuyahoga shale," of Dr. Newberry to be a very composite series, having a structure somewhat as follows, beginning with the base of XII, and descending to the *Berea Grit* (Corry sandstone):

Shenango shales	35′–50′
Shenango sandstone	25′
Meadville Upper shales	20′
" " Limestone	1′
" Lower shales	45′–55′
Sharpsville Upper sandstone	50′
Meadville Lower limestone	2′
Sharpsville Lower sandstone	12′
Orangeville shales	75′
Berea Grit	—
Total average thickness about	280′

The above succession, I have traced southward from Crawford county to the mouth of the Beaver river at the Ohio, more than half way to Cheat river, and in oil borings at Beaver falls, Smith's ferry and other localities, the series is still 270′–280′ thick.

As is well known, the geologists of the 2d Geological Survey of Pennsylvania, who have studied the *Sub-conglomerate measures* in the western counties, have all heretofore placed the dividing line between XI and X, in the *Shenango shales,* and regarded the massive sandstone below them as the beginning of the *Pocono.*

It will be seen at a glance that the "Mauch Chunk shale," interval on

Cheat river has a striking stratigraphical resemblance to the "Cuyahoga series" in Western Pennsylvania, a shale interval at top and bottom with an intervening sandstone interval—Shenango—Sharpsville Lower—of practically the same thickness in each case. The query here suggested is, can the "*Mauch Chunk shale*" interval, 300′ thick on Cheat river in Monongalia and Preston counties, be identical with the "*Cuyahoga shale*" series as given above from the Ohio line counties in Pennsylvania? The answer is yet quite doubtful, but the only evidence obtained at present, seems to point to an affirmative reply.

Stratigraphy gives an answer decidedly in the affirmative, for the succession in each case is practically the same, and yet we must not forget that the nearest points to which the series have been traced—mouths of Beaver and Cheat rivers—are separated by some 60 miles, in which these beds are buried from sight by the overlying Coal Measures. It should be stated, however, that the lithology of the 165′ sandstone series on Cheat river is often strikingly like that of the *Sharpsville beds* in Pennsylvania, and also that it sometimes contains, near its top, a massive brown sandstone that would correlate well with the *Shenango SS.*

But what say the *fossils* to this supposed parallelism?

On Cheat the "*Mauch Chunk beds*" are not fossiliferous, so that we cannot compare them directly in this respect.

The "*Cuyahoga*" *beds* are often quite fossiliferous, however, and the evidence that they furnish is curious, as showing an apparent contradiction in the answer to our query given by two classes of organisms—*Mollusks* and *Fishes.*

The *Meadville limestones* in the "*Cuyahoga*" *beds* are, in Crawford county, filled with *remains of fishes, scales, bones, teeth, dermal structures,* &c., and in the Spring of 1880 I sent some of these fossils to Prof. Worthen, the eminent Palicthyologist of Illinois, for his opinion as to their geological horizon. He replied that they seemed to him to belong unquestionably with the *fish beds* of the *Chester limestone* at the west, and I should add that this remark of Prof. Worthen first suggested to me the possibility of an identity between the "*Mauch Chunk shales*" of Cheat river, and the "*Cuyahoga*" *series.*

The *Molluscan remains* found in the "*Cuyahoga*" *series,* however, seem to ally them more closely with the *Waverly sandstones* (Pocono), which underlie the shales and limestones of No. XI, and in my Report on Crawford and Erie preference was given to their side of the story. It now seems possible, as suggested above, that the testimony of the *Fishes* may yet have to be received in preference to that of their more lowly cousins, the *mollusks,* and the "*Cuyahoga shales*" of Newberry, relegated to the horizon of No. XI, where they were long ago placed by Prof. Lesley on general stratigraphical grounds (see his scheme of Ohio and Pennsylvania formations correlated in Report I, 2nd Geo'l Sur. Pa.).

The apparent contradiction in the evidence given by the two classes of organisms may be satisfactorily explained, when it is remembered that the open sea in which the great Mountain Limestone of Cheat river—the Chester, St. Louis, and other beds of the West—accumulated, shoaled away to a beach line of muddy shallows in Eastern Ohio and Western Pennsylvania, similar in every respect to the *Waverly* and *Pocono* beaches that had preceded them, and consequently we should expect to find the life forms that had inhabited the latter, continuing on with but slight changes up into the edges of the Mauch Chunk series, where, overlapping the *Mountain Limestone*, it practically continued the Pocono beaches on to the close of the Subcarboniferous epoch.

Stated Meeting, November 3, 1882.

Present, 12 members.

Vice-President, Dr. Le Conte, in the Chair.

Letters accepting membership were received from C. Rau, dated Smithsonian Institution, Washington, Oct. 25, and from Garrick Mallery, Bureau of Ethnology, Smithsonian Institution, Oct. 28.

Letters of acknowledgment were received from Thomas C. Porter, Easton (111); and the Smithsonian Institution, Washington (110,111).

A circular letter was received from the Department of the Interior, dated Oct. 26.

Donations for the Library were received from the Zoölogischer Anzeiger, Leipsig; Academy at Brussels; Geographical Society, Paris; London Nature; Canadian Naturalist, Montreal; American Academy of Arts and Sciences; American Journal, New Haven; N. Y. Meteorological Observatory at Central Park; Franklin Institute, Philada.; Hon. Thomas H. Dudley, Camden; Signal Service Bureau and U. S. Engineer Department, Washington; and the Chapultepec Observatory, Mexico.

An obituary notice of Ralph Waldo Emerson was read by Rev. C. G. Ames.

The death of C. G. N. David, Ph.D., was announced from the Royal Danish Academy, Copenhagen. [No date or age given.]

The death of Mr. B. V. Marsh, at Burlington, on Oct. 30, aged 62, was announced.

The Committee on Com. McCauley's Memoir, reported progress.

The Committee on Dr. Wood's Memoir, reported progress.

Mr. Lesley exhibited some of the recent publications of the Second Geological Survey of Pennsylvania, and showed how near completion it now is.

The Minute, written by the President, at the request of the Society, at its last meeting, was read.

In accordance with the resolution adopted at the last meeting, the President presented the following for entry on the Minutes:—

The two hundredth anniversary of the founding of Pennsylvania was celebrated during the week ending October 28th, 1882.

The exercises and exhibitions were of a character to recall the scenes of the arrival of the Founder, his dealings with the aboriginal inhabitants, his offers to first settlers, and the enactment of his great laws for securing liberty of conscience, equality of civil rights, and the regular and impartial administration of justice.

To these were added civic displays showing the ancient and present forms of civilization that had existed and now mark the condition of our noble Commonwealth, and illustrate its present state of population, wealth, diversity of employments, manufactures, general resources, and the numerous forms in which society is divided for the promotion of benevolence, temperance, charity, and social enjoyment.

The closing displays were of the military organizations in which the defenders of the Union in the late civil war participated in large numbers and by the union of those representatives of the past with the representatives of the present in organizations for the defence of the country, for the protection of the people and for the general welfare of the republic, was seen the admirable working of our American systems of military provisions.

The celebration was a great jubilee participated in by immense numbers of the citizens of Pennsylvania and cordial sympatizing visitors from other States, and it will distinctly and vividly mark a great epoch in our history.

From the handful of settlers that landed with Penn, the population of the State has swelled to four millions and one-half of people, and that of the City of Philadelphia to one million.

Of all the history of State and City we may be justly proud, for the foundations on which it was built have been preserved and strengthened.

Of this vast growth our Society has been the living witness, for it was founded only sixty years after the landing of William Penn; and it is fitting that in addition to the full accounts that will be given by chroniclers of this great event and which will form part of our library, this brief notice of it should constitute part of our Minutes.

Pending nomination No. 969 and new nominations Nos. 970 to 976 were read.

And the meeting was adjourned.

Obituary Notice of Ralph Waldo Emerson. By Charles G. Ames.

(Read before the American Philosophical Society, Nov. 3, 1882.)

Ralph Waldo Emerson, whose name has honored the records of this Society since 1868, was born in Boston, May 25, 1803, and died in Concord, Mass., April 28, 1882. Of mixed Puritan and Huguenot ancestry, he brought into the 19th century the essences rather than the forms of Calvinistic creed and culture; and grew up as the handsome flower of a sturdy stock. His being was like a retort into which many generations of thoughtful piety had been distilled; for never was a clearer case of hereditary marking than in his tendency to the independent pursuit of high and sober studies. He had the physical make-up of a student, with just enough of healthy muscular development to furnish sheathing for a nervous structure of extraordinary fineness and vigor.

Of how many New England lads, in the early part of this century, may the same story be told: Graduating from Harvard at 18, then teaching for a while, then settling to the study of divinity. Already familiar with Plato and Montaigne, whose mixed coloring matter had passed into his blood, the lad was yet fond of Augustine, Pascal, and Jeremy Taylor. He had also come in contact with the free devoutness and benevolence of Dr. Channing, and had yielded to the spell of Wordsworth and Coleridge. A little later he was to feel the powerful influence of Carlyle and Goethe.

In 1826 he began to preach; in 1829 he was ordained and installed minister of a Unitarian Church in Boston. His sermons struck the dominant note of all his later thinking and writing, their evident purpose being to induce in each hearer the assurance of "life in himself." It was this intensity of faith in the intimate relations of each human spirit to the Divine, along with a clear perception of religious symbolism in all facts, that made traditional outward observances at first a matter of indifference, and then of oppressive unreality. In three years and a half, his pastoral relations were amicably dissolved, because he had reached conclusions essentially like those of the Society of Friends concerning the valuelessness of the ordinances.

The strain of these experiences was severe; but the liberty which now came to him was utilized to the advantage of mind and body by a voyage to Europe, which brought him to personal acquaintance with the eminent men whose genius had already lighted his way. On his return he established himself for life in the quiet rural village of Concord, and entered on a ministry for which no pulpit then seemed large or free enough—a ministry which, running through forty-eight years, to his death, gradually found through press and lecture platform its own fit audience; small at first, but, as the event has proved, sufficient to put him in vital connection with the mind of the world.

Carlyle, whose wine had not yet turned to vinegar, was then putting forth his testimony in England, with a limited hearing. He, as well as the American public, was indebted to Emerson for the reproduction of "Sartor Resartus" and a volume of "Critical and Miscellaneous Essays" on this side the water. Coleridge and Carlyle had inoculated the English mind with the nobler German literature; Emerson was one of those through whom it passed to America; and to many an ingenuous youth it was like the discovery of new worlds.

But no imported mental fertilizer has proved more effective than the native product. Emerson himself has probably influenced our ways of thought and feeling and expression quite as much as any man of the century; and all this without the arts or qualities of popularity, and even in spite of multitudinous protests. The semi-mystic quality of his thought predisposed him to sympathize with the subtle spirituality of Plato and the great Germans; and the New England mind, weary of the old mechanical theories of creation and revelation, was ripe for revolution. Transcendentalism, which is a wholesale believing, came in good time to save us from wholesale denials. Mr. Geo. W. Cooke describes this movement as "an attempt of the human mind to recover a natural and assured faith in moral things." This faith finds due warrant in our direct original perception of spiritual realities, by a power which transcends the senses—a power which is proper to all men, and which is our share in that universal and absolute Reason out of which flows the whole order of the universe.

The practical applications of such a philosophy are endless. Creation being an expression of the Infinite Intelligence, poetry finds its divine justification and rises into a hymn. Nature appears as a mirror of mind, and all her laws and secrets correspond to our clearest inward discoveries, so that science becomes a parable. And as reason is one thing in all men, all men become ministers to each other's completeness. What Emerson has to say of Personal Conduct and Social Aims comes to this: That, as it takes all sorts of men to make a world, each one of us can best contribute to the perfect result by giving full scope to all that properly belongs to himself. Be a brick and there will be a place for you in the wall. Every man, like every grain of sand, is a theatre for the play of all the powers and laws of the Kosmos. To distrust yourself is atheism; to despise your neighbor is blasphemy; to help yourself to all the benefits the universe offers—through nature, books, society, solitude, industry and repose—is only to come into your inheritance, and is therefore the true method of culture. Disorder, misery, chaos, perdition—they all come from inward defect and non-fidelity.

All this, and the system of thought to which it belongs, may seem tame and trite enough now, but it sounded strange and heretical a half century ago. It was indeed a republication of the best thought of earlier ages; but it was foreign to the common literature and the current religion.

In 1837, Emerson gave his address on "The American Scholar," before the Phi Beta Kappa Society of Harvard. Mr. Alcott tells us that it was heard with delight by some, but with confusion and consternation by others; or, as James Russell Lowell says, with "enthusiasm of approval and grim silence of foregone dissent." Yet it does not now strike us as dangerous doctrine to teach that America ought not to depend on imported ideas but should produce her own scholars, and that these should seek truth and reality from original sources. We are no longer scared if a bold thinker declares that truth should spring out of the earth whereon *we* tread, and that righteousness should look down from the heavens that bend over *our* heads, as well as from the soil and skies of ancient Palestine. Nor is it any longer an unsavory and *outré* discourse which teaches that character is the end and aim of all truth and all discipline. It is almost startling to consider how lightly and cheaply, and as matters of course, we hold certain grand truths which make our common daylight, but which to former times were like unrisen stars. A knowledge of the inward world has grown with a knowledge of the outward world.

> "Few mortal feet these loftier heights had gained
> Whence the wide realms of Nature we descry;
> In vain their eyes our longing fathers strained,
> To scan with wondering gaze the summits high
> That far beneath their children's footpaths lie."

It is not important to determine Emerson's relation to metaphysical systems. He was neither ignorant of them nor fond of them, being very shy of finalities. But in his attempt at simple and large statement, he seems to have incorporated the best results of other men's thinking.

There are passages in Mr. Emerson's writings which strongly arraign what he once called "this mountainous folly of Church and State;" but this is only his fine scorn of sham and make-believe. He is never violent against institutions ; he honors their real merits and services ; but he trusts wholly to vital energies for improvements and reconstructions.

The total effect of his work has been to disclose our undeveloped resources, to make us aware that we are born to an inheritance of infinite richness, and that no man need hesitate to avail himself of all the advantages which the universe offers. At the same time, his writings operate as a continual rebuke of self-consciousness, cowardice, cupidity, weak indulgence and pretence. To read Emerson *sympathetically* is to be enlarged, liberated, shamed out of mean, self-regard, and lifted into universal fellowships.

Not the least notable trait is a certain comprehensiveness, nurtured by his philosophy. His writings abound in allusions which show his mental omnivorousness, his quick sympathy with the thought of all ages and times, his hospitality to "many men of many minds," his ability to grasp and reconcile contrarieties, and the ease with which he found a place for all sorts of facts. Revelling in the abstruse, and living much on the mountain-top where he could catch and report downward to mortals the wandering whispers of the upper air, he yet joined with Bacon in honoring "the studies that are for delight, for ornament, and for ability," and held in high appreciation the men of affairs and the masters of action.

A tone of playfulness testifies to the health of his spirit. There is no trace of moodiness or indigestion in his writings, no sour eructations, no narcotized imaginings, no sore-headedness nor skin-blotches, nor any sign of the itch for praise. He makes it easier to believe in miracles of healing : virtue goes out of him for the driving away of sad and surly humors and the rectifying of small insanities.

The material of his poetry is too much like that of his prose to address a different class of minds. The ideas of his essays set themselves to music and mount on wings. Nature supplies imagery and vehicle ; for in nature, as in God, he lived and moved and had his being. There is a subtle, never-dying charm in this clear-obscure where earth and heaven meet. The verse, whose theme flames up toward the infinite, yet smells of the soil and the breath of kine ; it smacks of tree-sap and sea-salt ; the country-brook glides into the lines ; one hears the wind-harp and the bird-song ; the "dedicated blocks" of granite build the mountain into an altar from whose top the cloud-rack flows like incense. And nothing goes on in leaf or shell, in chemic eddies or solemn march of constellations, in the little life of the insect or the grand sweeps of history, but lo ! these are parts of the ways of the all-perfect Over-Soul—the mystery ever disclosed yet ever hidden.

Many random readers receive the impression that there is nothing like unity or method in Emerson's mind ; that his works are but a heap of brilliant, unrelated fragments. True, he lacks literary unity, and is careless of logical construction ; and he despises the charge of inconsistency as "the bugbear of little minds." But once grasp his larger meanings, or look from his central point of view, and his thought appears as whole as the globe or the solar system. It would not be easy to find a leading author whose mental products are more coherent or who is so free from self-contradictions. He is indeed at no more pains to protect himself from the *imputation* of contradiction than is a photographer who shifts his camera to secure a dozen views of the same landscape. If the pictures tell different stories, that is no affair of his: let nature look to it!

Emerson is said to have pleased himself with the "hope of a world in which we shall see things but once, and then pass on to something new." I construe this extravaganza, not as the sign of a mad love of novelty, but as a rebuke to mental inhospitality, as the expression of his strong faith that all facts and truths must agree, and that the universe can supply inexhaustible variety without danger of falling back into chaos.

With all his high soarings, he was at home on the ground, and astonished his friends by his practicalness and aptness for business. His occasional deliverances on public affairs were clear and weighty. One who sat with him on the Board of Overseers of Harvard University, says that his judgment was as much "waited for" as that of any other member. Another testifies that his discretion in regard to investments in stocks, etc., was quite equal to his ability as a writer and thinker.

It would indeed be possible to gather out of his ten volumes an excellent body of maxims for every day use, shrewd, pithy, and full of motherwit. But his claim to our grateful respect rests on far higher grounds. He was not merely virtuous; he was virtue itself; and he taught to all men its open secret. And he has illustrated in life-size, the close-blending of high intelligence with high excellence. In his writings and in himself, the ethical quality is inseparable from thought. He never puts it on, he never puts it off—a sore puzzle to those who judge of possession by profession, or who think of the Holy Ghost as an occasional visitor, and not as a permanent resident in the human temple.

One who knew him long ago and later, says he gave the impression of a humble listener and learner. This tells the whole story of his greatness. For such an attitude implies neither empty narrowness nor idle passivity. To be, as he was, in sympathetic relations with the thoughts of mankind in all ages, and yet to lie open, as he did, to the teachings of primal reality—passionless, unprepossessed and unprejudiced—requires not only fine susceptibility, but a mind of great breadth and power. But his activity is easy and unconscious to himself; his faculties play like the strings of an æolian harp, because they are played on by invisible power. One result appears in the impersonal quality of this work. He never attacks and never defends. He searches defects and exposes error as the light does. He criticises, not by analysis, but by insight; like his own humble-bee, he simply leaves the chaff and takes the wheat. This mental process implies great labor-saving. What need to handle over and over the crude mass of facts and phenomena, when one can directly seize their essence and meaning, as the evening wind seizes the fragrance of a whole meadow full of flowers, without disturbing root, stalk or petal?

I believe the first appearance of Mr. Emerson's name in the Proceedings of this Society, since his election to membership, is in the announcement of his death. But he was one of the few Americans who have deservedly gained the name of a philosopher, in both its original and its acquired sense. A lover of wisdom, he also searches with keen insight behind phenomena into the mystery of causation and the unity of law; and he converts all knowledge into value by showing its uses in the production and perfecting of the ideal life. "To live with the gods" and "to keep the divinity within us free from harm," was the lofty aspiration of ancient wisdom; and "the science of living" has not yet advanced beyond these maxims of the Stoics, which seem identical in purpose with the Hebrew and Christian ideal of a pure heart and a life fashioned in the image of the Highest. Though our great good friend has not wrought as an organizer of knowledge, he has accomplished the larger work of profoundly stimulating the human mind and turning it to noble pursuits; and he has illuminated the whole field of research. Structure in his view was always inferior to function, and function to purpose or spirit. As an interviewer of nature and of the soul, his office was to report—to interpret the universe to man, and man to himself. In all this there are no finalities; since, as J. S. Mill remarks, "On all great subjects there is always something more to be said." But many a coming seer will find a fountain of light for cleansing his eyes from earth-dust in the rays that stream from the mind of Ralph Waldo Emerson.

Stated Meeting, Nov. 17, 1882.

Present, 9 members.

Vice-President, Mr. PRICE, in the Chair.

Letters of acknowledgment were received from the Royal Society, Upsal (xv., 3; 104–108); Swiss Society of Natural Science (107, 108); Society of Physics and Natural History, Geneva (xv., 3; 106–108; List of Members); Royal Society of London (xv., 3; 107–109); and Cincinnati Observatory (65–80, 88, 92, 107, 110).

Letters of Envoy were received from the Royal Academy of Stockholm; Royal Society of Upsal, dated June 15, 1882;

Hungarian Academy, Buda Pest; Imperial Academy, Vienna, July 16, 1882; Royal Prussian Academy, Berlin, June, 1882; Society of Natural Science, Marburg, April, 1882; Swiss Natural Science Society; Royal National Library in Florence, March 24, 1880; Holland Society, Harlem, June 3, 1882; Fondation Teyler, Harlem; Meteorological Office, London, October, 1882; and Royal Observatory, Greenwich, November, 1882.

Donations for the Library were received from the Academies at Stockholm, Buda Pest, Vienna, Berlin, Modena and Dublin; the Observatories at St. Petersburg, Stockholm and Greenwich; Royal Society, Upsal; Société Hollandaise, and the Musée Teyler, Harlem; Royal Geographical Society, Royal Geological Committee and Anthropological Society, Vienna; German Geological Society, Berlin; Prof. G. D. E. Weyer, Kiel; the Societies at Bremen, Marburg, Leipsig, Görlitz, Freiburg i B., Lansanne and Geneva; Swiss Natural Science Society; Royal Venetian Institute; Royal National Library, Florence; M. Georges Edon, Paris; Royal Society, and Meteorological, Geographical, Geological, Linnean, Zoological, and Royal Asiatic Societies, London; Meteorological Committee, and Nature, London; American Academy of Arts and Sciences; Boston Natural History Society; American Journal of Pharmacy; Dr. D. G. Brinton, and Dr. E. W. Syle, Philadelphia; American Journal of Mathematics, Baltimore; and the National Museum of Mexico.

A letter was received from the Colonial Museum of New Zealand stating that they had received nothing from this Society since 1871.

The death of C. Arfwedson, of Sweden, was announced.

The Committee to whom was referred the Egyptian Vocabulary of Commodore McCauley reported in favor of its publication in the Transactions. The subject was referred to the Publication Committee.

The Committee to whom was referred the "Researches on Diphtheria" by Drs. Wood and Formad, reported in favor of its publication in the Transactions. The subject was referred to the Publication Committee.

The minutes of the last meeting of the Board of Officers and Council were read.

Pending nominations Nos. 969 to 976 were read and the meeting was adjourned.

Stated Meeting, Dec. 1, 1882.

Present, 11 members.

President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Prof. Hermann Kopp, dated Heidelberg, Nov. 7, 1882.

A letter of envoy was received from the Museum of Comparative Zoölogy, Cambridge, Mass.

A letter of acknowledgment (XIV, 2; 62, 97), and envoy was received from the Société de Géographie, dated 184 Boulevard, St. Germain, Paris, Nov. 13, 1882.

A letter requesting exchange of publications was received from the U. S. Naval Institute, Annapolis, Md., Nov. 21, 1882. On motion, it was resolved that the U. S. N. Institute be placed on the list of corresponding societies to receive the Proceedings.

Donations for the Library were received from the Department of Mining, Melbourne; Royal Museum of Natural History, Bruxelles; Revista Euskara; London Nature; Canadian Naturalist; Museum of Comparative Zoölogy; Meteorological Observatory of New York; Franklin Institute; Prof. E. D. Cope; American Chemical Journal; U. S. Naval Institute; U. S. National Museum and the Light House Board, Washington.

The death of Prof. Henry Draper at New York, November 20, aged 45, was announced. On motion, Professor Barker was requested to prepare a minute of Professor Draper's death for the Proceedings of the Society.

Mr. Lesley made some remarks on the Egyptian character of certain Hebrew names:

Mr. Lesley first described the history of the *user*, or Jackal-headed staff, representing victory, from it first appearance in the 4th to its habitual use in the 12th and 19th dynasties, in royal names; especially remarking on the form *User-n-ra* of the 5th dynasty. This name corresponds to the Hebrew name *Israel*, spelled ISR·AL, which an Egyptian would express by the hieroglyphic USR·RA. The origin of the personal name is given in the well known Scripture legend of Jacob wrestling with and prevailing over a mysterious visitor, in the night preceding his momentous interview with his brother Esau. This name, *Esau* (עֵשָׂו, ôsu), Mr. Lesley identified with the Edomite *Shasu*, who successfully invaded Egypt at the beginning of the 19th dynasty, but were the principal foreign enemies of Egypt on the east for some centuries earlier.

The Publication Committee reported that they had resolved that Commodore McCaulay's Egyptian Vocabulary be placed in the hands of the lithographer, to be printed as soon as practicable.

The annual report of the Treasurer was read.

Mr. Phillips, for the Special Committee appointed to examine the documents belonging to the Society, reported the following results of the investigations of that Committee:

1st. An Ordinance of Gov. John Evans creating Court of Equity, and giving certain powers to Courts of Common Pleas to hold special Courts to aid persons about to leave Commonwealth, of date Feb. 22, 1706.

No. 2. Letter of Attorney by William Penn, appointing Thos. Loyd his attorney, and memorandum in Penn's handwriting on back, dated June 6, 1684.

No. 3. Assignment of Mortgage, by Thomas and Richard Penn, dated Oct. 2, 1765.

No. 4. Charter of Chester signed by William Penn, dated Oct. 31, 1701.

No. 5. Charter of Privileges by Wm. Penn to Penna. 31st, 8 mo. 1701.

It is recommended by your Committee that the above valuable original papers be placed in the vaults of the Fidelity Insurance Company, with other property there, to be endorsed "Original Penn Papers."

No. 6. Printed report of order of business as settled by order of 1841. It is recommended that all except two copies be destroyed, the others preserved by the Librarian.

No. 7. Geological treatise in German with plates. It is recommended that they be bound and placed in Library.

No. 8. Distribution Book of Proceedings of American Philosophical Society. Recommended to be placed in Library.

No. 9. Communication from Mr. Duponceau with regard to History of the Society of 1841. Recommended that they be bound and placed in Library.

No. 10. Map of New Sweden. To be mounted.

No. 11. Plan for unknown of buildings. To be placed in Library.

No. 12. Duponceau manuscripts on international law. To be bound and placed in Library.

No. 13. Deed by John Fitch, Feb. 9, 1787, and others creating Steamboat Company. To be placed in vaults.

No. 14. 1769 Commission of Thomas Penn. Richard Penn to Edward Physick, appointing him Keeper of Great Seal. To be placed in vaults.

No. 15. Manuscripts relating to the Centennial of Society in 1841, also certain communications, &c. If these have not been printed to be bound.

No. 16. Subscription book to relieve the Society from Indebtedness of date of Jan., 1846. It is recommended to be placed in archives of Society.

No. 17. *a.* Two bank books of 1831 and 1849.
b. Lists of 1826, 1831, 1842 and 1846.
c. Four minutes of committees to be consolidated.
d. Stub of check book.
e. An account of Treasurer, old receipts of books from Library.
f. Lot of old account books.
It is recommended that the above be boxed up and placed in the Library.

No. 18. Package of letters of Peter Collinson to various persons.
These, if possible, to be repaired and bound, and for the present to be in the Safe Deposit.

No. 19. Copy of Definite treaty between Great Britain and United States, A. D. 1783. To be bound.

No. 20. Copy of proclamation giving prices for scalps. To be mounted.

No. 21. Letters to and from Benjamin Franklin. To be bound and indexed.

No. 22. Lot of old Diplomas not delivered. To be sent to lineal descendants if found.

No. 23. Lot of receipts taken by Franklin in France for advances. To be bound.

No. 24. Invitation to Dr. Franklin to attend a Masonic Lodge des Neuf Soeurs supper, signed by De Gebelin. To be bound.

No. 25. Printed invitations and notices to Benjamin Franklin when in France. To be bound.

No. 26. Correspondence of Benj. Franklin. To be bound.

No. 27. Various old shop cards to be mounted in scrap book.

No. 28. Sundry printed papers relating to Revolution. To be bound.

No. 29. Letter of Benj. Franklin with regard to non-importation agreement of 1770 to Humphrey Marshall. To be placed with Franklin papers.

No. 30. Letters with regard to pictures of Franklin.

No. 31. Old Catalogue of Donations. To be preserved.

No. 32. Certificates of membership in Sons of St. George of John Vaughn. To be given to relatives.

No. 33. Certain Bank notes of John Law's Bank to be placed in a scrap book.

No. 34. Certain memorandums of Heckwelder with regard to Indians. To be preserved.

No. 35. Accounts of prices with regard to building of Hall of Society. To be bound if possible.

No. 36. Accounts with regard to Society. To be bound.

No. 37. Letters and Accounts with regard to Society. To be bound.

No. 38. Communications from Lymes with regard to the hollowness of the earth. To be bound.

No. 39. A variety of old vouchers, manuscript catalogue and Treasurer's Accounts. To be boxed up.

On motion, the recommendations of the Committee were adopted, and the Committee empowered to carry their recommendations into effect.

After an informal interchange of views respecting the practicability of proceeding with the printing of the last part of the Catalogue, and of commencing the printing of the early records of the Society, the meeting was adjourned.

Stated Meeting, December 15, 1882.

Present, 9 members.

Dr. BRINTON in the Chair.

Letters accepting membership were received from G. Tschermak, Director of the Mineralogical Institute, dated XI Maximilian platz 15, Vienna; and from F. Reinhard Blum, dated Heidelberg, Nov. 20, 1882.

Donations for the Library were received from the Trustees of the Indian Museum at Calcutta; the Royal Academies at Munich and Brussels; the Zoologischer Anzeiger; the Batavian Society; the Royal Library at the Hague; the Royal Museum at Brussels; Dr. L. G. DeKoninck, of Liége; the Geographical Societies at Paris and Bordeaux; the Revue Politique; the Royal Astronomical Society, Lords Commissioners of the Admiralty, and Nature, London; Harvard College Observatory; American Journal of Science; Mr. Henry Whitall, Philadelphia; the U. S. Signal Service Bureau, and Fish Commission, and a copy of Lieut.-Com. Gorringe's illustrated book on the Obelisk, from Dr. Persifor Frazer, Philadelphia.

Dr. Frazer read a communication on "The horizon of the South Valley Hill Rocks in Pennsylvania."

Prof. Cope communicated a paper "On the Brains of the Eocene Mammalia: *Theocodus* and *Pteryptichus*," with two octavo plates.

Pending nominations 969 to 976, and new nominations 977 to 980, were read.

And the meeting was adjourned.

The Horizon of the South Valley Hill Rocks in Pennsylvania. By Dr. Persifor Frazer.

(Read before the American Philosophical Society, December 15, 1882.)

The regions of the State in which the above rocks occur having been independently studied by different observers, their labors have been brought to contact, and it is found that a difference of theory almost as old as geological investigation in this country, exists in the respective views of the workers.

The substance of one of these theories has just been issued in the Report C_6, of the Second Geological Survey Reports, of which the subject is, "Philadelphia County and the southern parts of Montgomery and Bucks, by Mr. Charles E. Hall." *

The first argument advanced to prove the formation of the schists of the South Valley Hill subsequently to the Chester limestone is, that all the dips of the latter are southward or under the former. That this is so in the majority of cases (though with dips differing both in direction and intensity), is undoubtedly true, but there are exceptions to this rule in Sadsbury, Caln, East Caln, West Whiteland, East Whiteland and Tredyfrin; in other words, in six out of the seven townships in which this contact occurs in Chester county. [See table on page 108 of Memoir on the Geology of S. E. Pennsylvania, by writer.]

These exceptions to the general rule are just of such a character as one would expect if a fault had traversed a region of high but generally reversed dips. †

* In the introduction to this volume, Prof. Lesley mentions the Serpentine of Bryn Mawr as turning south towards the town of Chester, and not continuing in its south-west course through Delaware and Chester counties. The evidence of this did not appear from a somewhat rapid search through Mr. Hall's volume. On page 88 he gives the course of the Serpentine as far west as to a point a little south of Bryn Mawr, and on pp. 25 and 26 he speaks of the outcrops as belonging to one deposit, and clearly indicates his belief that they are of synclinal structure though apparently scattered.

It is difficult to believe that the Serpentine at Bryn Mawr is not connected with that north of Radnor, &c., and does not belong to the belt which traversing Chester county with a breadth between the extreme lines of isolated outcrops of from five to eight miles, becomes very largely developed in West Nottingham and the neighboring townships of Chester and Lancaster.

† It is of course a slip of the pen when Prof. Lesley says that the presence of Hudson River plant-forms is shown in Prof. Frazer's Report C_2. C_2 is devoted to Adams and part of Franklin counties, &c. Nor is any such statement in C_3.

There was in the collection of specimens at the Lincoln University a fossil said to have been found in one of the Peach Bottom slate quarries which was determined to be *Buthotrephis flexuosa*. All efforts, however, to find this fossil in place were unsuccessful. Besides this, even if the Peach Bottom slates were determined to be of Hudson River age, it would be very far from proving that the great mass of the South Valley Hill schists was of this age. Pains were taken in the description of the Susquehanna Section, pp. 140–141, to show that the structure below Fishing creek, and especially near Peter's creek, was not by

The writer takes issue with Mr. Hall, as will appear further on in his statement, as to the absence of large masses of schist in contact with the Potsdam and with the Laurentian north of the Chester valley.*

Mr. Hall's argument is virtually as follows :

(1.) "*The Philadelphia, Manayunk and Chestnut Hill beds or the South Valley Hill, which is equivalent to part of them, cannot be lower than the Laurentian (Third Belt of Rogers).*"

This will be universally conceded.

(2.) "*It is clear that the Potsdam sandstone was deposited on this Third Belt.*"

This is not clear except, perhaps over a limited area. It is not true of the Potsdam in Lancaster, nor is it true of the Potsdam in Southern Chester, nor in parts of Northern Chester. For instance, the evidence that the Potsdam, between Doe Run and Toughkenamon, underlies the limestone and overlies the chlorite schists of that region is very strong. If the limestone interposed between the quartzite and the schists, then a border of limestone should show on the east and west ends along the irregular boundary of the Potsdam area, but it does not.

A series of small detached exposures of limestone stretch east by north from the Doe Run limestone and like the latter show no trace of Potsdam on their northern edges. These as well as the Doe Run limestone, are held to be older than the Potsdam, because the dip is S. or S. E. continuously from the South Valley Hill southwards, *decreasing* in intensity in that direction, so that if not monoclinal the structure must be considered *anticlinal*, and *cannot be synclinal*. The meaning of this is that the Doe Run limestone is younger than the crest of the Valley Hill, and that its southern edge is younger than its northern edge (since the preponderance

any means as clear as in the region north-west. It would be perfectly easy, as there pointed out, to place the Peach Bottom slates *above the quartzite* without deranging the structure of the upper region, as therein suggested. The objection to placing the series above the limestone, *i.e.*, that no limestone appeared between the gentle axis of Tocquan creek and the slates, of course would not be an objection to those who credit the Tocquan schists themselves with being above the limestone.

Two explanations of Hudson River slates at Peach Bottom are possible without changing the horizons of the measures to the N. W. One is the omission here altogether of the limestone in the series. The other (held by Prof. Barrois, who visited the region), a fault line north of the slate belt.

It is only fair to admit, however, that the Hudson River age of these quarries is not proven.

* The discovery of Mr. Lewis as to the two kinds of scratches made by the ice and the creep, must be regarded as an important application of the reasoning of the Scotch geologists to our own country. In some cases Mr. Peach and Mr. Horne have been able to distinctly ascribe three distinct lines of markings to movements of very different age.

The colors on the geological maps are somewhat confusing. The dark red, which in the scale is called the intermediate Manayunk belt, seems to be applied on the map to the northerly Chestnut Hill group, and *vice versa*.

of southerly dips continues across the belt). On its southern edge rests the Potsdam in W. Marlboro' township, still with a south dip (*i.e.*, S. 10° E.–45°; S. 5° E.–70°; S. 20° W.–40°; E.20° S.–40°, &c., &c.), that rapidly becomes gently undulating and almost horizontal: and this structure continues to the Delaware line.

The axes of the Chikis anticlinal folds can be seen to be mica schist of similar character to that of the South Valley Hill.

The rock underlying the possible Potsdam quartzites in the lower Susquehanna, are clearly of the same character and series.

The Potsdam in York county is seen to overlie the same schists near Wrightsville and York, near the former of which, as if to settle all doubt, two or three folds bring to the surface within a short distance all the measures above and below it. The Potsdam of Franklin county which lies upon the South mountain covers these same schists, and the very numerous varieties of clays and associated iron ores which are due to their decomposition.

The North Valley Hill quartzite in Sadsbury, Valley, East and West Brandywine, Upper and Lower Uwchlan, and other townships, is preceded and succeeded by gneissoid and chloritic mica schists, as seen at Atglen, Pomeroy,* Stottsville, Sadsburyville, north of Downingtown, on the Brandywine, north and south of Lionville, and at other places.

In this connection, the following, taken from the notes which were made by Mr. Hall and the writer, when, in September, 1876, they visited together Harper's Ferry, and made a section of the Potomac river in its vicinity, may not be without interest. It is necessary to premise that Mr. Hall holds the opinion, which is the natural deduction from his views of the horizon of the South Valley Hill schists, that the rock which the writer has designated "Mountain Creek Rock" from its occurrence in the part of the South mountain which is contiguous to this stream, is a representative of the Potsdam.

The exposure at the head of the bridge on the Maryland side, opposite Harper's Ferry, is of a great mass of this schistose rock with fragments of pink quartz, dipping S. 30° E.–45°. This continues for an horizontal distance of 1461 feet (445 meters) east and west of the bridge, along the Potomac river.

To the west there appears an hydro-mica schist, dipping S. 40° E.–18°, but curling so as to render it difficult to ascertain the true dip.

Further west are met in succession:

A {
- Greenish chlorite slates.
- Hydro-mica slates very much convoluted.
- Hydro-mica slates.
- Chlorite slates dipping E. 20° S.–35°.

All the above have practically one dip.

* Stottsville, which is omitted from the geological map of Chester county, is on the southern side of the valley opposite Pomeroy.

B {
Very compact dark blue slate S. 30° E.–26°.
Same, with N. W. dip for a short distance.
Same. Dip E. 30° S.–26°.
Same. Dip N. 30° W.–24° (in ravine 300 ft. wide).
Same. Dip E. 15° S.– ± 30°.
Same. Much intersecting quartz.
Same. Dip ± S. E. ± 40°.
Same. Dip ± S. 35° E.–25°.
Sandy slate, weathered nacreous schist E. 30° S.–20°.
Iron ore clays.
Limestone, with traces of fossils.

The horizontal distance covered by group A is 4341 feet, and by group B, 6060 feet.

It will not be easy to construct an inversion with these dips. It cannot be denied that *this* Mountain Creek rock lies on chlorite and hydro-micas, and, if there be no fault, according to Mr. Hall's theory, the fossiliferous limestone should lie about 3000 feet below these schists.

At 1029 feet east of the bridge the Mountain Creek rock, still dipping E. 25° S.–25°, is replaced by hydro-mica schist *as it were* by the gradual dying out of the fragments of quartz. The dip in the first part of these measures, which assumes the entirely changed form, is E. 30° S.–32°. This goes on alternating with quartzite and chlorite schists for 2700 feet, when a Mountain Creek rock comes in lying unconformably against the preceding. A repetition of the Mountain Creek rock commences from here, which is about 100 feet west of the first house* [*in 1876] of the settlement on the Maryland side of the river, opposite Harper's Ferry.

Chlorites, hydro-micas and quartzites therefore clearly lie above and in contact with the Potsdam if this be its representative.

(3.) *"But it is equally clear that the mica schists and gneisses are not found between the Primal and the rocks of the third belt."*

This is, perhaps, equally clear with Proposition 2, but no more so.

As incidentally mentioned above, the whole structure of the east flank of the South mountain is opposed to this view. Here the schists lie on the central kernel or axis which, whether it be Laurentian or Huronian is, without doubt, older than the rocks we are discussing.

In Section 9, of Report CC, small synclinals of Potsdam are seen resting on the schists. In Section 7 of CC, four miles S. E. of Mt. Holly, the Potsdam (?) quartzite is seen overlying and underlying the chlorite slates.

At Chikis a belt of schists underlies the upper Potsdam quartzite and overlies the lower quartzite.

If the quartz rock of Peter's creek be the Potsdam, it lies on chlorite schists. So do the detached masses of Potsdam quartzite of North Codorus, Spring Garden, and Manheim townships in York.

The same is true of the Potsdam between Doe run and Toughkenamon, and in other places in South Chester and in Sadsbury, E. and W. Brandywine (north of Downington), and Upper and Lower Uwchlan, north of the Valley.

As the premise is not admitted, neither can be the conclusion, which is, that :

(4.) "*If the mica schists were older than the Potsdam sandstone, they must have been deposited up to a geographical line which is sharply defined.*"

It does not seem that this follows ; but the suggestion about the geographical line opens the door at once to another explanation of which the grounds will be more fully stated presently.

This hypothesis is : That a fault line runs along the South Valley Hill, bringing up the lower pre-Potsdam schists and Laurentides. That this fault does not continue to the extreme eastern point of the synclinal, but leaves it near the eastern extremity, and pursues a course a little to the south of the latter, thus cutting off the southern extension of the Potsdam, but necessarily leaving a part of the northern sheet which, laid down unconformably on Laurentian and Huronian, has been subsequently eroded from the former except along the Bound Brook Branch R. R. This hypothesis is offered, with all modesty and reserve, simply from an inspection of Mr. Hall's map, and without personal study of the ground. But at least it seems possible that that which has happened to the limestone beds, when the fault passed through them, might happen to the enclosing Potsdam when its direction was through the latter.

(5.) "*Even supposing a fault which in all probability does exist along their northern edge, there would still be some remnants of these rocks to be found in their normal position upon the syenites of the Third Belt, and fragments of the rapidly disintegrating schists would have been entombed in the Potsdam sandstone itself, even supposing them to have been swept off the underlying rocks north of the present limit.*"

It seems evident that the conditions are very different here from those which obtain in Chester and further west. The Susquehanna River section illustrates at Tocquan creek just the state of things spoken of here.

The axis of this great anticlinal where, without any doubt whatever, the lowest rocks on this river, within the limits of the State, are exposed, consists of a gneiss nucleus on which lie chloritic and hydro-mica, and finally (where Potsdam might be expected) *quartz* schists or schistose-quartz slates.

Mr. Hall's own definition of his "Edge Hill rock," too, would seem to render it unnecessary to cite examples elsewhere. He defines this rock, the type of his Potsdam, to be "*usually* a fine-grained white or gray sandstone and quartzite, *with scales of light-colored mica.* It is usually thinly laminated. *Occasional beds of fine conglomerate are met with.*" (p. 45.)

What better example of the entombed remains of the underlying schists could be expected ? If the beds are thinly laminated, it is evident that the materials out of which they are composed were greatly broken up, and nothing would remain of the schists under the circumstances but the micaceous minerals composing them, Mr. Hall does not state the nature of the fragments forming the conglomerate, but on page 46 the significant statement is made that, "Itacolumite *and hydro-mica schist* have been applied to the specimens analyzed."

There can be no error as to the rocks thus spoken of, as appears from six field numbers which are given of specimens of Potsdam analyzed, of which the first two are found on referring to the analyses to be "Itacolumite" and the last four "Hydro-mica schist." It will hence be unnecessary to multiply examples of the same kind which might be taken from any of the four counties enumerated above. The fact is indisputably established by Mr. Hall himself that remains of the schists are abundantly found in the Potsdam.

At this point the simple statement is made that the same difficulties are encountered in trying to find a place for the schists until the upper limit of the limestone is passed. As it is well known that there is an abundance of slates above this limit, the inference is drawn that the schists belong there.

This part of the discussion may be left with the remark that to the knowledge of the writer no extensive series of *chloritic* schists has been found to belong to the measures which are without dispute above the limestone of II.

A brief resumé of the principal reasons for assigning to these schists a lower horizon may be here roughly sketched :

(1.) There can be no doubt that the straight and narrow valley called the Chester Valley is connected actually with the great Lancaster limestone, and that it represents a part of a synclinal fold. The anticlinal once connecting it with the larger mass of limestone passed over (and probably high over) all of northern Chester county. If the schists to the south of the valley lie on the limestone, then the entire thickness of the latter must plunge beneath the surface within the limits of the valley. At places (as between Atglen and Pomeroy), the actual space which may be filled by limestone varies from a few hundred to fifteen hundred feet. But the limestone as measured on the Neffsville and Wrightsville sections is about 2700 feet thick. Of course if there be an upthrow on the south, any amount of the upper part of the limestone may have been eroded and any small portion of the lower beds left.

The dips are northward along the western part of Sadsbury township ; and they are in sandy mica schist and gneiss on the north side [as for example N. 10° W.–30° (Atglen) ; N. 45° W.–10° ; N.–50° (near Parkesburg) ; N. 45° W.–40° (ditto)]. The limestone when first found in place by the machine shops in Parkesburg strikes E. 25° N.– vertical. Further east near Pomeroy it is on the northern edge of the valley *N. 10° W.-50°*. Decomposed gneiss just north of Pomeroy gives a succession of S. E. dips about S. 10° E.–85°. A few hundred feet south of the north dip in the limestone is a dip ± S.–80°, and a thousand feet or so in the same direction S. 15° E.–60° etc.

North of the gneissoid schists again the quartzite dips about S. 15° E–45°, and therefore underlies these schists while the limestone either abuts upon them or overlies them in a sharp upward curve, which can no longer be traced.

(2.) The objection to the mathematical straightness of the line of junction of such soft rocks as the hydro-mica schists and the limestones is a serious one. Nothing is more likely, on the other hand, than that such a mathematical line of demarcation should be established by a line of fracture.

(3.) The absence of limestone from the junction of the Potsdam and the schists from Huntingdon Valley eastward on Mr. Hall's map, is difficult to explain if these schists really belong above the limestone, and there be no fault along this line. If on the other hand there be a fault (which naturally extends along the South Valley Hill), it is singular that it does not bring up the underlying limestone and broaden that valley if the schists of the South Valley Hill are superior to the limestone.

(4.) The limestone of Adams, York and Lancaster counties believed to be No. II of Rogers is much mixed with schistose and micaceous matter in its inferior layers and is usually surrounded by schists from which this foreign matter is derived.

The limestone of Chester county, near Stottsville, Pomeroy, Parkesburg, and for the whole length of the Chester Valley, is similarly mixed with micaceous matter and frequently resembles a mica schist more than a limestone.

(5.) The Potsdam quartzite and sandstone near Coatesville are similarly mixed with micaceous material, and this texture may be very frequently observed in the lower layers of the Potsdam elsewhere in Chester as well as where Mr. Hall has observed it.

(6.) The contact of the limestone sometimes with the Potsdam and sometimes, when the latter is absent, with the schists, may be observed in lower Lancaster and apparently on the southern side of the great (Tocquan?) anticlinal which passes through Sadsbury townships of Chester and Lancaster counties.

(7.) In various places in East and West Brandywine and Lower Uwchlan, chlorite and hydro-mica schists are abundant below the Potsdam. The series is well exposed from a short distance north of the E. Caln border on the North Branch of the Brandywine past Dowlin's Forge and Dorlan's Mills.

(8.) If the schists south of the Chester Valley be younger than the limestone, and the Doe Run and Chester Valley limestones represent but one horizon, there must be a synclinal fold between the two.

But it has been stated above that the dips are flatter towards the south, so that if there be here a plication, it is an anticlinal.

(9.) There should be evidence of Potsdam south of the belt of limestones striking with that of Doe Run to the east, but there is not.

(10.) There should be evidence that the Doe Run limestone is above the Potsdam to the south, but the former appears to dip under the latter.

This limestone as well as the small detached bodies just alluded to seem to be analogous to that between Scottsville and Rockville in Bucks county.

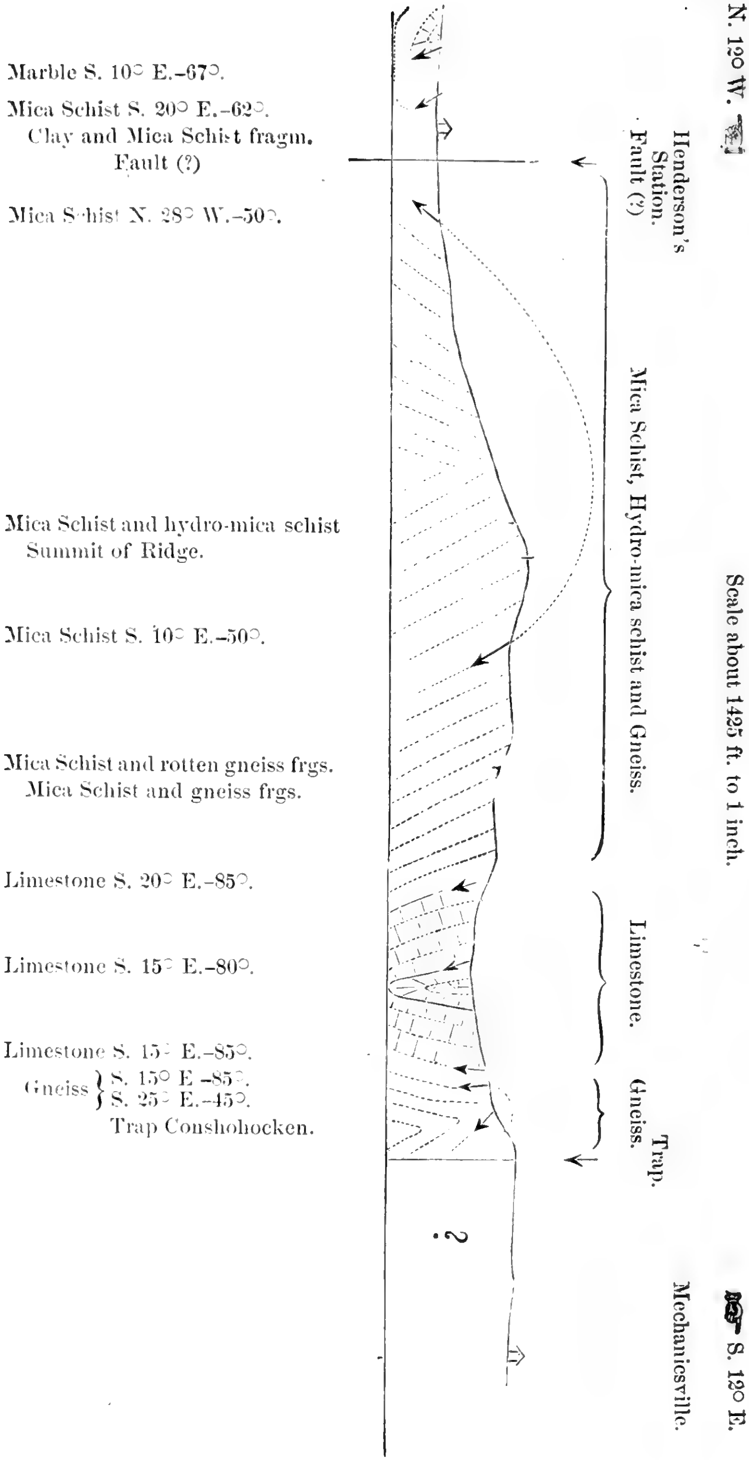
(11.) There are small tongues and isolated patches of Laurentian rocks occurring in the midst of these southern schists. One comes into Chester county from the east in Eastown and Treddyfrin townships, and another occupies a small area near West Chester. These patches are bordered on all their sides by these schists with no intervening rocks. The bordering rocks therefore cannot belong to a group above the Potsdam and the lower Silurian limestone.

(12.) Several localities in Kennett Square and New Garden townships exhibit areas of Potsdam rocks surrounded by these schists with no intervening limestone. The schists therefore cannot belong to an horizon superior to the latter.

These are some of the reasons which are opposed to the structure suggested by Mr. Hall.

The section on Mr. Hall's p. 32 is so different from the same section which the writer made in 1880, and the conclusions which Mr. Hall draws from his section, are so important, that a rough copy of the writer's section is herewith subjoined, on an approximate scale of 1425 feet = 1 inch. The direction of the section is about that of the average dip or S. 12° E. It is necessary to explain that the first group of dips is projected on the line of section at Henderson's Station from the road west of that point, and the Primal must lie west of where this section begins.

If this junction be accepted, however, from Mr. Hall's observations, it will not affect the important conclusions which suggest themselves. First, of a possible fault between the limestone with part of its underlying schists and the mica-schists to the S. E.; and secondly the synclinal character of the limestone near Conshohocken, with an anticlinal of the underlying schists to the south-east cut by a trap dyke.



N. 12° W.
Scale about 1425 ft. to 1 inch.
S. 12° E.
Henderson's Station.
Fault (?)
Mica Schist, Hydro-mica schist and Gneiss.
Limestone.
Gneiss.
Trap.
Mechanicsville.
Marble S. 10° E.-67°.
Mica Schist S. 20° E.-62°.
Clay and Mica Schist fragm.
Fault (?)
Mica Schist N. 28° W.-50°.
Mica Schist and hydro-mica schist
Summit of Ridge.
Mica Schist S. 10° E.-50°.
Mica Schist and rotten gneiss frgs.
Mica Schist and gneiss frgs.
Limestone S. 20° E.-85°.
Limestone S. 15° E.-80°.
Limestone S. 15° E.-85°.
Gneiss S. 15° E.-85°.
S. 25° E.-45°.
Trap Conshohocken.
2

Obituary Notice of Edouard Desor. By J. P. Lesley.

(Read before the American Philosophical Society, May 19, 1882.)

The winter of 1881–2 will be remembered for the great losses which the world of culture suffered in rapid succession : Draper, Longfellow, Emerson, in America ; Darwin and Desor in Europe. Other names, also, were erased from the roll of the world's prophets ; but these were teachers of the prophets—primates and patriarchs in the hierarchy—masters on whom others depended, and to whom they deferred—leaders in the procession of thought and expression of thought—founders of styles and methods—builders of superior edifices of human knowledge and human taste ; characterizing the century in an active as well as a passive mood, and therefore leaving Christendom in mourning for their disappearance.

