PROCEEDINGS

OF THE

Washington Academy of Sciences

Vol. XI

1909

WASHINGTON
MARCH-DECEMBER, 1909

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PROCEEDINGS

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WASHINGTON ACADEMY OF SCIENCES

VOL. XI, No. 1, PP. 1–16 Figs. 1–8 MARCH 31, 1909

SOME CALCITE CRYSTALS WITH NEW FORMS.

BY WALDEMAR T. SCHALLER.

1. CALCITE FROM ANDREASBERG

Several specimens of calcite labeled "Andreasberg, Harz Mts.," were purchased from a local mineral dealer. One specimen shows large tabular crystals with only the base {0001} and prism {10$\bar{1}$0}. Other specimens consist of groupings of tabular crystals which are somewhat unusual in their combinations. These tabular clacites are arranged in superimposed parallel, or nearly parallel groupings forming vertical columns several cm. long, the individual crystals being up to 13 mm. wide and to 5 mm. high. The dominant forms on these crystals are the base {0001} and prism {10$\bar{1}$0} but characteristically all of them also show the new prism $\dot{\imath}$ {7.6.$\bar{1}$3.0} as narrow rounded faces. Very narrow faces of s\{05$\bar{5}$1\} and minute faces of v\{21$\bar{3}$1\} are frequently present. Some of these crystals which seemingly consist of a single crystal show an easy parting parallel to the base and may be built up of numerous thinner tabular ones in parallel position. Associated with these calcites are numerous fourlings of harmotone.

Measurements of the ϕ angle for s\{05$\bar{5}$1\} varied from 78° 38′ to 78° 47′; calc. = 78° 32′.

The dihexagonal prism faces are bright but rounded, so that no accurate measurements could be made. They gave, however, a bright signal in the mass of reflections caused by the rounded surfaces and the measurements given below were of this bright signal.

The faces are seen to be in the prism zone mm' and therefore could not be scalenohedrons with complex indices.

ϕ meas.	= 27° 34′	ϕ calc. $\{7.6.\bar{13}.0\}$ = 27° 27′
	20	
	32	
	37	
Av. =	27° 31′	

This prism face is present on all of the crystals, of which but few, however, are suitable for measurement. The results just given were all obtained from one crystal. It seems odd that this form has not been described before—at least the writer could find no mention of it in the literature—as the specimens are supposed to come from a locality so well known for its calcites.

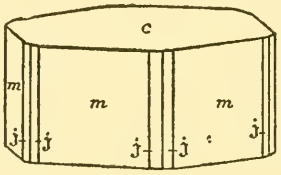

Fig. 1

It seems hardly correct to regard these prism faces as corrosion forms or some other secondary formation. While the base and prism faces on these calcites are dull, they do not show any definite signs of etching, and though the new prism faces are rounded, they are considered as belonging to a well established form for calcite. As stated, the form occurs on all of the crystals, and all twelve of the faces are present on each crystal. They are shown in fig. 1.

2. Calcite from England

The crystals here described are from a group containing individual ones, the largest of which measure 4 cm. by 2 cm. The exact locality is not known. The crystals have a trigonal habit due to the predominance of a steep negative rhombohedron. The forms present on these crystals are: $r\{10\bar{1}1\}$, $M\{40\bar{4}1\}$, $n\cdot\{50\bar{5}1\}$, $y\cdot\{60\bar{6}1\}$, $o.\{11.0.\bar{11}.2\}$, $e\{01\bar{1}2\}$, $f\{02\bar{2}1\}$, $d\{08\bar{8}1\}$, $C\cdot\{0.13.\bar{13}.1\}$,

$n\{4153\}$, $G:\{7295\}$, $w\{3145\}$, $v\{2131\}$, $r\{5382\}$, $y\{3251\}$, and a new form **p** $\{4.20.\bar{2}4.7\}$. The following table gives the average of the measured angles compared with the calculated value.

LETTER	SYMBOL	NO. MEAS.	MEASURED		CALCULATED	
			ϕ	ρ	ϕ	ρ
M	$40\bar{4}1$	3	0° 02′	75° 48′	0° 00′	75° 47′
n	$50\bar{5}1$	2	0 02	78 11	0 00	78 32
o	$11.0.\bar{1}\bar{1}.2$	1	0 12	79 35	0 00	79 33
y	$60\bar{6}1$	2	0 02	80 11	0 00	80 24
e	$01\bar{1}2$	2	0 00	26 15	0 00	26 15
f	$02\bar{2}1$	5	0 00	63 07	0 00	63 07
d	$08\bar{8}1$	4	0 00	83 01	0 00	82 46
C	$0.13.\bar{1}3.1$	1	0 12	85 30	0 00	85 32
n	$41\bar{5}3$	1	10 55	56 22	10 54	56 26
G:	$72\bar{9}5$	3	12 22	58 22	12 13	58 14
w	$31\bar{4}5$	2	14 25	35 05	13 54	35 25
v	$21\bar{3}1$	2	19 07	69 10	19 07	69 02
r	$53\bar{8}2$	8	21 43	74 28	21 47	73 51
y	$32\bar{5}1$	2	23 21	77 02	23 25	76 54
p	$4.20.\bar{2}4.7$	13	8 56	72 09	8 57	72 20

The indices of the form above referred to as $\{4.20.\bar{2}4.7\}$ could not be definitely determined. Many faces of this form are present in these crystals, in fact, the form is a characteristic one for this group as it is present on all the crystals. But it is always rounded and uneven and will give when mounted on the goniometer, either a group of reflections or else two or three distinct signals. The various measurements for this form are given below.