The world remarks that these men were much beloved. They were gentle, loving beings, as amiable as they were vigorous of soul. That the world loved them and heard them gladly proves that the world is better than it was. That they could sing, and think, and work, without molestation, proves that the world is wiser than it was. The powers hostile to human enlightenment have lost their thrones ; personal liberty is established. The tribune and the press are, the pulpit is becoming, enfranchised. And as with personal liberty a higher tone of private morals has supervened, so with liberty of speech and pen has come into the life of Christendom a gentler spirit of controversy and a more judicial method of investigation. Fear is the mother of cruelty and its brood of vices intellectual and physical. Persecution has always bred heresy. The excommunicated hate the excommunicators ; exiles are emancipated from all respect and affection for government. The suppression of ideas by physical force is like the compression of explosives ; times are always coming to apply the match or pull the trigger. Men who are forced to fly from their ancestral homes to begin a new career elsewhere, acquire rapidly by the struggle for life a noble development of all their powers ; gaze upon the new world around them with new eyes ; inform themselves of what would never have interested them ; ally themselves with the strongest and wisest whom they find ; invent enterprises ; place scaling ladders against the ramparts of fame, and in the end come to be of the number of the world's rulers.

Such was the experience of the man whom, as a member of this Society, we remember and lament, Edouard Desor of Neufchâtel.

The Desors were Huguenots expelled from France by the revocation of the edict of Nantes. They settled in Hesse-Homburg, and helped to form there a little colony which retained in use the French language in their dwellings, schools and churches, while it adopted the German language for intercourse with the world around.

In 1811 (Feb. 13th) our late distinguished fellow-member Edouard Desor was born at Friedrichsdorf near Frankford-on-the-Main. He was baptized Pierre Jean Edouard, but his publications and his literary correspondence show that he had dropped the first two names, and few persons were aware of his having any other personal designation than Edward.

His father's name was Jean Desor, and his mother's maiden name was Christine Albertine Foucar.

"Desor" was originally "Des Horts," meaning "of the gardens." A Catholic branch of the family Des Horts still reside at Marsillargues, in the south of France, on the route from Lunel to Aigues-Mortes. From this little village many Protestant families were chased into exile, by Louis XIV, in 1685. M. Fritz Berthoud in his "L'Hiver au Soleil," describes how, in one of their journeys to the Mediterranean coast, Desor and he stopped to make the acquaintance of this scene of persecution.

Jean Desor, at Friedrichsdorf, conducted one of those manufactures which France lost by the folly of her so-called Great Monarch. He died and left his two boys to the care of their mother; but she, too, worn out with misery and loneliness, died, and they grew up as best they could.

Young Desor's education was, however, on the whole a good one; and the peculiar constitution of his native town gave him this advantage: French and German were alike his mother-tongue. This made it easy for him, when the time came, to lead a useful life in Paris, and to settle finally at Neufchâtel, where both languages are spoken alike by all.

He acquired a good knowledge of English, also. Several years of residence in the United States made our language as familiar to his ear and tongue as his own native dialects. Although he never overcame the difficulty of pronouncing such sounds as *th*, and always spoke of *sick* and *sin* rocks, he nevertheless wrote English in a singularly pure style, and spoke it with admirable precision and force. His long intercourse with Italian geologists and his frequent residences in Italy gave him command of the Italian language.

His earlier education was gained at the gymnasium in Hanau. Thence he was transferred to the University of Giessen, and commenced his studies for the legal profession, which he afterwards continued at the University of Heidelberg. His elder brother adopted the career of a physician.

At Giessen also was educated Desor's colleague in science and life-long bosom friend, Karl Vogt, who was six years his junior, and who still survives to mourn his loss. Vogt afterwards studied chemistry with Liebig at Heidelberg, and (1835) anatomy and physiology with Valentin at Berne, when Desor was already established with Elie de Beaumont in Paris.

As his forefathers had been persecuted out of France into Germany for their religious and political heresies, so Desor and his brother were driven back from Germany into France by persecution, on account of their enthusiastic sympathy with the revolutionary excitement of 1830, which pervaded all Europe, the principles of which were elaborated in the universities of Germany, and preached and practised by the entire burschenschaft, inflamed with vague hopes of a repetition of the French revolution, the destruction of irresponsible princedoms, and the liberation and unification of the Fatherland. Vogt fled to Switzerland. Desor's brother, after a short stay in Paris, settled also in Switzerland, at Neufchâtel, although that canton was an appanage of Prussia, and its inhabitants spoke French and German indifferently. But Desor himself remained in Paris from 1832 onwards until his brother's marriage to a wealthy lady, M'lle de Pierre, in Bôle-over-Colombier, proved too strong an attraction, and he became a Swiss, not only in residence, but in heart and soul and character, and remained a Swiss to the last day of his life.

In Paris he tried at first to support himself by translating, for a French publisher, Ritter's Erdkunde. He was also employed by Dr. Hahnemann as his private secretary. I have heard him affirm of his own knowledge that the transfer of simple homœopathy on to the trancendental ground of infinitesimal doses, with correspondingly high powers, was the work of Madame Hahnemann; her husband having nothing to do with it.

In Paris, Desor studied geology under Elie de Beaumont who, then 34 years old, had become Professor of Geology in the College of France in 1832 the year of Desor's expatriation.

This year of 1832 is famous in the history of our science, for it marks best the date of the labors of Sedgewick and Murchison in England and Wales. It was also the year of the cholera. In 1833 Elie de Beaumont was made Chief Engineer of Mines; and with Dufrenoy commenced the preparation of the great geological map of France, published in 1841. His Mountain Systems did not appear until 1852; but during the interval of 20 years he was elaborating that masterpiece of geological genius in lectures which raised him to the pinnacle on which he stood until his death as the greatest living geologist, while it overthrew the factitious reputation of his great popular rival Leopold von Buch.

Desor, however, was not much influenced by the special views of his great master regarding the structure of the earth, and was too much influenced by the vague notions of the Swiss geologist Thurman, who tried to apply a modification of Von Buch's elevation theory to the anticlinals of the Jura. Nor is it strange that Desor, only 21 years old, should not have been more influenced by Elie de Beaumont's peculiar structural theories. It cannot be otherwise, however, than that his subsequent devotion to geology was born in him by the teaching of his great master. In after years he threw himself with ardor into orographic research; but it was always more practical than speculative; and the extensive orographic studies which he continued at intervals until his death were probably mainly due to his experiences on the glacier of the Aar. His memoirs on the Massifs of the Alps are inspired by quite a different motive from that which impelled Elie de Beaumont to the construction of his crystalline globe. For Desor the structure of valleys through which descended his glaciers was the main thing! The surface, and not the underground, held his attention. His systematization of Alpine ranges is wholly topographical; not at all mineralogical, much less plutonic. In my many conversations with him I heard no theory escape his lips which went deeper than the erosion of the surface, nor was Elie de Beaumont ever alluded to. His orography was essentially systematic and descriptive.

He accompanied Elie de Beaumont to the meeting of the Helvetic Society, at Neufchâtel, in 1837, and there became acquainted with Agassiz; and this became the turning point of his intellectual life. But the first result of the influence which Agassiz exerted over him was hostile to any train of thought suggested to him by Elie de Beaumont. It drew him first into the study of the fossil forms in the rocks of the Jura Mountains, and then into the study of the glaciers of the Alps. It was not until Desor joined the corps of Pennsylvania geologists, in 1852, that his eyes were really opened to the wonderful phenomena which had long before inspired the genius of Elie de Beaumont to reconstruct the fundamental axioms of structural geology. In fact, the bent of Desor's mind was for investigating the forms and habits and metamorphoses of the animal world; and the large way in which he afterwards pursued these studies was due not to the instructions of Elie de Beaumont in Paris, but to the influence of the superior genius of Louis Agassiz in Neufchâtel, and through Agassiz of that coryphæus of modern science, Agassiz's great master, Cuvier.

After his return from America to Switzerland Desor studied the structure of the Jura Mountains with a clearer vision; but, while his definition of structural forms was singularly precise and complete, his theoretical conclusions were always based on more violent hypotheses than those in vogue in the school of Lyell. He remained to his last days a moderate cataclysmist both as to plication and as to erosion.

After leaving Paris to take up his permanent residence in Switzerland Desor lived for a short time in the house of Professor Vogt, the father of Karl Vogt, in Berne. At one of the annual reunions of the Helvetic Society of Natural Sciences Vogt introduced Desor to Agassiz, who induced him to settle in Neufchâtel. Agassiz, born in 1807, was only 4 years older than Desor, and they soon established a close brotherhood in society and science, which lasted nearly twenty years. Agassiz had studied medicine at Zurich, Heidelberg and Munich; but by a curious accident, which he was fond of narrating, his residence in the same house with an old man whose rooms were filled with preparations of fish, Agassiz became enamored of that special branch of Natural History; had studied the fish brought from Brazil by Martius & Spix, and published his Latin description of them in 1829–31; and was appointed Professor of Natural History at Neufchâtel in 1832, where he was now in the full tide of his researches into the nature and distribution of fossil fish. It was during a visit to Paris that Agassiz made friends with Cuvier and Humboldt; and at Paris his great work on the Classification of Fish went through the press during the ten years from 1832 to 1842.

The summer vacations of Agassiz were spent on the glacier of the Aar.

his "Studies of Glaciers" appeared in 1840, and his "Glacial System" in 1847.

For eight successive summers Agassiz and Desor lived upon the glacier of the Aar, and each summer ascended, mostly for the first time, one or more of the peaks of the Oberland. With two friends and four guides they were the first to stand on the summit of the Jungfrau.

The great flat rock in the middle of the medial moraine of the glacier of the Aar, pictures of which are so familiar to all readers of books treating of the glacial phenomena of the Alps, was called the "Hotel des Neufchatelois," and during its slow majestic descent of the valley it entertained more celebrities, and listened to more scientific talk than any other house in Europe. All the world of science bent its steps, summer after summer, to this unique council chamber in which caroused and debated and slumbered side by side Agassiz, Desor, Vogt, Duchatelier, Nicollet, Pourtales, Coulon, De Pury, Dolfus-Ausset and their innumerable friends and visitors.

Perilous were the undertakings plotted beneath and executed from this alpine boulder on the moving ice; and exciting beyond the common text of scientific publication are the published descriptions of the first ascent of the Schreckhorn, the first ascent of the Jungfrau, and especially the first ascent of the terrible Galenstoc during which the son of Dolfus-Ausset lost his life.

Among the later comers was James Forbes, who, having learned from the veterans of the glacier of the Aar all that close and long and repeated observations could impart, established himself on the Mer de Glace, repeated and verified their data, and then returned to England and anticipated their conclusions by publishing his own celebrated book on the formation and movement of the ice.

Vogt also settled in Neufchâtel, but not until 1839, and assisted Agassiz for five years in natural history, especially in the preparation of his work on the fresh water fishes. Vogt published in 1842 his Geburtshelferkrote, and in 1843 his own book entitled "In the Mountains and on the Glaciers." Vogt then went to Paris (in 1844) and stayed until 1846, when he was appointed to a chair in his native city of Giessen. But the troubles of 1848 breaking out, he became again a political exile, and accepted the chair of geology at Geneva in 1852, and at Bern in 1853.

This brilliant coterie of men of science, in the prime of life and in the heat of investigation laying the foundations of more than one department of human knowledge, included two other names of equal fame, Arnold Guyot, and Leo Lesquereux, both of whom still live to illustrate and enlarge our science. While Agassiz, Desor and Vogt were at work in the mountains Guyot was at work on the plain ; while they studied the movement of the glacier, he defined the limits of the ancient moraines. As for Lesquereux, his study of the peat bogs of Switzerland, and then of all northern Europe, led naturally to those broad generalizations respecting the coal-beds of all ages which have given him an immortal fame.

In 1847 Agassiz settled in the United States and commenced his career at Cambridge, Mass., after having opened the eyes of the British geologists to the glacial phenomena of great Britain. He soon drew after him to America Desor, Guyot, and Lesquereux.

Desor, before going to America, had published his own "Geological Alpine Journeys," and had traveled through Norway and Sweden in order to compare the moraine phenomena of Scandinavia with those of Switzerland.

In the winter of 1847–8 I found Agassiz and Desor at work together in a zoological laboratory in East Boston, watching a multitude of living creatures which they had obtained from the neighboring shore and kept in plates and bowls full of sea water. When Agassiz moved to his professorial residence in Cambridge Desor insisted upon remaining in this laboratory at East Boston. He soon became one of the lions of Boston society, but attached himself with the ardor of warm friendship to Edward Cabot, Theodore Parker and Josiah D. Whitney, who remained ever afterwards his devoted friends. He became intimate also with Asa Gray and Henry D. Rogers. It is needless to say that the circle of his habitual personal intercourse included such men as Emerson, Longfellow, Dr. Howe, and James Freeman Clarke.

The story of the separation of Agassiz and Desor which produced so great a sensation in the brilliant society of Boston men of letters and science will never be told, and need not be. In fact, however, the closest intimacy of years was sundered in a few weeks and the two never met again. Agassiz pursued thenceforth an independent career; became the idol of the western world; connected himself closely with Pierce and Bache and Gould; founded a school of natural history research; erected a vast museum; trained a considerable number of scholars to be the men of science of the present generation, and in fact not only gave Harvard College a new destiny, but inspired the entire population of the United States with a zeal for discovery in every branch of human knowledge which continues to burn and illuminate the world.

Desor at first turned to the study of the osars of the coast, and spent a summer with Davis in the study of the tidal gravel banks, always with an eye to glacial action.

He then joined Forster and Whitney in the survey of Lake Superior, under a commission from the United States Government; his special task was to study the alluvions and their fauna.*

In 1850 and 1851 he accepted proposals made to him by Henry D. Rogers to participate in the revision of the geological survey of Penn-

*His term, *Laurentian* for the recent deposits along the St. Lawrence and the Lakes has not been accepted by geologists, because of its subsequent application to the fundamental gneiss of the mountains of Canada. His views on the Northern Drift he published in the Amer. J. S., xiii, 93, 1852.

sylvania. As his task was to investigate the surface deposits, with a special regard to the possible existence and activity of a boreal glacier invading Pennsylvania, I saw much of him in my topographical studies for the construction of maps to show coal terraces, &c. and learned much from him about the movements of the surface sub-soil and local drift.

The study of glaciers led him to regard with critical eyes all phenomena of erosion, and his measurements of the retrocession of the falls of Niagara gave him a very different scale of geological time from that of Hall, Lyell and others. His diagramatic cross-section of the Via Mala, placed him partly in accord with and partly in opposition to the glacialists of the Ramsay school.

His glacial researches led him also necessarily to study rain and snow, the föhn or schnee-fresser and other winds; in a word he became a good meteorologist and made one of the band of early investigators, with Dové at their head, who established that branch of modern science. After his return to Europe he published papers on the "Climate of the United States and its effect on habits and manners."

At the close of 1851, or early in 1852, Desor was recalled to Neufchâtel by the serious illness of his brother, whom he nursed until his death, taking care of his property and becoming his heir.

Here a new career opened before him; he became a teacher. He was appointed to a chair in the Academy of Neufchâtel, made famous first by Agassiz, and now more famous by the lively, clear, eloquent, fresh teachings of Desor.

In the meantime he pursued his train of original research, and gradually devoted himself to the special branch of fossil echinoderms. His "Synopsis des Echinides" procured him a doctorate from the University of Bâle.

In 1856 his brother's death and the care of his inherited property induced him to resign his chair in the Academy; but while he tended his vineyard overhanging the lake, and farmed the old hunting-lodge of Combe Varin overlooking the Val de Travers, he pursued his researches in natural history, and continued his dredgings on the sites of the aboriginal lake-dwellers. He made unobtrusive use of his wealth in assisting others in their researches.

"He was himself," says one of his intimates, "not without some ambition. It flattered him to stand in relations to the first men of science and be known as their equal. The hospitality which he practised in the most liberal manner enlivened and preserved to him this intercourse which he so dearly loved. Every summer Desor's farm at Combe Varin, on the mountain top overlooking the railway station of Noiraigues on the road to Pontarlier, was a gathering point for notabilites not only of Switzerland but of all foreign countries, not only his friends but his acquaintances; and there reigned in this old hunting-lodge of the Depierres such a comfortable simplicity of entertainment and such perfect liberty of occupation that each guest felt himself entirely at home.

"On both sides of the level road which led from the brow of the mountain to the house stood rows of trees, each dedicated to some guest and marked with his name. More than a hundred names distinguished in politics and science may here be read, many of them now, alas, beneath a cross, to indicate their departure to a better world."

Four times I have myself shared his hospitality, and can testify to the charms of the place and of its master; and I esteem it as a kind of patent of nobility that my name stands among the rest. Here in 1859 Theodore Parker found a retreat, the summer before he died in Italy (1860), and his double-headed pine stood, at some distance off the road, on the open slope descending to the peat bogs which spread across the plateau between Combe Varin and the village of Les Ponts. Desor followed Parker to Italy, and was with him when he died. His attachment to him was based on their intercourse in Boston; and whatever spiritual theories Desor accepted were more or less formulated under the guiding influence of this powerful thinker and good and generous soul.

Desor was an active member of the Natural History Society of Neufchâtel, and published many short memoirs in its transactions. He leaves his remarkable museum of prehistoric antiquities to its care.

He was a constant attendant at the meetings of the Swiss Congress of Science, and would make long annual journeys to attend other similar national associations; especially of late years the annual meetings of the Anthropologists, as at Copenhagen and at Stockholm, where he was received with distinguished honor.

In fact Desor may be considered the chief of modern geological archæologists. After the first discovery of lake-dwellings in the winter of 1853–4 at Meilen on the shore of the lake of Zurich, and the commencement of Keller's great museum there, all the lakes of Switzerland were explored for similar discoveries. At least 200 villages were found by Desor and Clement in the lakes of Neufchâtel and Bienne; by Morlot and Troyon in the lake of Geneva, and by other seekers in other lakes. It was concluded that the Swiss lakes were unique in this respect, although Herodotus was quoted as authority for the existence of lake-dwellers in his day in a lake of Thrace. Desor however insisted upon the generality of the phenomenon, and at length made a rendezvous with Von Siebold, of Munich, to test the question in company with his own trained dredger. The immediate result was their great discovery that the palace of the Bavarian King was built on an island in the Sternsee around the edge of which could be seen the piles of the aboriginal lake-dwellers; and in the little museum of the palace they found a considerable number of needles, knives, chisels, &c. which had been dredged from the foundation of the palace. Upon this demonstration of the correctness of the large view which Desor alone had taken of the subject the geologists and antiquaries of Southern Germany and Austria set heartily to work and did not fail to find prehistoric relics in all the lakes of that part of Europe.

Desor subsequently (1864) joined Escher von der Linth the Swiss geologist, and Charles Martins the botanist of Montpellier, with a commission from the French government to explore the desert of Sahara, which they discovered to be of recent age by finding in its rocks recent shells. Here also Desor gratified his love of dolmens and menhirs, and greatly enlarged his prehistoric studies in that direction; but it was not until 1875 or thereabout that he became a zealous student of the mysterious cup and circle markings on the erratic blocks of Switzerland, and learned by a wide spread and laborious correspondence with his fellow-workers in all countries that they were not only to be seen on rocks from India to Scotland, but on the walls of the most ancient Christian churches of Northern Germany.

Desor was always recognized as an able geologist. His local work in the Jura, mostly carried on with the assistance of his poor friend and able palæontologist Gressly, showed ample ability to grapple with difficult structural problems, although he never freed himself from the prejudice in favor of split anticinals which the extraordinary section across the mouth of the Val de Travers would naturally inspire in any man who lived within sight of it. This prejudice, moreover, he shared with all the geologists of middle Europe. His astonishment and admiration for the unbroken arches of the Appalachian belt therefore, when at length his eyes were opened to their true character, was unbounded. But in spite of the impression thus made, he remained a consistent opponent of those views of cyclical erosion which were gradually forced upon American geologists, and were afterwards made popular in England by Beete Jukes in the course of the Irish survey.

Desor was the colleague of Bernard Studer, Peter Merian and Esher von der Linth in the commission of the geological survey of Switzerland. During my last visit to his own home in Neufchâtel, in 1880, he showed me an upper room in which the commission kept its archives and met for consultation. But the venerable Studer, the chief of the survey, has his home at the capital of the Confederation, Bern. One of the most remarkable pieces of geological investigation ever made was a section of a range of the Jura north of Neufchâtel, through which a long railroad tunnel was to be driven. Desor and Gressly projected the stratification as it should be found by the engineers. When the tunnel was finished the actual and hypothetical sections were almost absolutely identical. Each formation, almost each stratum, was struck at exactly the point indicated. It was a notable triumph of exact application of science to practical ends.

The political life of Desor is viewed differently, of course, by different classes of his friends. There is intense conservatism in Switzerland, and the overthrow of the aristocracy of the Canton of Neufchâtel by the democrats or radicals has never been forgotten nor forgiven.

As late as 1878, when I rode one day with Desor and Berthoud up the Val de Travers, they were making merry over some scurrilous attacks upon themselves in one of the newspapers; Desor pointed out to me a passage in which they were called derisively *the two small gods of Neufchâtel.*

In one of the obituary sketches of Desor (Basler Nachrichten), written perhaps by Desor's very steadfast friend Prof. Rütimeyer, I find the following paragraph :

"The burghers of Ponts honored Desor with the burger-right, and sent him, alternately with Noiraigue and Neufchâtel (as soon as the radicals got the majority in Neufchâtel), as member to the Grand Council, which once chose him its President. For many years Desor was a member also of the Ständerath, and of the Nationalrath (or Swiss Parliament), and one of its most distinguished members. Perhaps it would have been better for Desor the investigator had he devoted less of his time to politics ; nor did politics always bring sweet fruits to Desor the man. For ever since he fell away from his old comrades on the question of the repurchase of the Jura railway, and engaged himself personally in an endless newspaper war, which became ever more and more bitter and thankless, his health began to fail, and five years ago the symptoms appeared of that serious malady which led him inevitably to his grave."

The last three years Desor was sent by his physicians to spend the winters in Nice, where he became an active member of two scientific societies. He thus came to preside at the discovery of the fossil man of Carabacel which produced so great a sensation in the geological world. He directed also the researches made in the grotto of Peymanade, discovered by M. Bottin de St. Vallier. He managed in spite his sufferings to ascend considerable heights, and discovered satisfactory proof of the former existence of glaciers descending the southern slope to the shore of the Mediterranean. His letters to me on that subject display all the pleasure and zeal of a boy. His little maps and sections of the structure of the Ligurean coast are perfectly fresh.

Last February I went from Paris to Nice to see Desor for as I feared the last time, and found him extremely feeble and full of pain ; but I had so often seen him thus in former years that I dreaded no immediate danger. In our conversations he dwelt with lively interest on a plan which he was organizing to observe the temperature along the summits of the Pyrenees, and at the level of the plain. He went over again the old story of the Föhn or Alpine snow devouring south wind, in connection with the establishment of high winter sanataria for invalids in the Tyrol ; and also in connection with the observed winter temperature observed on the Puy de Dome relatively higher than on the plain at Clermont-Ferrand. He earnestly demanded data from the American stations to help discover the law, if it were one.

In a few days Desor was no more. The lamp that burned so brightly flickered a moment, and went out. All research was at an end. One of the sweetest, simplest, most honest, most affectionate, most robust and energetic, most independent natures that ever acquired fame abroad and inspired respect at home, suddenly ceased to suffer and ceased to think. Science had lost another star, Switzerland a sturdy champion of democratic liberty, and many of us a rare friend who cannot by any means be replaced.

Geological Notes. By E. W. Claypole.

(Read before the American Philosophical Society, October 20th, 1882.)

A. *On an Error in Identifying Two Distinct Beds of Iron Ore in Report* **G** *of the Geological Survey of Bradford County.*

In Report **G,** *Bradford and Tioga Counties,* and on page 36, occurs the following passage :

"6. In Leroy township, about a mile and a half west of Leroy, in the main road, near the house of J. Wilcox, we found a bed of iron ore which appeared to be three or four feet thick, and of very good quality. See the following partial analysis by Mr. McCreath :

Iron	29.5
Sulphur	trace
Phosphorus	.204
Insol. residue	49.27

"7. The *same* bed is exposed at Leroy village, in Gulf brook, where it is nearly four feet thick and of good quality. A partial analysis of this ore by Mr. McCreath resulted as follows, though it can hardly be a fair test, for the average percentage of iron must be greater :

Iron	20.7
Sulphur	trace
Phosphorus	.185
Lime	8.71
Magnesia	1.3
Insoluble residue	46.655 "

In reference to this passage I was informed during a recent visit in Bradford county by Mr. A. T. Lilley, of Leroy, that he considered it entirely erroneous, and that these beds of ore so far from being one were separated by a very considerable thickness of rock. The arguments which he adduced appeared to me quite satisfactory, and we went out to examine the ground.

Antecedently, if the two samples of ore were fairly taken, the analyses induce suspicion : they differ so largely from each other ; the quantity of iron is half as large again in the former as it is in the latter. It seems improbable that a bed of ore should vary so much in so short a distance.

The plan of this part of the valley given in Fig. 1, page 535, will make this line of argument intelligible.

The lowest bed of iron ore occurs in the Gulf brook in connection with a mass of red sandstones, forming what are called the Mansfield Red beds. These beds, with a solid sandstone, continue westward and may be easily traced. The sandstone forms the buttress of the hill, and the Mansfield Red beds form a terrace higher up the slope. The direction of the strike of these beds is about N. E. by E. and S. W. by W.; but the flattening of the dip curves the outcrop line and throws the basset edge farther and farther from the road. In addition, higher beds continually pass across the road from south to north as one goes westward, the azimuth of the latter being slightly nearer the meridian than that of the former.

With the aid of Mr. Lilley, I traced the sandstone for about five hundred yards to the west from the mouth of the Gulf brook where the strata are vertical and found it gradually flattening down to a dip of about 45°. Leaving this bed I went across the outcrop of the strata southward, coming, of course, on newer and newer beds at every step. At the distance of about three-quarters of a mile from Leroy is a strong exposure of a hard red sandstone in thin beds covered with peculiar fucoidal marks. It forms a low ridge in the valley and crosses the road at a short distance farther on. The strike of this bed agrees with that of the others above mentioned, and the whole district is quite undisturbed by any dislocation. Following it for some distance, I left it and crossing the strike again to the southward, found a bed of green shale quite in the bottom of the valley, and immediately upon it a second bed of iron ore, very much like that at Gulf brook. It crops out in the road a little farther west, as mentioned in the extract from the volume **G,** given at the head of this note.

Beyond this bed of iron ore, which can be traced north of the road up the hill lie the highest beds of the Chemung group—the *Grammysia elliptica* bed, the *Productella bed,* and the Cap-rock—the last a thin shale full of crushed and unrecognizable fossils. Each bed is separated from the next by a considerable thickness of unfossiliferous shale.

It is therefore beyond a doubt that these two outcrops of ore mentioned in the extract from **G** given above, are not parts of the same bed, but belong to two different beds separated from one another by an interval of several, perhaps 250, feet.

If any further proof of this conclusion is desired it may be found near Franklindale. Reference to the map will show that the road forks about a mile west of the village.* The two branches again meet at the distance of half a mile east from the fork. By walking from the latter point along the south road the order of succession, from the Mansfield Red beds upwards, may be distinctly seen. In particular, the two seams of iron ore may be readily detected by the red ground and the red road formed by their destruction.

* The site of the village is wrongly given in the map in Report **G.** It should be where the four roads meet, about a mile east of the spot where it is marked. The two roads also should be drawn meeting each other again, as above mentioned.

B. *Note on the occurrence of Holoptychius, about 500 feet below the recognized top of the Chemung Group, in Bradford County.*

The base of the Castkill group has been assumed on palæontological grounds at the lowest stratum in which the remains of the great Ganoid fish *Holoptychius Americanus* have been found. Lithologically and stratigraphically this dividing horizon has been placed where the green fossiliferous shales of the Chemung are supplanted by red shales and sandstones, mostly without fossils. Sometimes these two principles of division give coincident, sometimes discordant, results. Often the fossil remains cannot be found, and almost as often the line between red and green material cannot be firmly drawn.

In Bradford county, however, these difficulties do not occur. The green rocks give place almost suddenly to the red ones, and the line between Chemung and Catskill is easily drawn on stratigraphical evidence. The red Catskill rocks also in many places abound in remains of fish near if not at their base, consequently the two lines of evidence converge to almost coincident results. The occurrence therefore of a well marked and unmistakable scale of *Holoptychius Americanus* considerably below the dividing plane is a fact worthy of some notice.

The scale in question is on the surface of a slab of green sandstone and was quarried out of the solid rock by Mr. Lilley, of Leroy, when getting stone for the foundation of a barn. Although I am unable at present to determine exactly the position of the sandstone, yet from the fact that it lies at a very small distance above the Mansfield Red bed with iron ore, it must be not far from four hundred feet below the base of the Catskill group, as recognized in this county.

In further proof of the occurrence of the above-named fossil in this horizon, I may add that while engaged with Mr. Lilley, in examining the evidence for the presence of the Catskill, north of Franklindale, Mr. L. picked up a loose slab of *green sandstone* showing on its surface three large scales of *Holoptychius.* The point where it was discovered is very near the horizon of the specimen first mentioned, the bed rock is very near the surface, little or no drift material is present, the slab is not rounded, and the Catskill rocks are on the other side of the valley of Towanda creek.

All this evidence concentrated, leads me to believe that this second specimen is of Chemung age and comes from the same horizon as the first.

C. *On a Mass of Catskill Rocks supposed to exist on the North Bank of Towanda Creek, near Franklin.*

Reference to the geological map of Bradford county will show a patch colored to represent the Catskill on the north bank of Towanda creek, in Franklin township. It measures about four miles in length by one in its greatest breadth, and is apparently intended to represent a cap of that formation overlying the Chemung of the same township.

The existence of this cap of Catskill, or at least of a great part of it, is beset with numerous difficulties to one who is familiar with the ground, and during my recent visit in Bradford county I became strongly suspicious of the accuracy of the map. The following consideration was very weighty in this direction.

The Chemung rocks all along the north bank of Towanda creek dip to the south at angles varying from 90° to 15°. At Leroy, the former occurs, and east and west of Leroy the dip flattens down, but not regularly to the latter figure. The dip also flattens down as one recedes from the road and goes northward, but very gradually, so that at Leroy it does not disappear, and render the strata horizontal in less than a mile.

With this inclination of the beds and with the highest beds of the Chemung far out in the valley, probably in the west end of it on the south side of the Towanda creek, it seemed quite impossible that any such mass of the Catskill could occur capping them so near the road upon the north bank. The generalized section along the valley is given in Fig. 2, page 535.

When it is recollected that the total thickness of Chemung rocks between the top of the group at *a*, and the horizontal exposure at *b*, must be at least 1500 feet, and is probably more, the difficulty of realizing a cap of Catskill on the top of a hill only 200 or 300 feet high becomes obvious.

Aside, however, from all antecedent and theoretical considerations, it was desirable to obtain the evidence of actual observation, in order to ascertain the truth, and also, if possible, to detect the cause of the mistake, if mistake had been made. On the morning, therefore, of leaving Leroy, I obtained the assistance of Mr. A. T. Lilley, a gentleman well acquainted with the district and with its geology, and set out to investigate the ground.

Leaving Leroy by the Towanda road we first established the fact that lower and lower beds of the Chemung come continually out of the hillside and point out into the valley for several miles, throwing the Catskill farther and farther to the southward, and giving a constantly thickening mass of Chemung to be placed on the hill-top, before the summit of that group could be reached. Turning to the northward up a road about one mile east of West Franklin, we followed it for nearly half a mile, until we attained an altitude of about 150 feet or more above the valley. The whole country on both sides of the road was deeply covered with drift, and no bed-rock whatever was visible anywhere. Nor was a scrap of the red Catskill sandstone to be found lying loose on the ground. Not only is it perfectly certain that no Catskill exists in place along this road (which follows a small run), but it is equally certain that many hundred feet of Chemung rocks are missing, and must be added to the top of the hill before the base of the Catskill can be reached. Yet this road on the map is drawn crossing a broad belt of Catskill at less than half a mile from the valley turnpike. This Catskill cap does not, therefore, extend so far west as the road in question marked xx on Fig. 3, page 535.

Continuing our search we reached the point *a*, where the old and new roads meet and, taking the former or northern one, we crossed to the point marked with a cross. Here is a bold exposure of the Mansfield Red sandstones standing with a dip of about 40° S. E. by S. This point is almost exactly on the place where, according to the above-quoted map, the edge of the cap of Catskill should lie. It is unnecessary to say that no such material is there present. Not only are all signs of Catskill absent, but the whole thickness of the Chemung above the Mansfield red beds must be put on before its presence is possible. Time at our command did not allow us to go back into the county through the woods to determine at what distance this high dip disappears and the Chemung beds flatten down to a level, but it is perfectly obvious that even if any Catskill at all is here present it must be of small dimensions, and must lie much further north than it is represented on the map. With a dip of 40° at the point and about 500 feet of Chemung rocks missing, the existence of any such Catskill cap is almost a physical impossibility.

I may add that the evidence, so far as the short time at my command allowed me to examine it on the spot, is strongly against the existence of any Catskill west or north of Franklindale.

It appeared certain that the wreckage of the Mansfield Red beds, which is strewn over the hill-side along this part of the road, had been mistaken for fragments of Catskill, the source of which was supposed to exist higher up the slope. To account for the extension of the color so far to the westward is less easy, because, as mentioned above, not a fragment can be found upon the road marked with a double cross and lying east of West Franklin.

D.—*On two small patches of Catskill represented near Leroy, on the map in Report* **G,** *of the 2d Geological Survey of Penna.*

In connection with what has been written above, I may remark that not a scrap of evidence can be found in favor of the existence of either of the two round patches of Catskill rock represented on the map, one at Leroy and the other about one mile to the westward. The place in which the former is marked is on Upper Chemung beds, of about the horizon of the Mansfield Reds (which may have led to the error), and STANDING VERY NEARLY VERTICAL. The place of the other is near or at where the red sandstone with fucoids (mentioned in an accompanying note), which lies between the Mansfield Red beds and the *Grammysia elliptica* bed, crosses the valley road. Hence, perhaps, this mistake. The beds here are undoubtedly Chemung, and more than 100 feet below the summit of the group.

If this confusion was the real cause of the error it is the more surprising because the iron ore bed which overlies the red fucoidal bed has been (as shown in the note above alluded to) confounded with another, occurring several hundred feet lower down in the series. If the presence of Catskill rocks is quite impossible with 100 feet of the Chemung missing, it would be much farther from possible if 400 or 500 feet were missing, as supposed in the report on Bradford and Tioga counties, p. 36.

E.—*On the Equivalent of the Schoharie Grit of New York in Middle Pennsylvania.*

The evidence of a single species, however "characteristic" it may be of a stratum or group of strata in one place in favor of identifying that stratum or group with another at any considerable distance, must always be of little weight unless strongly corroborated by collateral evidence. Even a single species, however, may be allowed to possess considerable value, *if thus corroborated.* From this point of view the following note may possess interest:

The *Cauda-Galli or Schoharie* grits of New York overlie the Oriskany sandstone. Of the former, Prof. Hall wrote in 1867 (Pal. of N. Y., Vol. 4, p. 1):

"The *Cauda-Galli* grit is almost a non-fossiliferous rock; a few fragments of plant-like fossils and the peculiar surface-markings of the slaty laminæ from which its name is derived, being the only objects resembling organic bodies which have fallen under my observation. A single specimen of *Platyceras,* similar to *P. tortuosum* of the Oriskany sandstone, has been found in this rock, * * * * It passes by almost imperceptible gradations to the Schoharie grit, which is marked by the presence of numerous fossils. The upper beds of the *Cauda Galli* grit, and also the lower beds of the Schoharie grit preserve those peculiar markings which have been termed *Fucoides Cauda-Galli* (*Spirophyton Cauda-Galli*)."

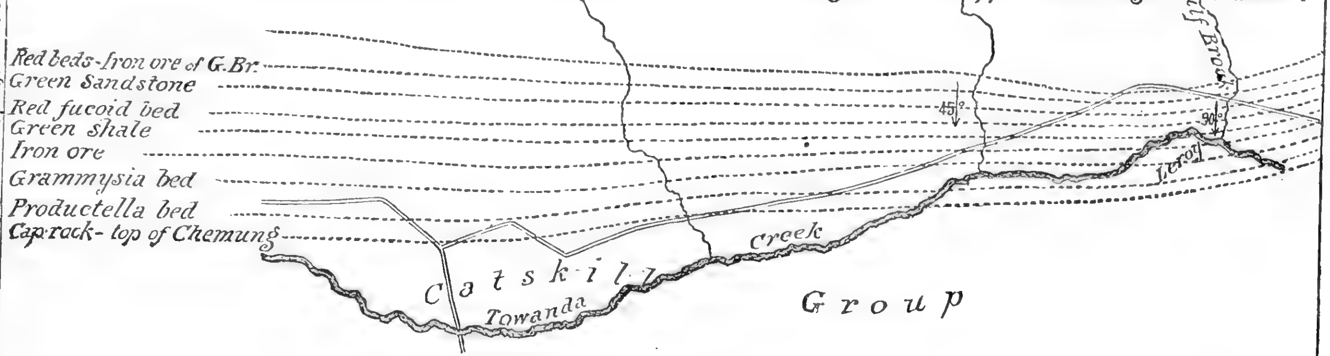
It thus appears that these two strata in New York form really one group within which no line of demarcation can be drawn. This group consists of unfossiliferous beds at the base, *Cauda-Galli* beds above them, and fossiliferous beds at the top.

The *Cauda-Galli* grit is, however, a stratum of very limited extent, considered lithologically. It does not occur in the western part of New York, but is well marked in the east and extends into New Jersey. It thickens toward the Hudson and reaches 50 or 60 feet in the Helderberg mountains.

The *Schoharie* grit is distributed over almost the same area as that of the *Cauda-Galli* grit, being specially well marked at Schoharie and in the Helderberg. Both strata doubtless owe their deposition to the same set of geological causes.

Neither of these *grits* occurs in Middle Pennsylvania in any spot which has fallen under my observation. The strata immediately overlying the Oriskany sandstone, in Perry and adjoining counties, consist of calcare-

Fig. 1. Plan of the Valley of Towanda Creek, near Leroy.



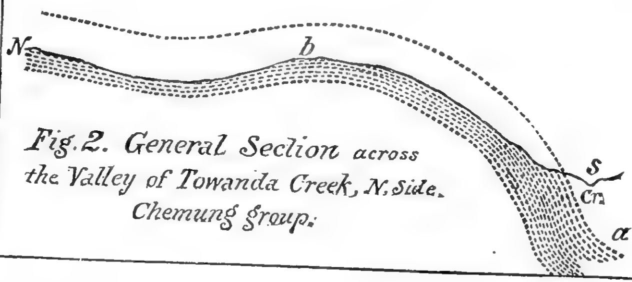
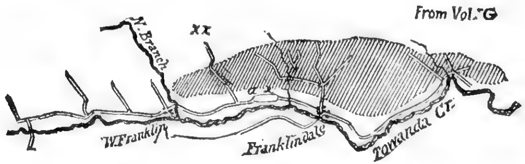


Fig. 2. General Section across the Valley of Towanda Creek, N. Side. Chemung group.

Fig. 3. The supposed outline of a Catskill outlier in Franklin T.



ous shales, argillaceous limestones and iron ores. For the most part the lowest of these is an impure, earthy, hæmatite or a very ferruginous shale. Apparently these two materials belong to the same bed, but appear differently at different places. Near Bloomfield it is a hæmatitic shale of no value, and yielding thus far no fossils except on its upper margin, where an undescribed *Beyrichia* occurs in great numbers. A few miles south of Bloomfield, in Sandy Hollow, it is a tolerably pure red ochre, much of which has been dug and ground for paint, but apparently the work has not yielded sufficient profit to lead to its continuance. Here also I have found no fossils, but have reason to think that some might be obtained if the exposure were larger. This ochre lies close against the Oriskany sandstone, here nearly vertical. At a short distance further south the same bed again yields red ochre, which has been dug out close to the Oriskany sandstone. The best layers for this purpose are the lowest, and these have thus far yielded me no fossils. But about ten feet higher up, where the beds are less ferruginous, I have met with abundance of specimens of *Atrypa impressa* Hall. They are well marked and in a good state of preservation, being little altered by compression. They also occur solely as internal casts.

Regarding this species Prof. Hall says (Pal. of N. Y., Vol. 4, p. 316): "This form of Atrypa occurs in the Schoharie grit. It is not known to me in any other geological formation." Also (p. 315), "The casts of the interior are more abundant than any other condition of the fossil in the Schoharie grit."

From the above facts the inference seems warranted that these two grits of Eastern New York or some parts of them are represented by the ferruginous shales above mentioned. The sandstones indicate a shore line for the time being extending, during the whole or part of the period, from Eastern New York through Northwestern New Jersey into Eastern Pennsylvania. But west of this there is no evidence of anything but open sea for a long distance, and the finer sediments accord with the conclusion. The same species, *Atrypa impressa,* which lived near the shore or was washed ashore when dead and was buried in the sandstone in New York, sank in Middle Pennsylvania into soft oozy shale and was there preserved.

What the conditions were which produced the deposition of marine iron ores and ochres it is impossible at present to say. We are too ignorant of the processes of marine metallic sedimentation to do more than guess at them—a useless expenditure of time and thought.

Note on the progress of the Second Geological Survey of Pennsylvania. By J. P. Lesley.

(Read before the American Philosophical Society, Jan. 19, 1883.)

The progress of the Geological Survey of this State, which interests so many of my fellow-members, both in America and in foreign countries, deserves some record on the minutes of this Society, the mother society of our country, and in former times the natural rendezvous of American physical and mechanical science.

I venture then to offer to the Society the following short account of the ground already covered by the survey, as exhibited by its publications since 1875, county by county, in alphabetical order; with occasional notes respecting those counties in which further field work must be done before reports upon them can be made ready for the press.

It is needless to say, that the already collected data withheld as yet from publication for this purpose must be added to express the sum total ot actual work done in the State.

Adams County. Surveyed in 1874 and 1875 by P. Frazer. See Report **C** on Adams and York (1876), and Report **CC** on Adams, York, Cumberland and Franklin (1877). *Note.*—Instrumental lines were run in both counties. The special topographical survey of the the South mountains in Franklin and Adams, commenced in 1876, was continued through 1877, 1878, 1879, 1880, northwards to Pinegrove furnace. In 1881 and 1882 this survey was carried forward in Cumberland and York counties towards Mount Holly Springs; and in 1883 it will be nearly or quite completed, to the end of the mountain range at Dillsburg. Four sheets have been printed, but will not be published until the remaining sheets of the South Mountain map are also printed. The whole will then be published in atlas form with a report, and in rolls for the use of surveyors.

Allegheny. Surveyed in 1875 and 1876 by J. J. Stevenson and I. C. White. See Report **K** on Greene, Washington and South-west Allegheny counties (1876); Report **KK** on Fayette, Westmoreland and eastern Allegheny (1877); Report **Q** on Beaver and N. W. Allegheny (1877).

Armstrong. Surveyed in 1879 by W. G. Platt. Report **H 5** (1880).

Beaver. Surveyed in 1876 by I. C. White. See Report **Q** (1877).

Bedford. Surveyed in 1881 by J. J. Stevenson. Report **T 2** (1882).

Berks. Surveyed in 1880 by R. H. Sanders. A geological map of the limits of the formations and the dip and strike of all exposed rocks in the valley is prepared, but not yet published. The sheets of the great topographical survey of the limestone belt and mountains of Lehigh and

Northampton (commenced in 1875, and completed in the spring of 1882), includes that part of Berks county lying east of the Schuylkill, with the hills west of Reading (by E. V. D'Invilliers). The sheets of this map are all printed, and will be published shortly in the Atlas to Report **D 3** (1883). The report on Berks county will be published after further work has been done in the county.

Blair. Surveyed in 1877 by F. Platt. See Report with Atlas **T** (1881). The topographical map of Morrison's Cove, Canoe valley and Sinking valley, with the Frankstown and Hollidaysburg region, reaching to the summit of the Allegheny mountain at Galitzen, was commenced by R. H. Sanders in 1875 and completed in 1877. See the Atlas to Report **T.** *Note.*—The delay in publishing this report was caused by the necessity which arose of detailing the assistant geologist for work in various other counties, which required immediate attention in view of the publication of their reports.

Bradford. Surveyed in 1874 by A. Sherwood. See Report on Bradford and Tioga counties, **G** (1878). *Note.*—The delay in publishing was caused by the fact that Mr. Sherwood was ordered to confine his attention to the rocks below the coal. In 1877 Mr. F. Platt reported on the coal basins, and Report **G** was then published. Subsequent work by I. C. White and E. W. Claypole has discovered such considerable errors in the survey of 1874 that a revision of the whole eastern and middle parts of the county, north of Towanda creek, should be made.

Bucks. The southern belt of the county was surveyed in 1879 and 1880 by C. E. Hall. See Report on Philadelphia county and the southern parts of Montgomery and Bucks, **C 6** (1881). This report gives a detailed description of all the rocks of the county south of the red shale country. The northern edge of the county has been included in the Atlas sheets of the topographical map of the South mountains (Reading and Easton range) about to be published with Report **D 3** on Northampton county (1883). The largest part of Bucks county has not yet been surveyed.

Butler. *Southern half* surveyed in 1876 by I. C. White. See Report on Beaver, and parts of Allegheny and Butler counties, **Q** (1877). *Northern half* surveyed in 1878 by H. M. Chance. See Report on Northern Butler, **V** (1878).

Cambria. Surveyed in 1875, by F. and W. G. Platt. See Report on Cambria and Somerset District, Part 1, Cambria, **H 2** (1877).

Cameron. Surveyed in 1878, 1879 by C. A. Ashburner and A. W. Sheafer. The report on Cameron, Elk and Forest was partly printed in 1881; but the publication was stopped by the transfer of the geologists to the Anthracite region, for organizing that survey. In 1883 there will be a revision of the work done in these three counties, and the Report **R 2** will then be published.

Carbon. The coal basin from Mauch Chunk to Tamaqua has been surveyed, and the sheets of maps and sections published to accompany Mr. Ashburner's first Anthracite report, **AA,** which will go to press in a few weeks. The survey of the Eastern Middle coal-field, commenced at Hazleton in 1881, has been continued uninterruptedly, and the sheets of the northern basins will be ready for press in 1883. The Beaver Meadow basin sheets will then be prepared. *Note.*—The geology of the Lehigh river below Mauch Chunk is described in the Report on Pike and Monroe counties, **G 6** (1882). The report on Carbon county requires further field work before it can be written.

Centre. Surveyed partially in 1880 and 1881 by F. Platt and W. G. Platt. Survey stopped by the resignation of both assistants. Mines revisited and sampled for analysis in 1882 by A. S. McCreath. Survey to be completed in 1883 for Report **T 3.**

Chester. Surveyed in 1879 and 1880 by P. Frazer. Southern townships re-surveyed in 1882 by C. E. Hall. See Report **C 4** just ready to issue from the press. *Note.*—The delay in publication was occasioned by the resignation of Mr. Frazer and his residence in Europe.

Clarion. Surveyed in 1879 by H. M. Chance. Report **VV** (1880).

Clearfield. Surveyed in 1874 by F. Platt. See Report on the Clearfield and Jefferson District, **H** (1875). *Note.*—This report was based on the work of an inexperienced party at the commencement of the survey, and before the recent important developments of the coal-fields of Clearfield. A resurvey of the county has been repeatedly ordered by the Board of Commissioners, and several attempts have been made to obey the order ; but the occupations of the Geological Assistants in the various districts of the State up to the winter of 1881 and 1882 prevented it. The delay in passing the last annual appropriation bill cost the survey the loss of the geologists who were successively detailed to make this revision, and there were no others to take their place. The revision will probably be made in 1883, and a new report be published.

Clinton. Surveyed in 1879 by H. M. Chance. See Report **G 4** (1880).

Columbia. Surveyed in 1882 by I. C. White. Report now in preparation, to be published in 1883. For the coal, see *Schuylkill* county.

Crawford. Surveyed in 1879 by I. C. White. See Report on Erie and Crawford, **Q 4** (1881).

Cumberland. Surveyed in 1878 by R. H. Sanders. County map exhibiting all exposed outcrops and mines prepared. No report yet written. All mines visited in 1880, and ores personally sampled and analyzed by Mr. McCreath. See Report **M 3** (1881). *Note.*—The peculiar character of the Great valley required that the same kind of survey should be made of Franklin, Cumberland, Dauphin, Lebanon and Berks together. Each county has been similarly mapped by R. H. Sanders. All will be published at the same time. Mountain survey to be finished in 1883.

Dauphin. Surveyed in 1879–'80 by R. H. Sanders. County map exhibiting all exposed outcrops, mines and limits of formations, prepared. Mines personally visited and ores sampled in 1882 by A. S. McCreath. Report delayed for general revision in 1883, in connection with Lebanon and Berks. For the coal, see *Schuylkill* county.

Delaware. Surveyed in 1881 by C. E. Hall. See Report **C 5** (1883), to be published in the same volume with the report on Chester county, **C 4.** *Note.*—This publication has been delayed by the impossibility of preparing the illustrations for the report until after the report on Chester, with its illustrations, had been provided. Delaware was formerly a part of Chester, and its geology is dependent on that of Chester. The combined report has been printed and its maps, &c., are mostly printed. The whole will be published this winter.

Elk. Surveyed in 1877 and 1878 by C. A. Ashburner and A. W. Sheafer. The maps and sections to accompany the report were printed in 1880. The publication of the report was stopped by the transfer of the geologist to the Anthracite region. The important developments made in the coal basins of this county since 1878 make it desirable to revise this survey. This will be done in 1883, after which the Report **R 2** will be published.

Erie. Surveyed in 1879 by I. C. White. See Report on Erie and Crawford, **Q 4** (1880).

Fayette. The western part surveyed in 1876, the eastern part in 1877, by J. J. Stevenson. See Report on Fayette and Westmoreland counties, **K 2** (1877), and Report on the Ligonier valley, **K 3** (1878). *Note.*—Report **L** (1876) gives the special survey of the Coke region.

Forest. Surveyed in 1879 by C. A. Ashburner and A. W. Sheafer. The report on the coal areas and general geology will be published in 1883 in conjunction with the report (**R 2**) on Elk and Cameron counties. The wells of Forest county are described in the Report on Warren county, **I 4,** by J. F. Carll, now just ready for binding, and which will be published in February.

Franklin. Surveyed in 1879 by R. H. Sanders. County map exhibiting all exposed outcrops and mines prepared. Mines revisited in 1880, and ores sampled personally by A. S. McCreath, and analyzed. See Report **M 3** (1881). Northern part surveyed in 1877 by J. H. Dewees.

Instrumental line run in 1878 by C. W. Ames. South mountains instrumental surveyed in 1880–'81 by A. E. Lehman. Report delayed by the office work on instrumental surveys.

Fulton. Surveyed in 1882 by J. J. Stevenson. See Report on Bedford and Fulton, **T 2** (1882).

Greene. Surveyed in 1875 by J. J. Stevenson. See Report on Greene and Washington, **K** (1876). A special Report on the Collieries and Coal of the Monongahela valley will be made by J. S. Wall.

Huntingdon. Surveyed partially in 1874–'75 by J. H. Dewees, C. A. Ashburner and C. E. Billin. See Report on the Juniata District, **F** (1878). *Note.*—That part of this report relating to the Broad Top coal basin was reserved for future publication. The eastern end of the county was surveyed by Mr. Billin in connection with his topographical survey of the Seven mountains, some maps and sections of which have been printed. Mr. Billin's resignation early in 1879 stopped both the work and the report; but he is now completing the report for publication. Much work remains to be done in various parts of the county before a complete county report can be prepared.

Indiana. Surveyed in 1877 by W. G. Platt. See Report **H 4** (1878).

Jefferson. Surveyed in 1880 by W. G. Platt. See Report **H 6** (1881). *Note.*—The first partial survey of Jefferson in 1874–'75, was published in Mr. F. Platt's report of Clearfield and Jefferson, **H** (1875).

Juniata. Surveyed in 1876 by J. H. Dewees. *Note.*—This voluminous report required rewriting, for which there has been no sufficient opportunity. Maps of Juniata and Perry have been prepared. A resurvey of both counties by E. W. Claypole is in progress. Reports on both counties to be printed in 1883.

Lackawanna. Parts lying outside the coal, surveyed in 1882 by I. C. White. See forthcoming Report **G 7** (1883). Coal basin survey by C. A. Ashburner and corps, commenced in 1881 and continued through 1882 and onwards, proceeds from west to east, and will not reach Lackawanna until 1884. See Luzerne. *Note.*—For the east end, see Report **G 5,** I. C. White (1881).

Lancaster. Surveyed in 1877 by P. Frazer. See Report **C 3** (1880). *Note.*—Elaborate and difficult illustrations caused the delay.

Lawrence. Surveyed 1877 by I. C. White. Report **Q 2** (1878).

Lebanon. Surveyed in 1880–'81 by R. H. Sanders. County map prepared, exhibiting all local outcrops, limits of formations, mines, &c. Report delayed for work to be done in 1883.

Lehigh. Surveyed in 1874–'75 by F. Prime. See Reports on the Iron Ore district, **D** (1875), **D 2** (1878), with atlas. *Note.*—The delay of the last report was occasioned by the fact that the instrumental survey of the limestone valley belt and of the mountains continued from year to year, and was not finished until 1882. The survey of the slate belt in 1881 by R. H. Sanders will appear in the Report on Lehigh and Northampton **D 3,** with atlas, mostly printed and to be published shortly.

Luzerne. Parts lying outside the coal, surveyed in 1882 by I. C. White. See forthcoming Report **G 7** (1883). Coal basin survey by C. A. Ashburner and corps, commenced in 1881 and continued through 1882 and onwards. Western sheets ready for printing. Middle sheets in preparation. A special report will accompany the sheets of each division.

Lycoming. Surveyed in 1877 by A. Sherwood, and again in 1878–'79 by F. Platt. See Report on Lycoming and Sullivan, **G 2** (1880). *Note.*—The delay was caused by imperfections in the first survey, which could not be corrected sufficiently early in 1878.

McKean. Surveyed in 1876, 1877 and 1878, by C. A. Ashburner and A. W. Sheafer. See Report **R** (1880). *Note.*—The length of this survey was due to the amount of instrumental work needful for its study; and the delay of its publication, to the careful preparation of its atlas of illustrations. The geology of Cameron, Elk and Forest was studied preliminarily in connection with that of McKean; and afterwards separately and in detail.