CRYSTAL NO.	SIZE OF FACE	NO. SIGNALS	REFL.	Calc. ϕ = 8° 57′	Calc. ρ = 72° 20′	
1	minute	2	p.	8° 17′	72° 08′	signal distinct.
			p.	8 20	71 36	signal very faint.
			f.	8 23	71 40	signal distinct.
1	small	3	p.	8 20	72 08	signal very faint.
			p.	8 23	71 15	signal very faint.
			f.	8 48	71 59	signal distinct.
1	small	3	p.	8 26	71 31	signal very faint.
			p.	9 01	72 19	signal very faint.
			p.	8 23	71 40	signal distinct.
1	small	3	p.	8 46	71 05	signal distinct.
			p.	9 06	72 19	signal distinct.
2	minute	1	p.	8 54	72 15	signal very faint.
			f.	9 13	72 17	signal distinct.
2	small	3	p.	8 52	71 58	signal very faint.
			p.	8 15	71 30	signal very faint.
2	small	1	f.	9 56	72 20	many signals.
			f.	10 19	73 23	signal very faint.
2	small	3	p.	9 24	72 04	signal very faint.
			p.	10 17	73 43	signal very faint.
			f.	9 16	72 41	signal distinct.
2	minute	2	p.	8 37	71 48	signal very distinct.
3	small	2	p.	8 44	71 56	signal distinct.
			p.	9 23	72 38	signal distinct.
			p.	9 07	72 38	signal distinct.
3	small	2	p.	8 34	71 58	signal distinct.
3	minute	1	p.	9 15	72 36	one distinct signal.
3	small	1	p.	8 48	72 51	signal distinct.

Average of meas. of 13 faces 8° 56′ 72° 09′

An average of the values with "signal distinct" is 8° 45′ 72° 11′ or nearly the same.

While these measurements are near to the angular values of the simple form $\{15\bar{6}2,\}$ which are $\phi = 8°57'$, $\rho = 70°00'$, the ρ angle is sufficiently different to preclude their reference to this form. If we take the average measured value $\phi = 8°56'$, $\rho = 72°09'$, we find that the ratio $h:k = 1:5$ (ϕ calc. $= 8°57'$), while the ratio $i:l = 3.392$ which gives as the indices $1.5.\bar{6}.1\frac{3}{4}$ or $4.20.\bar{24}.7$, which are not especially complex and the calculated angles for which are $\phi = 8°57'$, $\rho = 72°20'$

agreeing fairly well with the average of the above given measurements. The above detailed description is given in order to call attention to these trigonal calcites in the hope that some one would find a similar group having this new form which would admit of accurate measurement and thereby definitely determining the symbol of this form.

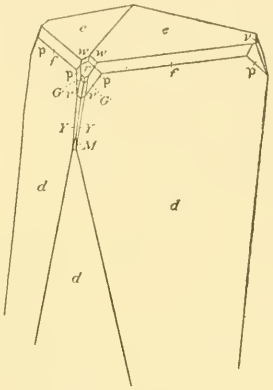

Fig. 2

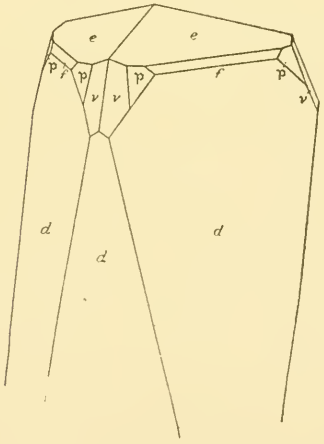

Fig. 3

A single minute face of $C\cdot\{0.13.\bar{1}3.1\}$ was noted and this was poorly developed, giving a poor reflection. Sansoni[1] gives this form

[1] Zeit. Kryst. Min., x, 564.
[2] Min. Pet. Mitth. xii, 487, 1891. (Ref. Z. Kryst., xxiv, 431.)

as new and it is also described by Höfer[2] as new, being determined by zonal relations; but it is considered as doubtful by Goldschmidt,[3] he suggesting that the correct symbol may be $\{0.14.\bar{1}4.1\}$ though Sansoni's measurements, like the writers above, agree well for $\{0.13.\bar{1}3.1\}$. Fig. 2 shows one of the smaller crystals of this group with the important forms developed at one corner. As shown in this figure, the combinations vary at similar crystallographical places, being ofttimes much simpler at some corners than others. While all the intersection lines are here drawn straight, most of them are considerably curved on the crystals, this being particularly true of the larger crystals, which, moreover, show a much simpler combination than the smaller ones. Fig. 3 is an attempt to show the actual appearance of these larger crystals.

3. CALCITE FROM CALIFORNIA

The crystals here described were collected by the writer some years ago. They occurred in cavities in what seems to be an altered rock near Fort Point, San Francisco. They were found in the same locality which has furnished pectolite and datolite[4] as well as apophyllite and gyrolite[5] though the crystals here described were not found directly associated with any mineral other than quartz. The crystals are of the common scalenohedral *v* habit of calcite with *e* and *r* as termination, and often reach a size of several cms. They differ somewhat from the ordinary calcite crystals, in that the form $\gamma\{53\bar{8}2\}$ is almost always present as a very narrow face below *v* and minute faces of $N\{4.16.\bar{2}0.3\}$ are also almost always present. One single crystal, colorless and transparent, and about 4 mm. in diameter showed some differences from the other crystals and was therefore measured. The essential difference was that the *e* faces were replaced by two faces of $y:\{235\bar{8}\}$, the *e* faces being entirely absent. In addition a new form in the zone *r e* was noted. The forms present on this crystal are: $r\{10\bar{1}1\}$, $v\{21\bar{3}1\}$, $\gamma\{53\bar{8}2\}$, $y:\{235\bar{8}\}$, $N\{4.16.\bar{2}0.3\}$, and the new form $\mathfrak{k}\{1.6.\bar{7}.13\}$. The average measured angles are compared with the calculated one in the following table:

[3] Index. Kryst. Form. I, 388.
[4] Bull. Dept. Geol. Univ. Cal., ii, no. 10, 1901.
[5] Bull. U. S. Geol. Survey, *262*, 124, 1905.

LETTER	SYMBOL	NO. MEAS.	MEASURED		CALCULATED	
			ϕ	ρ	ϕ	ρ
v	$21\bar{3}1$	2	19° 04′	69° 04′	19° 07′	69° 02′
r	$53\bar{8}2$	2	21 42	74 13	21 47	73 51
y:	$23\bar{5}8$	6	23 22	28 19	23 25	28 15
N	$4.16.2\bar{0}.3$	4	10 55	80 32	10 54	80 35
k	$1.6.\bar{7}.13$	3	7 31	26 27	7 35	26 27

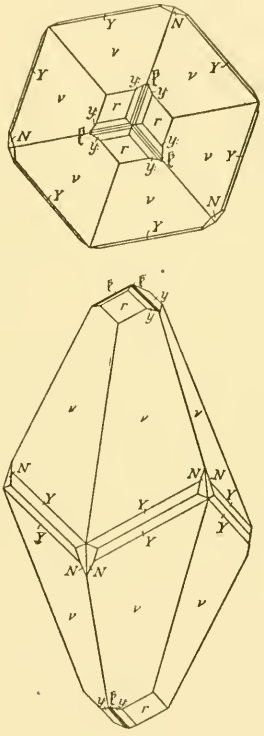

Fig. 4

Only three faces of the new form are present. They are all narrow and bright but striated like almost all the faces in this zone. This striation caused the reflections, particularly the first one, to broaden out so that accurate measurement was not possible. The three measurements are:

calc. for $\{1.6.\bar{7}.13\}$	$\phi = 7°\,35'$	$\rho = 26°\,27'$
meas. (1)	$= 7\ 57$	$= 26\ 34$
(2)	$= 7\ 04$	$= 26\ 24$
(3)	$= 7\ 01$	$= 26\ 24$

The form is considered as well established. It is shown in fig. 4 which illustrates the ideal combination found on the crystal measured.

4. CALCITE FROM NEW MEXICO

These crystals were received from Mr. C. H. Gordon, the locality being Macey's Mine, 2½ miles east of Hillsboro, New Mexico. They are in loose crystals, a centimeter thick and somewhat longer and are associated with large endlichite crystals. The calcites often have partially adhering white or pink gangue. Almost all the crystals, usually doubly terminated, show only the prism $m\{10\bar{1}0\}$ and the negative rhombohedron $e\{01\bar{1}2\}$. The e faces are striated parallel to their intersection with r while the prism faces are covered with triangular markings or etch figures. These triangular markings always point toward the e face, the base of the triangle being nearest the r face.

Two crystals showed considerable differences from the others and were therefore measured with the results given below. Crystal no. 1 is prismatic, 12 mm. long and 4 mm. thick, is colorless and transparent. It is shown in fig. 5 which represents the crystal as it actually is, excepting that the narrow scalenohedra in the zone r e are not shown. The forms present on this crystal are: $m\{10\bar{1}0\}$, $a\{11\bar{2}0\}$, $r\{10\bar{1}1\}$, $M\{40\bar{4}1\}$, $\omega\{28.0.\bar{2}\bar{8}.1\}$, $e\{01\bar{1}2\}$, $w\{31\bar{4}5\}$, $G\{52\bar{7}9\}$, $t\{21\bar{3}4\}$, $v\{21\bar{3}1\}$ and the new form $\mathfrak{l}\{3.10.\bar{1}\bar{3}.3\}$.

The following table shows the angular values:

LETTER	SYMBOL	NO. MEAS.	MEASURED		CALCULATED	
			ϕ	ρ	ϕ	ρ
r	$10\bar{1}0$	3	0° 01′	44° 36′	0° 00′	44° 36′
M	$40\bar{4}1$	3	0 01	75 44	0 00	75 47
ω	$28.0.\bar{2}\bar{8}.1$	3	0 01	87 48	0 00	87 55
e	$01\bar{1}2$	1	0 05	26 16	0 00	26 15
w	$31\bar{4}5$	1	14 08	35 20	13 54	35 25
G	$52\bar{7}9$	2	15 56	34 27	16 06	34 23
t	$21\bar{3}4$	1	19 55	32 57	19 07	33 07
v	$21\bar{3}1$	4	19 06	69 07	19 07	69 02
$\mathfrak{l}$	$3.10.\bar{1}\bar{3}.3$	2	12 56	75 33	12 44	75 31

For the new form $l\{3.10.\bar{13}.3\}$ only two faces are present both of which gave poor reflections, one much more so than the other. The one giving a poor but distinct signal, gave:

$$\phi = 12° 54' \text{ (calc.} = 12° 44')$$
$$\rho = 75\ 36 \text{ (calc.} = 75\ 31)$$

The limits of repeated measurements of these two faces gave:

calc. for $\{3.10.\bar{13}.3\}$	ϕ = 12° 44′	ρ = 75° 31′
meas. (1)	12° 42′ – 13° 03′	75° 30′ – 75° 36′
meas. (2)	12 24 – 13 17	75 29 – 75 36
Average..	12° 56′	75° 33′

The form was seen to lie in the zone *rm* and measurement of the angle $(10\bar{1}1) : (\bar{13}.10.3.3)$ gave 50° 35′ (calc. 50° 16′). The form, considered as well established is shown in fig. 5.

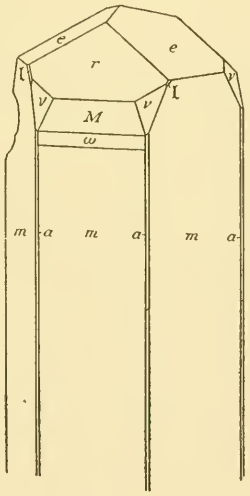

Fig. 5

Crystal no. 2 is incomplete, and as now formed, nearly equidimensional, measuring a centimeter in diameter. It is colorless and while transparent in part, is cloudy and translucent in other places. The forms present on this crystal are: $m\{10\bar{1}0\}$, $r\{10\bar{1}1\}$, $e\{01\bar{1}2\}$, $f\{02\bar{2}1\}$, and the three new forms $o\{0.14.\bar{14}.17\}$, $O\{8.2.\bar{10}.3\}$,

$\mathfrak{q}\{2.16.\bar{1}8.1\}$ of which the latter is doubtful. The angular values are given in the following table:

LETTER	SYMBOL	NO. MEAS.	MEASURED		CALCULATED	
			ϕ	ρ	ϕ	ρ
r	$10\bar{1}1$	1	0° 29′	44° 56′	0° 00′	44° 36′
e	$01\bar{1}2$	3	0 00	26 15	0 00	26 15
f	$02\bar{2}1$	2	0 00	63 33	0 00	63 07
o	$0.14.\bar{1}4.17$	3	0 00	39 02	0 00	39 05
O	$8.2.\bar{1}0.3$	2	10 29	70 58	10 54	71 38
$\mathfrak{q}$	$2.16.\bar{1}8.1$	4	5 43	86 33	5 49	86 36

The large faces of $O\{8.2.\bar{1}0.3\}$ are dull and give no distinct signal, only a blaze of light. Two faces were measured with the following result:

calc. ϕ	= **10° 54′**	ρ	= **71° 38′**
meas. (1)	= 10 21	meas. (1)	= 71 07
meas. (2)	= 10 36	meas. (2)	= 70 48

Although the faces are dull and give no distinct reflections, the measurements serve to fix the indices and as the form occurs in large plane faces it is considered as well established. The corresponding negative scalenohedron $B\{2.8.\bar{1}0.3\}$ has been noted a number of times. Measurements for the form $o\{0.14.\bar{1}4.17\}$ are as follows, the faces being bright and giving fairly good reflections.

The angles between the three faces of this form and e were measured.

$0.14.\bar{1}4.17 : 01\bar{1}2$	= 12° 52	− 12° 53′	ρ = 39° 07′ − 39° 08′
	= 12 44	− 12 45	= 38 59 − 39 00
	= 12 43	− 12 44	= 38 58 − 38 59
		Average (ρ)	= 39° 02′
		limits, 38°58′ −	39° 08′

The only form for which the angle agrees is the complex one $\{0.14.\bar{1}4.17\}$. Two simple ones which approximate to $\{0.14.\bar{1}4.17\}$ are given in the table below, but as can be seen neither one is sufficiently close to the measured values.

calc. for $\{05\bar{5}6\}$,	= 39° 25′
calc. for $\{0.9.\bar{9}.11\}$	= 38 54

Four faces of the form $\{2.16.\bar{1}\bar{8}.1\}$ are present, the remainder of the crystal having cleaved off. While all the faces are bright, they are very rounded and in some cases form with $m\{10\bar{1}0\}$ a rounded surface. They gave, however, a bright signal in the midst of the mass of signals caused by the rounded surfaces and it is these single bright signals that were measured.

calc. ϕ =	5° 49′	ρ = 86° 36′
meas.	5 48	86 39
	5 31	86 27
	5 54	86 33
	5 37	86 33
Av. =	5 43	86 33

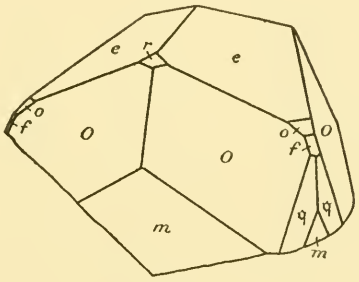

FIG. 6

Measurements of the prism face (in zone *cem*) gave $\rho = 89° 58'$ instead of 90° 00′. While the above measurements agree very well with the calculated angles, the form cannot be considered as determined, as it is too rounded. It must be classed as a doubtful form. The forms are shown in fig. 6, in which it is attempted to show the crystal as it actually is.

5. CALCITE FROM RHODE ISLAND

The crystals here described were received from Mr. A. L. Stevenson of Providence, R. I., and the locality is given as Dexter Lime Quarry, Lincoln, R. I. To the kindness of Mr. Stevenson in sending the specimens the writer's thanks are due. The crystals are on limestone and are associated with a pearly mineral forming almost color-

less spherulites which have become brown on the surface. Other specimens show "nacrite," a talcose or micaceous mineral, quartz in flattened crystals, and curved rhombohedra of dolomite.

The calcite is found in three types of crystals:

(1) simple rhombohedra $r\{10\bar{1}1\}$, abundant.

(2) crystals apparently prismatic and more fully described below.

(3) scalenohedral crystals showing large faces of $v\{21\bar{3}1\}$, but the crystals were so rounded that no measurements were made of them. Those of the second type are found on the rhombohedra of the first type and are not over several millimeters long while the simple rhombohedra are seldom over a millimeter thick. While the rhombohedral crystals are usually smooth and bright, those of the second type are very much etched and rounded, making it difficult to obtain satisfactory readings. The crystals have a prismatic appearance due to the presence of the negative rhombohedron $\Psi\{0.17.\bar{17}.1\}$ and a form vicinal to $a\{11\bar{2}0\}$ and having the approximate symbol $\mathfrak{t}\{17.16.\bar{33}.1\}$. No prism faces were noted on the single crystal measured. The forms present are: $e\{01\bar{1}2\}$, $\varepsilon\{01\bar{1}1\}$, $\Psi\{0.17.\bar{17}.1\}$, $S:\{11.8.\bar{19}.3\}$?, $\mathfrak{t}\{17.16.\bar{33}.1\}$?. The faces of most of these forms were so poor that the correct symbols could not be definitely determined. Fig. 7 shows the general appearance of the crystal except that while the intersection of two faces is here shown as a straight line on the crystal they are frequently curved and rounded. The

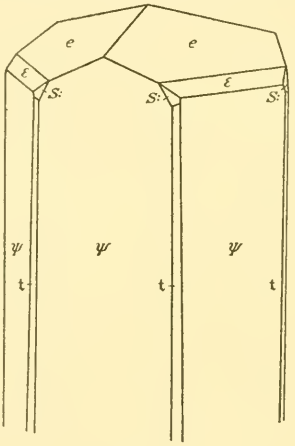

Fig 7.

crystal was set in polar position by means of the *e* faces and the other forms gave the following measurements:

$\varepsilon\{01\bar{1}1\}$. ρ calc. = **44° 36′**	meas.	47° 53′
		45 45
		42° – 45°

All faces gave a mass of signals.