Mercer. Surveyed in 1878 by I. C. White. See Report **Q 3** (1879).

Mifflin. Surveyed by J. H. Dewees, C. A. Ashburner and C. E. Billin in 1874–'75–'76. See Report on Juniata District, **F** (1878). *Note.*—Kishicoquillis valley not surveyed.

Monroe. Surveyed in 1881 by I. C. White. See Report on Pike and Monroe, **G 6** (1882).

Montgomery. Southern part surveyed in 1879, 1880 by C. E. Hall. See Report on Philadelphia belt, **C 6** (1881). The rest of the county to be surveyed in 1883. (See *Bucks.*)

Montour. Surveyed in 1882 by I. C. White. To be published in Report **G 7** in 1883.

Northampton. Surveyed in 1876 by F. Prime. Slate belt surveyed in 1881 by R. H. Sanders. Mountain survey finished in 1881. Mountains revised in 1882 by C. E. Hall. See Report **D 3** mostly printed and soon to be issued, with Atlas. See *Lehigh.*

Northumberland. Surveyed partially in 1877 by C. E. Billin; again in 1882 by I. C. White. To be published in Report **G 7** in 1883. For the coal see *Schuylkill* county.

Perry. Surveyed in 1877 by J. H. Dewees. Surveyed again in 1882 by E. W. Claypole. Report to be published in 1883.—*Note.* The delay in publishing the report of 1877 was occasioned by the necessity for completely rewriting it. See *Juniata*.

Philadelphia. Surveyed in 1879, 1880. See Report **C 6** (1881).

Pike. Surveyed in 1881 by I. C. White. See Report on Pike and Monroe, **G 6** (1882).

Potter. Surveyed in 1876 by A. Sherwood. Resurveyed in 1879 by F. Platt. See Report **G 3** (1880).

Schuylkill. Anthracite survey commenced in 1881 by C. A. Ashburner and corps, continued through 1882 and onwards. Eastern sheets of Western Middle coal-field now in press; western sheets in preparation. Special report on each division to accompany the sheets. In 1884 the survey of the Southern coal-field from Tamaqua westward will be commenced. See *Carbon* county.

Snyder. Surveyed in 1876, 1877 by J. H. Dewees. See Report on Juniata District, **F** (1878). Surveyed again in 1878 by C. E. Billin, for map. Further field work before a county report can be published.

Somerset. Surveyed in 1879 by G. W. Platt. Report **H 3** (1877).

Sullivan. Surveyed in 1877 by A. Sherwood, and again in 1878–'79 by F. Platt. See Report on Lycoming and Sullivan, **G 2** (1880). The Coal basins will be resurveyed as part of the Anthracite survey.

Susquehanna. Surveyed in 1880 by I. C. White. See Report on Susquehannah and Wayne, **G 5** (1881).

Tioga. Surveyed in 1874 by A. Sherwood, and in 1877 by F. Platt. See Report on Bradford and Tioga, **G** (1878). See Note on *Bradford.*

Union. Surveyed in 1878 by C. E. Billin for map. Requires much field work before report can be published.

Venango. Surveyed in 1874 and onwards by J. F. Carll. See Reports on the Oil regions **I** (1875), **I 2** (1877), **I 3** (1880) and **I 4** (1883 just being issued).

Warren. Surveyed in 1874 and onwards, especially in 1882, by J. F. Carll. See Report on Warren county, **I 4** (1883 just issuing from the press). *Note.*—The long delay in reporting upon this county was occasioned by the abundance of its fossils; the extreme difficulty of establishing the correct order of its rocks; and the continued oil discoveries.

Washington. Surveyed in 1875 by J. J. Stevenson and I. C. White. See Report on Greene and Washington, **K** (1876). A special Report on the collieries of the Monongahela valley will be made by J. S. Wall.

Wayne. Surveyed in 1880 by I. C. White. See Report on Susquehanna and Wayne, **G 5** (1881).

Westmoreland. Surveyed in 1876 and 1877 by J. J. Stevenson. See Report on Fayette and Westmoreland **K 2** (1877), and on the Ligonier valley **K 3** (1878). *Note.*—Report **L** (1876) gives an account of a special survey of the Connellsville Coke region.

Wyoming. Surveyed in 1876 by A. Sherwood. Resurveyed in 1882 by I. C. White. See Report **G 7,** to be published in 1883.

York. Surveyed in 1874, 1875 and 1876 by P. Frazer. See Reports on Adams and York, **C** (1876) and **C 2** (1877).

Of the above mentioned Reports, **AA, C 3, D 2, D 3, I 3, R** and **T,** are accompanied by octavo Atlases, containing maps and sections. The following Reports have been published:

Report **A** (1875). A history of geological surveying in Pennsylvania.

Report **A 2,** on Waste in mining Anthracite, by F. Platt (1881).

Report **AC** on the mining of Anthracite coal, by H. M. Chance, will be put to press this winter (1883).

Report **E,** on Azoic rocks, by T. S. Hunt (1878).

Report **J.** Special report on Petroleum, 1875.

Reports **B, B 2, M, M 2, M 3** are the successively published reports of chemical analyses made for the Survey by F. A. Genth, S. P. Sadtler, F. A. Genth, Jr., A. S. McCreath and J. M. Stinson.

Report **N.** (1878) contains the Levels of the State railroads, canals, roads, &c., collected in 1875, 1876, 1877 by C. Allen. Materials for **N 2** are largely collected.

Reports **O, O 2** contain the catalogue of specimens collected from 1874 to 1880. **O 3** has not yet been prepared.

Report **P** (and Atlas) figures and describes the coal plants, studied by L. Lesquereux, from 1874 to 1880.

Report **P 2** describes the Permian plants of Greene county and West Virginia, by Fontaine and White (1880).

Report **P 3** containing new species of coal plants by Leo Lesquereux and descriptions of articulates and mollusks, by C. E. Beecher, James Hall and E. W. Claypole, will be published in 1883.

Report **Z** on the glacial moraines and gravels by H. C. Lewis, is nearly ready for the press.

The small hand-book or traveling atlas of geologically colored county maps is two thirds prepared, and will be finished in 1883.

First Addition to the Fauna of the Puerco Eocene. By E. D. Cope.

(Read before the American Philosophical Society, Jan. 5, 1883.)

There are fifty-five species included in my synopsis of the vertebrata of the Puerco epoch*. Ten of these are reptilia, the remainder mammalia. In the present paper a number of interesting additions are made. The typical specimens are figured in the fourth volume of the U. S. Geological Survey of the Territories, now in press.

OPHIDIA.

HELAGRAS PRISCIFORMIS, gen. et sp. nov.

Char. gen. The generic characters are drawn from vertebræ only. These display a modified form of the zygosphen articulation, as follows: The roof of the zygantrum is deeply notched on each side of the median line so as to expose the superior lateral angles of the zygosphen. This separate median portion of the roof of the zygantrum forms a wedge-shaped body which may be called the *episphen*, It is surmounted by a tuberosity, which constitutes the entire neural spine. The latter is thus entirely different in form from that of other serpents. Articular extremities of centrum round, the ball looking somewhat upwards. Costal articulation 8-shaped, the surfaces convex and continuous. Hypapophyses none on the two vertebræ preserved. Zygapophyses prominent. Free diapophyses none.

This genus is readily distinguished by the presence, now first observed, of the *episphen* in addition to the zygosphen; and by the peculiar form of the neural spine. We have now several vertebral articulations originally discovered in American vertebrata. These are the *episphen* as above, the *hyposphen*, which characterizes the Opisthocœlous Dinosauria (*Sauropoda* Marsh), and the *Diadectidæ* of the Permian period; and the *zygantrapophysis*, which is present in the Diplocaulid family of Batrachia.

Char. specif. A section of the vertebra at the middle is pentagonal, the inferior side slightly convex downwards. The lateral angle is the section of the angular ridge which connects the zygapophyses The episphen has a shallow rounded groove on its infero-posterior side, which is bounded by a projecting angle on each side at its middle. The episphen does not project so far posteriorly as the postzygapophyses, and the degree of its prominence differs in different parts of the vertebral column. In one of the two vertebræ in my possession its prominence is small. The tuberosity on its summit is a truncate oval with the long diameter anteroposterior, and equaling two-fifths the length of the arch above. It is elevated above the rest of the median line, which is roof-like, with obtuse angle. The tubercular articular facet is entirely below the prezygapophyseal surface, but the free part of the prezygapophysis extends well in front of it. It is distinguished from the capitular surface by a very slight constriction. A slight ridge extends from the capitular articulation

* Paleontological Bulletin No. 35, Nov. 11th, 1882.

to the edge of the ball of the centrum. Below this the surface is slightly concave, and the middle line is gently convex. The latter terminates in an obtuse angled mark just in front of the edge of the ball. This edge is also slightly free from the ball. The capitular costal surfaces do not project inferiorly quite to the line of the inferior surface of the centrum.

Measurements of a Vertebra.	M.
Length of centrum (with ball)	.0070
Diameters of ball { vertical	.0035
Diameters of ball { transverse	.0040
Elevation of vertebra at episphen	.0085
" " middle	.0062
Width at prezygapophyses	.0120
" tubercular costal faces	.0105
" of zygantrum	.0058
Vertical diameter costal faces	.0040
Transverse diameter tubercular costal face	.0028

This snake was about the size of the black snake, *Bascanium constrictor.* It is an interesting species for two reasons. First, it is the oldest serpent known from North America. Second, in the imperfection of the zygantrum we observe an approximation to the ordinary reptilian type of vertebra, from which the ophidian type was no doubt derived. In the former there is no zygosphen or zygantrum.

Mammalia.

Triisodon levisianus, sp nov.

This creodont is represented by part of a right mandibular raums which contains the fourth premolar minus its principal cusp, and the first and second true molars, with the alveoli of the third. The ramus is deep, and probably belonged to an animal of about the size of the red fox. The molars have the structure most like that of the *T. heilprinianus*, especially anteriorly. The principal anterior cusps are united together for most of their elevation, while the anterior inner is much smaller and lower, and is situated between the middle and inner side of the anterior cusp. The heel is rather wide, and has a raised border. The external part of it is angular, and is somewhat within the vertical line of the base of the crown. The fourth premolar differs from that of the type the genus, *T. quivirensis*, in having two acute longitudinal tubercles situated close together on the heel.

The anterior masseteric ridge is very prominent. The masseteric fossa is strongly concave, but shallows gradually inferiorly. Its inferior border presents a low thickened ridge, which is recurved in front. This may be an individual character only. The inferior outline of the ramus is generally convex, and does not rise much below the masseteric fossa.

Measurements.		M.
Length of last four inferior molars		.0315
" true molars		.0230
Diameters of M. i.	anteroposterior	.0085
	transverse	.0055
Length of P-m. iv. on base		.0090
Depth of ramus at M.i		.0200
Thickness " "		.0085

This *Triïsodon* is not only materially smaller than the *T. heilprinianus*, but differs in the characters of the heel of the inferior molars. In that species the internal border is tubercular; in this one it is entire. The *T. conidens* and *T. quivirensis* differ in the arrangement of the anterior cusps.

Dedicated to my friend, Henry Carvill Lewis, professor of mineralogy and geology in the Academy of Natural Sciences, Philadelphia.

MIOCLÆNUS FEROX, sp. nov.

This new species is represented by three specimens. One of these includes various separate teeth and a considerable portion of the skeleton; a second includes loose teeth and a smaller number of bones of the skeleton; and the third consists of a part of a mandibular ramus, which contains the three true molars. These indicate the largest species of the genus yet known, the first individual above mentioned being about the size of a wolf.

The bones of the *Mioclænus ferox* enable me to refer the genus approximately to its proper position in the system. Although we do not possess the corresponding parts of the *Mioclænus turgidus*, the type of the genus, it is probable, if not certain, that they agree in generic characters. The agreement in dentition extends to all the principal technical points, though the specific differences are marked.

The skeleton is that of a creodont. The unequal phlanges are compressed claws, and the metapodial bones have protuberant condyles. The astragalus has a simple head with convex surface, and the trochlea is a shallow open groove.

The tubercular dentition refers this genus to the *Arctocyonidæ*.* With this family it is accordingly placed provisionally. It differs from the known fossil genera in the single tubercle of the internal part of the crown of the superior molars.

The species *M. brachystomus* and *M. etsagicus* of the Wasatch epoch must now be removed from this genus. I have shown that the former is an Artiodactyle. Now in technical points, the dentition of those species is identical with that of *Pantolestes* Cope, as well as with *Mioclænus*. Although the skeleton of the type of *Pantolestes*, *P. longicaudus* of the Bridger Beds, is yet unknown, it is safe to suppose that it does not differ from that of the *M. brachystomus*. I therefore refer the two species first mentioned to *Pantolestes*, and place that genus in the Artiodactyle sub-order.

* For the dentition of this family see Lemoine, Annales, Sc. Nat., 1878, July.

Char. specif.—The canines are well developed, and have a robust root. The crown is rather slender and is very acute. It is rounded in front, but has an acute angle posteriorly. It is not grooved, and the enamel is smooth. The single-rooted first superior premolar is situated close to the canine, and behind it is a short diastema. I have the probable first true molar or fourth premolar. The external cusps are rather small, and are well separated from each other. The inner outline of the crown is rather broadly rounded. The internal tubercle is connected on wearing, with an anterior transverse crest which terminates near the inner base of the anterior external cusp in an intermediate tubercle. There is a posterior intermediate tubercle. There is a cingulum all round the crown excepting at the posterior intermediate tubercle. The second (? first) true molar is like the one just described, but has relatively greater antero-posterior width. In this tooth the cingulum extends all the way round the crown.

There are but two inferior molars of this individual preserved, the second and third true. The former of these has a parallelogrammic outline with rounded angles. There are two posterior and two anterior rather large tubercles ; an anterior transverse ledge ; and a narrow external and posterior cingulum, the latter running into the internal posterior tubercle. The latter has a circular section, and is much smaller than the external posterior, which has a wide crescentic section. Of the anterior tubercles the anterior is much the larger, judging from its worn base. The third true molar is triangular in outline. Its crown includes two anterior and an external median tubercle. The inner and posterior parts of the crown form a wide shelf, with the internal edge denticulate. A weak external cingulum.

Measurements of Teeth.

		M.
Diameters base of crown of incisor	anteroposterior	.0045
	transverse	.004
Diameters base crown of canine	anteroposterior	.0130
	transverse	.0095
Diameters crown, superior M. i.	anteroposterior	.0095
	transverse	.0120
Diameters, M.? ii.	anteroposterior	.0110
	transverse	.0110
Diameters of inferior M. ii	anteroposterior	.0120
	transverse	.0105
Diameters of inferior M. iii.	anteroposterior	.0125
	transverse	.0090

The second individual includes part of the superior walls of the skull. The fragment displays a high sagittal crest, which is fissured in front so as to keep the temporal ridges apart to near its anterior apex. The brain surfaces show small, smooth, flat hemispheres, separated by a constriction from the wide and large olfactory lobes. The navicular bone shows three well defined distal facets, indicating probably five digits in the pes. The teeth of this specimen include a posterior superior molar, and an inferior third or fourth premolar, with other teeth. The premolar is like that of a creodont. Its principal cusp is a simple cone. To this is added a short wide heel, whose superior surface is in two parts, a higher and a lower, divided by a median ridge. A low anterior basal lobe, and a weak external cingulum.

The third specimen belonged to an individual a little smaller than the other two. It includes the first inferior true molar, a tooth lost from the others. Its form is somewhat narrowed anteriorly, where it has two low, but well separated anterior inner tubercles, which form a V with the external anterior.

Specimen No. 1 is accompanied by fragments of vertebræ and limbs. The former are principally from the lumbar region, but fragments of the atlas remain. This vertebra is of moderate length, and the cotylus is somewhat oblique. The vertebrarterial canal is rather elongate, and its anterior groove-like continuation in front of the diapophysis is not deeply excavated. The lumbar vertebræ are remarkable in the characters of their zygapophyses. These display subcylindric surfaces of the posterior pair, which indicates that the anterior ones are involuted, as in the specialized Artiodactyles and Perissodactyles of the later geological ages. Such a structure does not exist among carnivora, nor to my knowledge among creodonta, nor in any mammals of the Lower Eocene. I do not find it in *Didelphys* nor *Phascolarctos*, but it exists in a moderately developed degree in *Sarcophilus*. The articular surface forms more than half of a cylinder, and its superior portion is bounded within by an anteroposterior open groove. The surface within this is not revolute, as in *Bos* and *Sus*, but the articular surface disappears, as in *Cervus*. Eight such postzygapophyses are preserved, all disconnected from their centra. Two of them are united together. There are two other separated zygapophyses of smaller size, which have but slightly convex surfaces. One is probably a prezygapophysis of a dorsal vertebra. No centrum is preserved.

Of the anterior limb there is a probable distal half of a radius. It is of peculiar form, and resembles that of *Sarcophilus ursinus* more than any other species accessible to me. One peculiarity consists in the outward look of its carpal surface, which makes an angle of about 45° with the long axis of the shaft. The obliquity in *S. ursinus* is less. The external border of the shaft in *M. ferox* is, however, straight, and terminates in a depressed tuberosity. Beyond this, the border extends obliquely outward to the carpal face, which it reaches at a right angle. The internal border of the shaft is gradually curved outwards to the external border of the carpal face. Its edge is obtuse, while the external one is more acute for a short distance, and rises to the anterior (superior) plane of the shaft. The carpal face is a spherically subtriangular with rounded angles. It displays two slightly distinguished facets, one of which is superior, and the other is larger and surrounds it, except on the superior side. The internal marginal projection, or "styloid process," is not so prominent as in *S. ursinus*, and is a roughened raised margin. Joining it on the inferior edge of the carpal face is another rough projection of the margin. Immediately opposite this, on the superior edge of the carpal face, is a rough tuberosity, which encloses a small rough fossa, between itself and the styloid process. Internal to it is a shallow groove for an extensor tendon of the manus; then a low short ridge, and internal to that a wide shallow depression for other extensors. The carpal face differs greatly from those of *Sarcophilus* and *Didelphys* in having the inner portion wider than the outer, instead of the reverse, and in having no distinct styloid process. It indicates that the manus was turned outwards much more decidedly than in those genera.

Of carpal bones the only recognizable one is the unciform. Its proximal articular surface rises with a strong convexity entad, and descends to an edge ectad. The metacarpal surface is concave in anteroposterior section, forming a wide shallow groove, extending in the direction of the width of the foot. Its two metacarpal areas are not distinguished. The entire first and second metacarpals, with the heads of the third and fourth are preserved. They considerably resemble those of *Sarcophilus ursinus.* The distal articulations are injured in both, but both display a sharp trochlear keel posteriorly, which on the second extends nearly to the superior face of the articulation. The condyle is subround, and is constricted laterally, and at the base above. The second metacarpal is short and robust, shorter than in *Sarcophilus ursinus*. The first is also robust, but is relatively longer, as it is three-quarters the length of the second. Its head is expanded, especially posteriorly, and the large trapezial face is subtriangular, with round apex directed inwards as well as forward. The posterior face of the head is notched ectad to the middle. On the external side of the head there is a vertical facet with convex distal outline, for contact with the second metacarpal. The head of the latter is narrow, and is concave between the sides. The concavity is bounded posteriorly by a raised edge. The anterior part of the proximal facet is decurved. The shaft is deep proximally, but on the distal half is wider than deep. The lateral distal fossæ are remarkably deep and narrow, the condyle very much contracted. The head of the supposed third metacarpal is as wide as the second anteriorly, but narrows to the posterior third, and then contracts abruptly to a narrow apex. The supposed external side of the head is perfectly straight, and is continuous with the side of the shaft without interruption. The entad side displays no facet, but has a depression below the head which adapts itself very well to the head of the first metacarpal. In fact, if the metacarpals just named second and third, exchange places, so that second is placed third and third second, the metacarpal series fits far better. The fourth fits the so-called second much better than the so-called third. This may therefore be the true order, although that first used agrees better with the carpus of *Sarcophilus.* The head of the so-called third is slightly convex anteroposteriorly, and is oblique laterally, descending a little to the inner side. The fourth metacarpal is wider anteriorly than either the second or third. The inner edge is straight, while the outer is concave, the head being narrower before than behind. It has a lateral facet on each side; the inner plane, the external concave in the vertical as well as in the anteroposterior direction. It thus approaches the form of a metatarsal, but is not so strongly excavated, nor is the head notched on either side. The unciform face is convex anteroposteriorly and plane transversely.

The *femur* is broken up so that I cannot restore it. The head of the *tibia* is gone, but a considerable part of the astragalar face is preserved. This is transverse to the long axis of the tibia. It is narrowed anteroposteriorly next the fibular facet. Malleolus lost. The shaft is robust, and does not expand distally for articulation with the astragalus. Three centimeters proximal to the distal end, the external side throws out a low, rough, ridge-like tuberosity. Above the middle the crest turns outwards, leaving the internal face convex. There is a broken patella, which has one facet much wider than the other.

The *astragalus* has the trochlear portion a little oblique. That is, the internal crest is a little lower than the external, and the inner face is a little sloping. The latter is impressed by a fossa above the posterior part of the sustentacular facet, which runs out on the neck. The trochlea has a shallow groove which is nearer the external than the internal crest, and which passes entirely round the posterior aspect to the plane of the inferior face of the astragalus. The groove for the flexor tendon is thus entirely enclosed, and issues on the inferior face at the posterior extremity of the groove which separates the sustentacular from the condylar facets. The external crest of the trochlea is less prominent posteriorly than the internal, thus reversing the relations of the superior part. The internal ridge becomes quite robust, but does not flatten out and project sub-horizontally as in *Oxyæna forcipata.* The fibular face is vertical; neither its anterior nor posterior angles are produced. The neck is somewhat contracted (the internal side is injured). The head is a transverse oval, strongly convex vertically, moderately so horizontally, and without flattening. A *mesocuneïform* (or possibly *ectocuneïform*) bone is wedge-shaped in horizontal section, without posterior tuberosity, and its anterior face is a slightly oblique square. The narrower facet is oblique in the transverse sense.

The *metatarsals* are represented, excepting the first and second. The only complete one is the fifth. The heads of the third and fourth are much like those of *Oxyæna forcipata,* and of about the same size. Their anterior width is equal, and in both the external side is more oblique than the internal. Both have a notch at the middle of the internal side, but they differ in that the third has an open notch on the external side which is wanting to the fourth. The lateral excavations of the external sides are deep and rather large, and thin out the anterior external edge. The lateral facets are correspondingly large on the fourth and fifth; on the third metatarsal it is small, and a mere decurvature of the proximal surface. That of the fourth is longer proximo-distally than transversely. That of the fifth is about as long as wide, and presents more anteriorly; or, to express it more accurately, the shaft and head present more outwardly than those of the fourth. The proximal, or cuboid facet is narrow anteroposteriorly, and is curved, the external side being concave. On the external side just distal to this facet, the head of the bone expands into a large outward-looking tuberosity, which is separated from the posterior tuberosity by a strong notch. Between it and the head proper, on the anterior face, is a large fossa. The entire form is something like that of the proximal extremity of a femur with head, neck, great trochanter and trochanteric fossa. A somewhat similar form is seen in the corresponding bone of *Oxyæna forcipata*. The shaft of the fifth metatarsal, is one-fifth longer than that of the second metacarpal (? 3d) above described. Its direction is straight, but it is somewhat curved anteroposteriorly. Its section is subtriangular, the apex external. The condyle is narrowed and sub-globular above, and spreads laterally behind, the external expansion being wide and more oblique. The keel is prominent, and is only visible from above (in front) as an angle. The distal extremities of some other metatarsals differ in being flatter at the epicondyles, and concave between them on the posterior face. The condyles are more symmetrical, and are bounded above on the anterior face by a profound transverse groove. Several *phalanges* are preserved, including part of an unguis. They are all depressed, and with well marked articular surfaces, of which the distal are well grooved, and the proximal notched below. The lateral areas of insertion of the tendons of the flexors are well marked on the edges of the posterior faces. An ungual phalange is much compressed at the base. The basal table is well marked, and has a free lateral edge. The nutritive foramen enters above the posterior extremity of this edge. No trace of basal sheath.

Measurements of No. 1.		M.
Length of atlas at anterior vertebrarterial foramen		.0165
Expanse of postzygapophyses of a lumbar vertebra		.0230
Diameter radius at middle of shaft		.0100
Greatest distal width of radius		.0220
Diameters carpal surface	vertical	.0140
	transverse	.0185
Diameters of unciform	vertical (interiorly)	.0130
	anteroposterior (greatest)	.0140
	transverse (in front)	.0150
Diameters head metacarpal I	anteroposterior	.0130
	transverse	.0120
Length of metacarpal I		.0310
Width metacarpal I at epicondyles		.0110
Diameters head metacarpal II	anteroposterior	.0110
	transverse	.0070
Length of metacarpal II (or III)		.0400
Width do. at epicondyles		.0120
Diameter head of M. III (or II)	anteroposterior	.0125
	transverse	.0075

Measurements of No. 1.

		M.
Diameters head of M. IV	anteroposterior	.0120
	transverse (at middle)	.0070
Width of patella near middle		.0190
Diameters of tibia .07 M. from astragalus	anteroposterior	.0185
	transverse	.0130
Anteroposterior width of astragalar face		.0200
Total length of astragalus		.0310
Diameters of the trochlea	length on groove	.0210
	width above	.0160
	elevation externally	.0130
Greatest width of astragalus below		.0225
Length anterior to internal crest of trochlea		.0100
Diameters head of metatarsal III	anteroposterior	.0130
	transverse (in front)	.0110
Diameters head of metatarsal IV	anteroposterior	.0140
	transverse	.0105
Diameters head M. V	without tuberosity, anteroposterior	.0120
	without tuberosity, transverse, with lateral facet	.0080
	without tuberosity, transverse, without do.	.0040
	transverse over all	.0170
Length Mt. V		.0460
Width do. at epicondyles		.0120
Width do. at condyle above		.0065
Width of M. III or IV at epicondyles		.0120
Width of proximal end of phalange		.012
Length of smaller phalange (1st series)		.0230
Proximal diameter do.	vertical	.0070
	transverse	.0110
Ungual phalange, vertical diameter of cotylus		.0090

The specimen which has been partially described in the preceding pages as No. 2, has many pieces which are identical with those preserved in specimen No. 1. Among these may be mentioned the glenoid cavities of the squamosal bone. These display, besides the large postglenoid process, a well developed preglenoid ridge, as in *Arctocyonidæ*, *Oxyænidæ* and *Mesonychidæ*. A large distal caudal vertebra of elongate form, indicates a long tail. An articular extremity of a flat bone is intermediate in form between the proximal end of the marsupial bone of *Didelphys* and that of *Sarcophilus*. Its principal and transverse articular surface is transversely convex, as in the latter (*S. ursinus*), but the lesser articular face is separated from it by an even shorter concave interspace than in the opossum. It has almost exactly the form of that of the latter animal. It is a short, flat cone, with two faces presenting on the same side, the one part of the concavity mentioned, the other flat and presenting away from it. This piece has a slight resemblance to the very peculiar head of the fibula in the oppossum, but is not like that of *Sarcophilus ursinus*. I, however, think it much more probably the proximal extremity of a marsupial bone.

A supposed *cuneïform* is subtransverse in position, and resembles in general those of *Oxyæna* and *Esthonyx*. It has the two large transverse proximal facets, the anterior one-quarter wider than the posterior. The distal facet (trapeziotrapezoidal) is simple. The *navicular* is much like that of *Oxyæna forcipata*, but is more robust. Its external tuberosity is flattened anteroposteriorly, and is produced proximally. The three distal facets are well marked, the median a little wider than the external, while the internal is subround, convex, and sublateral in position. The *entocuneïform* is a flat bone, with cup-shaped facet for the navicular, and narrow facet for the first metatarsus. This facet is transverse transversely, and concave anteroposteriorly. It shows (1), that there is a pollex; (2), that it is probably small; and (3), that it was not opposable to the other digits, as is the case in the opossum. (4). It does not show whether the pollex has an unguis or not.

Measurements No. 2.

		M.
Transverse width condyle of mandible		.0230
Anteroposterior width condyle of mandible (at middle)		.0103
Diameters head of *os marsupii*	transverse	.0220
	anteroposterior	.0068
Diameters cuneïform	vertical	.0075
	anteroposterior	.0115
Diameters navicular	vertical in front	.0085
	transverse	.0180
	anteroposterior (middle)	.0110
Diameters ectocuneïform	vertical at middle	.0100
	anteroposterior (middle)	.0140
	transverse distally	.0060

Two other bones of specimen No. 2 I cannot positively determine. The first resembles somewhat the trapezium of *Sarcophilus ursinus*, and still more that of *Didelphys*. I will figure it, as a description without identification will be incomprehensible. The next bone is of very anomalous form. It may be the magnum, which is the only unrecognized bone of importance remaining, or it may be a large intermedium. It has no resemblance to the magnum of any mammal known to me. It was evidently wedged between several bones, as it has eight articular facets. Two are on one side; the largest (convex and oval) is on one edge; three are on one end, and two, the least marked, are on the other flat side, opposite to the first.

Restoration. We can now read the nature of the primitive mammal *Mioclænus ferox*, in so far as the materials above discussed permit. It was a powerful flesh-eater, and probably an eater of other things than flesh. It had a long tail and well-developed limbs. It had five toes all around, and the great or first toe was not opposable to the others, and may have been rudimental. The feet were plantigrade and the claws prehensile. The fore feet were well turned outwards. There were in all probability marsupial bones, but whether there was a pouch or not cannot be determined. These points, in connection with the absence of inflection of the angle of the lower jaw, render it probable that the nearest living ally of the *Mioclænus ferox* is the *Thylacynus cynocephalus* of Tasmania. The presence of a patella distinguishes it from Marsupials in general. Its dentition, glenoid cavity of the skull and other characters, place it near the *Arctocyonidæ*. Should the forms included in that family be found to possess marsupial bones, they must probably be removed from the *Creodonta* and placed in the *Marsupialia.*

This species is about the size of a sheep. The bones are stated by Mr. Baldwin, who discovered it, to be derived from the red beds in the upper part of the Puerco series.

MIOCLÆNUS BUCCULENTUS, sp. nov.

A part of the right maxillary bone which supports three molars indicates this species. The molars are P-m IV, M. i and M. ii. This series is characterized by the remarkably small size of the fourth premolar, and large size of the second true molar. The first true molar is intermediate.

The fourth premolar consists of an external cone and a much smaller internal one. There is a weak posterior basal cingulum. The reduced size of the internal cone suggests the probability that the third premolar has no internal cusp, and that there may be but three premolars. In either case the species must be distinguished from *Mioclænus.*

The first and second true molars have conic well separated external cusps, and a single pyramidal internal cusp. The intermediate tubercles are distinct. There is a posterior cingulum which terminates interiorly in a flat prominence. There is an anterior cingulum and a strong external one, which form a prominence at the anterior external angle of the crown. Enamel wrinkled.

Measurements of Superior Molars.

		M.
Length of bases of P-m. IV M. i and ii		.0180
Diameters P-m. IV	anteroposterior	.0040
	transverse	.0046
Diameters of M. i	anteroposterior	.0060
	transverse	.0065
Diameter of M. ii	anteroposterior	.0070
	transverse	.0085

MIOCLÆNUS SUBTRIGONUS Cope.

This species has been known hitherto* from a palate with three molars. I am now able to give the characters of the inferior molar series, which have been found, by Mr. Baldwin, associated with the true superior molars. Of the latter it may be remarked that the second true molar is not so much

*American Naturalist, 1881, 490–1.

longer than the first as in *M. bucculentus,* although the difference in size is very evident. The third is smaller than the first, and ovoid in outline, while the first and second are subquadrate. The external cusps are conic and widely separated and the intermediate areas are distinct. There is a cingulum all round the crown of the last two, and round that of the first except at the inner side, and at the anteroëxternal angle.

The last three inferior premolars are higher than long at the base, and are compressed and the apex acute. The posterior edge of the third and fourth is truncate, and simple. Each has a posterior cingulum which forms a narrow heel on the fourth. No other cingula. Of the true molars only the second is wanting. The form of these is like those of the *M. ferox,* with the cusps more prominent. The first only has trace of the anterior V; in the others, the two anterior tubercles are opposite and connected by a short anterior ledge. The heel of the first consists of a basin bounded by these tubercles, of which the external is pyramidal and largest. The median posterior is small. The heel of the third is narrow and prominent, and the internal lateral tubercle is represented by a short raised edge. The enamel of all the molars is wrinkled, and the inner side of the premolars is grooved with the height of the crown. A weak external cingulum on M. iii.

Measurements.		M.
Length of last three superior molars		.0265
Diameters of M. i	anteroposterior	.0060
	transverse	.0060
Diameters of M. ii	anteroposterior	.0062
	transverse	.0072
Diameters of M. iii	anteroposterior	.0047
	transverse	.0060
Length of last inferior molars		.0340
Length of last three premolars		.0140
Length of P-m. iv		.0050
Elevation of P-m. iv		.0050
Diameters of M. i	anteroposterior	.0057
	transverse	.0042
Diameters of M. iii	anteroposterior	.0070
	transverse	.0035

Rather larger than the pine weasel, *Mustela americana.*

Mioclænus corrugatus, sp. nov.

This species is known from a right maxillary bone which contains the last four molar teeth, with parts of pelvis and other bones of one individual.

This species is intermediate in size between the *M. protogonioides* and *M. ferox,* as the following measurements of the second superior true molar show:

	M. protogonioides.	*M. corrugatus.*	*M. ferox.*
Diameter, transverse	.011	.0118	.015
" anteroposterior	.008	.010	.013

The superior molars are more nearly quadrate than in the other species of the genus, owing to the better development of the posterior internal tubercle, which is, however, as in the others, a mere thickening of the posterior cingulum. It is wanting from the last superior molar. The cusps on the true molars are as in the *M. ferox*, small, and not large and closely placed as in *M. protogonioides*. The intermediate ones are nearly obsolete. The crowns are all entirely surrounded by a cingulum. The entire enamel surfaces wrinkled so as to be rugose, although the teeth are those of an adult and well used. The second superior molar is larger than the first, exceeding it in the transverse rather than the fore-and-aft diameter. The third is the smallest, and is of oval form with obliquely truncate external face. It is less reduced than in the *M. turgidus*.

The fourth premolar consists of a strong compressed-conic cusp with three basal cusps of small size, viz., an anterior, a posterior, and an internal. The last is the larger, though small, is formed like a heel, and is connected with the others by a cingulum. No external cingulum.

Measurements.			M.
Length of last four molars			.036
Diameters	P-m. iv	anteroposterior	.010
		transverse	.008
"	M. i	anteroposterior	.010
		transverse	.010
"	M. iii	anteroposterior	.008
		transverse	.011

From the Upper Puerco beds.

PANTOLAMBDA BATHMODON Cope, American Naturalist, 1882, p. 418.

In describing this genus and species, I remarked, loc. cit., that they were "founded on a mandibular ramus, which supports the first true molar, and the last two premolars. The characters of these teeth remarkably resemble those of *Coryphodon*. * * * It will be for additional material to demonstrate whether this genus belongs to the *Amblypoda* or *Perissodactyla*."

A considerable part of the skeleton of this species having been recently sent me by Mr. D. Baldwin, I am able to throw much light on the affinities of this curious genus.

In the first place, the phalanges (not ungual), show that the genus is ungulate. Secondly, the astragalus has a large distal facet for the cuboid bone. This proves that the genus cannot be referred to the Taxeopod order. The question as to whether it belongs to the *Amblypoda* or the *Diplarthra* would be decided by the carpus, but that part is unfortunately not preserved, and I have to rely on empirical indications for a provisional determination. Apart from the astragalus, the characters are those of the *Condylarthra* rather than of the *Perissodactyla*, and it is therefore to be supposed that the carpus has also the characters of that order. This would place the genus in the *Pantodonta*, which has the carpus nearly that of the *Taxeopoda*, and the tarsus of the *Diplarthra*. The points of resemblance to the *Condylarthra* are the following: The ilium is narrow. The humerus has an epitrochlear canal. The superior molar teeth have but one internal lobe. The resemblances to the *Pantodonta* are these: The cervical vertebræ are plane and short. The femur has a third trochanter. The premaxillary bone in dentigerous. The astragalar trochlea is as in the *Periptychidæ*, and the *Proboscidia;* that is without groove, and slightly convex anteroposteriorly, thus differing from that of the *Pantodonta*. The dentition is especially like that of the *Amblypoda* in general, and that of the superior series is unlike anything known in the *Diplarthra*.

I propose to place this genus in the *Amblypoda* for the present, next to the *Pantodonta*, but it cannot enter that sub-order on account of the form of its astragalus. The sub-orders of *Amblypoda* will be defined as follows:

Astragalus with a head distinct from trochlea, with distal articular facets .... *Taligrada*.
Astragalus without head; distal facets subinferior........... *Pantodonta*.

In the sub-order *Taligrada*, the single family *Pantolambdidæ* presents the following characters:

Superior and inferior molars with the cusps developed into Vs. Postglenoid process present; postympanic and paroccipital not distinct. All the vertebræ with plain articulations. Humeral condyles without intertrochlear ridge. Femur with third trochanter. Digits of posterior foot probably five. Metapodial keels small and posterior.

Of this family *Pantolambda* is as yet the only known genus. Its leading characters are as follows:

Canine teeth distinct; dental series continuous. Superior molars all triangular, that is with a single internal cusp. External cusps of premolars unknown; of molars two. Internal cusp V-shaped, sending its horns externally as cingula to the anterior and posterior bases of the external side of the crown, without intermediate tubercles. Inferior true molars with a crown of two Vs, the anterior the more elevated. Premolars consisting of one open V, with a short crest on a short heel, as in *Coryphodon*. Dental formula I. $\frac{?3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{?4}{?4}$; M. $\frac{3}{3}$; the last inferior with a heel. A strong sagittal crest. Auricular meatus widely open below. Large postparietal, postsquamosal and mastoid foramina.

Cervical vertebræ rather short; other vertebræ moderate, the lumbars not elongate. A large tail. Humerus with large internal epicondyle. Femur with all the trochanters large. Ilium with the anterior inferior spine well developed. Metacarpals short, plantigrade. Phalanges of second series flat, and of subquadrate outline. The astragalus has a wide head, but no neck, as it is not separated from the tochlear portion by a constriction. It is as wide as the trochlear portion, but about one-third of its length extends within the line of the malleolar face of the trochlear portion. The navicular face is flat, that of the cuboid bone is convex vertically, and one-half as long horizontally as the navicular, and only half as deep. These two facets are continuous with the sustentacular below. Interior to all of these, on the internal tuberosity of the head is a sub-round facet looking inwards, like that characteristic of the genus *Bathmodon*, but relatively larger. A continuous facet is seen on the adjacent edge of the navicular. The use of these facets is unknown.

The brain case indicates small and nearly smooth hemispheres, extending with little contraction into a rather large cerebellum. The olfactory lobes are produced anteriorly at the extremity of a rather long isthmus.

If we consider the dentition alone, *Pantolambda* is the ancestor of the *Coryphodontidæ*. The history of the feet requires further elucidation.

The *Pantolambda bathmodon* is about as large as a sheep.

From the upper beds of the Puerco.

MIXODECTES PUNGENS, gen. et sp. nov.

Char. Gen.—The position of this genus is uncertain, but may be near to *Cynodontomys* Cope, which I have provisionally placed among the Prosimiæ*. It is only known from mandibles, which have presumably the following dental formula. I. 0 ; C. 1 ; P-m. 4 ; M. 3. An uncertainty exists as to the proper names of the anterior teeth, which cannot be decided until the discovery of the superior series. For instance the formula may be ; I. 1 ; C. 1 ; P-m. 3.

The supposed canine is a large tooth, issuing from the ramus at the symphysis like a rodent incisor, and has an oval section, with long diameter parallel to the symphysis. The crown is lost from all the specimens. The second tooth is similar in form to the first, but is much smaller. It is situated posterior and external to the first. The next tooth is still smaller and is one-rooted. The third and fourth premolars have simple conic crowns, and more or less developed heels without cusps. The true molars are in general like those of *Pelycodus ; i. e.*, with an anterior smaller, and a posterior triangle or V. The supplementary anterior inner cusp is quite small, while the principal anterior inner is elevated. The posterior inner is much more elevated than in the species of *Pelycodus*. Last inferior molar with a fifth lobe.

This genus cannot be referred to its place without additional material, but the parts discovered indicate it to be between *Pelycodus* and *Cynodontomys ;* either in the *Mesodonta* or the *Prosimiæ*. I may here remark that in defining the latter genus I was in doubt as to the number of the inferior premolars. The discovery of the present genus renders it probable that it has three such teeth, and that the anterior two are each one-rooted.

Char. Specif. The mandible of the *Mixodectes pungens* is about the size of that of the mink. Its inferior outline is straight to below the second premolar, whence it rises upwards and forwards like that of a rodent. The anterior masseteric ridge is very prominent, but terminates below the

* Paleontological Bulletin No. 34, p. 151.

middle of the ramus. Inferior masseteric ridge much less pronounced. The inferior part of the ramus is robust below the base of the coronoid process, but there is no indication of recurvature of the edge. Mental foramina two ; one below the front of the first true molar, and one below the second premolar.

The oval base of the canine is not flattened on either side; that of the second tooth is flattened on the inner side. There is a great difference between the sizes of the last three premolars. The fourth is twice as large as the third, and the second, judging from the space and the size of its alveolus, was much smaller than the third, and the crown was probably a simple acute cone. The crown of the third is of that form, with the addition of a short heel. The long axis of the base of the crown is diagonal to that of the jaw. The fourth premolar has a relatively larger heel than the third, but it is shorter than the diameter of the base of the cusp. Its posterior edge is elevated. The cusps of the anterior pair of the true molars are elevated, but the interior is the most so. The supplementary one is not exactly in the line of the interior border of the crown. Each of the inner cusps are connected with the base of the external by a ridge, which together form a V. The posterior base is nearly surrounded by a raised edge, which rises into cusps at the posterior lateral angles. Of these the internal is the more prominent. The edge connecting these cusps is slightly convex backwards, and evidently bears a part in mastication. The lateral borders of the last molar are somewhat expanded, and the fifth lobe is very short. No cingula on any of the teeth.

Measurements.		M.
Length of dental series from "canine" exclusive		.0265
" true molar series		.0140
Diameters "canine"	longtitudinal	.0040
	transverse	.0030
Long diameter of base of "P-m. i"		.0028
" " " P. m-ii		.0017
Diameters P-m. iv	vertical	.0055
	anteroposterior	.0050
Diameters M. ii	transverse	.0038
	anteroposterior	.0050
Length of crown of M. iii		.0060
Depth of ramus at P-m. iii		.0090
" " M. iii		.0100

MIXODECTES CRASSIUSCULUS, sp. nov.

This mammal is represented by fragments of two mandibles from different individuals ; one less and the other more worn by mastication. The species differs from the last in its greater size, and in the relatively greater length of the last inferior molar. The length of the posterior four molars of the *M. pungens* equals that of the three true molars of the *M. crassius-*

culus; and the last true molar of the latter is half as long again as the penultimate, while in *M. pungens* it exceeds it but little.

The best-preserved true molar is the second. Its most elevated cusps are the anterior and posterior inner, of which the anterior is subconic and more elevated. The anterior external cusp is crescentic in section, and sends crests to the supplementary, anterior, inner and the posterior anterior inner, both of which descend inwards. The posterior crest reaches the posterior base of the anterior inner cusp.

The posterior external cusp is an elevated angle, sending crests forward and backwards. The former reaches the base of the anterior external cusp (not reaching the inner), while the latter passes round the posterior edge of the crown. As in *M. pungens*, it is convex posteriorly, and rises to the posterior internal cusp. In both species its appearance indicates that it performs an important masticatory function in connection with the superior molar. No cingula.

Measurements.		M.
Length of bases of M. ii and iii; (No. 2)		.0125
" base of M. iii; (No. 2)		.0070
Diameters crown M. ii; (No. 1)	anteroposterior	.0056
	transverse	.0050
Depth of ramus at M. ii; (No. 1)		.0100

PERIPTYCHUS CARINIDENS Cope.

Additional specimens of this species demonstrate that the last inferior molar has a different form from that of the *P. rhabdodon*. While of the same length, it is narrower throughout, conformably with the smaller size of all the other molar teeth.

PHENACODUS CALCEOLATUS, sp. nov.

This species is founded on fragments of the skull and limbs, with teeth, of a single individual. The teeth consist of two superior and four inferior molars of one side, and a smaller number of those of the opposite side.

The teeth are of the size of those of the *Phenacodus puercensis*, and like that species, there is no median external cingular cusp of the superior molars. In these teeth the external basal cingulum is weak, but there is a strong anterior cingulum, distinct from any of the cusps. No internal cingulum. External cusps conical, well separated; intermediate cusps rather large; internal cusps rather large, close together, but deeply separated. The last superior molar is reduced in size. It has well developed anterior and posterior cingula, a weak external, and no internal cingula. The intermediate tubercles are rather large, and there is one large internal tubercle.

The heel of the last inferior molar is short, wide and rounded. The posterior tubercle is but little behind, opposite the posterior internal tubercle. The latter is separated from the anterior inner by a deep fissure, while the opposite side of the crown is occupied by a large median external cusp, which has a semicircular section. The large anterior cusps are confluent on wearing. No anterior cingulum in the worn crown. The crowns of the first and second true molars of the specimen are rather worn. They show that the posterior median tubercle is very indistinct and probably absent. The bases of the smaller inner cusps are round, and on wearing unite with the larger external cusps. Of the latter the posterior is the larger. Anterior cingulum rudimental or wanting. No lateral or posterior cingula. The principal peculiarity of the lower dentition of this species and the one from which it is named, is the form of the third or fourth (probably third) premolars, both of which are preserved. They have a compressed apex, which descends steeply to the anterior base, without basal or lateral tubercle. The base of the crown spr?ads out laterally behind, and is broadly rounded at the posterior margin, so as to resemble the toe of a wide and moccasined foot. It is depressed, the surface rising to the apex from a flat base.

Measurements.		M.
Diameters of second superior molar	anteroposterior..	.0080
	transverse......	.0100
Diameters of last superior molar	anteroposterior.....	.0067
	transverse..........	.0085
Length of inferior true molars......................		.0258
Diameters of M. ii	anteroposterior..................	.009
	transverse......................	.008
Diameters of M. iii	anteroposterior..................	.0085
	transverse	.0068
Diameters of the P-m. iii	anteroposterior............	.008
	transverse.................	.005

About the size of the *P. puercensis.*

NOTE ON THE MAMMALIA OF THE PUERCO AND THE ORIGIN OF THE QUADRITUBERCULATE SUPERIOR MOLAR.—It is now apparent that the type of superior molar tooth which predominated during the Puerco epoch was triangular; that is, with two external, and one internal tubercles. Thus of forty-one species of Mammalia of which the superior molars are known, all but four have three tubercles of the crown, and of these thirty-eight triangular ones we may except those of three species of *Periptychus,* which have a small supplementary lobe on each side of the median principal inner tubercle.

This fact is important as indicating the mode of development of the various types of superior molar teeth, on which we have not heretofore had clear light. In the first place, this type of molar exists to-day only in the insectivorous and carnivorous Marsupialia; in the Insectivora, and the tubercular molars of such Carnivora as possess them (excepting the plantigrades). In the Ungulates the only traces of it are to be found in the molars of the *Coryphodontidæ* of the Wasatch, and *Dinocerata* of the

Bridger Eocenes. In later epochs it is chiefly seen only in the last superior molar.

It is also evident that the quadritubercular molar is derived from the tritubercular by the addition of a lobe of the inner part of a cingulum of the posterior base of the crown. Transitional states are seen in some of the *Periptychidæ* (*Anisonchus*) and in the sectorials of the *Procyonidæ*.

On the Brains of the Eocene Mammalia Phenacodus and Periptychus. By E. D. Cope.

(Read before the American Philosophical Society, December 15, 1882.)

PHENACODUS PRIMÆVUS Cope.

A cast of the cranial cavity gives the following as the general characters of the brain. The cerebal hemispheres are remarkably small, each one being less by one-quarter than the cerebellum. They are separated from the latter and from the large olfactory lobes by strong constrictions. The posterior one is occupied by a thick tentorium. In like manner a wide groove for a robust falx separates the hemispheres above, a notch represents the sylvian fissure, and the lobus hippocampi is quite large. The vermis of the cerebellum is quite distinct, and the lateral lobes are large. They are impressed laterally by the petrous bones as in various ruminants. The anterior columns of the medulla are not visible. There are traces of the convolutions on their hemispheres.

The brain displays the following more special features. The olfactory lobes are as wide as long, and they diverge, having two external sides. In section they are triangular, presenting an angle downwards. The hemispheres are depressed, and wider posteriorly. They are well separated from each other and from the cerebellum ; so much so that it is quite probable that the copora quadrigemina are exposed. Their outlines are however not distinguishable on the flat surface which connects the hemispheres posteriorly. No further indication of sylvian fissure can be seen in the cast beyond an entering angle defining the lobus hippocampi anteriorly. The latter is prominent externally, and less so downwards. There are distinct indications of convolutions. There are three on each side above the sylvian convolution, and a fourth extends from the sylvian upwards and posteriorly below the posterior part of the third or external convolution. The sulci separating the convolutions are very shallow. The internal and external convolutions unite anteriorly, passing round the extremity of the median convolution. The space between this gyrus and the base of the olfactory lobe is only three millimeters.

The cerebellum is larger than a single hemisphere. Its superior surface is somewhat flattened, and descends forwards; the lateral boundary of this face is a projecting edge which rises behind to an angle of the vermis. The posterior face is shorter than the superior, and is vertical. It is separated by a space from a very prominent lateral convolution, while the region of the flocculus is concave from the internal form of the ascending portion of the petrous bone. This concavity is open anteriorly. The base of the fifth pair of nerves is below its apex, and that of the sixth below the inferior extremity of the lateral convolution. The section of the medulla oblongata is a transverse oval; its inferior face and that of the pons varolii, smooth. A deep fossa just anterior to the bases of the optic nerves.

Measurements of brain.	M.
Length from vermis to olfactory lobes inclusive	.070
" of olfactory lobes from above	.015
" of hemispheres, from above	.030
" of cerebellum from above	.024
Depth of olfactory lobe	.010
" of hemisphere	.023
" of cerebellum and medulla	.026
" of medulla at vermis	.015
Width of olfactory lobes at middle	.030
" of hemispheres in front	.044
" " behind	.044
" of cerebellum	.036
" medulla at vermis	.020

PERIPTYCHUS RHABDODON Cope.

I have obtained a cast of the top and sides of the cerebral hemispheres, and the proximal portion of the olfactory lobes, from a skull of a *Periptychus* in which the teeth are preserved, and prove the species to be the *P. rhabdodon*. The olfactory lobes are enormous, and the hemispheres small and very flat. The *mesencephalon is entirely exposed.* The cerebral hemispheres are very flat, and are only differentiated from the olfactory lobes, by a moderate contraction and depression, which forms the peduncle of the latter. Only the proximal part of the olfactory lobes is preserved, but this expands so as to be only a little narrower than the hemispheres. The peduncle has a ridge on the median line, and a shallow fossa on each side of it. The lateral outlines of the hemispheres diverge, and the widest part is posterior. There is no indication of sylvian fissure. The transverse section of the hemispheres would be a flat arch, but for the presence of a longitudinal oval protuberance on each of them, which do not quite touch the median line, and which have definite boundaries. If their limits determine the size of the cerebral hemispheres, then the latter are wider than long, but they probably pass gradually into the mesencephalon behind them. These bodies remind one of the corpora olivæformia, and may represent the superior or median frontal convolutions. They are probably, however, not to be homologized with any convolutions, representing rather the cerebral vault of the lateral ventricle. Posterior to them the flat surface descends gently without indication of copora quadrigemina or other irregularity, and at a distance about equal to the length of the oval bodies, it begins to rise gently. The cranium is broken here, and no cast of the cerebellum was obtained.

I may remark that the cranium from which this cast is taken is not crushed, and that it consists of parts of the parietal and squamosal bones only. The latter remain as far as the incurvature to the pterygoid processes in front of the glenoid cavity.

Measurements of brain.	M.
Length from posterior rise to base of olfactory lobes....	.037
Length of oval bodies of hemispheres.................	.018
Width of proximal part of olfactory lobes.............	.027
Width of olfactory peduncles.........................	.021
Length from olfactory lobes to oval bodies of hemispheres.........	.005
Diameter of hemispheres at posterior part of oval bodies.	.038
Depth from sagittal crest to olfactory lobes............	.024

EXPLANATION OF PLATES.

Plate I.

Casts of the brain case of *Phenacodus primævus* Cope, natural size.

Fig. 1. Lateral view.
Fig. 2. Superior view.
Fig. 3. Anterior view.
Fig. 4. Posterior view.

Plate II.

Fig. 1. Brain of *Phenacodus primævus,* inferior view.
Fig. 2. Cast of brain case of *Periptychus rhabdodon,* superior view.
Fig. 3. Cast of brain case of *Periptychus rhabdodon,* lateral view.

Photodynamic Notes, VII. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, January 19, 1883.)

302. *Combined Cometary Harmonies.*

In Note 295, I showed that the primitive phyllotactic wave-tendencies in the spectrum of Comet Wells, were modified by linear oscillations, and also by two seemingly independent harmonic progressions. One of the arithmetical progressions which formed the harmonic divisors had a missing term, $1 + b$, for which Huggins observed no corresponding line. Upon further examination, I find that the completion of the harmony, by inserting the provisional wave length, ${}_{,}\beta_1 = \alpha \div (1 + b) = 4583.4$, furnishes a phyllotactic bond between the two observed harmonic progressions. For $4583.2 = \gamma + \frac{3}{5}\,({}_{,}\beta\text{-}\gamma)$, and ${}_{,}\beta_1$ represents a projectile locus of rotary oscillation between ${}_{,}\beta$ and γ. Moreover, the locus of the center of rotary oscillation, $\frac{2}{5}\,({}_{,}\beta-\gamma) = 50.8$, helps to determine phyllotactically the value of α, since $\frac{3}{8}\,(\alpha-{}_{,}\beta) = 50.625$.