$\Psi\{0.17.\bar{17}.1\}$ ρ calc. = **86° 35′**	meas.	87° 07′
		86 12
		86 45
		86 16
		86 30
		86 approx.

All faces gave merely a mass of brightness and the angles measured represent the center of this mass.

S:$\{11.8.\bar{19}.3\}$, calc. ϕ = **24° 48′**	ρ =	**79° 34′**
meas. = 25 15	=	78 42
meas. 25 35		78 05

t$\{17.16.\bar{33}.1\}$ calc. ϕ = **28° 59′**	ρ =	**87° 58′**
meas. = 29 27	=	88 08
meas. = 28 41		87 51
meas. = 29 21		87 21
meas. = 28 26		87 28

The agreement is only approximate, but the faces were so poor that only two out of the six could be even approximately measured.

Here again the symbol is only an approximate one. If we change the orientation of the crystal to that given by Goldschmidt in his Winkeltabellen the indices of this last form become $(49.1.\bar{5}0.1)$ and it is not possible to say whether they should not be, for instance, $(50.1.\bar{5}1.1)$, etc. Even in the orientation here taken, the average of the four measured angles agrees well for a number of forms.

Av. of 4 meas. angles	= 28° 59′	= 87° 42′
Calc. for $17.16.\bar{33}.1$	28 59	87 58
Calc. for $16.15.\bar{31}.1$	28 56	87 50
Calc. for $15.14.\bar{29}.1$	28 52	87 41

However, while the correct indices could not be determined, we have here a form with indices near to one of those given above and still too far removed from the prism $a\{11\bar{2}0\}$ to be referred to that form. The writer could find no form for calcite approximating to those just

given and the form would seem to be new, though it cannot be definitely determined.

6. CALCITE FROM TEXAS

A crystal of scalenohedral habit, from the Mariposa and Marfa Mine, Terlingua, Texas, associated with montroydite and terlinguaite showed the following forms, $r\{10\bar{1}1\}$, $\varepsilon\{01\bar{1}1\}$, $v\{21\bar{3}1\}$, $t\{21\bar{3}4\}$, $\mathfrak{s}\{12\bar{3}2\}$ and the new form $\mathfrak{h}\{11.5.\bar{16}.21\}$. The following table shows the measurements:

LETTER	SYMBOL	MEASURED		CALCULATED	
		ϕ	ρ	ϕ	ρ
ε	$01\bar{1}1$	0° 02′	44° 37′	0° 00′	44° 36′
t	$21\bar{3}4$	19 23	33 07	19 06	33 07
$\mathfrak{s}$	$12\bar{3}2$	19 06	51 34	19 06	52 32
$\mathfrak{h}$	$11.5.\bar{16}.21$	17 39	33 43	17 47	33 40

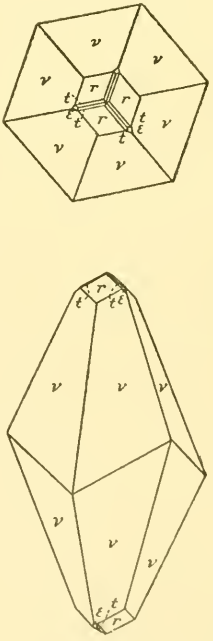

FIG. 8

The negative unit rhombohedron $\varepsilon\{01\bar{1}1\}$, a rare form, is present as three faces, all very small, giving poor reflections. The new form shows only one face, a very narrow one, not striated and giving a fair reflection. It is very close to $t\{21\bar{3}4\}$ with which it occurs. The signal is slightly blurred and measurements of the two sides of the signal gave:

$$\phi = 17° 25' \text{ to } 17° 53'; \ \rho = 33° 42' \text{ to } 33° 44'.$$
$$\text{calc.} = 17° 47'; \ \text{calc.} = 33° 40'.$$

While the indices are somewhat complex, if we change them to the orientation given by Goldschmidt (G_2) in his Winkeltabellen the indices become $\{72\bar{9}7\}$ and the form fits in well between two known forms.

$62\bar{8}2$ (G_2)
$72\bar{9}7$ new form.
$8.2.\bar{10}.8$ (G_2).

Though occurring but once the form is considered as well established. The crystal is shown in fig. 8, on which, however, the new form is not drawn, but its position can be easily determined as it lies very close to $t\{21\bar{3}4\}$.

SUMMARY

The new forms for calcite described in this paper are grouped together in the following table, the coördinate angles ϕ and ρ being given for each form.

Well established new forms

NO.	SYMBOL		ϕ	ρ
1	j	$7.6.\bar{13}.0$	27° 27′	90° 00′
2	o	$0.14.\bar{14}.17$	0 00	39 05
3	O	$8.2.\bar{10}.3$	10 54	71 38
4	ŋ	$11.5.\bar{16}.21$	17 47	33 40
5	k	$1.6.\bar{7}.13$	7 35	26 27
6	l	$3.10.\bar{13}.3$	12 44	75 31

Three doubtful forms are also described.

1 **p** {4.20.$\bar{2}$4.7}, probably correct symbols, but considered doubtful because the faces were too uneven to allow of satisfactory measurement.

2 **q** {2.16.$\bar{1}\bar{8}$.1}, a doubtful form too rounded for definite determination.

3 **t** {17.16.$\bar{3}\bar{3}$.1}, a doubtful form too rounded and uneven to allow of definite determination.

Chemical Laboratory, United States Geological Survey.

PROCEEDINGS
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. XI, PP. 17–26 MARCH 31, 1909

LINNÆUS AS AN EVOLUTIONIST.[1]

BY EDWARD L. GREENE.