303. *Telephonic Analogy.*

The telephone shows the influence of harmonic oscillations in successive media of different elasticity, and it may perhaps furnish suggestions which will prove useful in investigating the persistence of solar energy. The atmospheric sound-waves strike the diaphragm, exciting metallic sound-waves; these, in the mechanical telephone, are transmitted through the wire to the receiving diaphragm, where they excite new atmospheric sound-waves, which awaken audible sound-waves in the tympanum of the listener. In the electric telephone, the metallic sound-waves modulate the electric waves, which are forwarded with much greater speed than the ordinary metallic waves, affecting the air in the receiver and the ear of the hearer in the same way as in the mechanical telephone. In a communication to the American Philosophical Society, March 21, 1873 (*Proc.*, xiii, 149-54), I pointed out harmonies of light and sound, which, with the identity of Note 280, account for these successive transformations. Berthelot's explosive waves, (Notes 276, 278) must similarly produce luminous and electrical waves in Sun's atmosphere, and thus contribute towards the maintenance of solar radiant energy.

304. *Amount of Solar Thermal Radiation.*

A. Ritter, (*Wied. Annalen*, 1882, No. 10), estimates the solar radiation at 14,000 calories per square metre per second. This is equivalent to 3976100 foot-pounds per square foot. If the Sun were surrounded with an atmosphere like our own, but of superficial density proportional to the gravitating pressure, the pressure would be about 420 pounds per square foot. The radiation, therefore, would be sufficient to maintain a constant circulation of the entire atmosphere, at the rate of 9467 feet per second, which is but little more than half as great as the explosive velocity of

H_2O (Note 298), about 1.56 times the molecular velocity of hydrogen, and about $\frac{4}{3}$ of the equatorial velocity of Sun's rotation. All of these relations are of an order of magnitude which tends to confirm the belief that solar radiation and gravitating circulation represent equal actions and reactions, and that dissociation and recombination within Sun's photosphere may maintain luminous, thermal, and actinic æthereal oscillations.

305. *Cometary Fugues.*

The spectral harmonies in Comet Wells (Notes 295, 302), as well as the planetary harmonies on which I based some of my successful predictions, (Notes 33, 133, 261, etc.), are of the nature of fugues, or harmonies which follow each other at certain intervals which are determined by rhythmic laws. The principle of the fugues being susceptible of indefinite extension in two directions, it is not strange that even the stars should bear witness to it (Notes 24, 46, 85, 111-5, 130-2, 154-5, 168, 262). Among the intra-modular positions which have verified my anticipations, two (Note 32) are known to be cometary; two represent the places of brilliant bodies which were seen by Watson and Swift, during the total solar eclipse of 1868, but which, having been seen by no subsequent observer, may also have been cometary; two were deduced from a comparison of planet-like shadows crossing Sun's surface, and one from sun-spots of various forms, which have a harmonic period; seven indicate periods which are in strict harmonic accordance with motions of our stellar system's chief centres, of nucleation (Sun), of condensation (Earth), and of nebulosity (Jupiter). All the indications seem somewhat likely to be cometary, rather than planetary, and thus confirmatory of Herschel's theory of nebular "subsidence." As the statements of these confirmations of cosmical harmonic motion are scattered among various papers, I collect them here, in order to show, at a glance, the character of the various accordances.

Harmonic.	Observed.	Authority.	Notes.
296.52	285.2	Forbes	32, 261
94.38	96.7	Forbes	32
.27	.267	De la Rue, S. and L.	33
.207	.209	Kirkwood	"
.185	.180	Gaillot	"
.167	.164	Gaillot and Mouchez	"
.167	.163	Stewart	133
.141	.140	Earth's day and year	33
.121	.123	Von Oppolzer	"
.1065	.1069	Solar rotation, $v_\gamma = v_\lambda$	"
.0199	.0195	Earth's day	"
.0109	.0109	Jupiter's day	"
.0076	.0074	Solar oscillation	"
.0058	.0057	Solar "subsidence"	"
.0047	.0047	Sun's surface	"

The seven loci which represent harmonies of nucleation, condensation and nebulosity, illustrate the tendency of waves in elastic media to maintain and propagate motions which are harmonically dependent upon their loci of origination.

306. *Velocity of Incandescence.*

Draper found that all solid bodies become incandescent at the same temperature, reaching red heat at 977° F., or at the absolute temperature of 1436°.4 F. This indicates a lift, against earth's superficial gravitation, of $h = 1436.4 \times 772 = 1,108,901$, or a velocity of $v = \sqrt{2gh} = 8435.9$ feet per second. The mean velocity of hydrogen molecules is 6050 feet, which is $.717 \times 8435.9$ feet. The velocity of incandescence is, therefore, within $1\frac{1}{2}$ per cent. of the parabolic orbital velocity which would correspond to a circular orbital velocity equivalent to the molecular velocity of hydrogen, $(6050 \times \sqrt{2} = 8556)$. In other words, if the mean velocity of hydrogen, at the standard temperature, is a mean orbital velocity, its increase to a velocity of infinite projection would give the velocity of incandescence, or the velocity which creates æthereal disturbances of sufficient magnitude to cause luminous radiations. These disturbances are of the same order of magnitude as those which are indicated in Note 304, and they furnish new reasons for believing that the hypotheses of Siemens and Berthelot (Note 278) may suffice to account for the conservation of energy which is indicated by the fundamental equality, $v_\lambda = v_\varepsilon = v_\gamma$, (Note 280).

307. *Tails of Comets.*

Proctor (*Contemp. Rev.*, Oct. 1882) states some of the chief difficulties attending the attempts which have been made to explain the formation of comets' tails, by materials thrown off from the nucleus by solar repulsion, by actinic clouds, by tactic arrangement, or by electricity, and speaks of certain phenomena "which force upon us the belief that they are phenomena of repulsion, though the repulsive action is of a kind not yet known to physicists." He inclines, with Huggins, and "an American astronomer" whose name is not given, to attach great importance to electric action or something of a similar nature. He cites the notice by Huggins, of the remarkable persistence of meteoric trains in the rare upper atmosphere, where they sometimes last for more than three-quarters of an hour. The evidences of repellent action such as might be explained by electricity, of gravitating re-action, of luminous radiation from the sun in the direction of the axis of the tail, and of a general curvature of the extremity of the tail as if it were retarded in some way, are such as to need consideration in any attempts at explanation. All of these phenomena, except the one last named, may be correlated by the fundamental equality of Note 280. The curvature of the tails may be due to persistence of oscillation, combined with æthereal tendencies to orbital motion in times varying as $r^{\frac{3}{2}}$. The extreme tenuity of cometary matter points to a relative elasticity which is much greater than that of air, and which must, therefore, be peculiarly subject to harmonic oscillations; the waves of light, like auroral flashes, which have often been seen in the tails, point to electric, phosphorescent, and luminous rhythms; the frequent interchanges between the tail and the nucleus, as well as the rupturing explosions and the formation of nucleoli, must be subject to the laws of phyllotactic and gravitating rhythm; if the æther is material, it must be influenced by rotational and orbital tendencies, even if its elasticity is so great as to prevent actual orbital motion, and hence the "actinic shadows" may be curved.

308. *Other Cometary Considerations.*

Phyllotactic distribution in organic growth, in frost tracery and other forms of crystallization, and in satellite or planetary groupings, points to a continuance of tendency, over periods which are proportional to the resistance interposed by the inertia of the particles or masses which partake of the distribution. When the inertia is very small, as in the æthereal interferences to which spectral lines are attributed, the adaptation to requirements of "extreme and mean ratio" may be nearly or quite instantaneous. We may, therefore, reasonably look for evidences of adaptation, such as are shown in Notes 295, 302 and 305, as well as for various modifications by other forms or kinds of harmonic tendency. Refraction of energy (Note 286), and Draper's "latent light," may also contribute to the curvature of tails, in a medium which is perhaps more tenuous than the "fourth form of matter," and which imparts sympathetic vibrations to the adjacent æther.

309. *Effects of Cometary Eccentricity.*

The tendencies to æthereal rotation and revolution about stellar centres may, perhaps, be so adjusted to other oscillatory tendencies as to oppose little or no resistance to planetary motions in orbits of small eccentricity. Most of the cometary orbits, however, are so eccentric that their *vis viva*, at every stage of their journey, is nearly twice as great as it would be if their paths were circular. Such amount of living force is more than sufficient, whenever there is any appreciable resistance, to produce and maintain luminous and thermal phenomena, of the same kind as occur in the explosive combinations of gases. The orbital energy may be resolved into two rectangular components, one of which passes through the sun, while the other is tangential to the path of the revolving æther. The latter may adapt itself so readily to the æthereal vortices as to make no disturbance; the former being perpendicular to the æthereal track, must encounter a continual resistance and retardation, unless it is compensated by luminous, electric, gravitating, or other kinetic undulations.

310. *Eccentricity at Mean Centre of Inertia.*

The fundamental identity (Note 280) represents a uniform velocity, and we may, therefore, look for evidences of primitive photodynamic influence in the uniform velocities of important cosmical centres. One of these evidences is found in the proportion,

$$t_\alpha : t_\beta :: T_\alpha : T_\beta$$

In this proportion, t_α, is the orbital time at the chief centre of condensation (Earth); t_β, the orbital time at the centre of primitive nebulosity (Jupiter); T_α the time in which a photodynamic wave would traverse the secular eccentricity at the primitive centre of planetary inertia (Saturn); T_β the time in which the wave would traverse Saturn's semi-axis major. The accordance is shown by substituting the values, which give the proportion,

$$365.2564 : 4332.5848 :: .08431 : 1$$

Stockwell's estimate of Saturn's secular excentricity is .08433. T_α and T_β also represent the comparative living forces which would project a planet, against uniform resistance, through the distances traversed by the respective photodynamic waves.

311. *Harmonies of Terrestrial Acceleration.*

The cyclic oscillations at the chief centres of condensation and nebulosity would tend to produce corresponding accelerations through the action of central forces. An important harmony, which introduces the *vis viva* of acceleration, is shown in the proportion,

$$a^2_\alpha : a^2_\beta :: t_\alpha (t_\alpha + t_\beta) : t_\beta.$$

In this proportion, a_α is the rotary acceleration which Earth has undergone according to the nebular hypothesis; a_β, the acceleration according to Herschel's theory of "subsidence;" t_α and t_β have the same values as in the foregoing note. The value of a_α is $\left(366.2564 \div 2\pi\sqrt{\frac{r}{g}}\right)^{\frac{2}{3}} = 338.22$; $a_\beta = 86164.1 \text{ sec.} \div 2\pi\sqrt{\frac{r}{g}} = 16.983$. Substituting these values we get

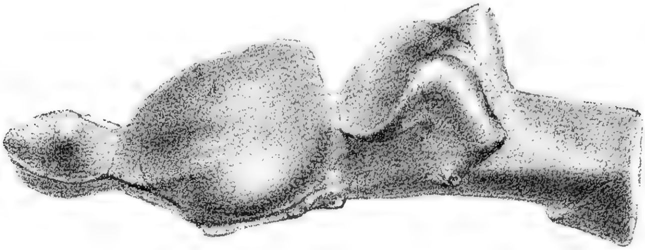
$$338.22^2 : 16.983^2 :: 396.62 : 1$$
$$396.62 : 366.2564 :: 1.0829 : 1$$
$$t_\alpha + t_\beta : t_\beta :: 1.0843 : 1$$

This harmony furnishes additional grounds for rejecting Delaunay's hypothesis of terrestrial retardation by tidal friction.

312. *Earth's Accelerated Rotation.*

I have already referred to the inconsistency of Delaunay's views with the nebular hypothesis. According to the form of that hypothesis which was taught by Laplace, at the time of nebular rupture the day and year should have been sychronous. In order to establish such sychronism at the present time, Earth's radius would need to be expanded ($\sqrt{366.2565} = 19.138$) times, and Laplace's terrestrial limit would be

$$\left(1 \text{ year} \div 2\pi\sqrt{\frac{r}{g}}\right)^{\frac{2}{3}} r, \text{ or } 338.218r.$$



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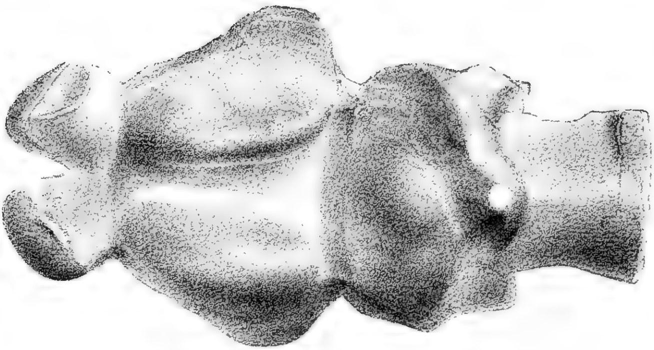

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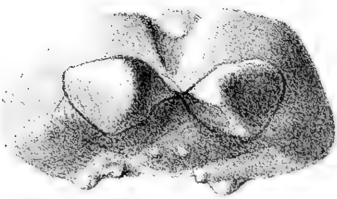

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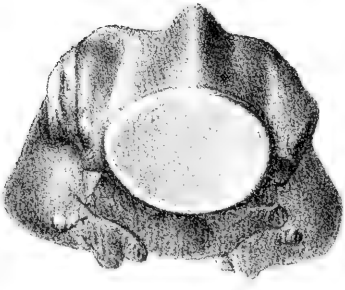

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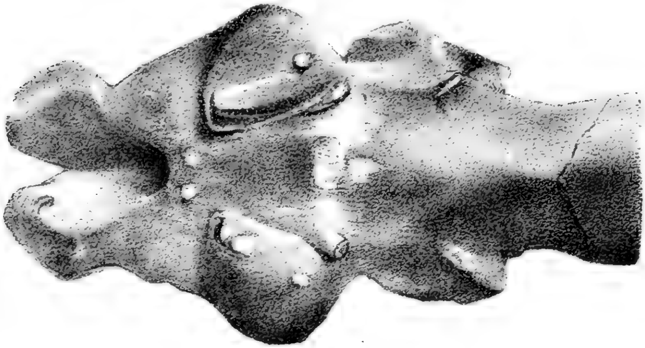
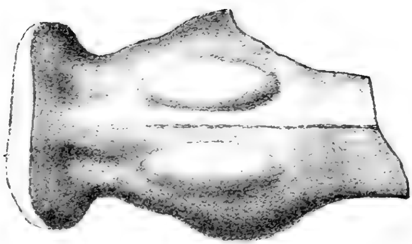
PHENACODUS PRIMAEVUS K





T. Sinclair & Son, Lith Phila.

1. PHENACODUS PRIMAEVUS ½. 2-3. PERIPTYCHUS RHABDODON ⅟₁

This represents a comparative acceleration of the velocity of rotation which may be very closely represented by the quotient of (Jupiter's year × Earth's year) by (the sum of Jupiter's and Earth's years × Earth's day), or by 4332.5848212 × 365.2563582 ÷ (4332.5848212 + 365.2563582) = 336.858. As this equation introduces considerations of the chief centres of nucleation, nebulosity and condensation which must still be efficient, it furnishes another reason for caution in dogmatizing about tidal friction and thermodynamic laws.

313. *Joint Relations of Sun, Jupiter, Earth and Venus.*

A succession of important harmonic motions is shown in the relations of solar mass and density, which make $g_0 t_0 = v_\lambda$; the relation of Sun's mass to Jupiter's mass which makes Sun's surface the projectile locus, or secular perihelion centre of gravity, of Sun and Jupiter; the relations of terrestrial mass and density which make $g_3 t_3$ = circular orbital velocity at the mean centre of gravity of Sun and Jupiter; and the relation of Venus to Earth which makes the incipient orbital *vis viva* of Venus (at secular aphelion) equal to Earth's mean orbital *vis viva*. If we adopt the British Nautical Almanac estimate of Sun's apparent semi-diameter (961.″83), the accordance of harmonic and computed values will be as follows:

	Harmonic.	Computed.	Authority.
Sun ÷ Venus	427326	427240	Hill.
" " Earth	330463	331776	(Oscillatory)
" " Jupiter	1047.879	1047.879	Bessel.

Earth's semi-axis major, 92,661,600.

314. *Joint Relations of Sun, Jupiter, Earth and Saturn.*

Alexander's harmony ($m_5 d_5^2 \doteq m_6 d_6^2$) is rendered more significant by Saturn's orbital situation at the nebular centre of planetary inertia, $(\Sigma\, md^2 \div \Sigma\, m)^{\frac{1}{2}} \doteq \rho_6$. The slight deviation from exact accordance is very nearly, if not precisely compensated by the equation, Sun × Earth × Saturn $\doteq$ Jupiter^3. Alexander's approximation gives, $m_0 = 3522.33\, m_6$; the other approximation gives, according to the foregoing note, $m_0 = 3481.86$; the arithmetical mean being $m_0 = 3502.1$, which differs by less than $\frac{1}{70}$ of one per cent. from Bessel's estimate. If ρ_5, ρ_6 represent Stockwell's estimates of the mean perihelia of Jupiter and Saturn, Bessel's estimates of their respective masses, and the equation (Sun ÷ Jupiter) × (Earth ÷ Jupiter) $= (\rho_5 \div \rho_6)^2$, give $m_0 \div m_3 = 330240$. The harmonic accordances which were given in Note 310 corroborate these evidences of joint relations, and encourage a search for modifications by combined harmonies in other cases.

315. *Photodynamic Relations of Uranus and Neptune.*

The increasing number of harmonic influences with increasing distance from Sun, was illustrated in my *Relations of Mass*, (*Proc. A. P. S.*, xviii, 231), and in Note 156. A connection in which the harmonies of luminous undulation are more directly shown, gives the following relations:

$$(\rho_7 + \rho_3) \div 2\pi\sqrt{\frac{r_0}{g_0}} = v_\lambda$$

$$m_7 : m_3 : : \sqrt{\rho_3} : \sqrt{r_0}$$

$$\rho_7^2 : \rho_3^2 : : 1 \text{ year} : 1 \text{ day}$$

$$m_7 : m_8 : : p_7 : a_7$$

Stockwell's estimates of p_7 and a_7 (secular perihelion and secular aphelion of Uranus) are 17.687929 and 20.679233. The closeness of harmonic accordance is shown in the following comparison, in which I have used Struve's constant of aberration and the estimates of Note 313.

Velocity of light	$.43073r_0$	$.43077r_0$	Struve.
Semi-axis major of Uranus	$19.184\rho_3$	$19.138\rho_3$	Stockwell
Sun ÷ Uranus	22592	22600 ± 100	Newcomb.
" " Neptune	19324	19380 ± 70	Newcomb.

The division of the outer planetary belt is, therefore, such that the aphelion mass is in accordance with aphelion influence at the inner portion of the belt, while the perihelion mass is in accordance with perihelion influence. The further considerations of Note 156 add to the interest of this relationship.

316. *Joint Relations of Sun, Earth, Venus and Moon.*

The three foregoing notes seem to show that the harmonic influence of the chief centre of condensation (Earth) upon planetary masses, has been greater than that of the centre of nebulosity (Jupiter). We may, therefore, naturally look for additional illustrations of terrestrial influence within the dense belt, such as are given in Notes 8, 85, 156, 246-7, 254-6, 313. The estimate of μ, in Note 246, would become 1 ÷ 81.08 if we adopt the value of ρ_3, which is given in Note 313. This value, if substituted in Note 8, would give 4.952 miles for the height of Earth's homogeneous atmosphere, through the proportion

$$\pi^2 \times 81.08 : 1 : : r_3 : .0012496r_3 : : 3962.8 : 4.952$$

The harmonies of Note 85 may well be studied in this connection. Stockwell's value for the secular perigee of Venus is $.9322648\rho_3 - .7744234\rho_3 = .1578414\ \rho_3$ = 14,625,840 miles = $1.0252 \times (3 \times 4 \times 5)^2 \times 3962.8$ miles. The solar modulus of light, according to the same estimates, is $2213.37\rho_3 = 1.00073 \times 4 \times (3 \times 4 \times 5)^4 r_3$.

317. *The November Meteors.*

The relations which were pointed out in Note 315 may be supplemented by cometary indications of a character somewhat like those which led Forbes to his deduction of two supra-Neptunian loci (Notes 32, 305). The secular aphelion of Uranus, or its locus of incipient subsidence (20.679233), represents a cometary major axis with a period of 33.2473 years. The period of the great "star-shower" of November 1833 and 1866 has been computed at "about 33.25 years." A similar cometary major axis (20.7072688), with a period of 33.315 years, would exactly represent, by its apsidal loci, the mean positions of Mars and Uranus. The special photodynamic indications of the first equation in Note 315, may be fairly presumed to have exerted an influence on each side of the central track, which would be sufficient to account for all of the approximations that have been indicated.

318.. *Geological Time.*

Dr. Haughton (*Am. Journ. Sci.*, Nov. 1882) read before the American Association, in August, 1882, some "New views of Mr. George H. Darwin's Theory of the Evolution of the Earth-Moon System, considered as to its bearing on the question of the duration of Geological time." He cites Sir William Thomson's views as to the present rigidity of the earth, the probability that Saturn's rings consist of swarms of discrete meteoric stones, the low specific gravity of the outer planets, the recent researches connecting the periodic swarms of shooting stars with comets, Huggins's comparisons of the spectroscopic appearances of comets and incandescent portions of meteoric stones, and Prof. H. A. Newton's hypothesis that the asteroids may be extinct comets, to justify the position "that the earth and moon when they separated from the solar nebula, did so as a swarm of solid meteoric stones, each of them having the temperature of inter-stellar space." He then shows that the meteoric problem resembles the hydrodynamical problem, giving equations "in all respects similar to those derived by Mr. Darwin, from the hypothesis of a viscous earth" and placing "a cool earth and almost indefinite time at the disposal of geologists." These views are in accordance with Herschel's theory of subsidence, which I have found so abundantly illustrated by the actions and reactions of gravitation and æthereal elasticity (*Proc. A. P. S.*, ix, 283–8, 345–9, 355–60; x, 261–9, 368–79; xi, 103–7; xii, 392–417, 518–22; xvi, 184–92; xvii, 294–307, *et al*). Dr. Haughton refers to Prof. Newton's application of the same theory to account for the asteroids and some of the satellites, but he has made no allowance for the modifications of planetary and satellite arrangements which would result from harmonic motion.

319. *The Key-Note of Nature.*

Gardiner says (*Music of Nature*, 2d, Ed. p. 417): "In the fifteenth century, music was generally written in the key of F, and its relative D minor. This order of sounds was first adopted, probably on account of its being the most familiar to the ear, as it will be seen that the cries of animals, the buzzing of insects, the roar of storms, the murmurs of the brook, and some of the grandest sounds of the natural world, are to be referred to this harmony and may be denominated *The Key of Nature.*" In 1873, (*Proc.*

A. P. S., xiii, 151), I showed the accordance between the wave length of the principal Frauenhofer lines and of the homonymous notes of the twenty-third musical octave, the greatest difference being $2\frac{2}{3}$ per cent., and the closest approximation being at F, where the difference is less than $\frac{3}{7}$ of one per cent. In the arithmetical mean, the difference is less than $\frac{1}{7}$ of one per cent.; in the geometrical mean the accordance is exact. Langley, in a communication to the British Association, at Southampton, reported experiments which show a fundamental solar "tint which must approximately represent that at the photosphere, and which is most similiar to that of a hue near Frauenhofer's F." (*Am. Jour. Sci.*, Nov. 1882). See also Notes 41, 42, 235.

320. *Limit of Thermal Velocity.*

In Notes 58, 61, 62 and 102 I introduced some thermodynamic considerations which were based on interstellar photodynamic influence. In April 1865, (*Proc. A. P. S.*, x, 101) I called attention to the fact that "even the thermal currents are occasioned simply and solely by the varying gravitation of fluids of varying density," and in nearly all my physical papers I have been guided by the belief that all ultimate energy is radiant from or toward kinetic centres, the various forms, (luminous, thermal, electric, gravitating, etc.) being merely due to subordinate modifications of primitive radiations. The simultaneous radiation of light and heat from the Sun, the "Thomson Effect" (see *Am. Jour. Sci.*, xxiv, 379–87), and the phenomena of thermo-electricity, furnish strong *a priori* grounds for believing that the limit of thermal velocity, v_θ, is the same as the limit of luminous velocity, v_λ.

321. *Extension of Fundamental Equality.*

In throwing a ball into the air, the thermal equivalent of the projectile force is equal to the product of the mass by the sum of the retardations which result from gravitating influence, atmospheric resistance and all other opposing circumstances. In solar rotation, all the solar superficial particles are alternately projected from and drawn towards the chief centre of gravity of the system, in cyclical periods of half-rotation. The thermal equivalent of this projection represents the whole work of gravity for the time, $\frac{mgt^2}{2}$, and the corresponding velocity, v_θ, is equivalent to the velocity of light. This gives the following extension of the equation in Note 280:

$$v_\lambda = v_\varepsilon = v\gamma = v_\theta.$$

The combination of centripetal and centrifugal tendencies which produces solenoidal terrestrial currents (Note 274), may, perhaps, suggest considerations which will be serviceable in general electrical research, and so lead to important developments of this fundamental equation.

322. *Disturbed Attraction.*

R. Lamont (*Jour. of Science*, Oct. 1882), says, "If we disturb the attraction which holds together the atoms of a chemical compound, whether it be in the solid, the liquid, or the gaseous state, we have this same emanation of light and heat. If, then, these great effects can be produced in our laboratories, what must result in our solar system from the continual struggle between attraction and centrifugal force?" I attacked the view that weight can be predicated of bodies at rest, as early as 1864 (*Proc. Am. Phil. Soc.*, ix, 357), and in February, 1868, I gave a summary of various phenomena which may be simply coördinated by the theory that motion, rather than rest, is the natural state of matter (*Proc. Am. Phil. Soc.*, x, 377–9). Although similar views had often been advocated by others, no attempt seems to have been made to confirm them by numerical measurements, prior to my investigations, which began in 1863 (*op. cit.*, ix, 283–8).

323. *Lunar Barometric Tides.*

The correlations of gravitating and magnetic tides (Notes 116–22), lend interest to Bergsma's observations of the lunar atmospheric tide at Batavia, 1866–80 (See *Nature*, Nov. 23, 1882, p. 79), a tide which appears to have been first observed by Luke Howard, in London. Assuming the lunar day to begin at the Moon's upper transit, the following are the phases above or below the mean, expressed in millimetres :—

	mm.			
1st max.	+ .057	at lunar hour		1
1st min.	— .053	"	"	7
2d max.	+ .064	"	"	13
2d min.	— .060	"	"	19

Buchan's isobar of 29.9 in. = 759.45 mm. passes through the Malayan Archipelago. This is 6491 times the mean range (.117) of lunar disturbance, which is much greater than can be explained by simple gravitating tide. It is, however, in simple harmonic relation to the square of the mass.

If $m_3^2 : \mu^2 : : 6491 : 1$, $m_3 = 80.56\mu$.

324. *Lunar-Tidal Rainfall at Batavia.*

"The influence of the moon's phases on the rainfall [at Batavia] is quite decided ; for while the mean daily rainfall is .205 in., it rises at full moon to .248 in., from which time it gradually falls to .181 in. at the third octant, rises to .212 in. at the fourth octant, then falls to .184 in. at the fifth octant, and finally rises gradually to the maximum at the time of new moon. The important conclusion follows that the attractive influence of the moon, and consequently that of the sun, must be taken into account as factors concerned in bringing about oscillations of the barometer." These evidences of lunar-tidal influence upon rainfall are greater than those which I found at Philadelphia (*Proc. Am. Phil Soc.*, x, 523–37), about the same as at Barbadoes (*Ib.*, xiv, 195–216), but less strongly marked than at Lisbon (*Ib.*, xii, 178–90), and at San Francisco (*Ib.*, xii, 523–42).

325. *The Neptuno-Uranian Belt.*

All the proposed forms of the nebular hypothesis seem to require evidences of retrograde motion, such as are shown by the outer planets of our system. The successive harmonic influences of central condensation, conversion of orbital into rotary motion, incipient projection and incipient subsidence are shown by the proportions which were given in Note 315. If we take the oscillatory estimate, $m_0 = (2 \times 3 \times 4)^4 m_3$, instead of the estimate in Note 313, we get $m_0 = 22656 m_7 = 19379 m_8$; $\rho_7 = 19.138 \rho_3$. Newcomb's mass-estimates are $m_0 = (22600 \pm 100) m_7 = (19380 \pm 70) m_8$. The observed value of ρ_7 is $19.184 \rho_3$, which is about $\frac{1}{4}$ of one per cent. greater than the harmonic value.

326. *Terrestrial Magnetic Vis Viva.*

Equation (1) of Note 91 may be modified by regarding v_0 as a mean proportional between Earth's mean orbital velocity and the velocity of light, and substituting the mass of the Telluric system, m_a, for Earth's mass. We then have,

$$m_0 v_0^2 : m_a v_\lambda^2 : : m_a v_\lambda^2 : m_5 v_0^2,$$

substituting $v_\lambda = \rho_3 \div 497.827$; $v_3 = 2\pi\rho_3 \div 31558149$; $m_0 = 1047.879 m_5$; we get $m_5 = 311.672 m_a$; $m_0 = 326594 m$, which differs by about $\frac{1}{3}$ of one per cent. from the magnetic estimate of Note 2 (327710). The identity of the velocity of electro-magnetic disturbance (*Maxwell, Electricity and Magnetism*, § 784) with the velocity of light, lends interest to this approximate coincidence. If we estimate $m_3 = 81.08 \mu$, these two values of m_a give

$$m_0 = \frac{82.08}{81.08} \times 326594 m_3 = 330622 m_3 \,; \;\; \rho_3 = 92678000 \text{ miles.}$$

$$m_0 = \frac{82.08}{81.08} \times 327710 m_3 = 331752 m_3 ; \;\; \rho_3 = 92783400 \quad ``$$

The latter estimate of ρ_3 differs by less than $\frac{1}{400}$ of one per cent. from the value which is indicated by centres of nodal oscillation (Note 91).

327. *Cosmic and Chemical Harmonic Motions.*

A harmony which involves considerations of the conversion of orbital into rotary velocity, projectile *vis viva*, inertia of central condensation, and energy of chemical combination, is shown in the proportion

$$\rho_a : \rho_0 : : g_a : g_0 : : r_3^2 : h^2$$

in which ρ_a = Earth's primitive locus of orbital projection, or secular perihelion (Stockwell's estimate of secular eccentricity and the Brit. Naut. Alm. estimate of Sun's apparent semi-diameter give $\rho_a = 200.385 \rho_0$); g_a = mutual gravitating acceleration of two equal particles at distance h; g_0 = like acceleration at distance r_3; h = theoretical height of secondary centre of oscillation in explosive combination (Note 16). Solving the proportion, we get, $h = 279.943$ miles; $\rho_3 = 92739000$ miles; $m_0 = 331280 m_3$.

328. *Comparison of Harmonic Mass-Estimates.*

The estimates of planetary mass in Notes 313–5 are, in some respects, more simple than those in Note 156. This is especially the case with Uranus and Neptune.

	Note 153.	Notes 313–5.	Computed.
Sun ÷ Venus.	427630	427326	427240
Sun ÷ Earth,	331668	330463	331776
Sun ÷ Jupiter,	1047.879	1047.879	1047.879
Sun ÷ Saturn,	3503.22	3502.1	3501.6
Sun ÷ Uranus,	22602	22592	22600
Sun ÷ Neptune	19392	19324	19380

The relations of mass, density, and time, at the stellar centre of the system, are determined by the velocity of light ; those at the chief nebular centre are influenced by the first harmony ; those at the chief centre of condensation introduce the two preceding harmonies ; those at the centre of planetary inertia show the combined influence of luminous undulation, nucleation, nebulosity and condensation. Venus and Uranus are rhythmically influenced by the chief centres of nucleation and condensation ; Neptune is similarly influenced, though less directly, through its belt-connections with Uranus.

329. *Comparative Harmonic Estimates of Earth's Mass.*

In Note 15 I gave a summary of eighteen kinetic estimates of Earth's semi-axis major, giving the mean value, $\rho_3 = 92737100$ miles. Subsequent harmonic estimates, introducing various nodal influences which must be obviously operative, furnish data for the following comparisons :—

		Sun ÷ Earth.	ρ_3.
Chemical energy,	Note 16	331631	92,772,200 miles.
Oscillatory "	" 23, 91	331776	92,785,700 "
Inertia	" 152	331890	92,796,300 "
Rotating energy,	" 313	330463	92,661,600 "
Luminous "	" 326	330622	92,678,000 "
Magnetic "	" 326	331752	92,783,400 "
Gravitating "	" 327	331280	92,739,000 "

The mean values are 331345 ± 137, and 92,745,200 ± 12900. The latter value differs by less than $\frac{1}{114}$ of one per cent. from the one given in Note 15.

330. *Nodal Influence of Jupiter.*

The joint influence of Sun and Jupiter which was shown in Note 328, may be further illustrated by various nodal relations of planetary apsides. I indicated the importance of harmonic motion in determining apsidal positions, in a communication to the American Philosophical Society, April 2, 1869, more than eight years before Professor Stephen Alexander called the attention of the National Academy to the subject (*Proc. Am. Phil. Soc.*, xi, 103–7 ; xii, 403–7, 412, 520 ; xiii, 146, 196 (11); xiv, 635 ; etc.).

α. Jupiter's locus of incipient subsidence (secular aphelion), is nearly a mean proportional between Neptune's locus of incipient subsidence and Earth's semi-axis major.

β. Jupiter's mean subsidence-locus (mean aphelion) is nearly a mean proportional between Neptune's locus of incipient subsidence and Earth's mean projectile locus (mean perihelion).

γ. Jupiter's mean subsidence-locus is nearly a mean proportional between the semi-axes major of Mars and Uranus.

δ. Jupiter's semi-axis major is nearly a mean proportional between the mean projectile locus of Mars and the semi axis major of Uranus.

ε. Jupiter's semi-axis major is nearly a mean proportional between the incipient subsidence locus of Uranus and the incipient projectile locus (secular perihelion) of Mars.

ζ. Jupiter's mean projectile locus is nearly a mean proportional between the incipient projectile-locus of Uranus and the mean projectile-locus of Mars.

η. All of Jupiter's orbital loci are at centres of explosive oscillation ($\frac{5}{9}$) of orbital loci of Saturn.

θ. Jupiter's mean subsidence-locus is at the nucleal locus of a condensing nebula, of which Saturn represents Laplace's atmospheric limit and Earth is the centre of condensation; Earth's semi axis major being the unit radius, and Laplace's limit varying as the $\frac{4}{3}$ power of the nucleal radius. Accordances η and θ, which are the closest of all, are especially interesting on account of the variety of indications which they give of the harmonic influence of luminous undulations upon the four great centres of nucleation, condensation, nebulosity and planetary inertia.

The following table shows the closeness of agreement between the harmonic values and Stockwell's.

	Harmonic log.	Stockwell.	Dif. of logs.	Percentage of difference.
α	.7419330	.7418817	.0000513	$\frac{1}{84}$ of one per cent.
β	.7344514	.7345879	.0001365	$\frac{1}{31}$ " "
γ	.7329514	.7345879	.0016365	$\frac{3}{8}$ " "
δ	.7150274	.7162369	.0012095	$\frac{2}{7}$ " "
ε	.7165515	.7162369	.0003146	$\frac{1}{13}$ " "
ζ	.6974010	.6970763	.0003247	$\frac{1}{13}$ " "
η	. . . . . .	. . . . . .	.0000000	0 " "
θ	.7346221	.7345879	.0000342	$\frac{1}{125}$ " "

See also, Note 334.

331. *Photodynamic Significance of the Temperature of Space.*

Sir John Herschel estimated the absolute temperature of interstellar space as about one-half as great as Earth's mean superficial absolute temperature. If the former temperature is due to stellar radiations, every star must have opposite hemispheres which are exposed to different temperatures, as well as to different gravitating tendencies. The fundamental equation of velocity (Note 321), may be fairly presumed to be universal, so that all stellar rotations may accord with solar rotation in alternately consuming and resuming, at alternate half-rotations, the photodynamic energy of all the superficial particles. At the outer limits of our æthereal system, the æther, if material, should rotate with the stars, so as to radiate and absorb heat like an ordinary atmosphere. A full discussion of conservation of energy in the several stellar systems, requires the consideration of time integrals of various kinds, gravitating, thermal, photic, rotating and revolving. Continual shiftings of position may, perhaps, continually restore to cosmical centres a reactionary *vis viva* which is exactly equivalent to their active radiations.

332. *Hirn's Hypothesis.*

G. A. Hirn (*Comptes Rendus*, Nov. 6, 1882), agrees with Faye in believing that astronomers need an absolute vacuum of matter in order to assure the stability of cosmical movements. He thinks that the doctrine must be discarded which excludes from the physical universe everything but matter and motion, and refers approvingly to Newton's letter to Bentley, implying the necessity of a constant spiritual activity, which cannot be subjected to any materialistic formulation. Seven years ago (*Proc. Am. Phil. Soc.*, xiv, 611, xvi, 302) I published a number of postulates, among which were the following:

"11. Any æthereal medium through which impulses are progressively transmitted, must be material.

"12. Any medium through which impulses are transmitted instantaneously, must be devoid of inertia and, therefore, spiritual."

333. *Laplace's Principle of Periodicity.*

I have elsewhere (*Proc. Am. Phil. Soc.*, xviii, 41–3). given some illustrations of the general principle, which was established by Laplace, that the state of a system of bodies becomes periodic when the effort of primitive conditions of movement has disappeared by the action of resistances. The periodicity of solar rotation shows the action of gravitating resistance against the efforts of luminous undulation. The resistance is just as constant as the radiation, and it would be far to seek any good reason why any provision for perpetuity which may be needful should not accompany every effort and every antagonizing resistance. If spiritual intervention is taken into consideration, its action may be merely directive, because there is a theoretical instant of absolute rest when one oscillation ends and its successor begins, so that there is no material *vis viva* to be overcome.

334. *Two-Fold Nucleation in the Dense-Belt.*

Jupiter's nodal influence (Note 331), co-operating with central condensation in the dense-belt, is shown in the following additional harmonies:

ι. Jupiter's semi-axis major represents Laplace's limit for its own condensing nebula, of which the nucleal limit is the locus of incipient subsidence of Mars.

κ. In tendencies to reverse condensation towards Jupiter, Earth's mean locus of subsidence is $4.1289304\rho_3$ from Jupiter's mean locus. This represents a nucleal radius for which Laplace's limit would be $6.70965\rho_3$, which is near the mean locus of Mars on the opposite side of Sun.

λ. In like reverse condensation, the mean locus of Mars, when in conjunction with Jupiter, represents a nucleal radius for which Laplace's limit would be $5.67968\rho_3$, which is near Mercury's incipient locus of subsidence.

μ. Taking Mercury's mean subsidence locus as final or unit radius, Venus represents a nucleal radius, for which Earth's projectile locus would be Laplace's limit.

The closeness of accordance is shown in the following table:

	Harmonic.	Stockwell.	Difference.	Percentage of difference.
ι	1.75789	1.73648	.02141	$1\frac{1}{4}$ per cent.
κ	1.50685	1.52368	.01683	$1\frac{1}{8}$ " "
λ	.47688	.47680	.00008	$\frac{1}{60}$ " "
μ	.93313	.93226	.00087	$\frac{1}{10}$ " "

For further evidences of nucleal and atmospheric limitations, see *Proc. Am. Phil. Soc.*, xvi, 496–505.

335. *Another Harmonic Estimate of Saturn's Mass.*

It cannot reasonably be expected, among all the different tendencies to harmonic motion, that we can immediately find all which have been operative in any given case. In view of the small amount of work which has been done in this field, such simplicity and closeness of agreement as were shown in Notes 329–31 and 334 are very encouraging. We have already found many evidences of reciprocal or retrograde action in the Neptuno-Uranian belt, of central planetary inertia in the Saturnian belt, and of Jupiter's paramount planetary influence. If we regard all of the dense belt of planets as originally belonging to the great central nucleus, Alexander's harmony, $m_5\,\rho_5^2 \doteq m_6\,\rho_6^2$, may be thus modified:

Jupiter	=	Sun	÷	1047.879	=	.0009543087
Earth	=	"	÷	331776	=	.0000030141
Venus	=	"	÷	427630	=	.0000023385
Mars	=	"	÷	3093500	=	.0000003233
Mercury	=	"	÷	4865751	=	.0000002055
Moon	=	Earth	÷	81.2	=	.0000000371
Amount	=	Σ_m			=	.0009602272

Log. Σ_m	$\bar{4}.9823740$
" $(\rho_6 \div \rho_5)^2$	.5265244
Log. m_6	$\bar{4}.4558496$
m_6 =	.0002856601
$m_0 \div m_6$ =	3500.67

336. *Mean Harmonic Estimate of Saturn's Mass.*

We have seen in Note 326, that in some harmonic approximations the most satisfactory results are reached, as in the foregoing note, by adding satellite or subordinate masses to their primaries, while in other cases it seems best to consider the primary mass alone. The choice of methods, in any instance, may be governed by considerations of static or kinetic equilibrium, instantaneous or progressive action, primitive or subsequent conditions, or other relations which may be unfolded by a more minute study of harmonic astronomy. If we substitute the rotary estimate of Note 313, ($m_0 \div m_3 = 330463$) in Note 335, we get $m_0 \div m_6 = 3500.62$. Combining this value with the two which are given in Note 314, we find an *exact* mean accordance with Bessel's estimate, as follows :

From central primitive nucleation,	3500.62
" " final "	3522.33
" nucleation, condensation, nebulosity and inertia,	3481.86
Arithmetical Mean,	3501.60

337. *Inner Limit of Saturn's Preponderating Influence.*

The two foregoing notes regard all the intra-asteroidal planets as in some sense satellites of Jupiter, which have been made planetary by the superior attraction of the Sun, somewhat as our Moon is both a solar planet and a terrestrial satellite. It may be asked whether Saturn's attraction when in opposition to Jupiter, is not sufficient to invalidate this hypothesis. Jupiter's mass being 3.3415 times as great as Saturn's, the extent of its equal gravitating disturbance is $\sqrt{3.3415} = 1.828$ times as great. Saturn's relative disturbance of intra-Jovian matter is greatest when Saturn is at secular perihelion ($8.734451\rho_3$) and Jupiter is in opposition, at secular aphelion ($5.519271\rho_3$). The limit of equal attraction is then at $\frac{1828}{2828}$ of $14.253722\rho_3 = 9.2134\rho_3$ from Jupiter, or $3.6941\rho_3$ from Sun, on the side towards Saturn, so that it includes all the orbits of the dense planets, and nearly all of the asteroidal belt. This fact gives new meaning to Notes 330 and 334.

338. *More About Comet Wells.*

Notes 295 and 302 illustrate the probable formation of spectral bands by the combination of different harmonic tendencies, as well as the precision of delicate measurements by a skillful observer and accuracy of judgment in estimating the centres of maximum brilliancy. It is, therefore, not unlikely that careful study may discover successive evidences of phyllotactic and other harmonic influences, as was the case in investigating atomic phyllotaxy. If we take the difference between lines α and ε in the Wells' spectrum (Note 295 ; $4769 - 4253 = 516$), the phyllotactic numbers 2, 3, 5, 13, 34, serve in the following sub-multiples ; $\frac{2}{5}$ of $\frac{2}{13}$ of $516 = 31.754$; $3 \times 31.754 = 95.262$; $4 \times 31.754 = 127.015$; $5 \times 31.754 = 158.769$; $\frac{1}{2} \times \frac{1}{5} \times \frac{34}{13}$ of $516 = 134.954$. These numbers give the following accordance :

	Huggins.	Harmonic.	Difference.
α	4769	4769	
β	4634	4634.046	134.954
γ	4507	4507.031	127.015
δ	4412	4411.769	95.262
ε	4253	4253	158.769

339. *Phyllotaxy in the Jovian System.*

The harmonies which are shown in Notes 330 and 334, supplement and help to explain the first four harmonies of Note 29 and the five harmonies of Note 14. Callisto's semi-axis major represents a phyllotactic power of a phyllotactic multiple (3^3), of Jupiter's semi-diameter. The semi-axes major of the three inner satellites are approximately connected with the nebular radius and with one another by the phyllotactic fractions $\frac{2}{5}$ and $\frac{5}{8}$, as follows:

Harmonic.		Observed.	
Nebular radius	38.45	Nebular radius	38.424
$\frac{2}{5}$ of 38.45	15.38	Ganymede	15.3502
$\frac{5}{8}$ of 15.38	9.613	Europa	9.6235
$\frac{5}{8}$ of 9.613	6.008	Io	6.0485

The greatest difference between the phyllotactic and observed loci is $\frac{2}{3}$ of one per cent.

The corresponding orbital times are connected by powers of the phyllotactic number 2.

$2^4 = 16$		Nebular radius	16.0135
$2^2 = 4$		Ganymede	4.0434
$2^1 = 2$		Europa	2.0073
$2^0 = 1$		Io	1.0000

340. *Phyllotaxy of Planetary Mass and Position.*

Peirce's phyllotaxy of orbital times (Note 135), my atomic phyllotaxy (Note 289), and my phyllotaxy of virtual areas (Note 190), encourage a search for phyllotactic relations of planetary mass and distance. Jupiter's mean projectile locus (mean perihelion), is an approximate phyllotactic basis for Saturn's mean locus of subsidence, the rupturing locus of the outer two-planet belt and the mean centre of gravity of the belt:

	Stockwell.	Phyllotactic.
Jupiter	4.978	5
Saturn	10.000	2×5
$\frac{1}{2}$ Neptune	15.017	3×5
c. g. Uranus and Neptune	25.031	5×5

If Saturn's mean perihelion were in the same longitude as that of the outer belt, the phyllotactic sum of their disturbing forces ($2 + 5$) would become an important limit of oscillatory inertia. Simple phyllotactic combinations of this sum with phyllotactic powers of 2, 3, and 5 give the following mass-approximations:

	Computed.	Phyllotactic.
Sun ÷ Jupiter	1047.879	$1050 = (2+5)\ (2\times5)\ (3\times5)$
Sun ÷ Saturn	3501.6	$3500 = (2+5)\ (2\times5)^2\ (5)$
Sun ÷ Uran. and Nep.	10433	$10500 = (2+5)\ (2\times5)^2\ (3\times5)$
Sun ÷ Earth	330463	$330750 = (2+5)^2\ (2\times5)\ (3\times5)^2(3)$
Sun ÷ Venus	427240	$428400 = (2+5)\ (2^3\times5)\ (3^2\times5)\ (34)$
Sun ÷ Mars	3093500	$3094000 = (2+5)\ (2\times5)^3\ (13\times34)$
Sun ÷ Mercury	4865751	$4873050 = (2+5)^2\ (3\times5)^2\ (13\times34)$

The greatest deviation is less than $\frac{7}{10}$ of one per cent.

341. *Centripetal Harmonies of Planetary Mass and Position.*

If we begin with the outer two-planet belt, we find evidence of the following successive influences:

α. Rotary *vis viva*, ($m\rho^2 \div 2$). (1). If we call the sum of the masses of Neptune and Uranus $m_{(7)} = m_7 + m_8$, we find that its influence of rotary perturbation introduces both the same and the diametrically opposite mean perihelion longitudes of Saturn, provided that $\rho_{(6)}$ and $\rho_{(7)}$ represent, respectively, the incipient loci of subsidence of Saturn and Uranus; $m_{(7)}\ (\rho^2_{(7)} - \rho^2_{(6)}) = m_6\rho_{(6)}^2$. (2). If we call the sum of the masses of Jupiter and the dense belt, $m_{(5)} = m_5 + m_4 + m_3 + m_2 + m_1$, we find that its mean influence of rotary perturbation is the same as that of Saturn; $m_{(5)}\rho_5^{\ 2} = m_6\rho_6^{\ 2}$.

β. Rotary momentum. The interior mass of the three primitive masses, $m_{(5)}$, was so divided that Sun's semi-diameter became the rupturing locus for the principal centre of gravity of the system (c. g. of m_0 and m_5). Designating Jupiter's radius vector at secular perihelion by $\rho_{(5)}$, we find, $m_0\rho_0 = m_5\rho_{(5)}$.

γ. Photic time-integral. Sun's mass and density are so harmoniously adjusted that the oscillations of solar rotation indicate the actions and reactions of a wave-velocity which is equivalent to the velocity of light (Notes 17, etc.).

δ. Secondary time-integrals. The solar superficial gravitating acceleration, which is determined by the photic time-integral, determines in its turn the velocity of circular-orbital oscillation ($\sqrt{gr}$) at all distances from Sun's centre. The velocity at Sun's surface gives Jupiter's time-integral: the velocity at the mean centre of gravity of the system gives Earth's time-integral.

ε. The photic time-integral (*γ*), the probability that Sun's density is harmonically determined by the density of hydrogen, and the equality of æthereal and solar mass which is implied by their equality of action and reaction, give the proportion at Sun's surface,

$$\text{Modulus}^3 : \rho^3_0 :: \text{density of hydrogen} : \text{æthereal density}.$$

342. *Secondary Harmonies of Planetary Mass and Position.*

The data of the foregoing note are sufficient for approximate determinations of the respective masses at the chief centres of nucleation, condensation, nebulosity, and rotary planetary inertia, (Sun, Earth, Jupiter and Saturn). The division of the outer two-planet belt, and the separation of Venus from the primitive interior belt were determined by simple relations of vector-radii, which may be regarded as indicative either of photodynamic time or photodynamic *vis viva.*

ζ. The radii which determined the aphelion and perihelion masses of the outer belt were, respectively, the aphelion and perihelion loci, or the loci of incipient subsidence and incipient projection, at the inner limit of the belt (Note 315).

η. The radii which determined the relative masses of Earth and Venus were, respectively, the mean radius-vector and the locus of incipient subsidence of the respective planets (Note 313).

343. *Centripetal Approximations*

If we take the phyllotactic estimates of Mercury and Mars (Note 340), with the gravitating or centripetal estimates of the other planets, and of solar and æthereal density (Notes 341-2), we find the following approximations, which may be compared with those of Notes 325 and 328 :

	Harmonic.	Computed.	Difference.
Sun ÷ Mercury,	4873050	4865751	$\frac{3}{20}$ of one per cent.
Sun ÷ Venus,	426721	427240	$\frac{1}{8}$ " "
Sun ÷ Earth,	330463	331776	$\frac{2}{5}$ " "
Sun ÷ Mars,	3094000	3093500	$\frac{1}{62}$ " "
Sun ÷ Jupiter,	1047.879	1047.879	
Sun ÷ Saturn,	3500.69	3501.6	$\frac{1}{38}$ " "
Sun ÷ Uranus,	22759	22600	$\frac{7}{10}$ " "
Sun ÷ Neptune,	19467	19380	$\frac{13}{29}$ " "

Density of Sun ÷ Earth .25492	Log. = $\bar{1}$.4064086
Density of Æther ÷ Hydrogen 106,939,930.000,000,000	17.0291400
Solar Modulus of light, $474657\rho_0 = 2213.37\rho_3$	3.3450539
Solar Rotation, 25.5064 days	1.4166487
Orbital time at ρ_0. 10049 seconds	4.0021223
Sun's semi-diameter, ρ_0, 432089 miles	5.6355735
Earth's semi-axis major, ρ_3, 92,661.550 miles	7.9668996

344. *Laplace, Herschel and Fourier.*

Laplace's statement of the nebular hypothesis has been generally thought to imply that the planets and satellites were thrown off by the centrifugal force of contracting nuclei. Many objections have been found to this hypothesis, of which the moons of Mars furnish a striking example. Herschel's theory of subsidence, by recognizing the equality of action and reaction, removed these objections, provided for the recognition of cometary and meteoric influences, and made the moons of Mars, as I have shown (*Proc. Am. Phil. Soc.*, xvii, 302), an unexpected confirmation of his views. Fourier's discussions of elasticity and cyclical motion, in a line of research to which American investigators have made important contributions (see *op. cit.*, xvi, 298–302), showed that all cyclical movements are *quasi*-elastic and may be represented by simple combinations of elastic formulæ, and thus paved the way for a wide extension of the theory of harmonic motion. The three foregoing notes show a combination of simultaneous and continuous activities, which it would be difficult, if not impossible, to explain by Laplace's theory. They are all, however, in full accordance with the views of Herschel and Fourier, and they indicate that the photic æther may still be regarded as nebulous.

345. *Photic Loci of Earth and Saturn.*

Note 341 suggests the influence of linear oscillation in subsiding particles. Neptune's locus of incipient subsidence ($30.47\rho_3$) became, by the relative slowness of its motion, a point of virtual suspension. Saturn's locus of incipient subsidence ($10.343\rho_3$) which was near its centre of oscillation ($10.16\rho_3$), was the origin of the belt of mean planetary inertia. While the Neptuno-Uranian and the Jupiter-Telluric belts were yet undivided, the theoretical period of rotation was $(30.46955 \times 214.45)^2 \times 25.5064$dy $=$ 3050950.7 years. The fundamental photodynamic equation (Note 321), with the equality of action and reaction, fixed the chief centre of condensation at a locus which is in simple photic relations with the solar nucleus, the photic radius of rotation and the centre of planetary rotating inertia. For the mean proportional between the mean locus of incipient planetary subsidence ($10.343253\rho_3$) and Earth's semi-axis major is $3.2161\rho_3$ $= 689.69\rho_0$. If we call this the photic radius, or the locus of luminous equatorial velocity for a sphere which would have orbital velocity at Sun's surface, Earth's semi-axis major should be $[31558149 \div (2\pi \times 497.827 \times 689.69)]^2\rho_0 = 213.99\rho_0$, which is within $\frac{4}{19}$ of one per cent. of the British Nautical Almanac estimate ($214.45\rho_0$).

346. *Mass-Relations of Earth and Saturn.*

The relative masses, as well as the relative positions, of the chief centres of condensation and of planetary inertia, show simple harmonic accordances with the energies of æthereal rotation and reacting inertia; Earth's locus of incipient projection ($.932265\rho_3$), bearing the same ratio to Saturn's mean locus of projection ($9.077645\rho_3$), as the square root of Earth's mass bears to the square root of Saturn's mass, thus indicating an exact equivalent between the moment of rotation and the inertia of mass. This gives $331988m_3 = m_0$; $\rho_3 = 92{,}805{,}400$ miles. The mass-value differs by less than $\frac{1}{33}$ of one per cent. from the value which was adduced from the relative inertia of Earth and Jupiter (Note 152), and by less than $\frac{1}{15}$ of one per cent. from the value which was deduced from centres of oscillation (Notes 5, 23).

347. *Phyllotaxy of Orbital Periods.*

The closeness of the phyllotactic mass-harmonies (Note 340), may be more strikingly shown by observing the discrepancies in Peirce's approximations to the orbital periods of the primary planets, which seem to have been the first extensions of the phyllotactic theory beyond the vegetable world :

	Phyllotactic.		Observed.	Difference.
		Neptune	60126.72	
$\frac{1}{2}$ Neptune	30063.36	Uranus	30686.82	$2\frac{1}{14}$ per cent.
$\frac{1}{3}$ Uranus	10228.94	Saturn	10759.22	$5\frac{2}{11}$ "
$\frac{2}{5}$ Saturn	4303.69	Jupiter	4332.58	$\frac{2}{3}$ "
$\frac{2}{5}$ Jupiter	1733.03	Asteroid 139	1723.37	$\frac{5}{9}$ "
$\frac{2}{5}$ Asteroid 139	689.35	Mars	686.98	$\frac{1}{.3}$ "
$\frac{1}{2}$ Mars	343.49	Earth	365.26	$6\frac{1}{3}$ "
$\frac{8}{13}$ Earth	224.78	Venus	224.70	$\frac{1}{28}$ "
$\frac{2}{5}$ Venus	89.88	Mercury	87.97	$2\frac{1}{8}$ "

The greatest deviation is more than nine times as great, and the mean deviation is more than ten times as great as in Note 340.

348. *Photic Relations of Earth, Jupiter, and Asteroid 139.*

In view of the many evidences of the important influence of Jupiter upon planetary harmonies, the following proportion becomes suggestive :

$$t_a : t_\beta : : \rho_\lambda : \rho_o$$

The second theoretical phyllotactic reduction of Jupiter's orbital period, $\frac{2}{3}$ Asteroid 139, is represented by t_a ; Earth's day, by t_β ; the photic radius (Note 345), by ρ_λ ; Sun's semi-diameter, by ρ_o. The value of ρ_3, as deduced from this proportion, is $214.2\rho_o$, which is about $\frac{2}{17}$ of one per cent. less than the British Nautical Almanac estimate. This is only $\frac{1}{156}$ as great as the mean accidental deviation (Note 288).

349. *Modifications of Harmonic Planetary Masses.*

The approximations of Note 342 are more closely connected than those of Note 328, and indicate a simpler bond of harmony. Among the various harmonic influences which may be presumed to have modified planetary masses and to be represented in their harmonic motions, are the following : (1). The fundamental velocity of Note 321, which was first indicated by my barometric investigations (*Proc. Am Phil. Soc.*, ix, 283–8). (2). Centres of linear, spherical and explosive oscillation (*Ib.*, xii, 392–4, 411–7 ; *et al.*). (3). The acquisition of nebula-rupturing velocities, by subsidence from nr to $\frac{nr}{n+1}$ (*Ib.* xii, 518–22). (4). Tendency to rupture in the periphery of a stationary nebula, at $2r \div (3 - \sqrt{8})$ (*Ib.* xvii, 98–99). (5). Belt-forming tendencies, through subsidence, at $\frac{2r}{3}$ (*Ib.*, xvii, 100*). (6). The

* Instead of "minor axis of $\sqrt{8r}$" *read* "minor axis of $\sqrt{2r}$."

ratio of the circumference of a circle to its diameter (*Ib.*, xiii, 140–1, xiv, 609–12, *et al.*). (7). Time integrals, rotation-waves, harmonic vibrations, polar forces, etc. (*Ib.* xiv, 141–7). (8). Laplace's limit, and its variation as the $\frac{4}{3}$ power of the nucleal radius (*Ib.*, xiv, 612, 622, 652, *et al.*). (9). Constancy of pressure and constancy of volume (*Ib.*, xiv, 651). (10). Instantaneous velocity, implying spiritual influence (*Ib.*, xiv, 611 ; xvi, 302, *et al.*). (11). Comparative variations of distance and density, in elastic media (*Ib.*, xvii, 109–12, *et al.*).

350. *Relation of Inertia to Time and Force of Oscillation.*

M. Lipschitz, in a letter to M. Hermite (*Comptes Rendus*, xcv, 1141), discusses some points which have an important bearing on my fundamental equation (Note 321), and on time-integrals in general. Supposing a heavy body to turn freely about a horizontal axis, he considers two kinds of movement. In the first, the angular velocity becomes 0 at θ_0; in the second, at $\pi - \theta_0$. The times in the two movements may be expressed by elliptic integrals of the first order, with complementary moduli. The corresponding integrals of the second order represent Hamilton's *accumulated vis viva*, or the integral of which the element is equivalent to the sum of all the living forces of the system multiplied by the element of the time. The result of the discussion, which he considers remarkable, gives an equation of oscillating times and accumulated *vis viva*, for the two kinds of movement, which depends solely on the moment of inertia of the body.

351. *Motion of Sun-Spots in Latitude.*

Spœrer, in a letter to Faye (*Comptes Rendus*, xcv, 1110), reports observations upon the movement of Sun-spots in latitude. Arranging the observations of twenty years (1861–80) in 5° belts, he finds a slight excess of movement towards the equator between the parallels of 5° and 10°, and a slight excess towards the poles between the parallels of 20° and 25°. Carrington and de Rico found a predominance towards the equator between 0° and 15°, and towards the poles in higher latitudes, but the indications were so slight that Carrington attached no importance to them. Faye regards these results as fatal to the theory of Siemens, for if the Sun is fed by the subsidence of matter towards the poles, he thinks that the equatorial centrifugal force should produce a constant tendency of spots towards the equator. He also calls attention to the fact that the centripetal force at Sun's equatorial surface $\left(\frac{gr}{3_0} \div v^2_{\text{rot}}\right)$ is about 48000 times as great as the centrifugal, and he attributes the equatorial increase in apparent velocity of rotation to the continual convection-currents between the photosphere and the interior of the Sun.

352. *Photodynamic Centrifugal Energy.*

At the very outset of my planetary investigations I called attention to the accelerating effects of "subsidence," and Hall's discovery of the moons of Mars strengthened my conviction that such acceleration was the *vera causa* of Sun's equatorial acceleration. Jupiter's influence upon harmonic masses and positions (Notes 313, etc.), and the close approximation of the photic radius (Note 345) to Jupiter's projectile centre of linear oscillation, show that there are activities, at various distances from the Sun, which should be considered in discussing the conservation of solar energy. The centrifugal force to which Siemens refers is by no means limited to Sun's surface; at Laplace's limit ($36.36r_o$), at the photic radius ($689r_o$), and at the solar modulus of light (689^2r_o), there are important rotating and consequent centrifugal tendencies which have been almost wholly overlooked. Darwin's discussions of terrestrial "viscosity" furnish many suggestive hints for an investigation which, as I fully believe, will help greatly to extend Laplace's views of universal stability. No one, probably, would think of limiting the centrifugal force of terrestrial rotation to Earth's surface, nor even to its atmospheric modulus; there is great likelihood that an appreciable atmosphere may extend even beyond Laplace's limit ($6.6r_3$), all portions within that limit rotating synchronously with Earth, while all portions beyond the limit are subject to combined influences of rotation and revolution. Sun's æthereal modulus extends to more than 73 times Neptune's semi-axis major, and if we suppose that to be the limit of æthereal centrifugal tendency, we have an available velocity which is 689 times as great as the velocity of light, If we suppose, still further, that Laplace's velocity of gravitating action, more than $100,000,000v_\lambda$ (*Mec. Celeste*, X, vii, 22), represents an actual physical velocity, we have a radius of rotating influence which extends from the Sun as a centre to more than 13000 times the distance of *a* Centauri.

353. *Motion in Perfect Fluids.*

Siemens calls attention (*Comptes Rendus*, xcv, 1040), to the results of Froude's Torquay experiments, which showed that a submerged body, moving with uniform velocity in a perfect fluid, will meet no resistance whatever. By "a perfect fluid" is meant a fluid free from viscosity or *quasi* solidity, and in which no friction is caused by the slipping of its particles either over one another or over the surface of the body. If there are any such fluids, the luminiferous æther is doubtless one. Ferrel's investigations have shown that the centrifugal force of rotation would draw it entirely away from the poles, so that more viscous fluids, such as our atmosphere, would serve, as Siemens says, as lubricators, to supply temporary vacua which would otherwise result from the slight lateral elastic oscillations of the æther. These considerations, as well as those of the foregoing note, open a new field for analytical research, which must be thoroughly explored before final judgment can be passed upon questions pertaining to the conservation of solar energy, the stability of the physical universe, and the reproach of thermodynamics.

354. *Centripetal Transformation of Radiations.*

When particles or bodies are moving in circular orbits, under the influence of central forces, the centripetal and centrifugal forces are in equilibrium; in parabolic orbits, the centripetal *vis viva* is twice as great as the centrifugal on approaching the centre, and one-half as great on receding from the centre; in elliptical orbits, the ratio of the living forces varies inversely as the ratio of the radius-vector to the semi-axis major. In actual orbital motions, the alternate oscillations between the apsides are equal, but in opposite directions. This must be true of the æther, as well as of planets and satellites, if the æther has any orbital motion, and reasoning from analogy we might fairly suppose that it is true of æthereal waves. What becomes of the heat which is supposed to be absorbed by the æther? Does it increase the mean distance of the æthereal particles, does it maintain an ever increasing amount of æthereal undulation, or is it resolved into some form of gravitating or other centripetal activity, which furnishes conclusive evidence of the universality of the law that "action and reaction are equal and in opposite directions?" A single fact is worth more than a million theories, however plausible they may be. The second law of thermodynamics is purely theoretical, inasmuch as it tries to account for activities which are beyond the reach of experimental investigation. The fundamental equality of Note 321 is a significant and far-reaching FACT, which illustrates Laplace's principle of periodicity (Note 333), and bears satisfactory witness to the continuance of activities which have hitherto been the reproach of thermodynamics.

355. *Primitive Photodynamic Locus of Neptune.*

The combined influence of the tendencies to rotation and revolution (Notes 348, 352, etc.), is shown in the outer limits, as well as at the centre of the planetary system. The outer extremity of the photic radius (Note 345), has an oscillatory trajectory which is $(\pi v_\lambda \div v_0)$ times as great as that of ρ_0. Its rotatory *vis viva*, and consequently, its radius of relative projection, is $(\pi v_\lambda \div v_0)^2$ times as great, and the orbital period of this projectile radius is $(\pi v_\lambda \div v_0)^3 \times 2\pi \sqrt{(r_0 \div g_0)}$. Jupiter's secular eccentricity, according to Stockwell, is .0608274. This gives, for the linear centre of oscillation of its locus of incipient subsidence, .0405516, and for the solar radius vector of that centre, 1.0405516. If we take a like projection of Neptune's locus of incipient subsidence ($1.0405516 \times 30.46955 = 31.70514$) as an original nucleal radius (ρ_ν) for which Laplace's limit (ρ_λ) was $(\pi v_\lambda \div v_0)^2 \rho_0$, we find $\rho_3 = (\pi^2 v_\lambda \rho_3 \div v_3 \rho_\nu)^{\frac{2}{3}} \rho_0$; $v_\lambda \div v_3 =$ 31558149 sec. $\div$ ($2\pi \times 497.827$ sec.) $= 10089.116$; $\rho_3 = 214.461 \rho_0$; $\rho_\nu =$ $6799.52 \rho_0$; $\rho_\lambda = 4684434 \rho_0$.

356. *Primitive Photodynamic Locus of Saturn.*

The value of Sun's apparent semi-diameter as deduced from the foregoing note is 206264.″806247 $\div$ 214.461 = 961.″78, the British Nautical Almanac estimate being 961.″82. A mean proportional between Sun's semi-diameter and ρ_λ ($2164.36 \rho_0 = 10.09206 \rho_3$) is within less than one per cent. of Saturn's mean subsidence locus ($10.000059 \rho_3$). The photic radius ($\rho_\phi = \rho_0 v_\lambda \div v_0 = 688.936 \rho_0$) is a mean proportional between Earth's semi axis major and Saturn's incipient subsidence locus ($2218.23 \rho_0 = 10.343253 \rho_3$) within less than $\frac{1}{8}$ of one per cent. A mean proportional between ρ_ϕ and ρ_ν is also a mean proportional between ρ_0 and ρ_λ. Hence we see that Sun's radius, Earth's radius-vector, the photic radius, as well as the original nucleal and limiting radii of the system, are all represented through their harmonic influences upon the belt of mean planetary inertia.

357. *Stellar Relations of Primitive Photodynamic Loci.*

In whatever way we may regard these many indications of harmonic influence upon planetary positions and orbital periods, whether as furnishing evidence of early nebular condensation or of nebular activities which still continue, we can hardly believe that they are confined to our immediate system. The nearest companion system being that of *α Centauri*, we need feel no surprise at finding that ρ_ν is a mean proportional between Sun's radius and the distance of *α Centauri*, and ρ_λ is a mean proportional between the solar modulus of light and the distance of *α Centauri*. The distance which is thus indicated differs by less than $\frac{1}{3}$ of one per cent. from the one which was deduced from the corona line and the masses of Earth and Jupiter (Note 46). The photic radius is, of course, a mean proportional between Sun's radius and the solar modulus of light.

358. *Photodynamic Relations of the Neptunian System.*

Stockwell (*Wash. Obs.*, for 1873, App. I), deduced two values for the quotient of Sun's mass by Neptune's mass, viz.: 19700 from perturbations of Uranus, and 19380 ± 70 from Neptune's satellite. The former value may, perhaps, indicate the mass of the planet; the latter, the mass of the Neptunian system, including the satellite which has already been discovered, together with any others which may be yet unknown, and one or more possible remote planets. The orbital period of the primitive projectile radius (Note 355) is 19613.1 times Neptune's orbital period. Designating these periods by t_0 and t_8, respectively, we have the approximate harmonic proportion,

$$t_0 : t_8 : : 19613.1 : 1 : : m_0 : m_8.$$

This value is intermediate between Stockwell's two estimates, differing but $\frac{3}{8}$ of one per cent. from their mean, but $1\frac{1}{5}$ per cent. from the smaller and but $\frac{4}{9}$ of one per cent. from the larger estimate. As the proportion is based upon time-integrals which must be operative, this closeness of accordances is interesting.

359. *Phyllotactic Relations of Earth and Neptune.*

To the harmonic relations which I have already pointed out, between the planetary masses at the centre of incipient subsidence (Neptune) and at the chief centre of nucleation, may be added a very simple phyllotactic relation, which is shown by the proportion,

$$m_3 : m_8 : : 2 : 34.$$

If we take the mass-estimate of Note 313, $m_0 \div m_3 = 330463$, this proportion gives $m_0 \div m_8 = 19439$, which is, within the limits of probable error, in accordance with Stockwell's second estimate. The interest of this harmony is increased by the fact that the ratio of Earth's equatorial velocity of rotation is to the limiting value of $\sqrt{g_3 r_3}$ in the same phyllotactic ratio of 2 to 34.

360. *Harmonic Relations of Saturn, Mars, and the Telluric System.*

The harmonic actions and reactions among the masses at the centre of planetary inertia (Saturn), the centre of incipient subsidence for the belt of greatest condensation (Mars), and the central system in the belt of greatest condensation (Earth and Moon), is shown by the proportion

$$m_6 : \pi\, m_{(3)} : : \pi\, m_{(3)} : m_4.$$

Taking Bessel's estimate, $m_0 \div m_6 = 3501.6$, with the rotary estimates of Notes 313 and 316, $m_0 \div m_3 = 330463$, $m_3 \div \mu = 81.08$, this proportion gives $m_0 \div m_4 = 3083416$, which differs by less than $\frac{1}{4}$ of one per cent. from Hall's estimate. These repeated harmonic relations of mass seem to show that every planet represents some special central tendency, and when that tendency is found, the harmonic calculus will furnish estimates which are generally closer than those which have been reached by the ordinary astronomical methods. If this is the case with the first approximations, we may well hope that a due regard to secondary and subordinate harmonies will give results of a very satisfactory character. In the present instance, if we regard Hall's estimate as correct, and deduce the value of Earth's mass, we find $m_0 \div m_3 = 331003$, which is within the limits of probable error.

361. *Synoptic Table.*

The six foregoing notes are, in some respects, more comprehensive in their harmonic indications than any that have preceded them. I therefore give the following comparative table :

	Harmonic Logarithms.	Anti-logs.	$n\, \rho_3$
ρ_3	2.3313488	214.461	1.
ρ_ϕ	2.8381787	688.936	3.2124
ρ_i	3.3353286	2164.356	10.0921
ρ_ν	3.8324785	6799.523	31.7051
M	5.6763574	474632.	2213.1381
ρ_λ	6.6706572	4684435.	21842.8
a Cent.	7.6649570	46233521.	215579.8
$v_0 \div v_r$	2.3410288	219.295	
t_0	4.0020883	10048.2 sec.	
t_r at ρ_0	6.3431171	2203520.3 sec.	
t_r at ρ_0	1.4066034	25.504 days.	
$\delta_0 \div \delta_3$	$\bar{1}.4064550$	.25495	

362. *The Terrestrial Series.*

The above table introduces two geometrical series; the first having the ratio π, and having for one of its terms a solar radius-vector for Earth, similar to the one for Jupiter in Note 355 ($1 + \frac{2}{3}\varepsilon_3 = 1.02258$).

	Harmonic.		Observed.
a	.32548	Mercury, mean perihelion,	.31873
$\pi\ a$	1.02254	Earth, l. c. o. of sec. ecc'y,	1.02258
$\pi^2\ a$	3.21240	Photic radius, ρ_ϕ,	3.21240
$\pi^3\ a$	10.09201	Saturn, mean aphelion,	10.00006
$\pi^4\ a$	31.70514	Neptune, ρ_ν,	31.70514
$\pi^5\ a$	99.60465	Forbes, I, Note 32,	100.
$\pi^6\ a$	312.91727	Forbes, II, Note 32,	300.

This series includes the inner and outer principal planets, the centers of planetary inertia and of maximum condensation, the photic radius, and the two supra-Neptunian belts of cometary aphelia. The planetary loci are those of my first anticipatory series (*Proc. Amer. Phil. Soc.*, xiii, 140), with such modifications as represent the photic radius and the linear centers of oscillation of Earth and Jupiter. Each of the two-planet belts is indicated, and the photic radius precisely marks the locus of Asteroid 108. It also differs by less than $\frac{1}{8}$ of one per cent. from a mean proportional between Earth's semi-axis major and Saturn's locus of incipient subsidence ($3.21609\ \rho_3$).

363. *The Stellar-Photic Series.*

The second geometrical series of Notes 355–61, has the ratio π^2 and has, for two of its terms, a stellar locus and the solar modulus of light.

	Harmonic.		Observed.
$_{,}\beta$	.00239	.5135 Sun's semi-diameter,	.00239
$\pi^2\ _{,}\beta$	.02363	5.0683 Sun's semi-diameter,	.02363
$\pi^4\ _{,}\beta$	.02324	$\frac{1}{2}$ Mercury's sec. aph.,	.23840
$\pi^6\ _{,}\beta$	2.30202	Mean prop. Jupiter and Earth,	2.28096
$\pi^8\ _{,}\beta$	22.72004	$\frac{3}{4}$ Neptune's mean aph.,	22.75153
$\pi^{10}\ _{,}\beta$	224.2378		. . .
$\pi^{12}\ _{,}\beta$	2213.1381	Solar modulus of light,	2213.1381
$\pi^{14}\ _{,}\beta$	21842.804	Photic projectile radius,	21842.804
$\pi^{16}\ _{,}\beta$	215579.86	*a Centauri*,	215579.86

The planetary indications are not quite so satisfactory as in the foregoing series, but the deviations are of the same order of magnitude as planetary eccentricities. Neptune's mean subsidence locus indicates a solar nebular density corresponding to Laplace's limit, for a rotating nucleus with a semi-diameter equivalent to $\pi_8\ _{,}\beta$. Mercury's primitive subsidence-locus indicates a degree of "viscosity" which would give a rupturing tendency at a mean proportionate locus between Sun's viscous rupturing locus and $\pi_8\ _{,}\beta$. The mean proportional between these two loci is also a mean proportional between Earth's primitive subsidence-locus and Jupiter's mean projectile-locus. The deviations from exact accordance, according to

Stockwell, are respectively, $\frac{1}{7}$ of one per cent., $\frac{1}{45}$ of one per cent. and $\frac{2}{13}$ of one per cent. The three terms which indicate mere photodynamic progression show an exact accordance; but there is a range of uncertainty which is of the same order of magnitude as planetary eccentricities, with regard to the exactness with which the third of those terms represents the locus of *α Centauri*. The harmonic term preceding the solar modulus is 7.466 times Neptune's semi-axis major. It has no obvious known representative, but future researches or discoveries may make it significant. The Terrestrial and the Stellar-Photic series are connected by the proportion:

$$\alpha : \beta :: \pi^{10} \rho_0 : \rho_\phi :: \pi^{10} v_0 : v_\lambda.$$

These several relations confirm the views which were expressed in Note 262.

364. *Photodynamic Subsidence-Relation of Earth and Jupiter.*

The photodynamic projections of β from Sun's rupturing locus, of the chief centre of gravity (Sun and Jupiter) from Sun's surface, of the centre of the dense belt from the chief centre of condensation, and of ρ_ν from Neptune's locus of incipient subsidence, seem partly to account for the photodynamic gravitating relations of Earth's day and year. The radius vector of the viscous rupturing locus of Jupiter's incipient subsidence (Note 355) is 1.0304137. If $t_3 = 1$ year, we have, very nearly if not exactly, the equations:

$$g_3 \, t_3 = 1.0304137 \, v_\lambda.$$
$$v_\lambda = 186125.8 \text{ miles.}$$
$$\rho_3 = 92,659,000 \text{ miles.}$$
$$m_0 = 330,419 \, m_3.$$

365. *Conservative Momentum of Vis Viva.*

Whether we accept or reject the hypothesis of Lesage, as a literal explanation of gravitating action, it may serve as a convenient concept for representing activities which are obviously incessant. There are constant centripetal tendencies towards the Sun, as well as constant radiations from the Sun, each varying inversely as the square of the distance, and each subject to the law of equality between action and reaction. Lesage supposed that they were opposite phases of a single energy, and his views are favored by the law of parsimony. If we reject them altogether, our perplexity is doubled, for we have two reactions to account for, instead of one. Even Newton, Peirce and Helmholtz; the first, in his hypothesis of an "æthereal spirit," the others in seeking an equivalent between solar radiation and solar contraction; were guided, though less directly, by the law of action and reaction. In circular orbital motion, centripetal gravitation continually deflects the tangential path, so as to make it π times as long as the radial path before the tangential oscillation reverses its direction. The influence of momentum in such a change is represented by the terrestrial series (Note 362); the influence of *vis viva*, in the stellar-photic series (Note 363); the influence of both, in the fundamental equality (Note 321). If there is neither waste nor accumulation of energy, and if there is a material æther, the hypothesis that the centrifugal action of every æthereal radiation is followed by an equal and opposite centripetal reaction, and *vice versa,* is justified by all the known phenomena of the heavenly bodies.

366. *Dynamics and Kinematics.*

William B. Taylor delivered an address on "Physics and Occult Qualities," before the Philosophical Society of Washington, Dec. 2, 1882, on retiring from the Presidency of the Society. He discusses with great skill and lucidity, the comparative views of the kinematists who hope in time to resolve all physical enigmas by molecular processes, and of the dynamists who, "having searched in vain for any plausible co-ordination of the indisputable facts of cohesion [and other material phenomena] with an intelligible mechanical agency, simply acquiesce in the result, and without invoking the unknown or the irrelevant, accept this established property as ultimate and inexplicable." In one paragraph (p. 30) he says: "Without the indestructible—unwasting—tensions of molecular attraction and repulsion, it lies beyond the scope of human ingenuity to devise or imagine a conservative system," thus corroborating views which I have been advocating for twenty years. In another (p. 48), he seems to be somewhat self-contradictory, in saying: "*Under the present system of dynamic law,* it is certain that as radiating and cooling bodies,

> 'The Stars shall fade away, the Sun himself
> Grow dim with age, and nature sink in years.'

Nor is there known to science any natural process whereby this cosmic doom may be either averted or repaired by ulterior reversal." This is true of kinematics, but dynamic law positing behind itself "an Infinite LAWGIVER," need give no thought to kinematic perplexities and paradoxes. Force "is attended with no expenditure and is capable of no exhaustion" (p. 30). In his reference (p. 27) to the experiments of Guthrie and Bjerknes, on attractions or repulsions by mechanical vibration, he has overlooked my own experiments, which were published more than six years before Guthrie's (*Proc. Amer. Phil. Soc.*, ix, 359; x, 151–66). In his antagonism of the doctrine of "unity of force" (p. 45), he makes no reference to the identification of velocity, in the most important known manifestations of photic, electrical, gravitating and thermal activity, as shown in the fundamental equality (Note 321).

367. *Anticyclonic Storms.*

Loomis, in his 18th Contribution to Meteorolgy (*Am. Jour. Sci.*, Jan., 1881), gives many illustrations of the frequency of anticyclonic storms, to which I called attention in 1871 (*Proc. Am. Phil. Soc.*, xii, 40). My views were afterwards adopted in the Signal Service "Suggestions as to the practical uses of Meteorological Reports and Weather Maps," in magazine and newspaper articles by S. S. observers, and in reports of the Chief Signal Officer. Prof. Loomis is, perhaps, somewhat unconsciously biased by a still lurking prejudice in favor of Redfield's views, which disposes him to trace all rainfalls to "a cyclonic movement of the winds about the rain area." As soon as the rain begins to fall, there must undoubtedly be a local cyclonism, as I stated (*loc. cit.*, 7); but a careful study of weather-maps, especially in winter storms and in cases of failing forecasts, satisfies me that the *origin* of storms is as much anticyclonic as cyclonic. The frequent instances of snows in a "high" area, with simultaneous rains in a "low" area, are very instructive. Ferrel's researches show that cyclonism and anticyclonism must be companions. It is, therefore, hardly right to regard either as peculiarly storm-breeding. The *vera causa* is a blending of moist and cold currents. When the precipitation begins in a high area, the initial currents are anticyclonic; when in a low area, cyclonic. Ferrel's middle-latitude ridge of high barometer also explains the anticyclonism of our Southern States, to which Loomis refers.

368. "*Central Forces and the Conservation of Energy.*"

Mr. Walter R. Browne (*Phil. Mag.*, Jan. 1883), confirms some of the views of central force which have guided my own researches, and which are embodied in Taylor's retiring address (Note 366). He shows that the conservation of energy requires, and results from the equation

$$\int_{a}^{a+b} \mathrm{F}\,dx = \int_{a+b}^{a} \mathrm{F}\,dx\,;$$

in which two particles, A and B, are alternately receding and approaching between the distances a and $a + b$; and that F can only be a function of r; "in other words, the force with which A acts upon B always tends towards A, and varies, if it varies at all, according to the distance from A only. But this is the definition of a central force." He also refers to his paper "On Action at a distance" (*Phys. Soc.*, 1881; *Phil.. Mag.*, Dec., 1880), in which he showed that it is "impossible to explain certain elementary facts of physics without the hypothesis of action at a distance." He deduces from the kinetic theory of gases, the conclusion that the collision "occasions the instantaneous development of a strictly infinite force." In 1876, I showed that "if the theory of Boscovich were true, at the centre, where $\rho = 0$, v_ρ would be infinite" (*Proc. Amer. Phil. Soc.*, xvi, 304). These conclusions, as well as Laplace's doctrine of the instantaneous action of gravity (*op. cit.* p. 302), are inexplicable by any hypothesis which does not either recognize spiritual activity or spiritualize its definition of matter.

369. *Mean Molecular Excursions.*

In discussing the kinetic interpretation of the law of gases, Taylor cites (*Address* p. 17) the application of the calculus of probabilities, by which Clausius inferred "that of the whole number of free molecular excursions in a given time (in any large enclosure), those having less than the mean length will be 0.6321, or nearly double the number of those having the mean length or exceeding it. The simplicity of thermodynamic relations in central force (*Proc. Amer. Phil. Soc.*, xiv, 651), suggests an equally simple means of estimating the proportionate number of mean excursions. Peirce's views respecting the *vis viva* of rotation (see *Proc. Amer. Phil. Soc.*, xvi, 300), involve the consideration of the mean moment of inertia, which is represented by $\frac{2 r^2}{5}$, the momentum being represented by $r \sqrt{\frac{2}{5}} =$ .632455 r, which differs from the estimate of Clausius by less than $\frac{1}{17}$ of one per cent.

370. *Cosmical Influence of Rotary Inertia.*

We may naturally suppose that, among the many harmonic influences which have combined in fixing the relative positions of the several planets, rotary inertia should be represented Among the evidences which strengthen such a supposition, are the following:

2.5 Mercury, sec. per.,	.7435	Venus, mean aph.,	.7489
1.5 Mercury, mean per.,	.4781	Mercury, s. a.,	.4768
2.5 Mercury, mean,	.9677	Earth, m. p.,	.9661
1.5 Mercury, m. a.,	.6832	Venus, s. p.,	.6722
1.5 Mercury, s. a.,	.7152	Venus, mean,	.7232
1.5 Venus, s. p.,	1.0084	Earth, mean,	1.0000
1.5 Earth, s. p.,	1.3984	Mars, m. p.,	1.4032
2.5 Jupiter, s. p.,	12.2158	$\frac{2}{3}$ Uranus, m. p.,	12.2153
1.5 Saturn, m. a.,	15.0001	$\frac{1}{2}$ Neptune, mean,	15.0169
1.5 Uranus, m. a.,	30.0663	Neptune, mean,	30.0339
.6 Neptune, s. a.,	18.2817	Uranus, m. p.,	18.3230

The ratio of the rotating radius to the projectile radius of mean rotary *vis viva* is 2.5 ; the reciprocal ratio gives the vector-ratio in opposition, 1.5 ; the ratio of the rotating radius, less that of the projectile radius is .6 ; the reciprocal of 1.5 is $\frac{2}{3}$, which also represents the centre of linear oscillation and the radius of subsidence-collision ; the viscous rupturing radius of subsidence is $\frac{1}{2}$.

371. *Reaction of Rotary Vis Viva.*

A fact which has an important bearing on Delaunay's hypothesis, as well as on the second law of thermodynamics, is shown by the reciprocal ratios of the foregoing note, and more strikingly, by the reactionary influence of Neptune. If we look to a like reaction on the part of the other planets, we find the following harmonic accordances :

.6 Uranus, m. a.,	12.0265	.4 Neptune, m.,	12.0135
.6 Uranus, s. p.,	10.6128	Saturn, s. a.,	10.3433
.6 Saturn, s. p.,	5.2407	Jupiter, m.,	5.2028
.6 Jupiter, m.,	3.1217	Asteroid 120,	3.121
.6 Jupiter, m. p.,	2.9869	Asteroid 61,	2.987
.6 Mars, s. a.,	1.0419	Earth, m. a.,	1.0338
.6 Earth, s. a.,	.6406	Venus, s. p.,	.6722
.6 Venus, m. a.,	.4493	Mercury, m. a.,	.4554
.6 Mercury, s. p.,	.1784	Laplace's limit,	.1696

The greatest deviations are at Earth's secular aphelion or locus of incipient subsidence, and at Mercury's secular perihelion or locus of incipient projection; the difference in each case being about five per cent. (1.0493 and .9507), and the mean difference being zero. The mean deviation of the four dense planets is only $\frac{1}{10}$ of one per cent. The mean difference in the light belt is about $\frac{2}{3}$ of one per cent., the greatest being that of Uranus, 2.5 per cent. The exactness of Jupiter's influence on Asteroids 120 and 61 is remarkable.

372. *Conservative Reaction.*

It may be readily seen that all the indications of the foregoing note point to a rotary *vis viva* of the several planets, reacting against a similar solar *vis viva*, and having no corresponding indications in opposition to the Sun. These indications are of a character like those which underlie the investigations of George H. Darwin, but their influence upon Sun is accelerating, instead of retarding, while any *quasi*-viscous tidal influence is retarding, instead of accelerating. If the two kinds of influence represent equal actions and reactions, the result would be a precise conservation of centripetal and radiant energies, without any solar expansion or contraction, other than in cyclic alternations, within limits of an order of magnitude like that of planetary eccentricities. The fundamental equality of Note 321 shows that Sun's centripetal rotating energy is wholly photodynamic. We may readily believe that the solar rupturing and expanding tendencies of planetary rotation represent a purely photodynamic reaction on gravitating action, which is exactly equivalent and opposite. The evidences of such equivalence in cosmical aggregations should encourage us to look, with increasing confidence, for further evidences in æthereal oscillations of various kinds, and especially in the electric and thermal undulations which are indicated by the fundamental equality. Edlund's researches point to electric and thermal equivalence of action and reaction, as plainly as Maxwell's point to electric and photic equivalence, and as my own point to a like photic, electric, thermal and gravitating equivalence.

373. *The Testimony of Mars.*

The many indications which I have found, of subsidence-orbital relations between Mars and the asteroidal belt, are supplemented by the direct and reciprocal influences (2.5 and 1.5; see Note 370), of solar photodynamic rotation upon the secular apsides and the mean locus of Mars, as well as upon intermediate positions.

2.5 sec. per.,	3.277	.6 Jupiter, m. a.,	3.256
1.5 sec. per.,	1.966	$\frac{1}{2}$ Asteroid 153,	1.977
2.5 mean,	3.809	.4 Saturn, m,	3.815
1.5 mean,	2.286	Asteroid 136,	2.287
2.5 sec. aph.,	4.341	.8 Jupiter, m. a.,	4.342
1.5 sec. aph.,	2.605	Asteroid 132,	2.603
.4 sec. aph.,	.695	Venus, m. p.,	.698
Mean	2.711	Mean	2.711

The greatest deviation is ⅜ of one per cent. The two mean asteroidal accordances are nearly as exact as those in Note 371. All of the direct and reciprocal influences are in the asteroidal belt. The direct influence at secular aphelion (4.341) points to a "viscous" rupturing influence of the Jupiter-Saturnian belt (.4 of 10.855 = 4.342). The exact agreement of the general means is very satisfactory.

374. *Centripetal Influence of Rotary Vis Viva.*

Some of my critics have supposed that it would be possible to find harmonic accordances with series which were taken at random, or with no known kinetic basis, but none of them have offered any such accordances to confirm their supposition. I have never published any harmonies which were not the natural outgrowth of well-known elastic laws, and the abundant confirmation which I have found for my anticipations is beyond all cavil or gainsaying. In Note 370 I gave evidences of the centrifugal influence of rotary *vis viva*, which may be compared with the following evidences of mean centripetal influence.

.4 Neptune	12.014	⅔ Uranus, m. p.,	12.215
.4 Uranus,	7.673	½ (Jup. and Sat.), m. a.,	7.714
.4 Saturn,	3.816	2.5 Mars,	3.809
.4 Jupiter,	2.081	⅔ Asteroid 120,	2.081
.4 Asteroid 3,	1.067	Earth, s. a.,	1.068
.4 Asteroid 4,	.944	Earth s. p.,	.932
.4 Mars,	.609	Venus, s. p.,	.672
.4 Earth,	.400	Mercury, mean,	.387
.4 Venus,	.289	Mercury, s. p.,	.297

375. *Lines of Force and of Motion.*

Taylor (*op. cit.* p. 28), very properly calls attention to the fact that "no atom can perform an oscillation or a revolution, or follow any other path than a straight line, excepting under the coercion of other atoms attracting and repelling. The first law of motion is that of perfect continuity both in amount and in direction. A shuttlecock rebounding in the empty air would not be more conspicuously a dynamic solecism and impossibility than the kinematists 'vibratory particle.'" His doctrine (*Ib.* p. 9), that elasticity is "a fact of nature, a property of matter, which can neither be interpreted by any form of motion, nor resolved into any mechanical concept," is in precise accordance with the due regard to "lines of force" which guided Boscovich and Faraday, and which has been very helpful in my own researches. My first paper on barometric estimates of solar mass and distance (*Proc. Amer. Phil. Soc.*, ix, 283–8) was attacked by kinematists, because it violated some of their preconceived notions respecting the composition and resolution of forces. It did not receive much favor, until the productiveness of the harmonic methods showed that the composition and resolution of motions, in elastic media, may often enable us to dispense with intricate integrations, which it would be difficult, if not impossible to solve, and that it is always safer to be guided by the FACTS of nature, than by any preconceived theoretical interpretation of those facts.

Some Microscopic Distinctions between Good and Bad Timber of the Same Species. By Dr. J. T. Rothrock.

(Read before the American Philosophical Society, February 2, 1883.)

A cross section of one of our ordinary "hard woods" shows, more or less conspicuously, pores which are known as ducts, and which from their relatively large size are distinctly visible to the naked eye; secondly, it shows much smaller pores which may, or may not, require the magnifying glass to detect, and whose walls constitute the woody fibre of the stick; thirdly, we should have (assuming the specimen to be an exogen), the annual rings which mark, *as a rule,* the limit of each year's growth; fourthly, there would be the radial lines extending from the centre outwardly to the bark, these being the medullary rays or the so-called "silver grain."

If, on the other hand, the specimen under observation were one of our ordinary cone bearing trees, the ducts would be wanting, and the mass of the section would be composed of woody fibre. There may be openings which will resemble the ducts in hard wood, but instead of showing regularly organized walls, these will be found to represent simply openings left by the destruction or the separation of the woody fibres. They are by no means so numerous ordinarily as the ducts in an average "hard wood stick."

Considered from the standpoint of resistance to longitudinal strain, the strength-giving element of wood is the woody fibre; and other things being equal, it is strong in proportion as the fibre walls are relatively thick, and the fibre cavities relatively small. Illustrating this, we have the following cross sections of wood fibres, all magnified 242 diameters: 1, is that of Abies subalpina (Pumpkin Pine) from Utah; a timber which is almost worthless; 2, is that of our American Linden; 3, represents the Butternut (or Juglans cinerea); 4, is the Pig-nut Hickory (or Carya porcina) and 5, is that of an average specimen of White Oak fibre (Quercus alba). Considering the areas of the cavities in each of these sections, the White Oak has about six times as much wood in its walls, as there is in that of the Pumpkin Pine—a fact which it must be allowed will go far toward explaining the differences in the strength of the two woods. It is true that there may be differences in the strength of wood which are due to the molecular differences involved in the structure of the fibre, but with these we are probably in no position to deal. The intercellular substance which is destroyed by boiling in nitric acid and potassium chlorate is to a certain extent an element in the strength of wood. There can be no doubt but that it aids in increasing the friction between the individual fibres, and is therefore the chief agent by which these are bound together, and thus resist longitudinal strain. So far as my investigations go, there is less relation between length of fibre and strength, than there is between thickness of fibre wall and strength. Some woods acquire additional strength, both longitudinal and transverse, from a twisting of the wood fibres among themselves. The Rock Elm is a notable example of this among our larger trees; as the Viburnum nudum or Withe-rod is among the shrubs.

So far as the ducts are concerned, while the material of which they are composed may be quite as strong as that of the fibres, yet owing to the enormous cavity they contain, it is apparent that as compared with fibres, they must be much weaker; that in fact every duct is to be regarded as an element of weakness to the stick. Hence then, other things being equal, the more fibres and the fewer ducts, the stronger is any given stick of timber as compared with another of the same species.

The question of durability in exposed positions is quite another thing, and has no close relation to strength.

Accepting the above facts as proven, mere examination of a cross section of timber with the naked eye, or at most with an ordinary hand lens, may afford a reasonably safe way of estimating the quality of a given specimen of wood.

Associated with the appearance presented by the ducts, and the mass of fibres, is another element of structure, ***i. e.***, that of the annual rings. These are usually caused as may be seen (A and B 6) by the thick, flat cells which are formed in autumn as contrasted (A and B 7) with the larger ones which mark the first growth of the ensuing spring. The number of rows which are thus flattened in the autumn wood is by no means constant. Sometimes, as in the case of the White Oak, there being but two, three or four; or as in the case of the Chestnut being often about eight, or more; or as in the Redwood of California (Sequoia sempervirens) as high as fifteen. As a rule the color in all these autumn fibres is deeper than in those made earlier. Hence both shape and color combine to mark the "year's growth."

The term "year's growth" is one which should not be depended upon too absolutely, inasmuch as it is well known to be misleading at times. Thus, in the American Linden, one frequently sees a ring more on one side than on the other; and indications are not wanting, which would prove that very frequently several such rings may form in our latitude in a single season.

There are some facts of practical importance connected with the wood formed during the season, or to speak more accurately, with all the tissue lying between the denser, flatter fibres which are assumed to be formed in the autumns of two successive years. In White Oak, as shown by figures A and B, there may be a great range in the distance between these zones of flat fibres. Thus fig. B shows that the growth for the year was about twice that shown by fig. A. The former of these figures represents a good specimen of White Oak, and the latter a bad one, each having been carefully tested for strength by competent mechanical experimenters. In these instances the reason for the difference in the quality of the wood is obviously in the relative predominance of solid woody fibre over open ducts in the good specimen (B), and the lesser quantity of wood as compared with ducts in (A), the bad. It so happens that in A the diameter of the duct (.01430 of an inch) is greater by far than in the better wood. This can, however, hardly be regarded as constant. What does appear to prevail in White Oak is, the fact that most of these *large* ducts are made early in the season, and that whether much or little wood is subsequently formed the number of the ducts will not greatly vary. Hence, then, for White Oak we may assert that the specimen with the larger year's growth is, other things being equal, the better. Very frequently two duct cavities are thrown into one, so that the width is greatly increased. These may usually be distinguished from true ducts by the irregular and disintegrated walls, which serve to explain the process by which the size was attained.* The above rule, as to the relation between size of "year's growth" and value, in Oak I have made the subject of some investigation, taking as test cases specimens of timber upon whose value opinions had been given by the most competent workers in the wood.

Hickory, good and bad (certainly Carya alba and C. porcina), involves another element than mere size of the annual ring. Though I must here add that the best bit of C. porcina I have ever seen was also one that had the largest year's growth I had ever seen. In this wood (Hickory), the large ducts are not so clearly limited in their production to the early part of the season (especially if the stick be one of poor quality), but are, or may be, clearly scattered through the wood. And the quality of the wood is determined mainly by the number and size of these ducts. Thus in bad Pig-Nut Hickory (C. porcina) I find in a surface of a quarter of an inch square, sixty-five, each with an average size of .01428 inch ; as against twenty-seven ducts having an average width of .01224 inch in good Hickory of the same species.

To a greater or less extent the same statements, as to cause of difference between good and bad qualities of Chestnut, and Locust (Robinia pseudacacia), will apply.

Figure C. illustrates the marked tendency which the ducts have to be associated in Hickory. It also shows the effect of the growth in pushing aside one of the medullary rays, 9 b. It is not uncommon, however, in this wood to find these rays broken by the growth of the duct, and in Oak this is still less rare. I have frequently seen specimens of bad White Oak which were as porous as the average Red Oak, the ducts being, as shown by the micrometer, quite as great in their diameter.

The medullary rays or "silver grain" appear also to have important relation to value of Oak certainly, and probably of Hickory, to say nothing of other kinds of timber. The fibres and ducts are ordinarily characterized as the vertical system from the line in which they are elongated. With equal propriety then the medullary rays are spoken of as the horizontal system of the plant, because they are elongated at right angles to the fibres and ducts. From the thick walls of the cells constituting these rays, we might suppose they had to do with the lateral strength of the timber. This view is *partially* confirmed by a microscopic examination of the cross section of the different woods ; as upon the whole, Red-wood, Chestnut and White Pine show either that these rays are fewer in number or less strongly

* Very often this process of disintegration of the wall may convert a true duct into a mere cavity without walls.

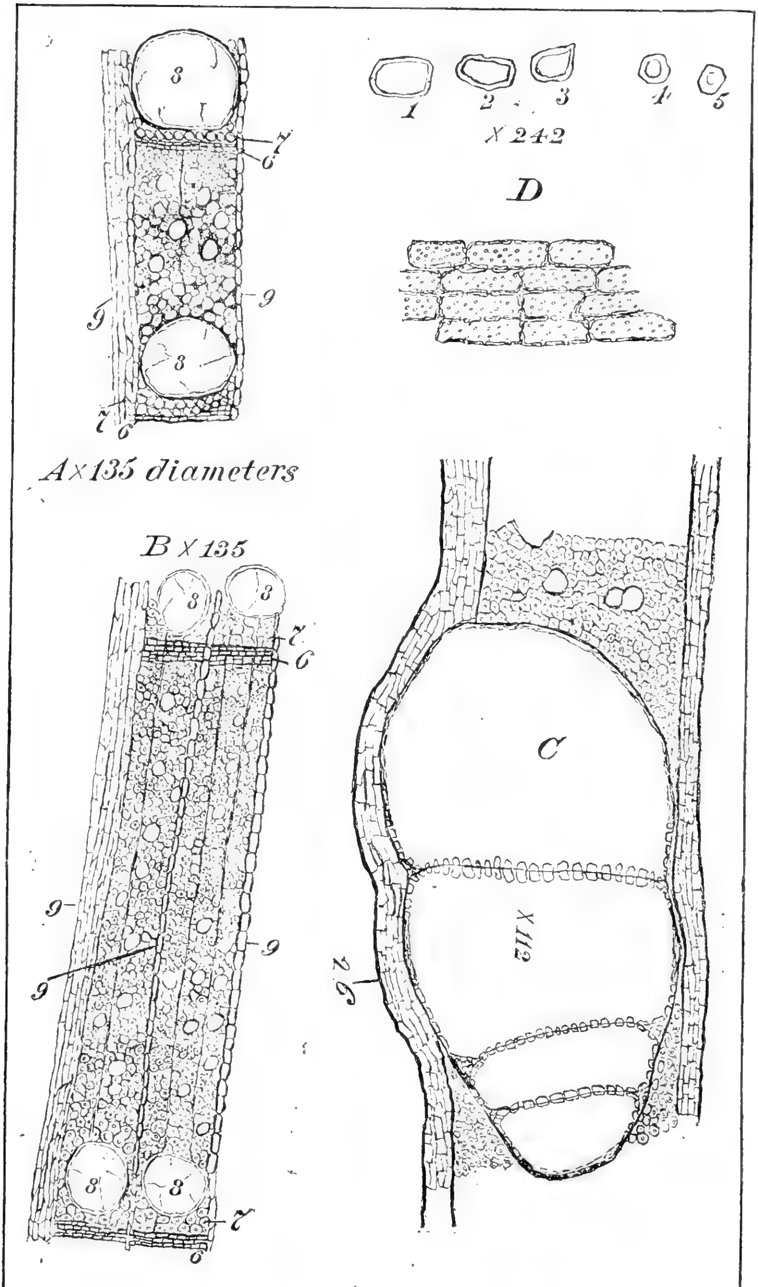
developed than in the Tupelo (Nyssa multiflora), or in a specimen of good White Oak. However, in making comparisons of this kind, we must be careful to make them at points equidistant from the centre; and to note whether these rays extend to the centre, or only part way in from the bark toward the heart of the tree, as this latter circumstance determines their age, and also generally their relative strength. In such species of timber as have rays extending vertically over two or more inches, as in some of the Oaks, the ray often indicates the line of easiest splitting, as is often seen by the effect of drying upon the exposed end of such timber. This is not an invalidation of the statement that one function of the rays appears to be to give lateral tenacity, *i. e.* to such portions of solid wood as lie between the rays. They form as it were a chain binding the periphery to the centre, but offer no resistance to the separation of one woody wedge which they outline, from another such wedge which is placed alongside. If this be so, then such specimens of wood as have the rays ruptured by encroachment of ducts or by any process of disintegration would be correspondingly weakened. It is furthermore worthy of note that in such specimens of good White Oak (Quercus alba), and good Pig-Nut Hickory (C. porcina) as upon actual trial had proven to be the best, these rays were as a rule either most numerous, or best developed, or both.

Examined microscopically, the cells making up these rays present an appearance when viewed from the side like figure D. That is to say they are quadrangular, thick walled and with numerous thin places in which the primary cell wall may or may not remain. Their very appearance suggests a somewhat easy communication between those (cells) which are adjacent, and thus afford a probable explanation of the fact, that when the starch made in summer by the younger portion of the tree is being conveyed into the interior of the branches for winter storage, these rays appear to furnish the most available avenues for accomplishing the work, and micro-chemical tests show that it is most abundant in them. While these thin or open places in the cells of the medullar ray usually communicate with each other, it is remarkable that they are much fewer in the sides toward the ducts and fibres.

It would be exceedingly interesting to know how far the facts indicated by this paper would conform to the value of timber as determined by specific gravity.

EXPLANATION OF ILLUSTRATIONS.

1. Cross Section of Abies subalpina wood fibre × 242.
2. " " Tilia Americana " " × 242.
3. " " Juglans cinerea, " " × 242.
4. " " Carya porcina, " " × 242.
5. " " Quercus alba " " × 242.
6. A and B. Flattened cells made in autumn.
7. " " Larger cells which indicate growth of following spring.
8. " " Open ducts seen in cross section.
9. " " Medullary rays.


A × 135 diameters
B × 135
C
× 112
D
× 242

A. Cross section of bad White Oak × 135.
B. " " good " " × 135.
C. " " Carya porcina × 112, grouping of ducts and pushing aside of Medullary rays.
D. Fragment of Medullary ray showing the pits or pores in the walls, × 300.

An improvement in the construction of the Hypsometrical Aneroid. By Dr. Persifor Frazer.

(Read before the American Philosophical Society, March 2, 1883.)

While in France last year the idea occurred to the writer to lessen the weight of the delicate Hicks Barometer by constructing as much as possible of it of aluminium. Supposing that this could be done without difficulty, though of course at an increased expense, the writer devised a case of cork to contain it, and wrote to Mr. Hicks of London asking him to make the attempt. After a number of interviews it was finally estimated that the cost of the new form of aneroid should not exceed £10, or just double that of the ordinary instrument of brass in a wooden case. Delays were experienced from the beginning and added very much to the expense of the instruments when they finally arrived here.

First it was found difficult to produce an aluminium dial plate with a graduation of the requisite delicacy and accuracy. Then the internal supports could not be easily cast in that metal of the shapes necessary to build the frame for the more delicate moving parts.

Finally the writer was obliged to leave England without having received the barometers. When they arrived a few days ago the Government duty on them was $30.40 a piece, added to which Mr. Hicks had found it necessary to increase the original charge of £10 to £15 apiece. In consequence they cost a little over $105 apiece.

They are, however, creditable to Mr. Hicks's workmanship, and if their manufacture should increase, could no doubt be obtained at a very much reduced price.*

In order to prevent the breaking of the cork, by friction on the clothing, a light canvas cover was added, weighing 50 grams.

The following is a comparison of the weights of the ordinary Hicks barometer with one of them.

	Old form.		New form.	
Case and strap,	400 grams.	(wood)	150 grams.	(cork)
Aneroid,	1000 "	(brass)	400 "	(Aluminium)
Canvas cover,	——		50 "	
Total weight,	1400 "		600 "	
" "	or 3.09 lbs. (av.)		1.323 lbs. (av.)	

The ordinary instrument weighs, therefore, $2\frac{1}{3}$ times as much as the new form, the weight of the old case being closely that of the new barometer.

* A letter received from Mr. Hicks, after the above was in print, reiterates the difficulties with which he contended, and states that notwithstanding the experience gained in making mine, he cannot deliver them for less than £15 apiece.

Some Comparative Tables showing the Distribution of Ferns in the United States of North America. By George E. Davenport.

(Read before the American Philosophical Society, February 2, 1883.)

The following tables have been prepared for a Text Book and Manual of the Ferns of North America (north of Mexico), but are believed to be of sufficient interest to justify publication in advance.

The attention of botanists is called to them, and their coöperation solicited in enabling the writer to render them more complete and accurate for final publication.

These tables are necessarily incomplete in their present form, no reliable data for all of the States and Territories being readily accessible. The number of species credited to many of the States might have been increased by assuming the presence of certain species from their well known geographical range, but it was thought best to give only those which could be verified, or had been vouched for by good authority.

Where a doubt exists in regard to the presence of a species said to have been collected in any State, and such doubt is not sufficient to justify exclusion, the species is credited with a query to indicate the uncertainty of its verification.

All varieties are excluded except where a variety stands as the sole representative of the species itself.

My thanks are due to John H. Redfield, Dr. George Engelmann, Professor D. C. Eaton, J. Donnell Smith and Wm. Stout for many additions, and it will further aid me greatly if others will send to me accurate lists of the species and varieties known to grow naturally in their respective States.

The list of ferns as given below may undergo some changes before final publication, the numbers correspond to those given in the tables :

1. Acrostichum aureum.
2. Polypodium Plumula.
3. " pectinatum.
4. " vulgare.
5. " falcatum.
6. " Californicum.
7. " incanum.
8. " Scouleri.
9. " Phyllitidis.
10. " aureum.
11. Gym. triangularis.
12. " hispida.
13. Notholæna sinuata.
14. " ferruginea.
15. " candida.
16. " Hookeri.
17. " Grayi.
18. Notholæna Lemmoni.
19. " Fendleri.
20. " dealbata.
21. " nivea.
22. " Newberryi.
23. " Parryi.
24. " tenera.
25. Cheilanthes Californica.
26. " Wrightii.
27. " viscida.
28. " microphylla.
29. " Alabamensis.
30. " leucopoda.
31. " vestita.
32. " Cooperæ.
33. " lanuginosa.
34. " gracillima.