Not more than two decades have passed since with most people who had interested themselves in such matters, and with quite all who had not, evolutionistic theory and Darwinism were synonymous; the supposition being that Charles Darwin had been the original inventor, as well as the strong promulgator, of the hypothesis of the descent of present-time species of living things from earlier types. That misunderstanding nowhere now prevails; and while a multitude of talkers and writers on all sorts of topics use freely the term evolution, Darwinism is less frequently mentioned; for it is coming to be realized somewhat generally that there were "Darwinians" not a few, not only before the Darwin of the nineteenth century, but even before that almost as remarkable grandsire Darwin of the eighteenth. There were evolutionists among the Greeks of five and twenty centuries ago, and even among the earliest luminaries of Christian philosophy and theology of a period only less remote; while after the revival of learning, and of an interest in nature study, evolutionistic ideas found expression not infrequently: and of late, historians of science are bringing all this to light.

The catalogue of more or less distinctly evolutionistic naturalists who lived before the end of the eighteenth century, and who gave some expression to their ideas on this topic, is not a short one; but the name of Linnæus has not, in so far as I can learn, been placed on that list hitherto, except very hypothetically.[2]

[1] Read before the Biological Society of Washington, November 11, 1905.

[2] In the environment of the idea of evolution Linnæus may be considered not as a positive but as one of the negative factors.—Osborne, From the Greeks to Darwin, p. 128.

For any possible expression of views as to the origins of groups of plants and the permanency or mutability of such groups, one would naturally look, not to his many volumes of taxonomic and descriptive writings, but to just such a work as the Philosophia Botanica. Yet there one looks in vain for any expression that is not positively and unmistakably contrary to the idea of evolution.

In respect to the origin of genera, that which he says—and with Aristotelian brevity and conciseness—is this: "Every genus is natural and was in the begininng of things created such."[3] And because of this—which might well enough be called the supernatural rather than the natural origin of genera—because of this origin, he argues that: "No one genus is ruthlessly to be divided and treated as if there were two; neither are any two or more to be put together as if constituting only one."

In the light of such a pronouncement, one could not attribute to Linnæus any notion of the gradual evolution of such groups of species as constitute genera; and if a genus is to have such origin, so, by the necessities of logic, are species also made; and he says: "All species are certain diversities of form which the Infinite Being created so in the beginning; which forms according to immutable laws of generation, produce always their like." From this he proceeds to establish more firmly, if possible, the immutability of species by defining generation as being the actual "continuation of the species;" and he concludes by calling attention to how, as by necessity, this origin of all species precludes the possibility of any new species ever arising. And thus, under the heading of species does our author seem to have builded even a more insurmountable wall against the possibility of one's successfully claiming him for the camp of the evolutionists.

There remains one other category of plant forms, of lower rank than species, recognized by Linnæus; that of varieties. Unless I err, he claimed that he had been the first of systematists to recognize varieties and to teach the distinctions between variety and species. Will he so define variety as to leave an opening for the possible development of a species out of that which started forth at first as a mere variety? If we use our own reason, and credit Linnæus with not momentarily forgetting to use his, we may not look to see him contradict himself

[3] Genus omne est naturale, in primordio tale creatum. Linn. Syst. Nat. and Philos. Bot.

quite so promptly. He has said, and that in the paragraph next preceding the definition of variety, that all species—not most of them but all of them—were constituted such by the Creator in the very beginning of the existence of plant life and form. He will not subvert this proposition; at least, not in the very next sentence. His notion of a variety is, that it is such alteration of a species as may have been induced by changed conditions of climates, soil, temperature, exposure to or shelter from high winds, or any such items of mere environment; and he does not fail to add that, on the restoration of the plant to its old environment, it reverts to the original type form. One sees at a glance that this is not our twentieth-century idea of a botanical variety; but it is the Linnæan idea, and with that alone we are here concerned. The man makes so small account of varieties, from the taxonomic point of view, that he concludes his discussion of the topic with an apology for giving them place and mention in his books of systematic botany. "Variation," he says, "is in such matters as the size of the plant, doubleness of flower, a crisped or curled foliage, a difference of color, odor, flavor, etc." But he adds: "Many varieties of plants are in favor with gardeners, and agriculturists, others with florists, while still others are in esteem with pharmacists." From these expressions it is plain that Linnæus did not consider these changeable and even transient forms worthy of any serious consideration by botanists proper, and admitted them to his books only as in condescension to the wants of those classes of tradespeople whom he mentions. It may here be added that in almost all more recent botany, varieties, such as Linnæus had in mind when he wrote the definition, find no place. One looks for the account of them, if anywhere, in the calendars and catalogues of gardeners, pomologists, nurserymen and florists.

I have long understood how very definitely and absolutely this fine book, the Philosophia Botanica, excludes every idea of a possibly evolutionary origin for any species of plant.

And yet, Linnæus was an evolutionist. Nor is this so passing strange, in a world where men in great numbers—even some of high standing and great ability—say one thing, and think the very opposite.

That he entertained doubts as to the truthfulness of the proposition that everything that ought to be called a species had been made as it is in the beginning, is a discovery that I made quite fortuitously.

In the study of some species of *Thalictrum* I had need to consult a certain page of the Species Plantarum. Reading his account of *T. flavum*, and next below it that of *T. lucidum*, his concluding note regarding the species last named quite startled me. His Latin sentence here, as in many another place, is highly figurative, quite after the style of many a classic rhetorician and poet; and I read it again, and very carefully, to see if the idea which the first reading conveyed to my mind was quite that which the author meant to convey. There could be no doubt. Putting it into plain English prose; making it read as one would now write the same thought, his note on *Thalictrum lucidum* is this: "The plant is possibly not so very distinct from *T. flavum*. It seems to me to be the product of its environment."[4]

As helping toward a full understanding of this pregnant remark it must be said that the species *flavum* inhabits the cool moist meadows of northern Europe, while *lucidum* belongs to southern France and to Spain. Each has then decidedly its own environment. Each was known to be equally established as a permanent and indigenous plant form. Linnæus's reason for naming *flavum* as the parent and *lucidum* as the offspring, was a reason no better than this. *T. flavum* was of his own northern country and he knew it well. *T. lucidum* was a southerner, and he was less familiar with it; probably had never seen it but in a northern garden. That was all. It was a thing far enough from being amenable to his definition of a variety. It seemed a species; yet he doubted that it was any more than a daughter species to *Thalictrum flavum*. The one had been created a species in the beginning, the other was probably not so old; more likely to have come into existence away down among the more arid hills of Spain; but it had come to stay. Rather many plant forms that had been reckoned good species before Linnæus and that are now again so considered everywhere today, were with Linnæus mere varieties of other species. But he declined so to treat *Thalictrum lucidum*. If the relation between this denizen of the fervid South and his plant of the frigid Scandinavian peninsula should be declared nothing more than the relation between a specific type and its variation, botanists would be asking how long before he would make an end of species altogether. He was not himself convinced that it was a mere variety,

[4] Planta, an satis distincta a *T. flavo*? videtur temporis filia. Species Plantarum, 1 Ed., p. 547; 2 ed., p. 770.

and so he retains it as a probable species, yet to his half secret thinking not at first created such, but the descendant of another species.