35. Cheilanthes tomentosa.
36. " Eatoni.
37. " Fendleri.
38. " Clevelandii.
39. " Parishii.
40. " Lindheimeri.
41. " myriophylla.
42. " argentea.
43. Cryptogramme acrostichoides.
44. Pellæa gracilis.
45. " Breweri.
46. " Bridgesii.
47. " atropurpurea.
48. " aspera.
49. " Wrightiana.
50. " ternifolia.
51. " ornithopus.
52. " brachyptera.
53. " andromedæfolia.
54. " cordata. ?
55. " flexuosa.
56. " pulchella.
57. " densa.
58. Pteris longifolia.
59. " Cretica.
60. " serrulata.
61. " aquilina.
62. Ceratopteris thalictroides.
63. Adiantum pedatum.
64. " emarginatum.
65. " tricholepis.
66. " capillus-veneris.
67. " tenerum.
68. Vittaria lineata.
69. Tænitis lanceolata.
70. Blechnum serrulatum.
71. Lomaria spicant.
72. Woodwardia radicans.
73. " Virginica.
74. " angustifolia.
75. Camptosorus rhizophyllus.
76. Scolopendrium vulgare.
77. Asplenium serratum.
78. " pinnatifidum.
79. " ebenoides.
80. " ebeneum.
81. Asplenium parvulum.
82. " Trichomanes.
83. " viride.
84. " dentatum.
85. " montanum.
86. " Bradleyi.
87. " Ruta-muraria.
88. " septentrionale.
89. " firmum.
90. " myriophyllum.
91. " cicutarium.
92. " angustifolium.
93. " thelypteroides.
94. " Filix-fœmina.
95. Phegopteris polypodioides.
96. " hexagonoptera.
97. " Dryopteris.*
98. " alpestris.
99. Aspidium Lonchitis.
100. " acrostichoides.
101. " munitum.
102. " aculeatum.
103. " Mohrioides.
104. " Thelypteris.
105. " Noveboracense.
106. " Nevadense.
107. " Oreopteris.
108. " conterminum.
109. " patens.
110. " fragrans.
111. " spinulosum.
112. " Boottii.
113. " cristatum.
114. " Floridanum.
115. " Goldieanum.
116. " rigidum.
117. " Filix-mas.
118. " marginale.
119. " unitum.
120. " juglandifolium.
121. " trifoliatum.
122. Onoclea sensibilis.
123. " Struthiopteris.
124. Cystopteris fragilis.
125. " bulbifera.
126. " montana.

* *Phegopteris calcarea* is included here as a variety with Hooker and Baker.

127. Woodsia Ilvensis.
128. " glabella.
129. " hyperborea.
130. " scopulina.
131. " Oregana.
132. " Mexicana.
133. " obtusa.*
134. Nephrolepis exaltata.
135. Dicksonia pilosiuscula.
136. Trichomanes Petersii.
137. " radicans.
138. Schizæa pusilla.
139. Aneimia Mexicana.
140. " adiantifolia.
141. Lygodium palmatum.
142. Osmunda regalis.
143. " Claytoniana.
144. " cinnamomea.
145. Botrychium simplex.
146. " Lunaria.
147. " boreale.
148. " matricariæfolium.
149. " lanceolatum.
150. " ternatum.
151. " Virginianum.
152. Ophioglossum vulgatum.
153. " crotalophoroides.
154. " nudicaule.
155. " palmatum.

Tables Showing Distribution.

Numbers correspond with those to the List.
*Verified or credited on good authority.
?Uncertain, or not positively verified.

	TOTAL.
ALABAMA—4, 7, 29, 31?, 47, 60, 61, 63, 66, 75, 78, 79, 80, 81, 82, 85, 86, 92, 93, 100, 105, 118, 133, 135, 136, 137, 142?, 150, 152, 153, 154.	29* 2?
ALASKA—4, 42?, 43, 63, 71, 95, 97, 98, 102, 107, 111, 124, 126, 145, 146, 147, 148, 149, 150, 152.	19* 1?
ARIZONA—4, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26, 29, 33? 35, 36, 37, 40, 41, 43?, 47, 49, 53?, 54, 55, 61, 63, 66, 104, 109, 117, 124, 130, 131, 132, 133, 151, 152.	37* 3?
ARKANSAS—4, 7, 20, 29, 31, 33, 35, 47, 61, 63, 66, 73, 74, 75, 78, 80, 81, 82, 86, 87, 92, 94, 95, 96, 100, 104, 105, 111, 113, 118, 122, 123, 124, 125, 133, 142, 143, 144, 150, 151, 152.	41*
CALIFORNIA—4, 5, 6, 8, 11, 15, 22, 23, 25, 27, 32, 33?, 34, 37, 38, 39, 41?, 43, 45, 46, 49, 51, 52, 53, 57, 61, 63, 64, 65?, 66, 71, 72, 82, 94, 95?, 98, 101, 102, 103, 106, 109, 116, 124, 130, 131, 145, 150, 151.	44* 4 ?
COLORADO—4, 19, 33, 36, 37, 43, 44, 45, 47, 49, 61, 80, 82, 88, 94, 97, 99, 117, 124, 126, 130, 131, 145?, 146, 149, 151.	25* 1?
CONNECTICUT—4, 47, 61, 63, 73, 74, 75, 79, 80, 82, 87, 94, 95, 96, 97, 100, 104, 105, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133,135, 141, 142, 143, 144, 146, 148, 149, 150, 151, 152.	40*
DAKOTA—4, 33, 47, 61, 97, 99?, 111, 117, 122, 124, 125, 127, 130, 131, 150, 151.	15* 1?

* *Woodsia Plummeræ* Lemmon (Botanical Gazette Jan. 1882), is apparently a very glandular form of this species.

DELAWARE—4, 61, 63, 73, 74, 75, 80, 82, 93, 94, 96, 100, 104, 105, 112, 113, 115, 118, 122, 127, 133, 135, 142, 143, 144, 150, 151, 152.	28*
DIST. OF COLUMBIA—4, 47, 61, 63, 74, 80, 82, 92, 93, 94, 96, 100, 104, 105, 111, 118, 122, 125, 133, 141, 142, 143, 144, 150, 151, 152.	26*
FLORIDA—1, 2, 3, 7, 9, 10, 28, 58, 59, 61, 62, 66, 67, 68, 69, 70, 73, 74, 77, 80, 81?, 82, 84, 89, 90, 91, 94, 96, 100, 104, 108, 109, 114, 119, 121, 122, 134, 136?, 140, 141, 142, 143, 144, 150, 151, 153, 154, 155.	46* 2?
GEORGIA—29, 31, 61, 73, 74, 75, 81, 85, 93, 122, 133, 142, 144, 154.	14*
IDAHO—61, 94, 102.	3*
ILLINOIS—4, 7, 33, 47, 61, 63, 73?, 75, 78, 80, 82, 93, 94, 95, 96, 97, 100, 104, 105, 111?, 118, 122, 123, 124, 125, 133, 135, 142, 143, 144, 150, 151.	30* 2?
INDIANA—4, 7, 31, 47, 61, 63, 73, 75, 78, 80, 82, 87, 92, 93, 94, 96, 100 104, 105, 111?, 115, 117?, 118, 122, 123, 124, 125, 133, 135, 142, 143, 144, 150, 151, 152.	33* 2?
INDIAN TERRITORY—36, 47, 115, 133.	4*
IOWA—4, 33, 44, 61, 63, 80, 82, 94, 95.	9*
KANSAS—20, 31?, 47, 63, 75, 92, 115, 122, 124, 133, 151.	10* 1?
KENTUCKY—4, 7, 31, 35, 47, 61, 63, 66, 75, 78, 79, 80, 81, 82, 85, 86, 87, 92, 93, 94, 95, 96, 100, 104, 105, 111, 113, 115, 118, 122, 124, 125, 127?, 133, 135, 137, 141, 142, 143, 144, 150, 151, 152?.	41* 2?
LOUISIANA—7, 61, 63, 73, 74, 80, 92, 93, 94, 95, 100, 104, 105, 109, 111, 114, 122, 125, 142, 144, 150, 151, 153.	23
MAINE—4, 61, 63, 73, 80, 82, 94, 95, 96, 97, 100, 102?, 104, 105, 110, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 142, 143, 144, 145, 148, 149, 150, 151, 152.	35* 1?
MARYLAND—4, 31, 61, 63, 73, 74, 75, 78, 80, 82, 85, 87, 93, 94, 95, 96, 100, 104, 105, 111, 112, 113, 115, 118, 122, 124, 127, 133, 135, 141, 142, 143, 144, 150, 151, 152.	36*
MASSACHUSETTS—4, 44, 47, 61, 63, 73, 74, 75, 80, 82, 87, 92, 93, 94, 95, 96, 97, 100, 104, 105, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 145, 148, 149, 150, 151, 152.	42*
MICHIGAN—4, 43, 44, 47, 61, 63, 73, 74, 75, 80, 82, 87, 92, 93, 94, 95, 96, 97, 99, 100, 102, 104, 105, 110, 111, 112, 113, 115, 117, 118, 122, 123, 124, 125, 127, 131, 133, 135, 142, 143, 144, 145, 146, 148, 149, 150, 151.	47*
MINNESOTA—4, 31, 44, 47, 61, 63, 75, 93, 94, 95, 97, 100, 104, 110, 111, 115, 118, 123, 125, 127, 130, 143, 150, 151.	24*
MISSISSIPPI—7, 66, 73, 80, 94, 96, 100, 122, 142, 144, 150.	11*

MISSOURI—4, 7, 20, 31, 33, 35, 47, 61, 63, 66. 75, 78, 80, 82, 92, 93, 94, 96, 100, 104, 111, 118, 122, 124, 125, 133, 135, 142, 143, 144, 150, 151, 152.	33*
MONTANA—4, 97, 99, 111, 122, 124, 125, 127, 150, 151.	10*
NEBRASKA—4, 33, 44, 47, 61, 63, 75, 80, 82, 92, 94, 95, 96, 99, 104, 105, 110, 111, 113, 118, 124, 125, 127, 133, 135, 142, 143, 144, 150, 151.	30*
NEVADA—37, 103.	2*
NEW HAMPSHIRE—4, 44?, 47?, 61, 63. 73?, 75?, 80, 82, 87?, 93, 94, 95. 97, 100, 102, 104, 105?, 110, 111, 112?, 113, 115, 118, 122, 123. 124, 125?, 127, 128, 133, 135, 142, 143, 144, 148, 150, 151, 152.	31* 8?
NEW JERSEY—4, 31, 44, 61, 63, 73, 74, 75. 79?, 80, 82, 83, 85, 87, 93, 94, 96, 100, 104, 105, 111, 113, 115, 118, 122, 124, 125, 127, 133, 135, 138, 141, 142, 143, 144, 149, 150, 151, 152.	38* 1?
NEW MEXICO—12, 13, 14, 16, 19, 20, 21?, 26, 28?, 29, 33, 34, 36, 37, 40, 47, 48?, 49, 50?, 54, 55?, 56, 66, 81, 82, 88, 124, 131? 132, 133, 139.	25* 6?
NEW YORK—4, 31, 44, 47, 61, 63, 73, 74, 75, 76, 79, 80, 82, 85, 86, 87, 92, 93, 94, 95, 96, 97, 100, 102, 104, 105, 110, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 128, 129, 133, 135, 141, 142, 143, 144, 145, 146, 148, 149, 150, 151, 152.	52*
NORTH CAROLINA—4, 7, 29, 31, 35, 47, 61, 63, 66, 74, 75, 78, 80, 81, 82, 85, 87, 92, 93, 94, 96, 100, 104, 105, 111, 118, 122, 124, 125, 127, 133, 135, 141, 142, 143, 144, 150, 151, 152.	39*
OHIO—4, 7, 47, 61, 63, 73, 75, 80, 82, 87, 92, 93, 94, 95, 96, 97, 100, 104, 105, 111, 113, 115, 118, 122, 123, 124, 125, 127?, 133?, 135, 142, 143, 144, 150, 151, 152.	34* 2?
OREGON—4, 5, 6, 8, 11, 34, 43, 46, 57, 61, 63, 64, 71, 82, 94, 97, 98, 101, 111, 124, 130, 131, 133, 151.	24*
PENNSYLVANIA—4, 31, 44, 47, 61, 63, 73, 74?, 75, 78, 79, 80, 82, 85, 87, 92, 93, 94, 96, 97, 100, 102, 104, 105, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 148?, 150, 151, 152.	42* 2?
RHODE ISLAND—4, 61, 63, 73, 74, 75, 80, 82, 93, 94, 95, 96, 97, 100, 104, 105, 111, 112, 113, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 150, 151, 152.	34*
SOUTH CAROLINA—7, 73, 80, 82, 84?, 109, 150, 153, 154.	8* 1?
TENNESSEE—7, 29, 35, 61, 63, 75, 76, 78, 81, 82, 85, 86, 87, 100, 111, 124, 125, 133, 135, 137, 141, 152.	22*
TEXAS—7, 12, 13, 14, 15, 16, 20, 26, 28, 29, 30, 33, 35, 40, 47, 48, 49, 50, 54, 55, 56, 61, 65, 66, 80, 81, 82, 109, 120, 121, 132, 133, 139, 152, 153.	35*

UTAH—23, 24, 33, 43, 45, 57, 61, 63, 66, 94, 99, 103, 117, 130, 131. 15*

VERMONT—4, 44, 47, 61, 63, 73, 75, 80, 82, 83, 87, 92, 93, 94, 95, 96, 97, 100, 102, 104, 105, 110, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 128, 129, 133, 135, 142, 143, 144, 145, 148, 149, 150, 151, 152. 45*

VIRGINIA, including W.Va.—4, 7, 31, 35, 61, 63, 66, 74, 75?, 80, 81, 82, 85, 87, 92, 93, 94, 97, 104, 105, 111, 113, 115, 118, 124, 127, 133, 135, 141, 142?, 144?, 150, 151. 30* 3?

WASHINGTON TERRITORY—4, 5, 8, 11, 34, 43, 57, 61, 63, 71, 82, 94, 99, 101, 103, 111, 124, 130, 145, 150, 151, 152. 21* 1?

WISCONSIN—4, 31, 33, 44 47, 61, 63, 75, 80, 82, 92, 93, 94, 95, 97, 100, 104, 105, 110, 111, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 142, 143, 144, 150, 151. 35*

WYOMING TERRITORY—57, 131, 145, 150. 4*

REMARKS. No positively accurate comparisons can be made from the incomplete data furnished by these partial tables, but so far as now known. New York, Michigan, Florida, Vermont and California, in the order named, have the greatest number of species of ferns within their respective limits.

In the first, second and fourth of these States, the number has, in all probability, reached, or very nearly reached, its maximum, while in the third and fifth it is likely to be largely increased, and those States from their favorable situations, climates, and comparatively extensive, unexplored territory, will, undoubtedly, lead all other States in the future. Arizona and Texas alone being at all likely to compete with them for the highest place.

If, however, we distribute our ferns according to the number of square miles of territory which each of the five first named States contains, then Vermont will lead the others, her ratio being as 1 fern to every $226\frac{2}{3}$ square miles, that for New York as 1 to 814, Michigan 1 to $1191\frac{1}{2}$, Florida, 1 to 1289, and California 1 to $4295\frac{1}{2}$ square miles of territory.

Taking the extremes of the territorial limits, excluding the District of Columbia, which has 1 species to each $2\frac{1}{2}$ miles of territory, Rhode Island gives us 1 species for each $38\frac{1}{4}$, and Delaware 1 to 75, as compared with Pennsylvania's 1 to $109\frac{1}{4}$, Colorado's 1 to 4200 and Texas 1 to $7878\frac{3}{5}$ square miles.

If we take an average of the fern-flora for the different geographical sections of the United States, on the basis of the present list, New England gives us an average of 40 species for each State, the Middle Atlantic States 40, the South Atlantic 27, the Gulf States 23, and the Central States 25, the Pacific States 23, and the Territories an average of 19.

The returns from most of the Territories are altogether too meagre at present to permit of any comparisons, and those already made will necessarily undergo considerable modification as the gaps in the lists for other States fill up.

But while no absolutely reliable comparisons can be made, nor the precise limits of each species be determined from the present incomplete tables, we may ascertain from them, with a tolerable degree of certainty, the range of certain species, and find material for some interesting observations.

Thus we find the cosmopolitan *Asplenium trichomanes* and *Pteris aquilina* in thirty-five and thirty-nine, out of the forty-eight States and Territories respectively, while their actual presence in a greater number may be safely assumed. *Polypodium vulgare* appears in thirty-three, with the same, or an even greater probability of its occurring in others in its favor, while its near congeners, *P. californicum*, and *P. falcatum*, as well as *P. scouleri* are restricted to two or three States. Of the remaining Polypodiums, all but *incanum*, which appears in twelve States are restricted to the single State of Florida, which furthermore monopolizes all the species we have in six genera, the tropical character of these being at once indicated by this fact.

The only other State (since the discovery of Scolopendrium in Tennessee has divided with New York the honor of that ferns presence) which may now claim a monopoly of a genus is New Jersey, the very local *Schizæa* being restricted to a portion of its limits and again restricted to a single species.

Adiantum pedatum occurs in thirty-five States or Territories, while its congener, *A. capillus-veneris*, is restricted to thirteen, and the tropical *A. tenerum* to a single State.

The Osmundas are represented by one or more species in twenty-nine, Onoclea in twenty eight States or Territories, and these probably occur in more, although not reported west of the Rocky mountains. *O. sensibilis* extends as far west as Dakota and Montana, and in the last mentioned Territory is said to have been discovered in a fossil state.

Cystopteris fragilis extends from Maine to California, through thirty-three States and Territories, apparently avoiding the South Atlantic and Gulf States, with the exception of North Carolina, while *C. bulbifera* occurs in twenty-five, covering a more unequal, but broader range south and west, the limits of which terminate in Louisiana and Dakota. *C. montana* so recently discovered in Colorado by Brandegee is reported elsewhere in the United States only from Alaska. The Aspidia are represented in forty-four, the Asplenia and Botrychia in forty-one States or Territories each, while the drought-resisting Gymnogrammes, Notholænas, Cheilanthes, and Pellæas are almost wholly restricted to the arid regions west of the Rocky mountains, a few scattering species only coming East, North or South.

It is interesting to note the changes which have taken place in the number and distribution of our ferns since Redfield published his valuable paper on the "Geographical Distribution of the Ferns of North America," in the Torrey Club Bulletin for January, 1875, and Watt, his admirable review of Mrs. Lyell's Hand-Book in the Canadian *Naturalist* for 1870. Mr. Redfield enumerated 125 species, which have been increased up to the present time to 153 or 156, according as we may consider the claims of certain ferns to specific rank, or their right to a place in our fern-flora, while the range of the older species has been more or less extended.

Taking the number in the list accompanying this paper for a basis, viz., 155, we have an increase of 30 species since 1875, and we may confidently expect a still greater increase as the vast regions of Arizona, New Mexico and Western Texas are more thoroughly explored.

Fournier enumerates 505 Mexican species, of which number only 55 are known to occur within our own limits; but how many of the remaining 450 are lurking in the cañons this side of the Mexican border, to reward the patient search of keen-eyed botanists, remains yet to be made known.

SUPPLEMENTARY.

The foregoing tables were prepared in March, 1882. Since that time several additions have been made to our Fern Flora, and many additional credits noted; these have so changed the status of the leading States as given in the text, and are so interesting for comparisons by which to mark progressive changes in the future, that it seems best to place them on record here in a separate note.

By the certain addition of 7, and the probable addition of 1 or 2 more to the entire fern flora of the United States, our list is increased from 155 to 162 or 164.

Numbers 94, 99 and 151 are to be credited to Alaska; 45, 131 and 124 to Idaho; 117 to Washington Territory; 124 to Utah, and 97 (*Var. calcareum*) to Iowa.

California by the addition of numbers 24, 99, 117 and 154, advances from the fifth to the second place, and, if a little Woodsia lately received from Lower California proves to be *obtusa*, as seems probable, and the doubtful credits were verified, would lead New York.

Florida by the addition of *Polypodium Swartzii* takes rank for the present with Michigan, although if we concede the presence of the doubtful credits Michigan will still lead by one species and take rank as third, a position, however, which she would be almost certain to yield up, perhaps before the close of another season.

Arizona by the addition of 81, 120, *Polypodium thyssanolepis, Pellæa marginata, Cheilanthes lendigera, Cheilanthes* ——— sp.? *Notholæna Aschenhorniana, Asplenium monanthemum, Asplenium Glenniei* and *Aspidium* ———sp.? pushes rapidly to the front, contests the honor of third position with Florida and Michigan, and threatens before long to become a close competitor for the leading place.

Glancing over the entire field of our Fern Flora at the present time, it is safe to assume from the nature of her territory, and the close proximity of an extensive and almost unexplored mountainous area to a portion of Mexican territory rich in ferns, that Arizona in time will lead all the other States in the wealth of her fern flora.

Obituary Notice of the Rev. Dr. Charles Porterfield Krauth. By F. A. Muhlenberg.

(*Read before the American Philosophical Society, March 16, 1883.*)

Both sacred and profane history is largely made up of biography. It is true, great events are also therein described, as intimately connected with the life of man ; but human beings themselves have ever been a more interesting study, than the changes produced by their agency. Man is the most luminous point, in the prose, or poetic narratives, found in the literature of all nations. His successes, his triumphs over obstacles, material and spiritual, as well his reverses, have been handed down, to successive generations, to imitate or avoid. Nations, civilized or uncivilized, have exalted through their bards, historians and orators, the fame of those, most eminent among them, in the varied departments of human enterprise or ambition, and have deposited these accounts in their archives, that the memory of their noble deeds might thus be perpetuated. The intuitions of the race have thus prompted them to pay a proper tribute to the divine and eternal in men. Thus the example of those most distinguished for their virtue, their learning, their benevolence, their skill, has always been a beacon light, to "allure to brighter worlds, and lead the way."

Such principles have, no doubt, influenced this venerable and honorable Society, to adopt the rule of having an Obituary Notice on the decease of one of its members. In accordance, therefore, with the wishes of this Society, and by the request and appointment of its honored President, we have prepared the following sketch of our lately deceased, much beloved, and illustrious member, Charles Porterfield Krauth.

The subject of our sketch was born in the town of Martinsburg, Va., March the 17th, 1823. His father was the Rev. Charles Philip Krauth, at that time pastor of the Lutheran Churches of Martinsburg and Shepherdstown, Va., and his mother's maiden name was Catherine Susan Heiskell, of Staunton, of the same State. Charles Philip Krauth was a native of Pennsylvania, having been born in Montgomery county, and was carefully educated in private in Greek, Latin and French by his father, who had emigrated to our State from Germany, in the capacity of teacher and organist, being a member of the German Reformed Church, whilst his wife was a Lutheran, and a native of this country. After the completion of his preparatory studies, under his father, having a preference for medicine, he pursued, for a time, his medical studies, as a pupil of Dr. Selden, of Norfolk, Va., and attended one course of lectures in the University of Maryland. From a conscientious change of views as to his duty, he abandoned medicine for the ministry, became, first, pastor of the churches in Virginia already mentioned ; then in 1827, of St. Matthew's Lutheran Church in this city, whence he was transferred, in the year 1833, to Gettysburg, Pa., to become "Professor of Biblical and Oriental Literature," in the Theological Seminary of the Lutheran Church, there located, and subsequently was elected President of Pennsylvania College, at the same place, in which useful and important positions, he labored with great fidelity and success, until his death in the year 1867, in the 71st year of his age.

The life, employments, and character of the elder Dr. Krauth, had so much to do with the usefulness and exalted fame of his son, Charles Porterfield Krauth, that the writer felt it to be necessary to give the above particulars with reference to him, and to append a few statements from some of those who knew him best, in regard to his extraordinary ability and excellence. In this way, we can obtain clear views of the genial and ennobling influences under which the younger Dr. Krauth was reared.

One of his most intimate friends, long associated with the father whilst he was President of Pennsylvania College, in an interesting sketch of his life, says of him: "A character so near perfection, a life so almost blameless is seldom found. He was one of the purest and best men that ever lived." Another friend, now Professor in Columbia College, gives us this estimate of him: "For me his character possessed attractions perfectly irresistible, and I loved him with an intensity that beggars description." A third gentleman, who spent a week with him at a comparatively early period of his life, remarks: "His conversation was so instructive, his counsels were so wise, his manners were so gentle, his spirits so buoyant that I learned more practical wisdom than in any other week of my life." It was the good fortune of the writer to know, and be intimately associated with this eminent man, for seventeen years; and it gives him pleasure to testify to the accuracy of his scholarship, soundness of judgment, keen perception, warmth of heart, eloquence of speech, nobility of nature, and eminence of Christian character. "He had," to use the terse language of a writer in Johnson's Encyclopædia, if I mistake not, his own son, recently deceased, "every quality which ensures a large distinction, except ambition."

Born of such parents, surrounded continually, from his earliest years, by such favorable influences for the improvement of his intellectual and moral powers, we have no difficulty in recognizing the cause, and in predicting, from such antecedents, the certainty of the future eminence of our lamented fellow-member. He had the same eminent endowments of his revered father, in an intensified form; the same keenness of perception, eloquence of speech, soundness of judgment, richness of imagination, and warmth of heart. Through his mother, he was, perhaps, also gifted with a vivacity greater than that enjoyed by his father. He thus united in himself the sober self-control of the Pennsylvanian, with the sprightliness and exuberant emotion of the Virginian. These native endowments were expanded also by early and constant companionship with his father, "who knew all literature," and his profoundly learned friends, "who knew all philosophy," and access to, and use of the valuable library he possessed. In society, as well as in the case of individuals, auspicious influences for growth, become cumulative, and a maximum good result is the product of their combination. Children often thus exceed in eminence illustrious parents, by the possession of accumulated endowments, and the faithful use of increased opportunities of culture.

The son continued under the more immediate care of his father during the remainder of his ministry at Martinsburg, his pastorate in Philadelphia, and the earlier years of his residence in Gettysburg. After the removal of his father to the latter place, he became a student in Pennsylvania College, and was graduated there in the year 1839, in a class of fourteen members, most of whom are now deceased,

As the bud conceals within itself the beauty of the future flower, so do the unfolding powers of the youth foreshadow the direction, and extent of the excellence of the fully developed man. From personal recollections, but chiefly from letters from some of his yet surviving classmates, and intimate friends, we can say something of the peculiar traits of character he exhibited when he was a student in college, or in his boyhood; for he was still a boy, at least in years, having become a college graduate, when he was but sixteen years of age.

The writer spent one session of a collegiate year at Gettysburg, fifty years since, with him whose earthly career has so recently terminated in such golden radiance. He cannot speak very confidently of him at that time, for in consequence of being older in years, and having removed to another institution, he was but seldom thrown into his society. Memory, however, still retains the image of his personal appearance, a frail, attenuated form, apparently destined to a brief period of existence. He is not able to speak, from his own personal knowledge, of his intellectual peculiarities, for the reasons already mentioned, and because, at that period, when he was about ten years of age, they had not yet been sufficiently displayed to form any satisfactory judgment. He can affirm this much of him, that he never thought at that time that he was destined to survive long, or to attain such extended and deserved fame in letters.

The writer's deficient knowledge is fully supplemented by letters which are before him, of his fellow-students and classmates, in which he is graphically presented to us, as he appeared to them. One of these, now a Doctor of Divinity in the Presbyterian Church, speaks of him, "as having inherited some of his father's easy-going disposition, but capable of great passions, and great efforts," "fond of fun," "an inveterate punster," "sarcastic," having "a ready and comical trick of exaggeration," a great lover and declaimer ot Shakespeare, and of large literary culture. Another classmate, the Rev. Dr. Charles Hay, of the Lutheran Theological Seminary at Gettysburg, in a letter to the writer, in which he says, "they were boys together, and bed-fellows for a year," speaks of his departed friend in the most kindly manner, and gives a very satisfactory account of his whole student life. The whole letter would be useful in print, but the limits to which we have to confine ourselves, will allow us only to quote so much of it as will be sufficient to give us a clear idea of his intellectual peculiarities at that period of his life. He remarks: "The cast of our brother's mind was metaphysical. He delighted in the English studies of the college course (with the exception of mathematics), and in these easily distanced his seniors, some of whom numbered twice his years. He was a voracious reader, devouring with avidity almost every thing that he could lay his hands upon. Thus absorbed, he became oblivious to the lapse of time, and was frequently, we may almost say, habitually negligent of the proper preparation for the regular recitations. * * * His mind worked with amazing celerity, and his fund of general information was remarkably extensive in one so young. * * * The drudgery of routine was always distasteful to him, and he had often, in the recitation room, to be aroused from a reverie, into which his poetic fancy had led him away, as into the dreamland, where he loved to linger. With a keen sense of the ludicrous, he seemed unable to resist the temptation to make sport of the unfortunate weaknesses and blunderings of the less active minds around him. The youngest in a large class * * * he found abundant opportunity for the display of his lively wit, which, with all its native kindliness and playful geniality, was sometimes the reverse of welcome to those at whom it was aimed." Those who had constant opportunities of seeing Dr. Krauth in his subsequent life, will recognize the coincidence of this accurate portraiture of his early life with the features of character he displayed, almost to his dying hour, the only difference being that they were placed more under the control of reason, and their rough edges had been removed "by his native kindliness," made more kindly, by continual advances in Christian principle and love.

His collegiate career was now closed, and it was necessary for him to decide upon a profession, in which he might more usefully employ his native and improved capacities. I do not think he was long in coming to a conclusion; for two years before his graduation, in connection with the dear friend already named, he had determined to devote himself entirely to the service of the Redeemer, and had been admitted, by the rite of Confirmation, to the communion of the Christian Church. On the occasion when these two interesting youths made up their minds to take this decided stand, Dr. Hay remarks that the elder Dr. Krauth, intensely interested for the welfare of his son, made a most fervent prayer in their behalf, and he gives his conception of it, by exclaiming: "Such a prayer!" And the same thing is alluded to by another, well acquainted with the facts, who remarks: "Many there are who will never forget that prayer. * * * A prominent lawyer in the State, and an elder in the Presbyterian Church, ascribes his usefulness to the influence of that prayer." The elder Dr. Krauth was inimitable for the fervency and pathos of his supplications on all occasions.

This first determined step of the son on the side of Christianity, in connection with the instructions, wishes and prayers of his venerated father, prepared the way for the second, the devotion of himself to the church in the ministry of the gospel. The loving father of our lamented friend experienced greater joy, without doubt, in this determination of his son to devote himself to the holy and responsible office of the ministry, than did Philip, of Macedon, when he counted himself happy, not so much on account of the birth of a son, as because he had an Aristotle to conduct his education. Acting in accordance with this purpose, the subject of our notice entered the Theological Seminary of the Lutheran Church, at Gettysburg, as student, and finished his theological course, in the Institution in which his own father was one of the professors, in the year 1841, and first was licensed in the same year to preach the gospel by the Synod of Maryland; and then ordained, by the same ecclesiastical body, to the holy office of the ministry, when he was but nineteen years of age.

The preparatory stages of his education are now over, and he enters into the arena of conflict. Nearly one-third of his life, as we now know, had been passed in the work of preparation; the remaining two-thirds were to be spent in more active efforts for the good of others; in the further development of his powers, and in extending his studies in new and more difficult fields of intellectual toil. As we intend to contemplate his successful efforts, during this latter period, as preacher, editor, theologian and philosopher, as well as his estimable qualities as a man, we regard it to be both useful and necessary, before proceeding with the consideration of the topics, to give a condensed summary of the facts with reference to the positions he occupied, whilst discharging these different offices.

His regular *pastorate* of Lutheran churches extended from 1842 to 1868; at Baltimore from 1842–47; Martinsburg, Shepherdstown and Winchester, successively from 1848–55; Pittsburg, 1855–59: St. Mark's, Philadelphia, 1859–64; St. Stephen's, in the same city, 1866–68, including ten months spent in the islands of St. Thomas and Santa Cruz, West Indies, and a short temporary service at St. John's Lutheran Church, Philadelphia, in the absence of the regular pastor. Though not a regular pastor after this period, he continued to preach, when requested, throughout his life. He was elected "Norton Professor of Systematic Theology and Ecclesiastical Polity," in the Lutheran Theological Seminary at Philadelphia, in the year 1864; "Professor of Intellectual and Moral Philosophy" in the University of Pennsylvania in 1868; Vice-Provost, in 1873; the subject of Logic was added to his chair in 1874, and that of History in 1881; and these positions he held with distinguished ability until his death.

Besides these positions as professor, he was editor of the "Lutheran and Missionary," from 1861–66; Trustee of the University of Pennsylvania from 1866–68; President of the General Council of the Lutheran Church 1870–80. He was likewise a Member of the Oriental, Philosophical and Historical Societies of this State; and also of the Committee for the Revision of the Scriptures. In each and all of these important positions, his profound learning and wisdom were eminently useful, and greatly appreciated by his distinguished associates.

A few particulars, of a more private nature, are here also added, to give this part of our sketch completeness. He was twice married; in 1843, to Miss Susan Reynolds of Baltimore; and in 1854, to Miss Mary Virginia

Baker, of Winchester, Va. The degree of D.D. was conferred upon him, by Pennsylvania College, in 1856 ; and that of LL.D., by the same Institution in 1874. He spent the summer vacation, in the year 1880, in Germany ; gathering information, and visiting places, for a Life of Luther, which he had been requested, by the Church to which he belonged, to prepare ; but which we deeply regret he did not live to complete ; the same period in the summer of 1881, he was visiting Canada, for the benefit of his health, during which time he wrote his, "Cosmos," the last one of 1882 he was at Mt. Desert Island, on the coast of Maine ; and his death occurred, January 2d, 1883.

It will be seen, from the preceding particulars of his life, that his labors were divided between two professions, often either permanently, or temporarily conjoined, in aim and usefulness closely allied with each other, that of the ministry and professor in institutions of learning and religion. Whilst our friend had qualities of mind and heart to make him useful, in either of these professions, he frequently informed me, that he much preferred the chair of the professor to the pulpit. Nor was this owing to the fact, that his pastoral labors and pulpit efforts had not met with the approval of the people, or had been wanting in success ; but because he believed, that the sphere of influence for good was wider in the former, than in the latter.

We know, from the best evidence, that both in the country, as well as in the city, in the congregations he served, he was highly honored for his ability in the pulpit ; and greatly esteemed and beloved for his personal character. With increase of years and experience, he gave increasing satisfaction, and acquired additional fame. A few, it is true, found fault with the peculiar tones of his voice, and peculiarities of attitude, in his early ministry ; and some, at a later period, with the labored character of many of his written discourses, but his greatness was generally recognized.

These slight defects of manner disappeared with increase of years, so that the tones of voice and mode of delivery became agreeable, and little open to censure. He preached both with, and without a manuscript. His written discourses displayed more fully his imaginative power, beauty of expression, and the depth and extent of his learning ; but his unwritten ones, the pathos and force of the eloquent orator. When he spoke without notes, his words were, like those of his excellent father, who always used this method of preaching, for the pleasure and edification of the people. It was then, that "the common people heard him gladly," whilst his written discourses were better adapted to a higher grade of hearers. The latter class of auditors were carried away with admiration for his learning and great ability ; whilst the former were instructed and deeply moved, by the glowing words which welled forth spontaneously from his loving heart. The writer recalls to mind four separate occasions, especially, when he had the pleasure of listening to his preaching. The earliest one was in the year 1864, during a rebellion of the students in Pennsylvania College, against the Faculty of the Institution, on account of dissatisfaction with the distribution of college honors. The theme selected by the speaker, on this occasion, was the conduct of Rehoboam, in listening to the advice of the young men, instead of being guided by the counsel of the more aged, whereby the kingdom of Israel was rent into two parts. The subject was handled with such excellent judgment, and great power, that its effects were very marked upon the minds of the intensely excited youth ; and contributed largely in bringing them again under the control of reason and Christian principle. Another very elaborate sermon, on the distinguishing peculiarities of the Lutheran Church, marked with all the profundity of thought, copiousness of illustration, vigor and beauty of expression, which are found in his written and printed sermons, the writer heard with great satisfaction, on two separate occasions ; when it was listened to and admired by the large audiences, before whom it was delivered, with enraptured attention. The last two, however, which were delivered without notes, and without much previous preparation, made the greatest impression upon the mind and heart of the writer; one, descriptive of the mission of the Saviour, based on the passage : "He went about doing good ;" the other, within quite a recent period, explanatory of the verse : "the whole creation groaneth and travaileth in pain together until now." This was a grand effort, and was upon a subject which seems to have been, at this period of his life, a favorite one with our departed friend, for it is alluded to in one of his last literary publications, the "Cosmos," in the two following stanzas :

> "Yet the world we may not love,
> Melts into a happier day,
> When at God's transforming word
> Sin and death shall pass away.
>
> Oh, for that transcendent change
> Which her bridal shall recall,
> And with robes of spotless white
> Cover o'er her crimson pall."

There are, lying before me, quite a number of his printed discourses, sermons and essays, in volumes appropriated to such literary productions, belonging to different periods of his pastoral life ; they all present the same general features of excellence, and defects. They are full of inventive and imaginative power, display great extent of reading and profundity of thought, but sometimes, owing to the neglect, perhaps, of mathematical study during his collegiate course, are deficient in perspicuity, by a too abundant accumulation of particulars, or variety of illustrations. This characterizes more especially his earlier writings ; after he turned his attention more fully to philosophical study, there is a marked improvement, in precision of statement, perspicuity and terseness of expression. Our limits will not allow us to quote any passages in proof of our assertion.

The *pastoral* life of our fellow-member prepared the way for his profound studies, as a theologian and theological professor. Circumstances might have so influenced him, as to have conducted him on to the further cultivation of the imaginative and poetic element of his nature, as it was manifested in his collegiate life, and in his first sermons ; but he was led by what we might call an accident, but which, no doubt, was the providence of God, to the more complete improvement of the rational faculty ; and then he was turned aside into the domain of logical and speculative theology. In the list of his published writings, during the period from his ordination to the ministry, to the time of his election to the theological professorship, numbering twenty-six, more than half of the entire number are profound papers on theology and psychology. In one of them, written in 1858, which contains an account of the bibliography of the Augsburg Confession, there are twenty pages of the "Evangelical Review," taken up with the list of titles of books on the subject, one hundred or more in number, all, or most of which, he had in his own library. He must have had at that time, the idea in his mind, for some reason or other not known to us, that he was to be distinguished as a theological professor ; and with a view to this, had already commenced collecting that valuable library, in this special department, which at his death amounted to 14,000 volumes, and had cost him $30,000. Many of these papers, on the, "Relation of the Confessions to the Reformation ;" the "Lord's Day ;" "The Mass ;" "Liturgies," &c., were modified, improved, and inserted with his latest views, in his greatest and best book : "The Conservative Reformation," which first appeared in the year 1871.

How this particular direction was given to his studies, we are taught by one of his friends, whom we have already quoted. He remarks, that he asked on one occasion, the elder Dr. Krauth, how his son, "the poet and preacher," was changed into "the theologian and controversialist," and he replied, that it was owing to the fact, that he had presented to his son "Charles," a copy of Chemnitz, who was a distinguished Lutheran theological champion, in the era of the Reformation, against the dogmas of the Roman Catholic Church, as laid down by the Council of Treat. This, so far as known to us, was the first stimulus given, for the intensified development of his native turn, for speculative truth. The same kind of studies was pursued, and the same kind of writing continued also during the five years, from 1861 to '66, whilst he was editor of the "Lutheran and Missionary." And though the poetic vein often re-appeared in him, in all the subsequent years of his life, and was exercised in the composition of fugitive pieces of poetry, either original or translations, the burden of his work was of a controversial character, on the subject of liturgies, divergencies of theological belief and kindred matter, during all this time. These discussions were conducted with amazing skill and learning, and with a wit and power of expression, sometimes tinged with severity, unequalled in the Church ; and which always silenced, if they did not convince, those who were opposed to him. His words, during the heated controversies, which prevailed in the Lutheran Church in America, in the five years of his editorship, were like the arrows, sent into the Grecian camp, by the "god of the silver bow." Hundreds of such polished shafts were sent, with convincing and controlling power, during each week of the period of his editorship of the "Lutheran and Missionary."

Brought thus to the front, by his studies, and his positions of influence, he was not long in realizing the dream of his early ministerial life, if we are right in our supposition, for in the year 1864, he was elected to the position of "Norton Professor of Systematic Theology and Ecclesiastical Polity," in the Theological Seminary of the Lutheran Church, in Philadelphia. He had now ample time and opportunity for exercising his skill in theological dialectics. Additional articles of the same kind were published, with those which had appeared at an earlier period; and the culmination of his work in this department took place, when he prepared and gave to the world, in a grand volume, his "Conservative Reformation," to which allusion has already been made.

This volume demands more than a passing notice, for it is the noblest monument of his vast theological learning and dialectical skill, immense acquaintance with the whole field of literature, and of his intense love for the faith and church of his forefathers. Besides this, it has other points of interest. One of these is stated by the distinguished author himself in the preface. In the Lutheran Church, both of the Fatherland and this country, there have always been two parties; one more liberal in the interpretation of the Confessions; the other more strict, allowing no deviation, in the smallest particulars, from the standards of belief. The Doctor, with great candor, acknowledges, as is known to most of the older ministers of our Church, that he once occupied a position entirely divergent from the views he defends, in this splendid volume. Thus he speaks: "No man can be more fixed in his prejudice against the views here defended, than the author himself once was; no man can be more decided in his opinion, that those views are false than the author is now decided, in his faith, that they are the truth. This decided change from laxity, to strict conformity with the old Lutheran faith, as it is sometimes called, was permanent with him, and he maintained it with unvarying consistency, until his departure from the Church Militant to the Church Triumphant. Again, the author shows that he has changed his views with sufficient reason, for all the prominent doctrines of the Lutheran Church, as presented in the Augsburg Confession, are discussed with great skill and independence of judgment, and in connection with this chief symbol, the subsequent ones are not overlooked. It is a complete defence of the whole system, with that independent survey of the field for himself, for which the author was noted, for he could truthfully quote, as applicable to himself, the sentiment of the Roman poet: "Nullius addictus jurare in verba magistri."

The subjects of Baptism, Original Sin and the Lord's Supper, receive the most extended and varied discussion, because the most difficult, and the most frequently assailed by others. It is not generally known, that the Lutheran Church has a mode of presenting these subjects, in her judgment in accordance with the Scriptures, which require careful and discriminating study to understand, as is sufficiently proved by the mistakes into which men of the highest ability in some of the other Christian denominations have fallen, in the attempt to state them as they understand them.

The mode of the Saviour's presence in the Supper; the doctrine of the "communicatio idiomatum;" the union of natures in the person of the Redeemer and consubstantiation, which the Lutheran Church is said to hold, but does not, have especially been the occasion of the grave mistakes made by the gentlemen to whom reference has above been made. They are known and believed by those only who have been brought up in the Lutheran Church, but they require profound acquaintance with the subject, and native and philosophical acumen, to defend them against objections, without falling into error. In this field, difficult though it be, our friend showed himself a complete master, and the careful study of these profound subjects is visible on every page. The volume contains several elaborate chapters, prepared years before, designed specially to correct the mistakes made on the above subject, by learned Doctors of Divinity in sister churches.

The chapter also, on the history of the "Formula of Concord," which was prepared at a later period than some of the others, is exceedingly well fitted to show the solid theological learning, superior penetration, and independence of judgment of our gifted and diligent associate. It amazes me whenever I read it, to see how he unravels the tangled history of the theological controversies which agitated Germany, during the latter part of the sixteenth century, and how he follows, with clearness of intellectual vision, the intricate thread of truth, with which he started, to its final issue in the adoption of this Symbol. It pleases me to find, that he does not condemn, where others bitterly condemn "the gentle Melanchthon;" who had, by his laudable, though sometimes mistaken desire for peace and aversion to controversy, given occasion to some of those acrimonious disputes. Yet, with all his high regard and esteem for this fine scholar and excellent man, he is not blind to his faults, but censures him when he thinks him deserving of it. It is easy to see that the writer is guided in his judgment by the love of truth, and not by prejudice, and Melanchthon fares better in his hands, than he does with many of his own countrymen and contemporaries. This was a fine field, for the exercise of that "speculative" mind, with which Providence had endowed the author of this volume, and which is displayed in it, with such happy results.

The independence of our able friend is shown also in an article, which he prepared during his ministerial life in the year 1857, on the Lord's Day, which does not appear in this volume, but which must be alluded to, because in it he expresses and defends views which do not harmonize with those of many of the German theologians, but which he defended, as in accordance with the teachings of Luther and the Confessions, and which he continued to hold, as he informed me near the end of his life. We are not able say why it was not published with the others, possibly he did not think it necessary to put it into this more permanent form. Some of the German theologians so explain disconnected statements of Luther, without taking them as a whole, that they dissipate altogether the divine obligation with reference to the observance of the Lord's Day. Not so our friend. We allow him to speak for himself. "If Germany has not enjoyed a Christian Sabbath, it is because she has refused to follow what the principles of Luther would have given her. The Sunday of Luther is an entire day, not a half-day ; not a morning for the church and an afternoon for the beer saloon or the dance, or the idle saunter ; but a day for holy works ; and holy thoughts ; a holy day, not a holiday. Neither the Augsburg Confession, nor the greatest theologians of the Church of the Augsburg Confession, denies the divine obligation ot the Christian Sabbath. * * * Divine in its generic origin and obligation, and apostolic in its specific determination."

There is one delightful chapter of the book which has but little of a controversial character in it; it is a solemn requiem of praise in honor of Luther, from almost every land of Christendom. The instrument selected by God, for the great work of the Reformation, is the hero, who has caused their strings to vibrate, in such perfect unison. No where else can there be found such a collection of literary gems, bearing upon this one point. The writer's soul was aglow with admiration and love for Luther, when he wrote this admirable chapter, and after the full array of testimonies of the most illustrious characters in his behalf, he closes the subject with these striking words : "Luther abides as a power for all time. His image casts itself upon the current of ages, as the mountain mirrors itself in the river at its foot—the mighty fixing itself upon the changing."

We may safely say, in passing from this volume, to the consideration of his last publications on another subject and in a different sphere of his useful and honorable toil, that no one can read it without reaching the profound conviction that the author of it will bear favorable comparison with the ablest theologians of this or any other land. Little else can be said of it, except to express admiration of its merits ; if we may be allowed to say anything of a contrary nature, we would merely respeat a remark already made, with reference to some of his earlier writings, that his logic occasionally is wanting in perspicuity, from an excessive accumulation of particulars, and now and then he exceeds the bounds of truth by indulging that vein of his complex nature, alluded to by one of classmates, "a ready and comical trick of exaggeration." A single illustration will sufficiently explain our meaning. Thus he speaks of sects : "The insect-minded sectarian allows the Reformation very little merit, except as it prepared the way for the putting forth, in due time, of the particular twig of Protestantism, on which he crawls, and which he imagines bears all the fruit, and gives all the value to the tree. * * * The Reformation, as they take it, originated in the divine plan for furnishing a nursery for sectarian Aphides."

His native fondness for speculative truth, together with his studies in connection with theology, which, from the standpoint he accepted, almost necessarily involved the study of philosophy, prepared the way for his last position, Professor of Intellectual and Moral Philosophy in the University of Pennsylvania, to which he was elected in the year 1868; the subject of Logic having been added to it in 1874. In some of the articles of the "Conservative Reformation," he shows his large acquaintance with the foremost philosophers of the English and Scotch schools, such as Mill, Hamilton and others; and his fondness for studies of this kind, led him to publish an edition of Fleming's Vocabulary of Philosophy, eight years before he was elected to the post of professor. If we mistake not, the attention of some of the Board of Trustees was first directed to him, on account of his prominence among the Lutheran pastors in Philadelphia, and thus he was elected trustee in 1866, to represent the Lutheran Church, and the ability there displayed, and the acquaintance made with its members, and especially with Dr. Stillé, the Provost of the Institution, to whom it owes so much, his warm personal friend, shortly afterwards elevated him to the responsible position he occupied in it, which, with other additional duties and offices, he continued to discharge and to hold until his death.

The department of Philosophy was the chief one, in which such volumes as Hamilton's Metaphysics, Berkeley's Philosophy, Whewell's Morality, Butler's Analogy, constituted the text books, which made the basis of his instruction, and through which he exerted a wide and lasting influence on his pupils. For the use of his department he edited Berkeley, and enriched it with notes of great value, from all the different schools of philosophy among Christian nations, which appeared in 1874; and at the same time republished in the same way, with a very learned introduction, Ulrici's Strauss. Through these publications, and his lectures to his classes, from year to year, his reputation as a philosopher became as great in our land as in the department of theology. He was frequently appealed to as the highest authority in questions of a philosophical nature, and it was easy to anticipate from the instructions of his able and excellent father, and his own subsequent studies in theology, what position he would take in this vast and intricate field of speculation. These two things dominated his views. Philosophy had been settled in his theological studies, for we find the principles of Butler, Berkeley and Hamilton, presenting salient points in these earlier investigations. He was, as we might have expected, from such antecedents, an "Idealistic Realist," to quote the words of one of his favorite pupils, who understood well his views, and a philosopher of decided Christian character. It was his great aim to infuse these principles into the minds of the students of the University whom he instructed in successive classes for almost fifteen years, and upon whom he left the indelible marks of his power and varied learning. He has left behind him no regular system, and this is a matter to be regretted, except so far as it can be gathered from his annotated works, and the notes and recollections of his pupils. These, with his favorite authors, in this department, will always show us the genuine Christian philosopher. Butler's Analogy was one of his favorite books, we see its principles brought out in his discussion of Original sin; in his Introduction to Strauss and in his last poetic effusions, and we are gratified to quote his own words on this subject, to this effect: "that he regarded this as a monument to the truth of the Christian religion, which shall endure to the end of time."

The edition of Ulrici's Strauss, which he superintended, translated and furnished with an introduction, is a work of immense practical value. It is small in form, but on this account, not less, but more valuable. Ponderous volumes, like heavy artillery, are hard to manage, and have but few readers, but the smaller ones, which you can take with you to the fireside, are popular and effective with the largest number, like the small arms in the close and well-contested battle. The reader of the introduction contemplates with wonder the immense, almost boundless extent of the author's reading in physiology and philosophy. As he was regarded and called in early life a "voracious" reader in literature and the department of the imagination, so his appetite in later life was equally insatiate in physiology and philosophy. He seems to have sounded with his plummet the subject in its profoundest depths, and widest extent, and after all his studies he remains the Christian philosopher still. It is gratifying to find a gentleman of such breadth of culture, defeating, on their own soil, and with their own weapons, the enemies of truth, of God and of man. He is, in his own peculiar style, severe on materialism, and still more severe on Strauss, the great advocate of infidelity and atheism. Speaking of the union of the supernatural, everywhere with the natural, in Butler's line of thought, but his own words, he says: "Science moves ever toward the proof, how supernatural is the natural; religion moves toward the proof, how natural is the supernatural. For nature, in the narrow sense, is in her spring, supernatural." To expose such a system as materialism "would involve the compression of a world to the dimensions of a pea." "Without the metaphysical spirit, the geologist possesses the penetration of an artesian auger, no more." "The intellectual beats the material in all long races." The "new faith" of Strauss is characterized "as conscious matter, reverencing and worshiping unconscious matter," "as reason bowed at the altar of unreason, which had given it being;" as "without God, without Providence, without spirit, freedom or accountability;" "recognizing no creation or redemption or sanctification;" "no heaven, no hell, * * * whose last enemy is not death, but immortality, its goal, extinction." These and a long list of other features, severely yet truthfully present, in the language of the author, the repulsive deformity of this proposed "new faith."

The volumes, on which the Doctor's fame will chiefly rest, are the three which have been mentioned. "The Conservative Reformation;" "Ulrici's Strauss" "Berkeley, with Notes," and the translation of "Tholuck's Gospel of St. John." Through these, with the many and varied essays, articles for encyclopædias, editorials, lectures at the Seminary and University, sermons published or heard, and the large number of young men whom he helped to educate for the ministry, the other learned professions, and practical life, will cause his influence to be felt, for good, through all future time. Throughout the forty years of his very active and laborious life—had he lived, forty years this day—in imitation of the Great Teacher, "he served his generation faithfully, according to the will of God," and he will be held in everlasting remembrance, as one of the great benefactors of the race.

Our subject would be incomplete, did we not speak of his excellent qualities as a Christian man. Scholarly acquisitions are often tarnished, by moral, or personal defects, or obliquities. It was not so with our friend. The grand elements of his character were harmoniously united, with a natural simplicity, and an affluence of kindly feeling. He was very condescending towards inferiors, and extremely fond of children, whom he could most successfully entertain and instruct. In his addresses to them he laid aside all that was repulsive, became one of them, disarmed all their fears, and attracted them to himself. Nor was this attractive power limited to them; it was general. The extent of it was realized fully since his lamented death. Friend and foe, the aged and the young, those of the same belief with himself, as well as those who occupied positions in theology directly opposite to his own; officers of the churches he served, and gentlemen associated with himself in public bodies, have, with great unanimity, testified both to his general excellence, as well as the warmth of heart, by which he drew them to himself. One, eminent in position, but often opposed to him in debate, speaks of him as "cordial, genial, magnetic and brilliant, often winning his way to hearts that were closed to others, and forming personal attachments which no changes of time or circumstances could break." Such a man could not fail to be respected and beloved.

But the bowstring, after long use, when subjected to extraordinary tension, will snap asunder. So it was with our departed friend. There is a limit to human exertion, and our bodies and minds will not endure indefinite pressure. The superabundant labors, apparent in what we have said, but more fully known to his associates, together with the anxieties, sorrows, disappointments—greater, because kept to himself—which his friends knew but did not venture to allude to, out of regard for his feelings, by degrees brought his manly form to an early grave. We will not draw aside the veil which conceals these special troubles from the public gaze, to which he never himself made any allusion, except to say, "the heart knoweth its own bitterness." They are too sacred for publication, but they exerted no little influence in gradually undermining his vigorous health. The first intimation of any serious illness was communicated to the writer by a friend of the Doctor, who visited Germany with him, and was his almost constant companion for three months. The next communication was made by his family physician, who remarked at that time, that the only relief for the Doctor would be total cessation from work, but that mode of relief his multiplied engagements, and his conscientiousness did not allow him to adopt. He acted, as far as possible, in accordance with the advice of the physician, and spent the two succeeding long vacations of the years 1881 and 1882 in Canada, returned with his health recruited, but when his double duties in the two Institutions in which he was engaged, were resumed, he again lost ground, and it was apparent that the disease was preying on the vitals of his system. On his return from the last trip, in answer to a question of one of his friends as to his health, he replied with sadness, as though looking forward to an unfavorable result, "better, but not well." The truth of this became painfully manifest when he resumed his duties in the University. He was very far from being well. His associates soon observed that his vivacity and vitality, and his powers of endurance were rapidly decreasing. Especially marked was this decline in the daily chapel services. Each succeeding day, through increasing weakness, he brought his chair nearer to the reading desk, until the day before he was ordered by his physicians to relinquish all his duties, they were placed alongside of each other, and it was with difficulty he could stand up to perform the devotions. With such Christian fortitude did he continue to discharge his duties during the progress of the disease to its final issue. His principles would not allow him to forsake his post, until his powers were exhausted.

The writer now believes. the Doctor was fully conscious of his approaching dissolution, for he could not take sufficient nourishment to support life, and, besides this, the tenderness and deep pathos of his prayers, whenever allusion was made to death, disclosed the thoughts and feelings within. The writer conversed with him, for the last time, the day before he completed his official duties. He bade farewell to him, as he thought, for a few days, in front of the University, at the close of the recitations for the day; it was with difficulty that he moved his exhausted body, yet the writer will never forget the almost angelic tenderness and sweetness of his language and his looks.

Two days after this he was ordered by his physicians to take his bed, and, contrary to the expectations of all, he declined more rapidly than before, and two weeks subsequently, when the new year 1883 had but commenced, January 2d, amid his sorrowing friends, without much suffering, his noble spirit, sustained by the faith and hopes of the Gospel, was conveyed to the bosom of his Saviour, whom he had loved and served so well.

The removal of such a man must be deeply mourned, for his place cannot readily be filled; but we may comfort ourselves with the thought, to which the Provost of the University gave utterance in the chapel, two days after his death, that as he was suffering from an incurable disease, he could do no more on earth, his work was done, and well done, he had secured the victor's crown. We recall to mind, at this point, the distinguished Grecian philosopher, Socrates, surrounded by his weeping friends and pupils, whom he was reproving for their sorrow, and endeavoring to console with his own joyful hopes for the future world as he was bidding them farewell; and we can thus think of our Christian philosopher addressing us, from the glory he has attained, in words used by himself, many years ago, in some reflections on the Transfiguration: "Why do we think of the parting pressure of the hand, the last words of love, the dying moan, and not of the crown, the communion with Christ, their eternal repose, and our re-union with them? Why, with desolate hearts, will we continue to stretch our hands to the home of their rest and cry, come, come to our arms? Blessed be God, that he will not hear our prayers. Blessed are the departed, that we cannot recall them from their joy, or wound their hearts by the knowledge that we are willing to disturb their bliss. No, it is not good to be here; we know not what we say."

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*Fourth Contribution to the History of the Permian Formation of Texas. By E. D. Cope.**

(*Read before the American Philosophical Society, March 16, 1883.*)

PISCES.

ECTOSTEORHACHIS CICERONIUS, sp. nov.

The genus *Ectosteorhachis* Cope, is known up to the present time from ichthyolites, which do not exhibit the interior details of the structure of the skull. Several portions of crania having recently come into my hands, I am able to add some important features, and a new species, which I name as above.

The base of the skull consists of ossified parachordals, which embrace the chorda dorsalis posteriorly and are continued for a short distance posteriorly as a tube. Anteriorly the chordal groove is open. Trabeculæ not ossified. The cranial structure is an excellent illustration of a permanent embryonic type. Above and in front of the opening for the chorda, the neural canal enters the groove. The parachordals are subtriangular, presenting one angle forwards, and having the internal side that bounds the groove straight and longitudinally grooved. The anteroexternal side is oblique and nearly straight, and is overhung by the osseous roof of the skull. These characters are identical in both species.

The *E. ciceronius* differs from the *E. nitidus* in having a narrower interorbital region, and in the possession of small tubercles of ganoïne on the posterior parts of the superior surface of the skull. These are seen on the sides of the surface, and are quite small, not numerous, and

*The third contribution can be found at page 447 Proceedings of the Society for 1882.

of various sizes and shapes. They resemble shining seeds. In *E. nitidus* these points are wanting, but there are rugosities on the postfrontal and pterotic regions of a radiating character, not found in *E. ciceronius.*

Measurements.	M.
No. 1.	
Length of skull to occiput above (muzzle worn)	.069
Interorbital width	.014
No. 2.	
Length of osseous base of cranium (parachordal)	.039
" open median groove	.022
Width of base at parachordals	.036
" groove at apices of parachordals	.011
" foramen notochordæ	.0095

Found by Mr. W. F. Cummins.

GNATHORHIZA SERRATA, gen. et sp. nov.

This presumed fish is represented by some teeth which are processes of osseous bodies, which may be roots properly so called, or may be jaws. The osseous bases are shallow, and thickened on the free edge, which is directed obliquely away from the plane of the crown of the teeth. The teeth obtained are flat, and doubtless bilaterally symmetrical, though no complete pairs are preserved. The largest of these has a curved edge, and a branch extending posteriorly at right angles to it, joining it at a point at one side of its middle. The longer (and more curved) part of the convex edge, has two coarse angles; the shorter part is finely denticulated, as is the transverse lamina. The principal edge is worn posteriorly by use. The external convex face is marked by coarse and finer lines of growth, like those on corneous processes. A second form of tooth is not curved, but flat, so far as preserved. It has three coarse obtuse teeth. Two other toothed bodies resemble it. All the teeth are covered with brilliant ganoïne on both sides.

Measurements.	M.
Length of chord of larger tooth	.010
" cross lamina	.0055
Elevation of principal edge	.006
" with root	.008
Thickness of root at base	.002

The genus *Gnathorhiza* may belong to the Petalodont family, though I think it very doubtful. The characters of the roots of the teeth are more like those of sharks.

BATRACHIA.

TRIMERORHACHIS BILOBATUS, sp. nov.

Among the many specimens of animals of this genus which have passed through my hands, I have not until now been able to select more than one species, the *T. insignis*. Mr. Cummins, however, now sends me parts of skeletons of four individuals, which present distinctive characters. Two of these include vertebral elements, and all embrace jaws and bones of the limbs and arches.

The vertebræ present no important difference from those of *T. insignis*, but the surface of the intercentrum is not yet cleaned of a thin layer of matrix. The peculiar character of this species is most readily seen in the posterior portions of the mandibular ramus. The angle consists of two subequal tuberosities which are separated by a deep groove, instead of one prominent one. The external tuberosity is represented in the *T. insignis* by a small protuberance of the lateral enlargement of the external face of the ramus. The extremity of this tuberosity is in the *T. bilobatus* strongly honeycombed, and it is bounded below and externally by a groove which is faintly indicated in *T. insignis*. Above it, on the inner side, is another, shallow groove, from which it is separated by a sharp ridge. Both grooves are smooth. The superior one is wanting in *T. insignis*. The quadrate cotylus is more depressed externally than in *T. insignis*, thus making it more oblique. The internal fossa of the cotylus is not divided by a longitudinal groove, as it is in *T. insignis* The dental foramen is large, and is located as in the *T. insignis*. There is also an inferior longitudinal groove of the ramus as in that species. The surfaces preserved show that the sculpture is more marked in the *T. bilobatus* than in the *T. insignis*.

Measurements.		M.
Depth of ramus at interior edge cotylus		.026
Length " from " " "		.020
Width " at " " "		.017
" of both tuberosities of angle		.0125
Diameters of intercentrum	anteroposterior	.011
	transverse	.021
Thickness of intercentrum		.004

The specimens described came from the same locality, and a different one from that which has produced the specimens of the *T. insignis* (Type No. 39, 1882).

REPTILIA.

PARIOTICHUS MEGALOPS, sp. nov.

This reptile is known to me from a nearly complete, somewhat distorted cranium. A thin layer of matrix conceals the greater number of the teeth, so that the presence of canines cannot be demonstrated. Those which are visible are on the premaxillary and anterior parts of the maxillary bones. They are small, conic, slightly curved, acute and absolutely smooth.

The muzzle is short and broadly rounded. The nareal opening is laterosuperior, and is just above the principal convexity where the lores pass into the muzzle. Canthus nostralis rounded off. Interorbital region wide, convex in section, nearly plane anteroposteriorly, its width a little exceeding the diameter of the orbit. Orbit large and round, its diameter equal to the length of the muzzle in front of it, obliquely measured, and one-half the distance from its posterior edge to that of the temporal roof (? squamosal bone). Posterior outline of skull above, truncate, surface slightly convex transversely.

The premaxillary spines are short and wide, the nasals are also short and wide. The prefrontals and postfrontals form the superior edge of the orbit, excluding the frontals. The intercalaria (or ? pterotics) are very large; at the externoposterior angle is a very small element in contact with the supraoccipital which may be the true intercalare. The supraoccipitals have considerable transverse extent, running out externally in narrow apices. All the bones of the cranium are sculptured in honeycomb fashion, the ridges radiating on some of the bones. That is, on the posterior parts of the frontals and parietals and anterior part of the intercalare and squamosal. A groove follows the edge of the orbit, and turns inwards on the prefrontal bone, forming a rudimental lyra. External surface of mandible grooved below; superior part concealed.

Measurements.	M.
Width of skull between posterior angles	.018
Interorbital width	.008
Axial length of skull	.024
" from muzzle to between centres of orbits	.0096
Width of muzzle at nares	.0095
Length from orbit to nostril	.0035
Depth of skull posteriorly, to mandible	.010

The superior part of the posterior region of the inner face of the dentary bone supports a patch of small obtuse teeth, which narrows forwards into the single row of the edge of the ramus. This patch is no doubt homologous with that which is so largely developed in *Pantylus*.

The surface of the cranium has been mostly weathered away in the type of *Pariotichus, P. brachyops*, and I suspect that it is really sculptured and not smooth, as I originally stated. The *P. megalops* differs from the *P. brachyops* in the larger orbit, the narrower interorbital space, and the smaller and more numerous teeth.

Pariotichus and *Pantylus* and probably *Ectocynodon* must be referred to a special family, the *Pariotichidæ*, which has teeth like the *Edaphosauridæ** but differs from it in the entire overroofing of the temporal fossæ.

CHILONYX RAPIDENS Cope, gen. nov.

Char. Gen.—Teeth with the long diameter of the crowns transverse to that of the jaws, and with the crown contracting to a single slightly incurved apex. Maxillary series of teeth short. Temporal fossæ overroofed. Superior surface of cranium divided into more or less swollen area by grooves.

The characters above enumerated indicate for this genus a position near the *Diadectidæ*. From these it differs in the form of the teeth, and the

* Proceed. Amer. Philos. Soc., 1882, p. 450.

short and narrow maxillary bone. Two ilia accompanying the cranium have the form of those of the *Clepsydropidæ*, and differ entirely from those of the *Diadectidæ*. On the other hand, the *foramen magnum* is wide, and the exoccipitals present two articular facets downwards as in the latter family. It is possible that the genus should be referred to the *Bolosauridæ*, which is in dentition intermediate between the *Clepsydropidæ* and *Diadectidæ*.

A femur, which is included in the lot of specimens, has a wide head without trochanters, convex in the plane of the distal condyles and flat in the direction at right angles to it. There is a huge trochanteric fossa extending from the head two-fifths the length to the condyles, bordered by a ridge on each side. The condyles present in the same direction as the fossa posteriorly. They are separated by a deep anterior and posterior emargination. Their anterior edges overhang the condylar articular surfaces, making acute angles with them. One of the articular surfaces is smaller, is anteroposteriorly extended, and has a convex ectad, and concave entad border. The other surface is also anteroposterior, reaching further distad, but not so far proximad as the other. Its area is greater than that of the other, and it is deeply notched by the entering surface of the bone ectad and proximad. It is then contracted into a wide isthmus, and the lateral grooves which produce this isthmus are overhung by the expansion of the anterior face. The anterior face of the femur is without ridges or processes.

The condition of the specimen is such that the composition of the skull may be readily made out. The postfrontal bones are large, and form the superior border of the orbit. At the front of the orbit they reach the prefontal, thus excluding the frontal. The parietal bones are wider than the frontals, and are bounded laterally by the postfrontals and the squamosals and by an element between the squamosal and exoccipital, which occupies the position of the *intercalare* of the *Stegocephali*. Below this bone, on the inner side of the suspensorium, is the probable proötic. The squamosal, or an element which I cannot distinguish from that bone, extends to the condyle of the quadrate, concealing that bone from view from externally. The quadrate is short, and thins out rapidly upwards, being closely united with the squamosal. Its condyle is set at an angle of 45° with the axes of the skull, and consists of one flat and one convex surfaces, continuous but forming a deep angle together. Exterior to the exoccipital, and interno-inferior to the intercalare, is a small distinct element, apparently in the position of an opisthotic or external occipital.

The excavation for the auditory apparatus appears to be in the exoccipital. It is almost entirely filled by what I suppose to be a large stapes. This bone is in shape like a compressed flask, with the head directed inwards and forwards, and its inferior edge produced into a prominent keel, which is produced into a point below, and free from the neck of the flask. The head is truncate, and is separated from the internal cranial wall by a narrow interspace. Its external extremity is not absolutely perfect in the specimen, but does not appear to have extended in an ossified condition beyond the exoccipital bone. In a specimen of *Empedias molaris** there is a meatus auditorius, in which the stapes was not found on cleaning out. This element is coösified with the surrounding bones laterally and posteriorly. Consequently when broken open, the vestibule is represented by two deep grooves, directed inwards and anteriorly.

The single species of this genus is one of the largest saurians yet obtained from the Permian of North America.

Char. specif. The superior surface of the skull is everywhere flat, as is the external face of the maxillary. The surface of the latter is marked by moderately coarse fossæ and grooves, separated by more or less fine irregular but generally longitudinal ridges. The minute sculpture of the superior cranial surface, is finer and more punctate in character. The areæ of this surface, already mentioned, are arranged as follows : There is a series over the orbits, which are separated from each other by straight grooves, and which grow larger and more swollen posteriorly. Between these supraorbital rows, the areæ of the top of the skull are separated by longitudinal grooves, except immediately between the widths of the orbits, where there are some narrow transverse areæ. On the supraoccipital region there is a median subtriangular area, and three narrow longitudinal ones on each side of it. External to these, and on the posterior part of the squamosal region, the areæ are larger and more swollen. A cluster of three of these lies between the exoccipital bone, and the smooth descending surface of the posterior edge of the squamosal. Of these the one bounding the exoccipital bone, is a robust cone, forming a short horn, like that occupying a similar place in the horned toad, *Phrynosoma douglassi.* Between the temporal areæ, and in front of the supraoccipital areæ, on each side of the middle line, there are three longitudinal areæ, which are successively narrower externally, the exterior being very narrow. On the frontal region anterior to the transverse areæ, are two wide longitudinal areæ. Each nasal bone has a small median area, from which radiate grooves, of which some of the posterior are close together.

The occiput is excavated into a large fossa on each side of a large triangular supraoccipital region. The fossæ are bounded externally by a strong exoccipital crest and at the anteroinferior corner by the "opisthotic." This bone projects posteriorly and downwards, in the form of a robust hook. The foramen magnum is not excavated so abruptly above the exoccipital facets as in *Empedias molaris.*

Measurements of Skull and Femur.	M.
Interorbital width	.108
Length from supraoccipital crest to frontonasal suture	.135
Width between apices of tuberosities of the intercalaria.	.113
Length from apex of tuberosities to inferior extremity of quadrate	.129

* Figured in the Proceed. Amer. Philos. Soc. xix. p. 56.

Measurements of Skull and Femur.

		M.
Diameters of quadrate condyle	anteroposterior	.020
	transverse	.039
Length of maxillary on alveolar edge		.087
Diameters base of a posterior tooth	anteroposterior	.007
	transverse	.010
" of base of another posterior tooth	anteroposterior	.005
	transverse	.010
Length of femur		.236
Proximal diameters of femur	anteroposterior	.047
	transverse	.085
Width of shaft		.052
" distally (greatest)		.115

Empedias fissus, sp. nov.

The species of *Empedias* form a series which diverges from *Diadectes* in a successive widening of the crowns of the teeth and diminution in their number. Thus the *D. phaseolinus* is nearest to *Diadectes ; D. molaris* succeeds it, and in *E. fissus* we have the molariform character most strongly developed. In the *E. latibuccatus,* on the other hand, the diminution of the transverse extent of many of the teeth and the areolar sculpture of the superior surface of the cranium points in the direction of the genus *Chilonyx.* The species of *Empedias* may be easily distinguished as follows :

I. Surface of skull divided by grooves into areæ.

Superior teeth, 16 on each side, a number on each end of the maxillary bone of little transverse extent........................*E. latibuccatus.*

II. Surface of skull uniformly rugose.

Superior teeth narrower, 16 on each side, the last one small, sphenoid flat, pterygoids narrow................................*E. phaseolinus.*

Superior teeth wider, 14 on each side, the last one smaller, sphenoid keeled medially, pterygoids wide................................*E. molaris.*

Superior teeth wider, 14 on each side, the last the largest, sphenoid not keeled... .....*E. fissus.*

Of the *E. latibuccatus* I have two specimens with teeth, one including a large part of the cranium and lower jaw. Of the *E. phaseolinus* I have five specimens with teeth, one of which embraces a nearly complete skull and a large part of the skeleton. Of the *E. molaris* I have also five individuals, of which three are crania. The *E. fissus* is represented by two individuals. One of these is one side of the entire upper jaw ; the other is a broken skull with the four series of molar teeth. Of other parts of the skeleton, not identified as to species, I have a large number.

The *Empedias fissus* is nearest the *E. molaris,* and has the same number of teeth. It differs, however, in various essential points. The last maxillary tooth, which is much reduced in size in the *E. molaris,* is here as large as any of the others. The portion of the crown within the medium cusp is fissured medially in the direction of its length ; that is, transversely to the axis of the jaws. This fissure is not so distinct in the mandibular teeth. The median cusp has a straight edge at right angles to the long axis of the crown. The specimen where the entire dental series of one side is preserved, shows that the latter has a sigmoid flexure, the middle of the maxillary bone being incurved, and the anterior part convex outwards. There are five or six conic teeth between the incisors and the molars.

The inferior surface of the sphenoid bone is medially flat in transverse section, and concave anteroposteriorly, in this resembling *E. phaseolinus* rather than *E. molaris.* The upper jaw specimen shows that the muzzle projects beyond the incisor teeth, which is not the case in *E. phaseolinus,* which has the incisors very prominent. The supraorbital border is regularly convex, and not depressed and notched as in *E. phaseolinus* and *E. latibuccatus.* The superior surface of the skull is marked with innumerable small impressed pits, and assumes a spongy appearance above the orbits.

Measurements.

		M.
No. 1.		
Length of last six superior molars		.055
Diameters of antepenult molar	anteroposterior	.010
	transverse	.020
Diameters of crown of incisor	vertical	.013
	transverse (at base)	.007
	anteroposterior	.011
No. 2.		
Length of dental series in a straight line		.093
Width of palate at anterior expanse		.062
" " contraction		.068
" " between widest molars		.036

Discovered by Mr. W. F. Cummins.

Empedias phaseolinus Cope, Proceeds. American Philosoph. Society, May, 1880 (*Diadectes*).

The fine specimen of this species above mentioned, which was obtained by Mr. Cummins, includes some parts of the skeleton not or rarely found hitherto. The pelvis shows that the corresponding part described by me, Proceedings of the American Philosophical Society, 1882, p. 448, belongs to another species of this group. The clavicles are preserved, and enable me to identify the corresponding part of another species in which the structure is more distinctly visible. This shows an episternum wedged in between the adjacent extremities of the clavicles, which are here very robust. But a small part of it appears in the inferior surface, but superiorly it forms a plate which covers the symphysis of the clavicles, but does not extend posterior to them. The suture of the episternum with the clavicles below is a coarse interdigitation. Posterior to it is the symphysis of the clavicles.

The skull of this specimen is the first that I have seen in this group which possesses a basioccipital bone and condyle. This proves that in the five other crania of allied species, it has fallen out, which indicates its very weak attachment to the sphenoid. The lateral superior articular facets of the exoccipital bone are characteristic of the family, and of the genus *Chilonyx*. This skull also shows that the premaxillary bones may be distinct, and that they extend but a short distance on the superior face of the muzzle.

In this species the interorbital region is wide and concave, and the parietal regions are swollen and convex. The supraorbital border is nearly straight, and has an open notch medially.

The hyposphen varies in size in different parts of the vertebral column, and is generally very large. The neural spines have bilobate extremities.

Stated Meeting, Jan. 5, 1883.

Present, 8 members.

President, Mr. FRALEY, in the Chair.

The resignations of A. E. Outerbridge, Jr., dated May 15, 1882; of B. B. Comegys, dated Nov. 1 1882; of Alfred Stillé, dated Dec. 28, 1883; and of Horatio C. Wood, dated Jan. 3, 1883, were announced by the Treasurer, and on motion accepted.

The death of John Forsyth Meigs, M.D., at Philadelphia, Dec. 17, 1882, aged 65, was announced.

The death of the Rev'd Charles P. Krauth, D.D., Vice-Provost of the University, at Philadelphia, Jan. 2, 1883, aged 59, was announced. The President was authorized to provide for obituary notices of the deceased.

Donations for the Library were reported from the Geographical Societies at Munich, Bordeaux and Paris; the Meteorological and Astronomical Societies in London; the Society at Riga; the American Society at Paris; the Peabody Fund and the Museum of Comparative Zoölogy at Cambridge; the Boston Zoological and Natural History Societies; American Journal of Science; American Academy of Medicine; N. Y. Academy of Science; Franklin Institute;

Academy of Natural Sciences; Second Geological Survey of Pennsylvania; Union League; Library Co.; Mrs. Tyndale; U. S. Bureaus of Ethnology and Education; Washington Philosophical Society; U. S. Coast Survey; U. S. Naval Institute; Royal Asiatic Society of Shanghai; M. Leon Fernandez and the Revista Euskara.

Prof. Cope communicated a paper entitled: "First addition to the Fauna of the Puerco Eocene."

Pending nominations Nos. 969 to 980 were read.

Annual appropriations for 1883 were passed.

The request of Dr. Frazer to withdraw his Summary of the Geology of Egypt was granted.

The result of the *Annual Election* was reported:—

President.

Frederick Fraley.

Vice-Presidents.

Eli K. Price, E. O. Kendall, J. L. LeConte.

Secretaries.

P. E. Chase, G. F. Barker, D. G. Brinton, J. P. Lesley.

Counsellors for three years.

R. E. Rogers, O. Seidensticker, R. Wood, P. H. Law.

Counsellor for two years (in the place of B. F. Marsh deceased), C. A. Ashburner.

Curators.

C. M. Cresson, Henry Phillips, Jr., Geo. H. Horn.

Treasurer.

J. Sergeant Price.

The meeting was then adjourned.

Stated Meeting, Jan. 19, 1883.

Present, 8 members.

Vice-President, Mr. PRICE, in the Chair.

Dr. Pepper by letter, Jan. 8, accepted his appointment to prepare an obituary notice of Dr. J. F. Meigs.

Dr. Muhlenberg, by letter of same date, accepted his appointment to prepare an obituary notice of the Rev. Dr. Krauth.

A photograph of Admiral J. Downes, for the Album, was received.

Donations for the Library were reported from the Royal Academy, Brussels; Flora Batava; Annales des Mines; Commercial Geographical Society, Bordeaux; Royal Geological Society and London Nature; Canadian Institute; Essex Institute; Museum of Comparative Zoölogy and Peabody Museum; American Journal of Medical Science; American Journal of Pharmacy; Mr. Henry Phillips, Jr.; Ohio Mechanical Institute; T. L. Campbell; and the American Antiquarian Society.

The death of Dr. W. H. Allen, President of Girard College, August 29, 1882, aged 74, was ordered to be inserted in the minutes.

Prof. P. E. Chase communicated "Photodynamic Notes, No. VII."

Mr. Lesley communicated a Memorandum of the Progress of the Second Geological Survey of Pennsylvania, from the beginning, by Counties alphabetically arranged.

Prof. Barker exhibited and explained his new Standard Cell for testing potentials of electricity.

Dr. Frazer exhibited and described a collection of rock specimens from St. Davids and elsewhere in Great Britain, with special regard to their likeness to certain rocks in Pennsylvania.

General Thayer described some curious effects observed by him in using a secondary electrical battery.

Mr. Lesley was elected Librarian for the ensuing year.

Standing Committees were appointed, as follows:

Finance.

Eli K. Price,
Henry Winsor,
J. Price Wetherill.

Hall.

J. Sergeant Price,
W. A. Ingham,
C. G. Ames.

Publication.

J. L. LeConte,
D. G. Brinton,
C. M. Cresson,
G. H. Horn,
Persifor Frazer.

Library.

E. K. Price,
E. J. Houston,
Henry Phillips, Jr.,
W. V. McKean,
Thos. H. Dudley.

The reading of the list of members was postponed.

Pending nominations Nos. 969 to 980 were read; 979 was postponed; the rest were balloted for.

The Library Committee were instructed to proceed with the printing of the last part of the Catalogue. (530 MSS. pages = 270 ± pp. of text.)

A Committee of three was appointed to draw up a *Memorial to Congress* urging the continuance of the Light House Board and the Coast Survey under the direction and control of the U. S. Treasury Department, the Committee to consist of Messrs. Fraley, Dudley and Frazer.

New members elected:—

J. Bennett Lawes, LL.D., of Rothumstead, Herts, Eng.
J. O. Westwood, Hope Prof. Entom., Oxford, Eng.
J. Cheston Morris, M.D., of Philadelphia.
Jas. Russell Lowell, Min. Plen. U. S. to England.
Herbert Spencer, of England.
Rev. Joseph May, of Philadelphia.
Wm. Morris Davis, of Philadelphia.
S. F. Emmons, U. S. Geologist, Washington, D. C.

James Macfarlane, of Towanda, Penna.
E. W. Claypole, 2d Geol. Survey, New Bloomfield, Perry Co., Pa.
Wm. H. Pancoast, M.D., of Philadelphia.

And the meeting was adjourned.

Stated Meeting, Feb. 2, 1883.

Present, 14 members.

President, Mr. Fraley, in the Chair.

Letters accepting membership were received from Rev. Jos. May, Jan. 23, and Mr. W. M. Davis, Milestown (Phil.), Jan. 23.

Letters of envoy and acknowledgment were read.

Donations for the Library were reported from the Mining Department, Melbourne; Geographical Soc., St. Petersburg; Turin Observatory; Academia dei Lincei; Revue Politique; Commercial Geographical Society, Bordeaux; Royal Museum of Natural History, Brussels; Royal Astronomical Society and Kew Observatory, London; Nova Scotia Institute; Massachusetts Historical Society; Museum of Comparative Zoölogy; Amer. Jour. of Science; Meteorological Observatory, Central Park, New York; New Jersey Historical Society; Franklin Institute; H. Phillips, Jr.; McCalla & Stavely; Amateur Naturalist (Germantown); American Chemical Journal; American Journal of Mathematics; Signal Service Bureau; U. S. National Observatory; Engineer Department U. S. A.

Proceedings A. P. S. No. 112, was laid on the table.

Dr. W. H. Pancoast was appointed to prepare an obituary notice of Prof. Joseph Pancoast.

Dr. Rothrock read a memoir on the microscopic differences in woods. (See page 599.)

After a discussion of the subject by Messrs. Price, Davis, Rothrock, Lesley, Frazer and Kane, with special reference to the occurrence of abnormal rings in timber, Mr. Price desired it to be remarked that Dr. Rothrock's important practical discovery was the direct result of the practical use to which the American Philosophical Society had put its portion of the Michaux Legacy, as the minutes of the last few years show.

Dr. Frazer communicated a paper entitled : "Some Comparative tables showing the distribution of Ferns in the United States," by Geo. E. Davenport, of Medford, Mass. (See page 605.)

Dr. Frazer presented the report of the Special Committee on a Memorial to Congress, which was approved, and the Officers were authorized to sign the Memorial and transmit it to Congress. The Committee was discharged from the consideration of that part of the subject which related to the Light House Board.

The President reported that he had received and paid over to the Treasurer $132.75, being the quarterly interest on the Michaux Legacy last due.

On motion of Mr. Price, the expense of preparing the illustrations of Dr. Rothrock's paper was charged to the Michaux Legacy fund.

Stated Meeting, Feb. 16, 1883.

Present, 11 members.

President, Mr. FRALEY, in the Chair.

Messrs. Macfarlane, Claypole and Emmons by letter accepted their election to membership.

Letters of acknowledgment and envoy were read.

Donations for the Library were reported from the S. N. Antiq., Copenhagen; Royal Academia dei Lincei; Geographical Societies at Paris and Bordeaux; Revista Euskara;

Kew Observatory; London Nature; Royal Geological Society, Cornwall; Boston Natural History Society; Mr. Geo. B. Dixwell; American Antiquarian Society; Wesleyan University; Regents of the University, N. Y.; Numismatic and Antiquarian Society; Engineer Club; Mr. H. Phillips, Jr.; Dr. D. G. Brinton; American Journal of Pharmacy; Second Geological Survey of Pa.; U. S. Mint; War Department; Wisconsin Historical Society; and Mrs. R. Norris of Nice in France.—A rare copy of Kaempfer's Japan; and a MS. volume of Japanese flowers, painted by native artists for Mr. Geo. Tyson of Boston during his residence in China, were presented by Mr. Morris Davis of Milestown, Phila.— —Capn. A. D. Bache, presented, through Mr. Fairman Rogers, an old MS. of the Address of the Earl of Macclesfield to the Royal Society at the presentation of the Coplay Medal of 1753 to Benjamin Franklin. This MS. has the appearance of being the original document. On motion the thanks of the Society were tendered to Mr. Bache.

The death of Dr. B. H. Rand, at Philadelphia, February 14, aged 55, was announced.

Mr. Lewis introduced a discussion upon the thickness and movement of the Continental Glacier, in which Messrs. Frazer, Lesley and Price took part.

The minutes of the last meeting of the Board of Officers were read.

Pending nominations Nos. 979, 981 and new nominations Nos. 982, 983 and 984 were read.

Resolved, That the President be authorized to appoint as delegates to the Congrés des Americanistes, to meet at Copenhagen next September, any members of the Society who expect to be present on that occasion, provided that the Society be not subjected to any expense by the delegation.

Dr. Brinton and Mr. Henry Phillips, Jr., were appointed.

Resolved, That the Finance Committee be requested to investigate the condition of the Magellanic Premium funds, and make recommendations for the appropriation of the surplus income fund for such purpose or purposes as they may think appropriate to the objects of the Society.

And the meeting was adjourned.

Stated Meeting, March 2, 1883.

Present, 14 members.

President, Mr. Fraley, in the Chair.

Letters accepting membership were received from J. O. Westwood, of Oxford, England, dated February 12; and from James Russell Lowell, dated London, Feb. 11.

Letters of acknowledgment and envoy were read.

Donations for the Library were received from the Geographical Societies of Paris and Bordeaux; Revue Politique; Belgian Academy; Abbé Renard; E. Ludwig; Royal Society, Society of Antiquaries and London Nature; Dr. Ed. Jarvis; U. S. Military Academy; Prof. Mansfield Merriman; Dr. C. H. F. Peters; New Jersey Historical Society; Mr. T. H. Dudley; Franklin Institute; Mr. E. S. Holden; U. S. Naval Institute; San Francisco Mercantile Library Association; American Journal of Science; "Science"; U. S. National Museum; Census Bureau; C. A. Ashburner, and B. S. Lyman.

Mr. Horatio Hale read a paper on the Tutelo Indians and their language. (See Vol. XXI, page 1.)

Dr. Frazer exhibited two aneroid barometers and described some useful improvements suggested by him, executed by Hicks of London. (See page 604.)

Pending nominations Nos. 979, 981 and 984 were read.

Prof. Cope described as preposterous certain current newspaper explanations of the cause of the extinction of fossil mammalia in the West, by cold and by drought.

And the meeting was adjourned.

Stated Meeting, March 16, 1883.

Present, 16 members.

President, Mr. FRALEY, in the Chair.

Letters of envoy and acknowledgment were read.

Donations for the Library were reported from the Societies at Moscow, Königsberg, St. Gall, Frankfurt, Wiesbaden, Bordeaux and Cherbourg; the Observatories at St. Petersburg, Cambridge, Mass., and Mt. Hamilton; the German Geological Society, Physical Society, and W. Franzen of Berlin; the Belgian Academy, Bureau of Statistics, and Bureau of the Interior; the Lyons Society of Agriculture and Musée Guimet; the Flora Batava; the Society of Geography, Antiquaries, Anthropology, and Geology of Paris; the Revue de l'Histoire des Religions and Revue Politique; the Royal Institute, Victoria Institute, Met. C. R. Society; Royal Geographical, Royal Asiatic, Geological and Zoological Societies; London Nature; Boston National History Society; "Science"; N. Y. Linnean Society; Index Medicus; American Journal of Pharmacy; H. C. Lewis; Public Building Commission, Phil.; U. S. Coast Survey, Bureau of Education, Interior Department, National Museum; Missouri Historical Society; Hamilton A. Hill, of Boston; P. P. Sharples (Copy of the Monthly Mag. for Jan. 1784); and Mr. Henry Phillips, Jr.

An Obituary notice of Dr. Krauth, was read by Dr. Muhlenberg. (See page 613.)

The death of the oldest member of the Society, Mr. Henry Seybert, at Philadelphia, March 3, aged 82, was announced by Mr. J. S. Price; and the President was requested to select a suitable person to prepare an obituary notice of the deceased.

Dr. Brinton read a paper entitled "On Mediæval Sermon Books and Stories," by Prof. T. F. Crane, of Cornell University. (See Vol. XXI, No. 114.)

Prof. Cope communicated a paper entitled "Fourth Contribution to the History of the Permian Formation of Texas." (See page 628.)

The action of the Curators was approved in regard to lending for scientific examination the Mexican flutes belonging to the Cabinet of the Society, deposited at the Academy of Natural Sciences.

Dr. Frazer took occasion from Dr. Brinton's remarks prefatory to the reading of Prof. Crane's paper, to express his views regarding the presumptive restriction of authors of papers from using already published matter in said papers. Mr. E. K. Price and Mr. Fraley explained the habitually liberal policy of the Society in respect of communications made for publication. Mr. Lesley expressed the hope that the broadly "philosophical" character of the Society would be maintained, and that the Proceedings would not become restricted to the narrow limits of Natural History or the Physical sciences, so called, but that the Society would encourage its members to communicate for publication their best mature thinking in whatever department of human knowledge they might engage.

Pending nominations Nos. 979, 981 to 984 were read, and the meeting was adjourned.

Stated Meeting, April 6, 1883.

Present, 13 members.

President, Mr. Fraley, in the Chair.

Memberships accepted: G. Planté; J. B. Lawes.

Membership declined: Jos. May.

Letters of acknowledgment were received from the Royal Society of New South Wales (107–111); M. Edw. Dupont (111); Geological and Natural History Survey of Canada, Toronto (57-60, 61-62, 67, 69, 75, 87; III, IV, V); Smithsonian Institution (112); and Mr. Thos. C. Porter (112).

Letters of envoy were received from the Geological Survey of India; University at Lund; Batavian Society, Rotterdam; Oberhessischen Gesellschaft, Giessen; and the Meteorological Office, London.

A letter of envoy, requesting exchanges, was received from the Historical and Scientific Society of Manitoba, Winnipeg, March 20, 1883. [See below.]

Donations were received from the Academies at St. Petersburg, Copenhagen, Brussels, Rome, Madrid and Philadelphia; the Royal Societies, in N. S. Wales, Victoria, Rotterdam and London; the Royal Astronomical Society at London; the Royal Society of Antiquaries, Copenhagen; the Geological Society at Halle; the Geological Surveys of India, New York, and New Jersey; the Geographical Societies at Paris and Bordeaux; the Historical Societies in Providence, Wilkesbarre and Winnipeg, Manitoba; the Swedish Bureau of Statistics; Lund University; Upper Hessian Society; General Society of Prisons at Paris; Observatory at San Fernando; the Revista Euskara; London Nature and National Review; Boston Society of Natural History; S. H. Scudder; H. A. Hill; Silliman's Journal; Franklin Institute, American Journal of Pharmacy, American Journal of Medical Sciences, T. Dudley, H. Phillips, Jr., H. C. Lewis, Dr. J. G. Lee, P. P. Sharples, of Philadelphia; American Chemical Journal; F. B. Hough, of Washington; Ohio Mechanics' Institute; National Mexican Museum.

A letter from Mr. Moncure Robinson was received accepting his appointment to prepare an obituary notice of Henry Seybert.

The death of Daniel B. Smith, at Germantown, March 29th, in the 92d year of his age, was announced by Mr. Fraley; and Prof. P. E. Chase was appointed to prepare an obituary notice of the deceased.

Mr. Davis read a paper "On the conversion of chlorine into hydrochloric acid, as observed in the deposition of gold from its solution by charcoal."

Prof. E. W. Claypole communicated, through the Secretary, two papers entitled, "On the Kingsmill white sandstone," and "Note on a large fish-plate from the Upper Chemung (?) beds of Northern Pennsylvania."

Rev. J. Hagen, S. J., Prof. College of the Sacred Heart, Prairie du Chien, Wis., communicated, through Dr. Brinton, a paper entitled, "On the reversion of series and its application to the solution of numerical equations."

Mr. John Sharples communicated through Prof. P. E. Chase, a paper entitled, "The latitude of Haverford College."

Mr. Lockington read a paper entitled, "The role of parasitic protophytes; are they the primary or the secondary cause of zymotic diseases."

Dr. Barker exhibited two bronze medals which he had received, in Paris, as a delegate to the International Congress of Electricians, and as a Commissioner to the International Exhibition of Electricity, held in Paris in 1881; and also a medal struck by the Institut de France in commemoration of the transit of Venus.

Pending nominations Nos. 979, 981–984, and new nomination No. 985, were read.

The Historical and Scientific Society of Manitoba, Winnipeg (see its letter, March 20), was ordered to be placed on the list of corresponding Societies to receive the Proceedings from date.

Dr. Brinton in behalf of the owners offered some valuable documents. On motion, the President was requested to examine them and report to the Society.

The Finance Committee reported "that in the matter of the Magellanic Fund referred to it, the subject was considered, assisted by the President, and it was concluded that no change in the present regulations was needed." Report accepted.

The Secretaries were authorized to publish with Mr. Hale's paper on the Tutelo Indians a fac-simile photograph of the old Tutelo Chief, the last of his tribe. (See No. 114.)

The Committee on the Michaux Legacy reported as follows:

"That the appropriation made for a course of lectures in Fairmount Park for 1882 by Professor Rothrock, to wit, two hundred and eighty dollars for the Professor, and fifty dollars for advertising, was duly received from the Treasurer, and applied as intended.

"The lectures, fourteen in number, were upon the subjects in the annexed printed schedule; and were attended by increased numbers of citizens of both sexes. There is a growing interest in these subjects in our community, amply to justify the Society's appropriation in that direction. The Committee recommend the same amounts to be voted for 1883, for lectures as in Schedule No. 2, annexed."

It was then, on recommendation of the Committee,

Resolved, That an appropriation be made from the Michaux Legacy of two hundred and eighty dollars for Professor Rothrock's lectures in Fairmount Park, and fifty dollars for advertising them, and that the Treasurer be authorized to make payments under the direction of the Chairman of the Committee on the Michaux Legacy.

The following schedule of proposed lectures for 1883 was appended to the report:

Free Lectures in Fairmount Park, on Botany and Tree Culture, by Professor Rothrock, on Saturdays, at 4 P. M.

April	21.	The value of Science to Mankind.
"	28.	Young Plants; how studied in life.
May	5.	Relations of Plants to National Prosperity.
"	12.	The Microscope; what it is; what it does; how to use it.
"	19.	A thriving colony on a Spruce Tree.
"	26.	What the Leaves do, and how they do it.
June	2.	Wasted food.
Sept.	8.	The Forests of the Sea.
"	15.	The American Forests, and their special importance.
"	22.	American Timber, and its special value.
"	29.	Old and new systems of Classification.
Oct.	6.	Vegetable Units, and how they make the plant.

The Curators reported the safe return of the Mexican flutes borrowed by Mr. Cresson, and studied by Mr. Cox, who had obtained from them a diatonic scale of an octave and a quarter in extent.

The Librarian reported the completion of his MS. condensed copy of the early records of the Proceedings of the Society from 1744 to 1837. The subject of printing the same was referred to the Committee of Five (Phillips, Horn, Lewis, Brinton and Law) appointed December 16, 1881.

And the meeting was adjourned.

On the Measurement of Electromotive Force. By George F. Barker.

(Read before the American Philosophical Society, January 19, 1883.)

The term electromotive force is applied to that force which tends to set electricity in motion. It appears to have been used first by Ohm, who in 1827 gave precision to the study of electric currents by formulating his well known law:—The strength of an electric current is directly proportional to the sum of the electromotive forces and inversely proportional to the sum of the resistances in the circuit.

The measurement of electromotive force may be absolute or relative; absolute when it is determined directly, relative when its value is obtained by comparison, the ratio of an unknown to a known electromotive force being the object of the measurement. In both measurements, the final standard of electromotive force is an absolute unit, based upon the fundamental units of mass, length and time; since these are respectively the centimeter, the gram and the second, absolute units are often called C. G. S. units. In electrostatics, electromotive force and difference of potential are synonymous, the same unit being used for both. The unit difference of potential exists between two points, when to carry a unit of positive electricity from one to the other, requires the expenditure of a unit of work; or in the C. G. S. system, of an erg. Now a unit of work, *i. e.*, an erg, is done when a unit of force, *i. e.*, a dyne, overcomes resistance through an unit of distance, *i. e.*, a centimeter. And a unit of force, *i. e.*, a dyne, is that force which produces a unit of velocity in a unit of time; *i. e.*, produces an increase of velocity of one centimeter in one second. Since in this latitude, gravity produces a velocity of about 980 centimeters per second, the force of a dyne corresponds to the attractive force which the earth exerts upon the 1-980th part of a gram. To raise one gram therefore to the height of one centimeter requires the expenditure of 980 ergs of work. Obviously then if two electrified bodies at unit distance attract or repel each other with a force equivalent to that which the earth exerts on a gram weight, there exists between them a difference of potential of 980 absolute units. By measuring the force between two electrified bodies in grams, the difference of potential or the electromotive force between them is easily calculated in absolute measure. By multiplying this value in electrostatic units, by thirty thousand million, the electromotive force is obtained in absolute electromagnetic units.

The instrument used for measuring differences of potential is called an electrometer; if by direct measurement, an absolute electrometer. The absolute electrometer of Sir William Thomson is the best thus far devised. This instrument consists of two metal plates, one of which, the smaller, is provided with a guard ring so that the electrical distribution shall be uniform; these plates being so arranged that the attraction between them may be very accurately measured. The force may be measured at a constant distance by varying the weight necessary to balance it; or the distance may be varied until the force balances a constant weight. The latter method is preferred in the absolute electrometer of Thomson. With this instrument, the electromotive force of a Daniell cell was found to be 0.00374 electrostatic unit, corresponding to 112 million electromagnetic units.

Relative measurement of electromotive force, especially for practical purposes, is much more frequent than absolute measurement. Although the same units may be used, yet in practice it has been found more convenient to employ a separate unit called the volt, the value of which is given as one hundred million absolute electromagnetic units. Moreover, this unit is represented not in the abstract form alone, but also concrete. Some distinct electromotor, the difference of potential between the electrodes of which has been accurately measured, is taken as the standard. For example, the Daniell cell above mentioned has an electromotive force, by the definitions already given, of 1.12 volts. Such a battery, used for measurement, is called a standard battery.

For determining an unknown electromotive force, it is only necessary to determine the ratio between this and the electromotive force of the standard battery. Two general methods of doing this are in use; the one direct, the other indirect. In the direct method, an electrometer which has been calibrated is employed; *i. e.*, one whose constants have been determined by comparison either with the standard battery or with an absolute instrument. Such are the portable and the quadrant electrometers of Thomson. In the latter instrument an 8-shaped needle of aluminum swings in a cylindrical metal box with separated quadrants. The alternate quadrants are electrically connected when the instrument is in use. A small charge being communicated to the needle—previously adjusted so that its axis is parallel to the line between adjacent quadrants—any electrification of the quadrants is made apparent by the motion of the needle to the right or left. By connecting these quadrants, first with the electrodes of the standard cell, and then with the cell whose electromotive force is to be measured, the ratio of the deflections gives the ratio of the electromotive forces, provided the angle of rotation be small. A mirror attached to the suspension of the needle enables these deflections to be accurately read with a telescope and scale. A simpler instrument suffices when the zero method is employed. In this case the two electromotors are simultaneously connected to the quadrants, their electrodes being reversed. If equal, the deflection will be zero. If unequal, it will be equal to the difference. By varying the known electromotive force until the deflection is zero, the two are again equal.

While, in the direct method, the electromotive force is the quantity which is measured, in the indirect method some other quantity or quantities are measured, and the electromotive force deduced by calculation from the known relation between the quantities. When, for example, the current strength is measured on the galvanometer and the resistance of the circuit is known, the law of Ohm enables the electromotive force to be computed. In Wiedemann's method, the electromotor to be measured is joined up with the standard battery, in circuit with a galvanometer, first with the electrodes in the same direction, then reversed. The electromotive force required is then the product of the standard electromotive force by the quotient of the difference of the current strengths divided by the sum. Another method consists in putting the standard cell in circuit with a galvanometer, the resistances of both being known. The standard cell is then replaced by the electromotor to be tested and the resistance in circuit varied until the same deflection is obtained. The electromotive force of the standard cell multiplied by the ratio of the second total resistance to the first gives the electromotive force required. The electrometer methods have the advantage of not using the current of the electromotor to be measured; and hence any change in its condition due to the current produced is avoided.

From what has been said, it will be evident that the selection of the standard cell is a matter of prime importance. The advantages of the Daniell cell for this purpose are too well known to require elaborate statement here. As used on closed telegraphic circuits and the like, two forms have come into general favor. One of these is that employed originally by Professor Daniell. It consists of a glass jar containing copper sulphate, in which the copper plate is immersed, and of a porous cup containing the zinc plate, a more or less dilute solution of zinc sulphate. The other form is the modification first proposed by Varley and afterward by Callaud, in which the porous cup is done away with, the differing densities of the two solutions being depended upon to keep them separated. The copper sulphate solution is placed at the bottom of the jar in contact with the copper plate. As the density of this solution when saturated is 1.186 at 15° C. the solution of zinc sulphate ordinarily rests upon it and in contact with the suspended zinc plate. But as the action of the battery goes on and the zinc sulphate accumulates in the solution, this later finally becomes heavier than the copper sulphate solution (the density of a saturated solution of zinc sulphate being 1.44 at 15° C.), and falls to the bottom; thus reversing the normal conditions in the battery. In 1871 Sir Wm. Thomson attempted to reverse the position of the plates in this gravity battery and place the zinc at the bottom in contact with the heavier solution. But the collateral disadvantages arising from the change more than balanced the advantages. He returned to the old form, therefore, but arranged a siphon in such a way that the zinc sulphate solution should be gradually withdrawn and too great concentration avoided. In practice the zinc sulphate should never be allowed to accumulate so as to increase the density of the solution above 1.17. This may be accomplished readily by pouring off the solution from the top of the jar and replacing it by pure water. When freshly set up, both of the forms of battery above described require to be kept on closed circuit for a day or two. Their condition of equilibrium is then reached and they may be used for the determination of electromotive force.

The difference of potential between the electrodes of a Daniell cell has been determined by many experimenters; by Regnauld, by Poggendorff, by Buff, by Beetz, by Petruschefsky, by Clark and Sabine, and by Ayrton and Perry, among others. They find that while it varies somewhat under variations of condition, yet that on the whole, it is remarkably constant, the maximum being 1.081 and the minimum 0.901 volt. In all these experiments the copper was immersed in a saturated solution of copper sulphate. The zinc was placed in solution of sodium chloride, in dilute sulphuric acid or in solution of zinc sulphate, all of varying strengths in the different experiments. It is noticeable that in none of these measurements made by indirect methods is the electromotive force as high as that already mentioned as having been obtained by Sir William Thomson by means of his absolute electrometer. Since the electromotive force of a Daniell cell is the sum of the differences of contact-potential within it, it would seem that any variation in the value of this electromotive force must be due either to a change in the character or concentration of the solutions, or to a difference of temperature. Moreover it has been observed that the electromotive force of the gravity form of battery is always a little higher than that of the cell in which a porous cup is used; a result due, probably, to the different conditions under which the diffusion of the two liquids takes place, a fact pointed out by J. W. Draper in 1834.

Using, therefore, the same form of battery, the solutions being always the same in kind and in concentration, and the temperature being the same, it is fair to infer that the Daniell cell may be made sufficiently constant to serve as a reliable standard of electromotive force. Several attempts have been made to do this. Raoult in 1864 (*Ann. Chim. Phys.*, IV, ii, 345), proposed a standard cell consisting of two covered jars of glass, one containing a copper plate in a saturated solution of copper sulphate, the other a zinc plate in a solution of zinc sulphate in an equal weight of water. The two were connected by an inverted U tube, whose ends were closed by porous plates of earthenware cemented to them. By means of a tubulure in the bend this tube was filled with the zinc sulphate solution. When not in use, the U tube is removed and kept in a separate vessel. Kempe in 1880 (*J. Soc. Teleg. Eng.*, June, 1880), described a standard Daniell cell which has been adopted in the British Post-Office. The containing vessel is of porcelain, having two compartments. In one of these is a half saturated solution of zinc sulphate, reaching to the lower edge of the zinc plate. In the other is a flat, porous cup containing the copper plate surrounded with crystals of copper sulphate, and immersed in copper sulphate solution. To use this battery, the porous cup is transferred from one compartment to the other, thus raising the zinc solution into contact with the zinc plate. After making the measurement, the porous cup is replaced in its own compartment. Any copper which may have been carried into the zinc solution is precipitated upon a fragment of zinc kept constantly in it.

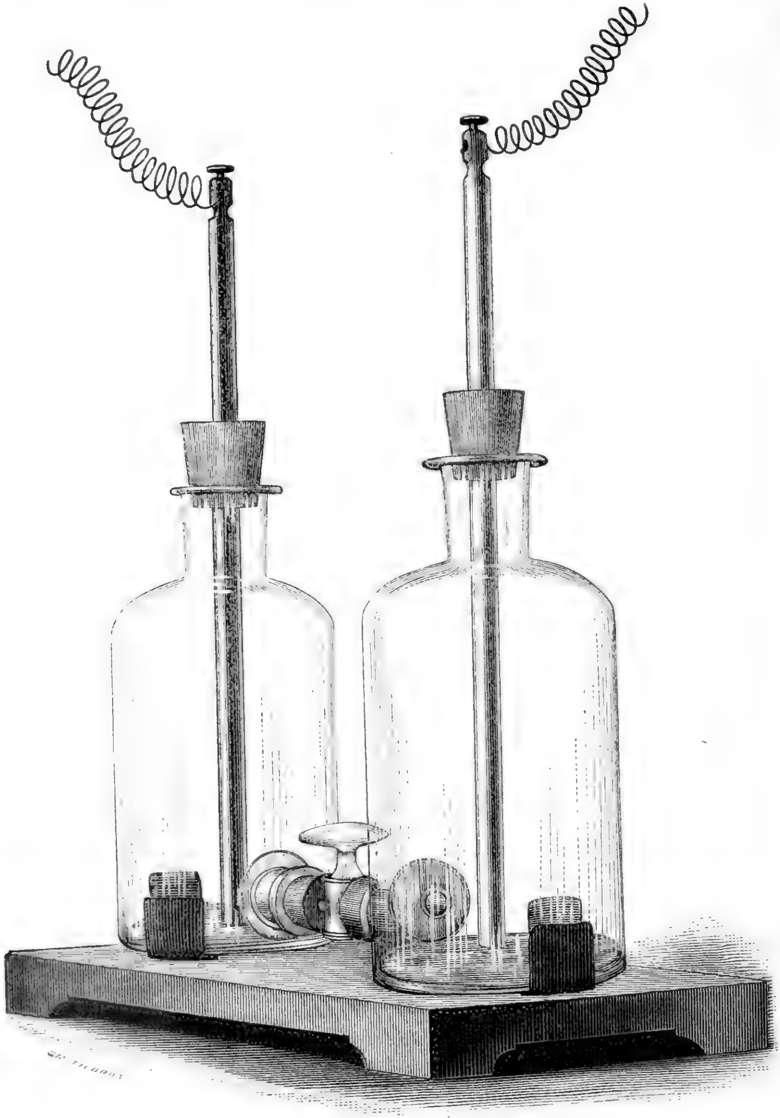
Having had occasion for a series of months, at intervals, to make measurements of electromotive force by the method of comparison, I have been led to devise a form of standard Daniell cell which appears to have so important advantages over others heretofore used as to justify me in bringing it to the notice of the Society. The form of apparatus which has been adopted is represented in the annexed wood-cut. It consists of two bottles with lateral tubulures near the bottom. These are closed with rubber corks through which passes a stop-cock of glass. The necks of the bottles also carry corks of rubber, through which pass the rods of zinc and copper. The bottle containing the rod of zinc is filled about three-fourths with a solution of zinc sulphate saturated at 15° C. That containing the copper rod with a saturated solution of copper sulphate. When the cell is to be used for measurement, the cock is opened and the two liquids are thus put in communication. At the end of the experiment, it is again closed and all diffusion is prevented.* For ordinary use, especially where a large number of cells in series is required, a much cheaper apparatus may be constructed. Those set up in my own laboratory consist of a couple of the cheap bottles now in general use for the nasal douche and for containing dry plate developers, which have a small lateral spout at the bottom. Over these a rubber tube may be passed and tied, being closed when required by a wire compressor. In practice I have found it an advantage to place a wisp of spun glass in the rubber tube to prevent adherence between its sides. The zinc and the copper rods pass through corks in the mouths of the bottles as before.

The advantages which are claimed for this new form of cell are :

1st. Its constancy. When set up, all such cells are identical. The zinc is in contact with a solution of zinc sulphate, and the copper with one of copper sulphate both saturated at 15° C. Moreover, this identity continues. When on closed circuit, the liquids are altered by diffusion to a scarcely appreciable extent, the surface of contact being so small. During action copper sulphate is decomposed on one side and cop-

*The cell here represented was made for me by J. W. Queen & Co., of this city.

per deposited ; zinc is dissolved on the other side and zinc sulphate produced. The amount of current used in a measurement is small, first be-



cause the internal resistance of the cell is high, and second because the duration of the test is brief. But the minute change thus caused in the solution is prevented, first, by keeping a crystal of copper sulphate in the copper solution, and second, by the deposition of the excess of zinc sulphate in crystals. Since the zinc solution is the heavier, any hydrostatic transfer will be into the copper solution where no damage is done. When the cell is on open circuit, no diffusion takes place, communication being cut off. And since the apparatus is wholly closed to the air, no change in the conditions can arise from evaporation. Provided therefore the temperature be uniform, the electromotive force of the cell may be expected to be constant within narrow limits.