Familiar as I had been for many years with the Species Plantarum as a book of reference, this one discovery upon which I had now stumbled, seemed so much like a new revelation of the mind of Linnæus that within a very few days I had read every one of the 1682 pages of the edition of the year 1764 in search of other kindred expressions regarding the possibility of the descent of some species from others.

Only three pages away from the record of his thought about the origin of the Thalictrum, under *Clematis maritima* occurs this remark: "Magnol, and also Ray have adjudged this to be a variety of *C. Flammula*. I should rather think it is derived from *C. recta* under altered conditions." Now while this remark, standing by itself, might indicate an opinion that the plant under discussion was a mere variety of *Clematis recta*, yet Linnæus did not so place it in this or any other of his books. He gives it the rank of a species, distinctly, and must needs have done so in view of his own definition of varieties as transient forms, developed mostly under cultivation. *Clematis maritima*, as its name indicates, is a seaside species, unchanged in its character from immemorial ages. He knew all this and held it to be not a variety but a derivative species; not one so created in the beginning.

Again, next to the familiar *Achillæa Ptarmica*, of almost all Europe, he places the name and description of *Achillæa alpina* known only from the mountains of Siberia. No botanical authority has ever seemed to think of this as possibly a mere variety of *A. Ptarmica* of Europe; no more does Linnæus; but while according it full specific rank, and as if forgetful of all he had said in the Philosophia Botanica upon such matters, he appends to his technical account of *A. alpina* this most evolutionistic suggestion: May not the Siberian mountain soil and climate have molded this out of *A. Ptarmica?*[5]

Among the more elegant flowering plants adorning the borders of subsaline marshes southward in the United States is one which Linnæus denominated *Hibiscus Virginicus*.[6] It is exclusively North

[5] An locus potuerat ex præcedenti formasse hanc? Species Plantarum, 2 Ed., p. 1266.

[6] *Kosteletzkya Virginica* of more recent authors.

American, and even here of somewhat restricted range. A similar species, of distribution as limited and peculiar, belongs to southern Europe, inhabiting the shores of the Adriatic Sea. Now between these two kinds of Kosteletzkya occupying widely sundered continents, and neither one much more than local, each along its own little line of seaboard—between these two Linnæus apprehends the existence of a more intimate relationship than the most advanced evolutionists of the twentieth century would be likely to affirm. He remarks a very close superficial likeness between them; so close that, were that all, he would declare them to be specifically one and the same; but, in the characters of their little seed pods or capsules they are so unlike that on this account separate specific rank must be accorded both, and so he places them; concluding, however, with this thoroughly evolutionistic query: May not the Venetian species have sprung from the Virginian?[7] The more probable theory of the evolutionist of our time would be, that both are descendants from some common ancestor that had a more general distribution and is now extinct. But, that Linnæus was disposed to regard the Virginian species as having been created such as it is, and the Venetian as having originated from that in after times, is enough to warrant our regarding him as an evolutionist.

I shall cite but one more instance of Linnæus's tacit acceptance of species as derived from other species through altered environment. The case is that of the cultivated beet. The genus *Beta*, in his view, consists of two species only, one the *Beta maritima* indigenous to Old World seashores, a wild plant altogether, and never under cultivation, and, in this wild condition not given to variation, but always one and the same thing. The second species is *Beta vulgaris*, one not known as a wild plant anywhere, but existing from immemorial ages in gardens and fields as a cultivated plant, and that under many marked varieties. Now the short and easy method of dealing with a genus like this—a method many an indifferent systematist would follow—would be to make the guess that, as only one wild species is known, all the cultivated things of that genus are but so many varieties of the one species. The whole tendency of Linnæus's mind was in this direction, that is, of reducing both genera and species to a minimum.

[7] Species Plantarum, 2 Ed., p. 981.

But there was a difficulty here with these two members of the genus Beta, the simple and unvarying wild kind, and the extremely variable one of cultivation. The cultivated plant was hardy, often ran wild, as it were, by escape from cultivation; but these reverts never were found to be equivalent to *Beta maritima* or anywhere near it. The *Beta vulgaris* self-sown and run wild for years, and greatly altered from its cultivated condition, yet invariably retained a character of its own; so that no one would think of calling it *Beta maritima;* therefore, with Linnæus the collection of the varieties of cultivation must be admitted as forming a distinct species of which the native original was unknown, and probably long ages ago extinct. To this view of the case he was perhaps inclined; yet not so strongly as to preclude his offering, in a note, this very different suggestion: "Possibly born of *Beta maritima* in some foreign country."[8] The force of this alternative proposition will be lost to any one who does not recall that, according to the Linnæan account of a variety, *Beta vulgaris* if it originated from seed of *Beta maritima* originated not as a variety but as a species; and such an origin as he thinks the cultivated beet may have had from the wild one would amount to nothing less than what is now called a mutation: one of those sudden leaps or transitions from one thing to another which we have been learning to take into account only lately.