2d. Its transportability. In the use of the ordinary Daniell cell, particularly of the gravity pattern, any change of position disturbs more or less the conditions of equilibrium, and so varies the electromotive force. After moving such a cell, therefore, or after altering in any way its normal state, as by adding water lost by evaporation, it is necessary to allow twenty-four hours or more of rest, before the battery can be trusted to give proper measurements. But in the cell now preposed, no change can take place in its conditions by being moved from place to place. Hence for local testing in circumstances where a permanent battery cannot be had, its value is considerable.

3d. Its convenience and cheapness. The common form of Daniell battery requires to be especially prepared for use. If set up anew, twenty-four aours are needed before it comes into good working action. Even the improved forms of standard cell above described are more or less inconvenient, since they require something to be done to put them in action. But in the form now proposed the cell is always ready for use, no matter how long a time may have elapsed since it was used before. The opening of a stop-cock puts it in full operation. Moreover, this cell is readily constructed from apparatus and material at hand in every laboratory. And if douche bottles are used, the cost is not over a dollar.

It is evident that the form of apparatus now described has a much wider range than has yet been claimed. By its means not only may the effect of using various solutions in contact with either plate of a Daniell cell be accurately studied, free from many of the disturbing causing hitherto encountered, but by the use of various metals also, the innumerable questions of importance, concerning not only primary but also secondary batteries, may be conveniently investigated. One of these for example, is the question whether the zinc of a Daniell cell should be amalgamated. The impression is very generally in favor of amalgamation, since in a zinc sulphate solution amalgamated zinc is said not to become polarized; and since the electromotive force is one or two per cent. higher. But experiments have shown, that while amalgamated zinc should be used when the solution is acid, yet that when it is neutral, local action is greater with amalgamated than with unamalgamated zinc.

Experiments now in progress with this new form of cell, it is hoped, will enable some of these doubtful points to be satisfactorily settled.

PHILADELPHIA, January 18, 1883.

Henry Draper.

(Minute prepared by Geo. F. Barker, Secretary American Philosophical Society, for Proceedings, December 1, 1882.)

Henry Draper was born on the 7th of March, 1837, in Prince Edward county, Va., his father being at the time Professor of Chemistry and Natural Philosophy in Hampden Sidney College. When but two years old, his father was called to the chair of Chemistry in the University of the City of New York, and removed to that city in 1839. Henry was entered as a regular scholar, first in the primary, and subsequently in the preparatory schools connected with the University, and at the age of fifteen, entered the collegiate department as an undergraduate. Upon the completion of his sophomore year, however, he abandoned the classical course and entered the medical department, from which he graduated with distinction in 1858. The following year he spent in Europe. While abroad he was elected on the medical staff of Bellevue Hospital; and on his return he assumed the position and discharged its duties for eighteen months. In 1860, at the age of 23, he was elected Professor of Physiology in the Classical department of the University, and, in 1866, to the same chair in the Medical department; being soon after appointed Dean. In 1873, he severed his connection with the medical department; and in 1882, upon the death of his father, he was elected Professor of Chemistry in the Classical department; a position which he held until the close of the current academic year.

Reared in direct contact with science and scientific thought, as Dr. Draper was, it is not surprising that at an early age he developed a decided preference for scientific pursuits. His father was a man not only of the widest scientific knowledge, but he was also of exceptional ability as an investigator. To live in contact with this genial and learned man, was of itself a scientific education of the highest type. Henry was early taken into his confidence in scientific matters, and was called upon to assist his father not only in his lectures, but also in his investigations. The scientific spirit which presses forward unflaggingly in the pursuit of truth and which wrests from Nature the profoundest secrets by patient and long continued application, had long been characteristic of the elder Draper; it was now fully developed in his son. While yet a medical student, he undertook a most difficult research upon the functions of the spleen; and, conscious of the inaccuracies incident to drawings, he illustrated this research—afterward published as his graduating thesis—with microphotographs of rare perfection for those early days, all taken by himself. While engaged with the microscope in making these photographs, he discovered that palladious chloride had a remarkable power in darkening or intensifying negatives; an observation subsequently of much value in photography.

During his sojourn in Europe, he had visited the great reflecting telescope of Lord Rosse at Parsonstown, Ireland. The sight of this instrument inspired him with a desire to construct one like it, though on a smaller, scale, and turned his attention toward astronomy and astronomical photography. Soon after his return he began the construction of a metal speculum, fifteen inches in diameter, completing it in 1860. Subsequently he accepted a suggestion contained in a letter written to his father by Sir John Herschel, and abandoned speculum metal for silvered glass. In the year 1861, he made several mirrors of silvered glass, 15½ inches in diameter. The best of these was mounted as a Newtonian telescope, in a small wooden observatory erected at Hastings-on-Hudson, his father's country seat. The details of grinding, polishing, silvering, testing and mounting this reflector, all of which he did with his own hands, were published as a monograph by the Smithsonian Institution. This publication has had a deserved popularity, and has become the standard authority on the subject. Much experimental work was done with this telescope; that which is best known, being his photograph of the moon. More than 1500 original negatives were taken with this instrument. They were one and a quarter inches in diameter, but such was the perfection of their detail that they bore enlargement to three feet, and in one case to fifty inches without injury. The success of this mirror stimulated him to undertake a still larger one, and, in 1870, he finished a silvered glass mirror, twenty-eight inches in diameter. A new dome was built for it by the side of the old one, the mounting being equatorial, and the telescope Cassegrainian; though subsequently a plane secondary mirror was substituted for the convex one. A refracting telescope of five inches aperture was attached to the tube of the reflector, as a finder. With this larger instrument, work was at once begun upon photographic spectra; and, in 1872, a beautiful photograph was obtained of the spectrum of *a* Lyræ (Vega), which showed the dark lines; a step far in advance of anything which had been accomplished in this direction up to that time. Desiring to make simultaneous eye-observations, Dr. Draper, in 1875, placed upon the same axis, a refracting telescope of twelve inches aperture, made by Alvan Clark & Sons. In 1880, this was exchanged for another refractor by the same makers, of eleven and a half inches aperture, but furnished with an additional lens to serve as a photographic corrector. The work of stellar spectrum photography went steadily on, the new refractor now doing the principal work. More than a hundred such photographs were made, most of these having upon the same plate a photograph of the spectrum of Jupiter, Venus, or the moon. These latter, giving the solar lines by reflection, enabled the stellar lines to be identified by direct comparison.

Reflecting on the extreme sensitiveness of the dry-plate process in photography, he was led to experiment on the reproduction of nebulæ by its means; and on the 30th of September, 1880, he succeeded by an exposure of fifty-seven minutes in obtaining a photograph of the nebula in Orion. Satisfied now that the idea was an entirely feasible one, he devoted himself uninterruptedly to securing the greatest possible perfection in the driving clock and to improving the details of manipulation. In March, 1881, a second and much superior photograph of this nebula was secured after an exposure of 104 minutes. And finally, a year later, on the 14th of March, 1882, he succeeded in making a successful exposure of 137 minutes, and in producing a most superb photograph, which showed stars of the 13.7 magnitude, invisible to the eye, and in which the faint outlying regions of the nebula itself were clearly and beautifully shown. This unrivaled photograph, by far the most brilliant success yet achieved by celestial photography, will ever have a very high astronomical value, since by a comparison with it of photographs of this nebula, taken many years subsequently, changes which are going on in it may be traced and their history written. Ordinarily the photograph of a spectrum is more difficult than one of the object itself. But in this case it is not so. The spectrum being of bright lines, the light is localized and readily impresses the plate. Moreover, any error in the rate of the clock or any tremors of the instrument, which are fatal to the nebula, count for little in photographing its spectrum; since the image is thereby simply shifted off the slit and no injury results to the definition. Many excellent photographs of the spectrum of the nebula in Orion were obtained by Dr. Draper, however, the chief interest in which consists in the fact that beside the characteristic bright lines, there are traces of continuous spectrum in various parts of the nebula, suggesting the beginning of condensation.

Beside the work done at his observatory at Hastings, which may be called astronomical work proper, Dr. Draper occupied himself with collateral questions of not less importance, in the admirably equipped physical laboratory he had built in connection with his residence in New York City. It was here, in 1873, that he made the exquisite, and to this day unequaled photograph of the diffraction spectrum. The region from wave-length 4350, below G, to wave-length 3440 near O, was contained upon a single plate. The Roman astronomer Secchi reproduced this photograph as a steel plate for his great work on the Sun, and the British Association, in 1880, endorsed it as the best known standard spectrum by publishing a lithograph of it in their Proceedings. The grating used to produce this photograph was one of Mr. Rutherfurd's superb plates, ruled with 6481 lines to the inch. It was in his New York laboratory, too, that he made the most important discovery of his life, perhaps; that of the existence of oxygen in the sun. After months of laborious and costly experiment, he succeeded, in 1876, in photographing the solar spectrum and the spectrum of an incandescent gas upon the same plate, with their edges in complete contact; thus enabling the coincidence or non-coincidence of the lines in the two spectra to be established beyond a doubt. On examining the spectrum of oxygen thus photographed, he saw that while the lines of the iron and the aluminum used as electrodes, coincided, as they should do, with their proper dark lines in the sun's spectrum, the lines of oxygen agreed with bright solar lines. Whence the important conclusion announced by him, 1st, that oxygen actually existed in the sun, now for the first time proved; and, 2d, that this gas exists there under conditions either of temperature or pressure, or both, which enable it to radiate more light than the contiguous portions of the solar mass. This view of the case however, required radical modification in the then accepted view of the constitution of the sun ; a modification which he pointed out and advocated. So exceptional were these results, and especially the conclusions from them, that it was hardly to be expected that they should be at once accepted. Dr. Draper, however, in this, as in all his work, was his own severest critic. Increasing constantly his appliances and perfecting his methods he produced, in 1879, another photograph on a much larger scale, which showed the coincidences which he claimed, especially of groups of lines, so unmistakably as to leave no question of the fact in a mind free from bias. To strengthen still more the evidence on the subject, he had planned for execution the present winter, a research upon the spectra of other non-metallic gases, in the hope that some of these, too, would be found represented as bright lines in the sun spectrum.

In 1878, he was the director of a party organized by himself to observe the total eclipse of the sun of the 29th of July. His familiarity with the locality led him to select Rawlins, Wyoming, an important station on the Union Pacific Railway, as the objective point. The result justified his selection. The expedition was entirely successful, and the observations which were made were of great value. By means of his splendid apparatus, Dr. Draper himself obtained an excellent photograph of the corona and also a photograph of its diffraction spectrum which was apparently continuous. In 1880, he obtained a number of spectra of Jupiter in connection with stellar work. On examining one of these spectra, the photograph appeared to him to show that the planet really furnished a certain amount of intrinsic light. The exposure on Jupiter was fifty minutes, the spectrum of the moon being taken in ten. The original negative was sent over to his friend, Mr. A. C. Ranyard, who presented it to the Royal Astronomical Society. In June, 1881, he took several excellent photographs of the comet, and also of its spectrum. With a slit and two prisms he obtained three photographs of the spectrum, with exposures of 180, 196, and 228 minutes, respectively. On each plate, a comparison spectrum was also photographed.

Upon the organization of the United States Commission to observe the Transit of Venus in 1874, Dr. Draper's great attainments in celestial photography pointed him out at once as the man best suited to organize the photographic section, and he was accordingly appointed Director of the Photographic Department. He went at once to Washington, entered heartily into the work, and during three entire months devoted himself to the labor of organizing, experimenting and instructing ; declining subsequently all compensation for the time thus spent. Although his duties at home prevented him from joining any of the expeditions, yet so instrumental had he been in making the transit observations a success, that upon the recommendation of the Commission, Congress ordered a gold medal to be struck in his honor at the Philadelphia Mint. This medal is 46 millimeters in diameter. It has the representation of a siderostat in relief upon the obverse, with the motto: "Famam extendere factis, hoc virtutis opus." On the reverse is inscribed the words: "Veneris in sole spectandæ curatores R. P. F. S. Henrico Draper, M. D., Dec. VIII, MDCCCLXXIV;" with the motto: "Decori decus addit avito."

Professor Draper was appointed, in 1861, Surgeon of the Twelfth Regiment of New York Volunteers; a position which he accepted and in which he served with credit. In 1876, he was made one of the Judges in the Photographic Section of the Centennial Exhibition. In 1875, he was elected a member of the Astronomische Gesellschaft. In 1877, he received an election to the National Academy of Sciences; and in the same year he was made a member of the American Philosophical Society. In 1879, he was elected a Fellow of the American Association for the Advancement of Science. In 1881, the American Academy of Arts and Sciences worthily enrolled him among its members. In 1882, the University of Wisconsin and the University of New York conferred on him, almost simultaneously, the degree of LL.D.

For several years it had been Dr. Draper's custom to join his friends, Generals Marcy and Whipple, of the Army, in the early fall, for a few weeks' hunting in the Rocky mountains. In 1882, the party left New York on the 31st of August, went by rail to Rock creek, on the Union Pacific Railway, and from there went north in the saddle; reaching Fort Custer, on the Northern Pacific Railway, near the middle of October. During the two months of their absence the party rode fifteen hundred miles on horseback, as Dr. Draper estimated. When above timber line early in October, they encountered a blinding snow storm with intense cold and were obliged to camp without shelter. Dr. Draper reached New York on the 25th of October. Ordinarily, he returned refreshed and invigorated with the splendid exercise of the trip; but this year the distance traveled seemed to have been too great, and this, together with the hardships encountered, seemed to have wearied him. Pressure of delayed business awaited him and occupied his time at once. Moreover, the National Academy was to meet in New York in November; and he was to entertain them as he had always done. This year the entertainment was to take the form of a dinner. In order to offer them scientific novelty, he determined to light the table with the Edison incandescent light, the current being furnished from the machine in his laboratory. But the source of power being a gas engine, and therefore intermittent, a disagreeable pulsation was observable in the light. To obviate this he contrived an ingenious attachment to the engine whereby at the instant at which the speed was accelerated by the explosion of the gas in the cylinder, a lateral or shunt circuit should be automatically thrown in, the resistance of which could be varied at pleasure. With his admirable mechanical skill he extemporized the device from materials at hand and found it to work perfectly. The dinner was given on the evening of November 15th, and was one of the most brilliant ever given in New York; about forty academicians, together with a few personal friends as invited guests, sitting at table. But Dr. Draper's overwork now told upon him ; slightly indisposed as he had been before, he was unable to partake of food, and a premonitory chill seized him while at the table. As soon as the dinner was over, he took a hot bath, thinking thus to throw it off. But while in the bath a second and severer chill of a decidedly congestive type attacked him, and it was only with the greatest difficulty that he could be carried to his bed. His warm friend and former colleague, Dr. Metcalfe, was at once summoned and pronounced the attack double pleuritis. The best of treatment and the most careful nursing seemed for two or three days to be producing an effect for the better. But on the Sunday following, heart complication developed and he died about 4 o'clock in the morning of Monday, the 20th of November.

Viewed from whatsoever standpoint, the life of Henry Draper appears as successful as it was earnest, honest and pure. His devotion to science was supreme ; to him no labor was too severe, no sacrifice too great, if by it he could approach nearer the exact truth. The researches he had already made, and much more those he had projected, involved the largest expenditure of his time and means. But such was his delight in his scientific work, and his enthusiasm in carrying it on, that he was never happier than when hardest at work in his laboratory, never more cheerful than when most zealously laboring with his superb telescopes. Moreover, he was as eminent as a teacher of science as he was as an investigator. His lectures were simple, clear and forcible. They held the interest of the class and awakened their enthusiasm while they enriched the student's store of knowledge and strengthened his powers of observation and of reason. In the laboratory he was keen, thorough and impartial, while at the same time considerate and helpful ; ever striving to encourage honest endeavor and to assist the earnest worker.

Still another sphere of labor, however, made demands upon his time. In 1867, he married Mary Anna, the accomplished daughter of Courtlandt Palmer, of New York. Upon Mr. Palmer's death, in 1874, Dr. Draper became the managing trustee of an immense estate and, with his characteristic energy and efficiency, entered at once upon the task of reducing it to a basis of maximum production with the minimum amount of attention. The responsibility which thus rested upon him, the harassing demands of tenants, the endless details of leases, contracts and deeds, and the no less annoying complications of necessary law suits, worried him incessantly. And had it not been for his unsurpassed business capacity, he might have failed. But he was equal to the demand upon him, and within a few years, order had come out of confusion, and a few hours at his office daily enabled all to flow along smoothly.

To indicate the esteem in which Dr. Draper was held by his confrères in science, the following passages may be quoted from an excellent biographical notice of him written by Professor Young, of Princeton : "In person he was of medium height, compactly built, with a pleasing address, and a keen black eye which missed nothing within its range. He was affectionate, noble, just and generous; a thorough gentleman, with a quick and burning contempt for all shams and meanness; a friend most kind, sympathetic, helpful, and brotherly; genial, wise and witty in conversation; clear-headed, prudent and active in business; a man of the highest and most refined intellectual tastes and qualities; a lover of art and music, and also of manly sports, especially the hunt; of such manual skill that no mechanic in the city could do finer work than he; in the pursuit of science, able, indefatigable, indomitable, sparing neither time, labor nor expense."

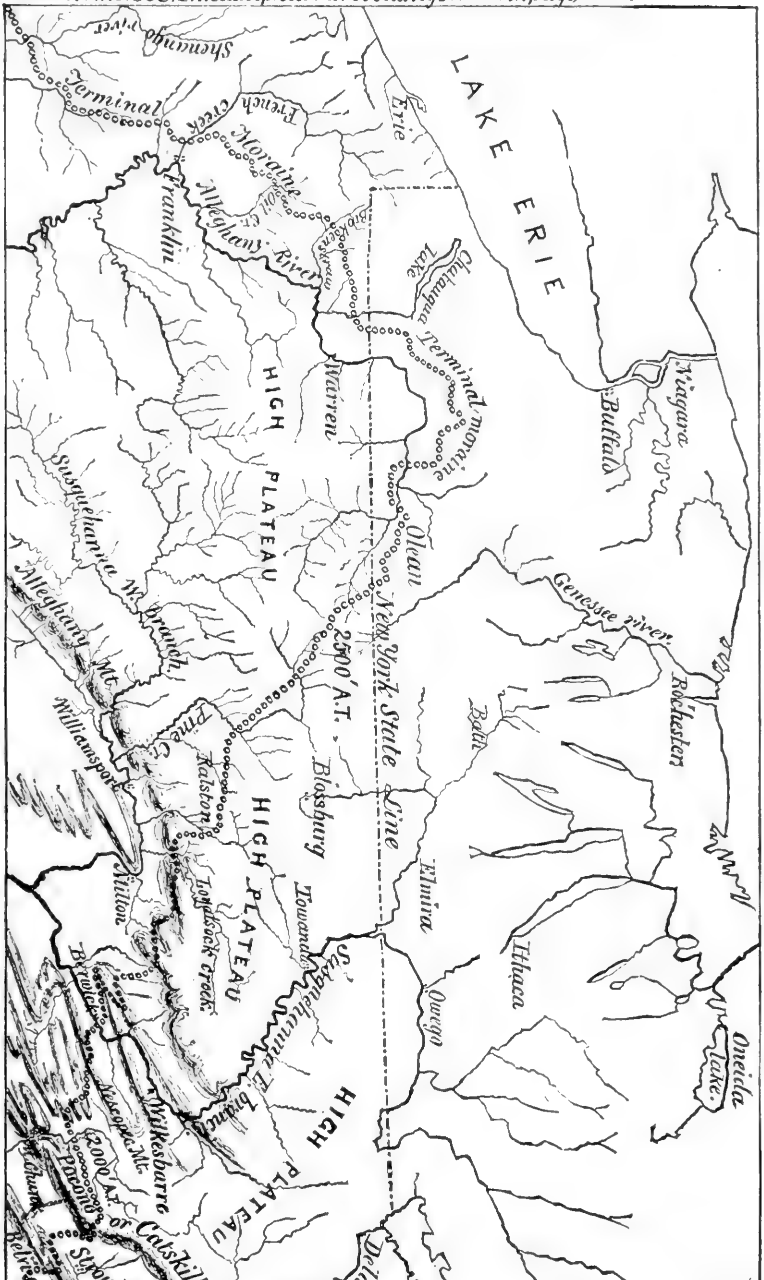
"Excepting his early death, Dr. Draper was a man fortunate in all things; in his vigorous physique, his delicate senses, and skillful hand; in his birth and education; in his friendships; and especially in his marriage, which brought to him not only wealth and all the happiness which naturally comes with a lovely, true-hearted and faithful wife, but also a most unusual companionship and intellectual sympathy in all his favorite pursuits. He was fortunate in the great resources which lay at his disposal, and in the wisdom to manage and use them well; in the subjects he chose for his researches and in the complete success he invariably attained."

Such a man as this it is whose name we are sorrowfully called upon to strike from the roll of our living membership. Professor Draper was a man among men, a scientist of the highest type. Stricken down in the midst of his life-work, at the early age of 45, the bright promise of his noble life is left unfulfilled. What brilliant researches in his favorite science he would have made, we can never know. But with a mind so richly endowed and so thoroughly trained, with an experimental ability as earnest as it was persistent, with facilities for investigation which were as perfect as they are rare, with abundance of time and means at his disposal, and above all, with a devoted wife, who keenly appreciated the value of his scientific work, was ever at his side as his trusty assistant and always shared in the glory and the honor of his discoveries, we may be sure that, had he been permitted to reach the age of his honored father, results would have been reaped by his labors which would have added still brighter lustre to the science of America.

Map of the Terminal Moraine.

On page 476 it is recorded in the minutes of the meeting, October 6, 1882, that Prof. Henry Carvill Lewis read a paper on the course of the great Terminal Moraine through Pennsylvania, studied by him as volunteer Assistant of the Second Geological Survey of Pennsylvania, and described in his unpublished Report of Progress, Z, illustrated by photograph pictures taken by Mr. E. B. Harden, Topographical Assistant to the Survey.

Amer. Phil. Soc. Philadelphia. Proceedings. Vol. XX. page 663.



Mr. Lewis described the hummocks west of Bangor in Northampton county; the striated boulders; the clay plain; S. W. pointing striæ near Bangor; the moraine ascending and descending the slopes of the Kittatinny mountain, west of the Delaware Water gap; boulders, 30 feet long, of fossiliferous Lower Helderberg limestone, from the outcrop in the valley in Monroe county, now perched on the crest of the mountain, 1400 feet above tide; boulders of well rounded Adirondack syenite from Northern New York; the moraine ascending to the summit and stretching westward across the Pocono plateau, 2000′ A. T. where it forms Long ridge, twelve miles long, a mile wide and 100 feet high; damming Long pond; descending to the bed of the Lehigh river, and crossing the Hazleton coal field mountains, Cunnyngham valley and Nescopec mountain and the Susquehanna river above Berwick; its curious ascent and descent of the Shickshinny mountain, with a perched boulder on the crest; the ascent of the Alleghany or Great North mountain; the course of the moraine through Lycoming and Potter counties into the State of New York; its return, and its south-west course through Warren, Butler and Beaver counties to the Ohio State line.

The accompanying map was prepared to show the course of the moraine with regard to the topography.

Note on a large Fish-plate from the Upper Chemung (?) beds of Northern Pennsylvania. By E. W. Claypole.

(*Read before the American Philosophical Society, April 6, 1883.*)

During a visit paid in the northern counties of this State in October last, I met a gentleman residing in Susquehanna county, Mr. A. Carter, who told me that some time previously he had ploughed up in one of his fields a large stone containing very peculiar markings upon its surface. Being unable to recognize it from his description, I requested him to send it down to me for examination on his return home. This he did, and a single glance showed an impression of a very large fish-plate in excellent preservation. Except one or two marks which had been made by the point of the ploughshare the cast was perfect.

It was, however, unlike anything which I had previously seen, and no material within my reach gave me the means of identifying it. It was apparently a nondescript. I accordingly forwarded a rough outline and description to Prof. Cope, who told me in reply that he could not at the moment of writing, recall anything resembling it.

I next sent a similar communication to Dr. Newberry, with the request that he would inform me if in his collection there was any similar specimen. In reply he told me that he thought he had fragments that might belong to the same species, but they were not sufficiently perfect for description. Feeling anxious to have Dr. Newberry's decisive opinion I next forwarded to him a photograph of the plate, asking if that would enable him to express an opinion whether the specimen belonged to a described or an undescribed species of fish. In reply he informs me that the fish in question is undescribed, but that he has some fragments of what he thinks is the same species, too imperfect for description.

Knowing that Prof. Whiteaves, Palæontologist to the Canadian Survey, had been working recently among some new Upper Devonian fishes, I sent him a photograph, requesting his opinion upon it. He has replied, saying, that there is no similar specimen among all those which he has seen from Scaumenac bay, and that he believes it is undescribed.

Description.

The specimen in question so far as the means at my command enable me to determine belongs to some species of the genus Pterichthys, or to some kindred genus, and is apparently the ventro-median plate. It is pentangular in outline but inequilateral, nearly symmetrical but not perfectly so. The front (?) is formed by one of the angles of the pentagon and the two sides enclosing this angle (of about 80°) are slightly concave outwardly. One of these sides—the right on the cast—is four and the other three and a quarter inches long. The former meets the third side of the pentagon at an angle of about 120°. This side is six and a quarter inches long. The latter meets at an angle of about 130° the fourth side of the figure which measures six and a half inches in length. The pentagon is closed at the base (back) by a short side of one and three-quarters of an inch long and very concave outwardly. The base is, in consequence of the inequality of the sides, slightly oblique.

The surface of the plate is marked with an ornamentation which I cannot find mentioned in the accounts of any other species. Instead of showing the tubercular or pustulose appearance of Pterichthys, its character more resembles (if we compare the great with the small) a magnified scale of Holoptychius. It is completely covered with close set interrupted wrinkles, slightly wavy, anastomosing and again separating without any appearance of regularity. These wrinkles meet the outside line almost at right angles and radiate inward in the following manner: If from the middle point of the axis of the plate straight lines be drawn to the upper (front) and two lower (back) angles, and lines, upwardly convex, to the lateral angles, the wrinkles in question start from these lines so as to meet the periphery (as said above) nearly at right angles. The wrinkles are subequal in size, largest anteriorly and posteriorly where they measure as much as one-eighth of an inch in breadth and are separated by furrows of about equal width. They increase slightly in size towards the periphery and in the middle are very small and much interrupted.

A flat, finely striate margin surrounds the whole plate, commencing at the anterior angle where its breadth is nothing and widening to the lateral angles where its breadth equals half an inch. The outer line of this margin between the lateral and basal (?) angles is straight, giving its greatest breadth about the middle of these sides where it equals an inch. The margin of the basal side is about three-quarters of an inch in breadth in the middle. The whole of this margin is very finely striate nearly at right angles to the sides of the plate.

This margin is evidently the portion of the plate which was overlapped by the adjoining plates and in this respect the resemblance between it and the ventro-median plate of *Pterichthys oblongus* Ag. is obvious.

The outline of the plate corresponds very closely with that of the dorso-median plate of *Pterichthys*, and were it not perfectly flat I should be inclined to refer it to that part of the exo-skeleton. But this flatness renders it more probable that it represents the ventro-median or well known "lozenge-plate" of Hugh Miller—the central piece of the armor of this fish on the lower side—overlapped on all sides by others.

Prof. Whiteaves has very kindly lent me for comparison the original and only specimen of the ventro-median plate of his new species, *Coccosteus Acadicus*. This, much more closely than my specimen, resembles the ventro-median plates of *Pterichthys* and *Coccosteus*, as given by Hugh Miller in his "Old Red Sandstone." It is quadrilateral, with two outwardly concave and two straight sides. The ornamentation is very peculiar, the plate being "quartered" if we may borrow an expression from heraldry, and having crenulated ridges parallel to the outer side in the first and fourth quarters and irregularly scattered tubercles in the second and third. Altogether it shows little resemblance to the plate here described.

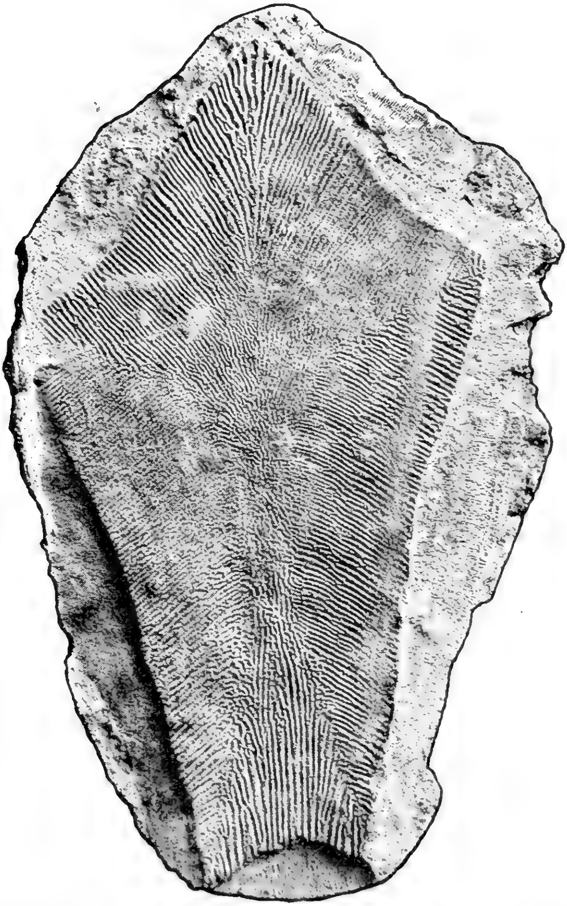
Prof. Newberry remarked in his letter that he very much doubted if the plate here described belonged strictly to *Pterichthys* and was inclined to consider it the type of a new genus. Probably this will be the result of a better knowledge of its structure, but it would be premature in this note to found a new genus on the fragments already known. When other parts of the exo-skeleton have been found it will be time to consider its generie position. Meanwhile I suggest for it the provisional name, PTERICHTHYS RUGOSUS.

The accompanying figure is taken from a photograph and will suffice to preserve the appearance of the specimen for future comparisons in the event of its loss or destruction.

On the Kingsmill White Sandstone. By E. W. Claypole.

(Read before the American Philosophical Society, April 6, 1883.)

Near the base of the red sandstones and shales which compose the Great Ponent series of Professor Rogers, lies a thin bed of white sandstone which promises to be of much interest, and perhaps of some importance in the



PTERICHTHYS? RUGOSUS, sp. n. UPPER CHEMUNG, PENNA. From a photograph of a plaster cast taken from the impression in sandstone.

geology of Perry county and of Middle Pennsylvania. In itself in nowise remarkable, it abounds in organic remains which when worked out will yield a rich fauna.

It is at present impossible to decide the *exact* horizon to which this sandstone belongs. For this reason, and to avoid prejudging the question, I have retained the term "Ponent." The transcendental nomenclature of Rogers is doomed to deserved extinction, but until we can determine finally what terms shall take the vacant places, it is wise to retain such of them as are necessary or convenient.

There is no question regarding the extent or signification of the term "Ponent" as employed by Professor Rogers. It is purely a lithological term, and is neither based on nor supported by palæontological evidence. In many parts of Middle Pennsylvania the dividing line which limits this Ponent Group is almost as easily seen in the rocks as on a geological diagram.

By the term "Ponent," Professor Rogers intended to designate all that great mass of red sandstone and shale, which intervenes between the top of his olive "Vergent" shales (Chemung of New York), and the Great Lower Carboniferous sandstone above them. The color and material of the beds are the sole foundations on which the distinction is based.

Palæontological considerations were not in the least regarded, partly because the time and means at the command of the First Survey forbade any extensive search for fossils, and partly because the great barrenness of these red shales and sandstones discouraged the same.

In New York, on the other hand, though fossils were also very scarce, yet an attempt was made by Professor Hall to establish a palæontological basis for his "Catskill Group," and the few relics that were obtained from the scanty exposures of these red shales and sandstones in that State were considered "characteristic." These are, strictly speaking, only two in number—*Holoptychius Americanus* and *Sauripteris Taylori.*

The base of the Catskill Group in New York is therefore double, lithological and palæontological. It may be to some extent an open question, whether or not these two horizons exactly coincide, and possibly the question may not admit of solution from the few and obscure exposures in that State. But until the coincidence of the horizons in New York with those in Pennsylvania is definitely settled, it would be premature to assume it. Consequently I retain for the present the term "Ponent" in writing of these beds.

The Kingsmill white sandstone lies near the base of these red sandstones and shales. Consequently it is in the Ponent Group of Pennsylvania. Its exact position is about 600 feet above the actual base of the red shales and sandstones. Palæontologically, the evidence leads to the same conclusion for about 400 feet below it are two fish-beds full of the remains of *Sauripteris* and *Holoptychius.* There is consequently no question of its position, judging from the data that have been hitherto accepted by geologists. Whether or not further examination of the Kingsmill sandstone will compel some modification of these data time will show. As the lines ot discrimination are now drawn, this sandstone must therefore be placed in the Ponent Group of Pennsylvania, and on palæontological evidence in the Catskill Group of New York. And no future changes can raise it. Any alteration, if made, can only lower it by placing it in the underlying or Chemung (Vergent) Group.

These details are necessary as an introduction to the facts and argument which follows.

Among the numerous fossils of the Kingsmill sandstone (many of which, though casts, are in excellent preservation, often showing the finest detail of structure), is one which at an early stage of the work arrested my attention. Its beautiful condition and the immense number in which it occurs were sufficient for this purpose. It is no exaggeration to say that at some of the exposures this fossil occurs in millions.

For some time I could get no clue to its name. At length, however, after going through with care all the material in my possession or within my reach, that bore upon the subject, I became almost certain that it was a fossil figured by Professor Hall in the geology of the Fourth District of New York, under the name *Cypricardia rhombea.* Possible inferences from this determination, however, deterred me from making use of the conclusion, and I laid the matter aside for further consideration.

Returning to the subject during the winter, while engaged in the study of my summer's collection, I found no reason whatever to distrust my previous determination, but in order to obtain the confirmation of another observer, I enclosed a specimen in a small parcel which I had occasion to send to Professor Whitfield, of the American Museum of Science, requesting his opinion on the identification. In his reply, he said:

"The shell sent is, I think, without question, *Schizodus rhombeus* Hall (*Cypricardia rhombea*) of the Fourth District Report. We have no really authentic specimens here, they being all in Professor Hall's hands at present."

In order to make the identification perfectly certain, I packed up a specimen, and sent it to Prof. Hall, with a request for his opinion upon it. In reply, he writes under date of March 10th, 1883.

"I do not perceive any important difference between the specimen sent, and *Schizodus rhombeus,* though I have not before had the casts of the interior, which I am glad to receive."

There remains therefore no doubt that the specimens here alluded to belong to the species *Schizodus rhombeus* Hall, of the Geological Report of the Fourth District of New York, where it was described and figured under the name of *Cypricardia rhombea.* It was found four miles north of Panama, Chautauqua county, New York, and attributed to the conglomerate at the base of the Carboniferous system. This opinion is now probably held by few or by no one. Prof. Hall said in the Twenty-third Regent's Report (p. 10):

"In the original collections of the Geological Survey, some of the conglomerates of the southern counties containing certain fossils were referred to and arranged with the Chemung Group, while those from other localities, but without fossils, were referred to Carboniferous age. This latter reference arose from finding some ferruginous beds supposed to be outliers of the red sandstone of Tioga, near the summits of some of the hills and below the conglomerates. These have since been proved by their contained fossils to belong to the Chemung Group, and it has not yet (1871) been demonstrated that the red sandstone of the adjacent part of Pennsylvania does occur within the limits of the south-western counties of New York.

"To a very great extent the conglomerates have been ascertained to belong to the Chemung Group, and to contain numerous fossils of that formation, while in some localities at least two hundred feet of shales and shaly sandstones, charged with Chemung fossils, lie above the conglomerates. So many localities have now been examined that we may conclude that all the conglomerates of the southern counties are of the age of the Chemung, but from the great difference in character of the fossils from different localities, it may not be regarded as proven that these beds are all of the same horizon.

"The relations of some of the outlying conglomerates south of Olean in New York and the adjacent parts of Pennsylvania in McKean county, to the Chemung Group and Coal Measures have not yet been satisfactorily determined."

Mr. Carll in Report III has given a minute account of the Panama conglomerate at its several exposures in Chautauqua county, New York, and has pointed out its peculiarities. He has also given a list of fossils obtained from it, which agrees, so far as the species were determined, with that given by Prof. Hall (Geol. 4th Dist. p. 291), except in one point. The following are the lists :

Prof. Hall's list.	Mr. Carll's list.
Euomphalus depressus	*Euomphalus depressus*
Cypricardia rhombea	*Cypricardia rhombea*
Cypricardia contracta	*Cypricardia contracta*
	Spirifer disjunctus

Mr. Carll does not give his locality, but as he describes a quarry four miles north of Panama, it may be inferred that he obtained some of them there. This is the locality mentioned by Prof. Hall.

One curious fact is the great discordance between the two accounts of the rock. Prof. Hall says :

"Fossils are exceedingly rare in this rock, having been seen in one locality only, four miles north of Panama."

Mr. Carll says :

"One of the exceptional features of the Panama rock is the great abundance of fossils found associated with it, and even in the pebble mass itself."

Probably, judging from the resemblance between the lists given above, the abundance of fossils is a local character of the rock. In this way we may perhaps reconcile the two accounts.

Without laying too much stress on a single species, it may be worth consideration whether or not the Panama conglomerate of Report III may be of approximately the same age as the Kingsmill white sandstone above described.

The following points of resemblance may be noted :

1. The Kingsmill sandstone is often conglomeratic.

2. The Kingsmill sandstone contains abundance of flat lenticular quartz pebbles. I have never seen a pebble of any other shape in it. This is a distinguishing feature of the Panama rock according to Mr. Carll and Mr. Ashburner.

3. The Kingsmill sandstones contain abundance of fossils, among which, in one locality at least, is found in profusion *Schizodus rhombeus*, one of the three characteristic species of the Panama rock.

The Sub-Olean or Sub-Garland conglomerate of Messrs. Carll and Ashburner is the only other conglomerate in that part of Pennsylvania holding similar flat pebbles. See Rep. III.

I have not yet identified with certainty either of the other three species mentioned by Prof. Hall and Mr. Carll to occur near Panama in the conglomerate, but so far as I have yet observed *Schizodus rhombeus* is strictly limited in Perry county to this single bed of sandstone not exceeding ten feet in thickness. A scarce form, usually imperfect, much resembles *S. contractus* (*Cypricardia contracta*), and may prove to be so. The Gasteropods are in so ill preserved a condition that their identification is attended with great difficulty.

If any importance be attached to this suggestion, it only remains to point out the horizon of the Kingsmill sandstone, which admits of no doubt, although it may admit of slight differences of opinion. As mentioned at the beginning of this note, it lies near the base of the great "Ponent" seriet. of Prof. Rogers. It must, therefore, be about the top of the Chemung or the base of the Catskill of New York, or perhaps better in what we may call the "Chemung-Catskill passage beds." It is not probable that the palæontological evidence, when complete, will warrant the placing of this sandstone and its associated strata fully within either of these two great groups of New York.

The Kingsmill standstone cannot of course be a continuation, unchanged, of the Panama conglomerate for, according to the testimony of Mr. Carll and Mr. Ashburner, the latter graduates down into soft shales when followed a few miles to the south-east of Panama. But it may be a bed on the same or nearly the same horizon, and the deposit of a sea tenanted by the same species. It may even be a continuation of the same bed taking on its sandy nature again in consequence of changed conditions.

It only remains to add that, though the three or four species above enumerated form the whole of the known fauna of the Panama conglomerate*

* The list of fossils from the Panama conglomerate or its associated conglomerates has apparently been increased since the publication of the Geology of New York, by the addition of the following three species :

Edmondia æquimarginalis = *Cardinia æquimarginalis* Win.
Allorisma Hannibalensis = *Grammysia Hannibalensis* Shumard.
Sanguinolites clavulus Hall.

in New York, yet the Kingsmill sandstone contain a rich fauna, the names of which will form, when worked out, a long list.

In addition to what has been said above concerning the fossils of the Panama conglomerate, the following notes are worthy of a little space.

Prof. A. Winchell in a paper printed in the Proceedings of the Acad. of Nat. Sciences, 1865, says, when speaking of the fossils of the Marshall Group of Michigan :

"Perhaps the most interesting feature of all is the identification of four Western species with fossils contained in the supposed Carboniferous conglomerate of Western New York. These are :

Euomphalus depressus Hall = *Straparollus Ammon* White.
Cypricardia contracta Hall = *Edmondia bicarinata* Win.
= *Sanguinolites rigidus* Win.
= *Cypricardia rigida* White and Whitf.
Edmondia æquimarginalis Win.
Allorisma Hannibalensis Shum.

"Further than this, two of the above species—*E. æquimarginalis* and *Allorisma Hannibalensis*—occur in what has been regarded as another conglomerate whose position is beneath the first, and at the top of the Chemung rocks of Western New York."

In regard to this last remark, Mr. Ashburner in Report III, pp. 70–79, says that the Panama conglomerate is the lowest sandstone in the N. W. of Pennsylvania and S. W. of New York. He says that an oil well sunk close to the base of the Panama rock passed through 1200 feet of soft shale and slate, and that other wells in the region gave similar sections. He says that, granting all the conglomerates cropping out and forming rock-cities along the State line hills to be distinct beds, they lie thus :

1. Olean (Garland = Sharon = Ohio).
2. Sub-Olean, Sub-Garland, Shenango.
3. Tunangwant.
4. Salamanca.
5. Panama.

On his view, therefore, there is no older conglomerate than the Panama in the region.

Prof. Winchell argues that because these four species occur in the Marshall Group in Michigan, and in the Panama (or its equivalent) conglomerates of New York, therefore the Marshall Group is more or less the equivalent of these conglomerates which he assumes to be of Lower Carboniferous age as stated in the Geology of New York. Consequently, he infers that the Marshall grits and conglomerates of Michigan are of Lower Carboniferous age. The evidence given above, shows that one of the species of the Panama conglomerate is not Lower Carboniferous, but belongs at the base of the Catskill. The other species may be found in the same horizon. The inference from this datum, somewhat slender it is true, is that the Panama conglomerate belongs to the base of the Catskill, and probably also the Marshall grits of Michigan.

No representative of the Catskill has yet been found or recognized so far as I am aware in Michigan. A gap is left in the Michigan section between the Chemung and the Lower Carboniferous.

Mr. Lesley remarked on this paper of Prof. Claypole's, that he could not agree with the sentiment expressed in its introduction respecting the doubtful propriety of the use of the term "Catskill formation" as an equivalent of Prof. Roger's "Ponent formation."

It is a mistake to suppose that the "Catskill formation" was based in any degree upon fossil forms, any more than was the "Ponent." The two terms are completely and exactly identical. The New York geologist meant by it the red rocks constituting the Catskill Mountain massif, overlooking the Hudson valley, and extending unbroken far into Pennsylvania, and in fact through Pennsylvania into Maryland and Virginia. It was described as a pile of nearly horizontal Devonian strata destitute of fossils remains, except a few macerated plants and one or two types of fish. Mr. Rogers had to describe the same mass of strata, with the same lithological constitution and topographical aspect, and perfectly continuous with it geographically. There never was any question, nor is there now any question of the identity of this mass of strata in the two States. But as Mr. Rogers declined to accept any of the Palæozoic names of New York and invented a new nomenclature for his own use in Pennsylvania, he substituted *Ponent* for "Catskill," as he substituted *Medidial* for "Oriskany," *Postmedidal* for "Upper Helderberg," *Cadent* for "Hamilton," *Vergent* for "Chemung and Portage," &c. The only essential change he made was in giving a separate name, *Vespertine*, to the gray sandstone strata forming the *peaks* of the Catskill. These had been left unnamed (or included under the general name "Catskill") because the N. Y. geologists had no clue to their topographical significance, which only appears after passing west of the Lehigh, where, upturned vertically, they constitute a separate range of mountain.

In the reports of the Second Geological Survey the transcendental nomenclature of the brothers Rogers has been set aside in favor of the older, classical and generally accepted nomenclature of the New York geologists. As the gray sands of the Catskill peaks form the top coating of the Pocono tableland in Pennsylvania, the name "Pocono" has been substituted for *Vespertine;* but this leaves the term *Ponent* represented, as it always has been, by "Catskill."

The discussion in New York respecting the lower limit of the Catskill formation (recently settled by the proper placing of the Oneonta sandstone) has always left the great Catskill formation unaffected. So in Pennsylvania, the 100′ of transition beds at the bottom of the *Ponent* and at the top of the *Vergent,* do not affect in the least the broad fact that *Ponent* is "Catskill" and *Vergent* is "Chemung." No palæontological discoveries can ever alter these established relationships.

The discovery of Catskill fish-forms down in the Chemung has no more bearing on the name "Catskill" than it has on the name *Ponent;* for "Catskill" and *Ponent* are merely synonyms for the 3000′ + of red and gray sands and shales of the Catskill-Pocono-Alleghany mountain range which present a continuous outcrop from the Hudson to the Potomac.

The discovery of Catskill fish-forms down in the Chemung merely adds one more item of evidence to the now almost accepted conviction that the task of devising geological names of the first and second order cannot safely be entrusted to palæontologists, but that they must limit their function as namers of strata to names of the third and fourth order, as the geologists of the continent of Europe have been content to do for some years back, designating the groups of beds in a subdivision of a formation by some characteristic fossil form; as, for instance:—TRIAS; 1. Grés bigarré; 1. b. *Grés à Woltzia.* The fact is becoming patent to all eyes, that the occurrence of special fossil forms in a rock is no evidence of the exact age of that rock until after its exact age has been settled topographically or structurally.

If then the new fish-form be a Catskill fish found in Chemung rocks, it will not make the upper part of the Chemung, Catskill. It merely happens that a Chemung fish is also a Catskill fish. And so of any other fossil form discovered under similar circumstances.

Mr. Lesley added that the discovery of the Kingsmill White Sandstone fossils by Prof. Claypole is important for the future settlement of the question: What becomes of the Catskill formation going west into Western New York, Ohio and Michigan? If we could trust the evidence of fossil forms for establishing a lithological horizon — if we were sure that there were an immovable horizon extending more than 500 miles (S. E. and N. W.) characterized by Hall's *Euomphalus depressus,* and *Cypricardia contracta,* Winchell's *Edmondia æquimarginalis,* and Shumard's *Allorisma Hannibalensis*—and if this horizon be seen at Marshall in Michigan just under the *Coal measures,* at Panama in Western New York considerably below the *Venango Oil measures,* and in Perry County, Middle Pennsylvania, just below the bottom of the great *Catskill formation*—everybody who believes in this kind of evidence must accept the conclusion that there is a *time gap* in the Michigan and Northern Ohio section to be measured by many thousand feet of Pennsylvania strata, the majority of which are Catskill; and that this gap happens between the "Marshall grit" of Michigan and the next overlying strata.

But the fact must be kept in view, that no interval of time can elapse between emergence and resubmergence, without the interval being accented by erosion which has gone on during the interval. If the time interval in question extended through the Catskill era, Michigan standing above sea level, there should not only be a plane of paleontological nonconformity, but also nonconformable bedding; and, in soft Devonian measures, this would be deeply sculptured. None such being known in Michigan, we must conclude that the time-interval was spent *under water;* but in that case sedimentation must have gone on. We are therefore shut up to the conclusion that several thousand feet of Perry County, Pennsylvania, deposits are represented by a few yards, feet, or perhaps only inches of Michigan rocks; yet nevertheless perfectly and conformably represented.

Early Records of the Society.

Mr. Lesley, in reporting the completion of his MS. Condensed Copy of the Minutes of the Society, upon which be has been engaged, at intervals, during the last two years, said:

These Minutes, preserved in ten volumes, commence with Franklin's letter of 1744, and reach to the last meeting in December, 1837, after which the Proceedings were regularly printed for the use of the members, at first four times, and then twice a year, the first issue of 1838 being numbered 1, and the last issue of 1882, 112.

Vol. I,	1838, 1839, 1840, contains	Nos. 1 to 14.
Vol. II,	1841'3, contains	Nos. 15 to 26.
Vol. III,	Celebration of the Hundredth Anniversary, No. 27.	
Vol. IV,	1845'7, contains	Nos. 28 to 39.
Vol. V,	1848 to 1853—	Nos. 40 to 50.
Vol. VI,	1854 to 1858—	Nos. 51 to 60.
Vol. VII,	1859 to 1860—	Nos. 61 to 64.
Vol. VIII,	1861, contains	Nos. 65 and 66.
Vol. IX,	1862 to 1864—	Nos. 67 to 72.
Vol. X,	1865 to 1868—	Nos. 73 to 80.
Vol. XI,	1869 and 1870—	Nos. 81 to 85.
Vol. XII,	1881 and 1872—	Nos. 86 to 89.
Vol. XIII,	1873 and 1874—	Nos. 90 and 91.
Vol. XIV,	1875, contains	Nos. 92 to 95.
Vol. XV,	1876, contains	No. 96.
Vol. XVI,	1876 and 1877, contains	Nos. 97 to 99.
Vol. XVII,	1877 and 1878—	Nos. 100 and 101.

Vol. XVIII,	1878 to 1880—	Nos. 102 to 106.
Vol. XIX,	1880 and 1881—	Nos. 107 to 109.
Vol. XX,	1881'2'3—	Nos. 110 to 113.
Vol. XXI,	1883, June onward,—	No. 114.

I propose that as a substitute for Vol. I, now out of print, the Society shall print a Vol. I, beginning in 1744 and containing the condensed Minutes of ninety-six years, *i. e.*, up to the beginning of 1841, thus including a condensed reprint of the present Vol. I.

The MS. which I lay on the table consists of reports of the Proceedings of every stated, adjourned or special meeting in more than seventy years, *condensed ;* omitting nothing of the nature of an act or fact however unimportant, but stating it in the fewest possible words, and using a certain number of easily understood contractions, such as Soc., Lib., Don., Com., for Society, Library, Donations, Committee, &c., in order to get as many paragraphs as possible to occupy each not more than one line of printed text.

Another means made use of for diminishing the bulk of the MS. was the omission of all titles and initials to proper names, except in cases where the title or initial was needful to distinguish one individual from another of the same name.

With the same object in view, the lists of members present at meetings subsequent to 1800 are only given on important occasions, or at times when the Society was specially active or specially inactive, or after numerous admissions of new members, or at elections, or during debates protracted from meeting to meeting.

Much space was saved, and great clearness given to the record, for consultation, by ignoring most of the prolix formality and tedious verbiage of both minutes and resolutions. Short formulæ were adopted for many of the constantly recurring proceedings, such as references to and reports from committees. But resolutions of the slightest financial or historical importance are given *verbatim ;* and where they are contracted or condensed, the essential wording is retained, and every word or sentence in the original is furnished in the copy with *quotation marks,* to obviate the necessity of reference to the original for the purpose of verifying the real meaning of the transaction.

Quotation marks are used throughout the copy, and by these the completeness of the copy as well as its fidelity, can be judged.

All unusual spellings of words and names are followed by the signal (*sic*). Many of the names of members are spelled by different Secretaries, in different years, and in the same year, in two or more ways ; as for example : Lesueur, Le Sueur, Le Seur ; Beesley, Beasley ; Du Ponceau, Duponceau ; Nicholls, Nicolls, Nichols ; Pennington, Penington ; and even Vaughan, Vaughn. Many of these variations are not due to careless transcription, but to unestablished orthography. This is especially apparent in the lawless variations in the use of initial capitals, especially in the earlier years. All these curious features of our minute books have been sedulously retained in making the copy.

All annotations are placed in brackets.

Side notes, corrections and blanks are noted.

Thirty or forty blank pages have been left, in different parts of the mass of copy, to be filled by a literal copy of the original MS. in such cases as the letters of Jefferson, or long resolutions, every word of which should be retained. This filling-in can be done by a careful copyist at any time previous to the publication of the copy, or while it is going through the press.

For nearly fifty years the records of the earlier years of our Society have stood exposed to destruction, especially by fire; and it is surprising that a copy of them has never been made before now. The present copy is preserved by the President in the fire-proof vault of the Western Saving Fund Society, Walnut and Tenth streets, to be forthcoming at the order of the Society.

Its publication would not only secure it against destruction, but would no doubt give lively satisfaction to the members of the Society, who would then for the first time be able to gratify a natural and affectionate curiosity respecting the origin, growth, struggles and labors of the venerable institution to which they belong. Most of the names of noted Philadelphians appear in these minutes, and many famous men of other States, and of foreign countries.

Not the least important feature of the record is its representation of the first appearance of potent ideas; the first efforts for the improvement of the mechanic arts; the first steps taken in scientific paths; early explorations of the New World; with a pronounced eagerness to import the faculties of the Old World into it. It is not so much a record of the growth of an American Society, as a record of the growth of society in America, and in this sense alone it possesses an extraordinary historical value.

If printed, it will make a volume of about 400 pages, and can be cursorily read through at two or three sittings. The reader will probably feel what the biologist feels while spending some hours in watching, through his microscope, the metamorphoses of one of the protozoa.

The printing will be cheap, as it is all plain copy, and will require little or no correction.

It should be printed as one of our set of Proceedings; and entitled "The Proceedings of the American Philosophical Society, Vol. I, Part I, from 1744 to 1838," or simply Vol. I, 1744 to 1848. It will then be placed by corresponding societies and libraries in its proper place at the beginning of the row of our Proceedings, the present Vol. I, will be recognized (even without reprinting its title page) as Vol. I, Part II. But it would be well for the Society to print an extra title page, to go out with it, and be pasted by our correspondents over the old title page of Vol. 1, designating that as Part 2.

The principal use of this volume, *well indexed,* will be for referring to the past action of the Society on subjects of order and discipline, ownership of property, and financial investments, which have always necessitated references to the written minutes tedious and often unsatisfactory. Also, when questions arise as to the ownership and history of the objects of art and books in the possession of the Society, this printed record will be found convenient.

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