A like instance confronted Linnæus under the genus *Cynara,* the type of which genus is the true artichoke, and has been culitvated from no one knows how far anterior to all written records. Under this old type species, *Cynara Scolymus,* Linnæus admits three marked varieties. Then he proceeds to name and define a second species, a very distinct one, but with a well authenticated history as having arisen nd come into existence as a seedling of the other species. He intimates that he would have liked to be able to consider it a hybrid,[9] but as its parentage as a hybrid could apparently lie nowhere but between two of the three varieties of the other species, the fact would remain that it was a species derived not from two parent species but from one alone. It was another of those abruptly derivative species in which Linnæus was disposed to believe despite those hard half-theologic definitions of his Philosophia Botanica.

[8] Species Plantarum, 2 Ed., p. 322.
[9] Species Plantarum, 2 Ed., p. 1159.

In the progress of these enquiries into the mind of Linnæus as to the origins of species nothing that I have come upon has more deeply interested me than his remark upon the two species of sundew common in northern Europe, *Drosera rotundifolia* and *D. longifolia*. They are very peculiar plants, uncommonly interesting from several points of view, and have in recent years profoundly engaged organographers and physiologists; but Linnæus was most interested in their ecology as bearing upon the problem of their genealogy. Both are bog plants, though far enough from being found in every northern bog. They seem to be particular about the kind of soil, the amount of moisture, the nature of the exposure, and also the plant associates amid which they will establish their habitation; and both species are at perfect agreement as to all special details of bog environment which they demand; for where one is found, there too is the other. They are much alike in size, mode of growth, degree of hairiness, form and color of flowers, etc., but the leaf blades in one are round, while in the other they are so much elongated as to be called narrowly oblong; and this one strong distinguishing mark is constant. There are no plants among them to show leaves intermediate between orbicular and oblong. They ought to be, and I think that by all botanists except Linnæus, both before his day and ever since, they have been held distinct; and even he did not positively affirm the contrary, but only expressed a doubt; and the sole reason he has for doubting the validity of *D. longifolia* is, that it and its mate species always occur under precisely the same conditions and together.[10] It is such a reason as none but a confirmed evolutionist could give; the expression, perhaps unguarded, of a mind no longer very patient of the opinion that two species of the same genus can have the same native environment. A creative fiat could, of course, as readily make two species of a genus suited to certain conditions as one, and as easily twenty as two; and so no believer in the special creation of all species could have felt this doubt about the sundews to which Linnæus gave expression.

It has been thought that the mind of Linnæus as to the absolute fixity of species underwent a change between the years 1751 and 1762, though only in so far as to induce him to admit the origin of more

[10]Habitat ubique cum præcedente; an itaque satis diversa species? Species Plantarum, 1 Ed., p. 282; 2 Ed., p. 403.

recent species by hybridization.[11] My own impression is that few if any of the plants thought by Linnæus to be hybrids are at all of that origin, according to the views of modern botanists, but rather, for the most part at least perfectly distinct and genuine species. But what I have herein, I think, clearly shown is, not only that Linnæus accepted and admitted to his books, as species, forms he thought of as developed from other species, not by any crossing, but through mere environment—natural environment in some instances, artificial in others. And this bent of his mind was so strong that he could scarcely admit two m mbers of a genus to be specifically distinct if found to occur always under the same physical conditions. Again: while it is generous to allow to the great nature student the eleven years between 1751 and 1762 in which to have changed his views a little as to the fixity of all species, the simple fact is that nowhere were the views set forth in the Philosophia Botanica of 1751 more squarely contradicted than in the Species Plantarum of 1753. There were two years intervening between the dates on the respective titles; but most likely he was engaged in writing the works, at least in part, simultaneously. But the great man was writing and publishing as other men of genius had done before him, under environment.

In a letter written by Linnæus as early as 1747, addressed to his most intimate and trusted friend, J. G. Gmelin, author of the Flora Sibirica, he gives confidential expression to the restraints under which he feels that he is obliged to write on matters that impinge upon the domain of theology; to his unwillingness to face the disapproval of the Lutheran and orthodox ecclesiastics who, in his day, ruled the destinies of all seats of learning in Sweden. He says to Gmelin:

> You disapprove my having located Man among the Anthropomorphi· But man knows himself. Now we may, perhaps, give up those words. It matters little to me what name we use; but I demand of you, and of the whole world, that you show me a generic character—one that is according to generally accepted principles of classification—by which to distinguish between Man and Ape. I myself most assuredly know of none. I wish somebody would indicate one to me. But, if I had called man an ape, or vice versa, I should have fallen under the ban of all the ecclesiastics. It may be that as a naturalist I ought to have done so.[12]

[11] Osborn, From the Greeks to Darwin, p. 129.

[12] This, though written as we have said in 1747, was never published until 1861. The original Latin text of the letter occurs in "Joannis Georgii Gme-

The good orthodox Lutheran ecclesiastics that ruled the Swedish university in every department of it would be thoroughly content with the pronouncements of the Philosophia Botanica; and that was a book any scholar would read with pleasure and with profit; but nothing like that could be said of the Species Plantarum. Here, at least, in footnotes, or even in places more obscure, very briefly, veiled in figures of rhetoric, and even under the further protection of question marks, he could express his profounder convictions and feel secure. And he was secure, indeed.

lini, Reliquiæ quæ, supersunt commercii epistolici cum Carolo Linnæo Alberto Hallero Guilielmo Stellero et al., Floram Gmelini Sibericam ejusque Iter sibericum potissimum concernentis, ex mandato et sumtibus Academiæ scientiarum Cæsareæ Petropolitanæ publicandas curavit Dr. Guil. Henr. Theodor Plieninger; Stuttgart, 1861," p. 55, and is as follows: "Non placet quod Hominem iter anthropomorpha collocaverim; sed homo noscit se ipsum. Removeamus vocabula, mihi perinde erit, quo nomine utamur; sed quæro a Te et Toto orbe differentiam genericam inter hominem et Simiam, quæ ex principiis Historiæ naturalis. Ego certissime nullam novi; utinam aliquis mihi unicam diceret. Si vocassem hominem simiam vel vice versa omnes in me conjecissem theologos. Debuissem forte ex lege artis."

PROCEEDINGS

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. XI, No. 1, PP. 27–45. MARCH 31, 1909.

THE LARAMIE FORMATION AND THE SHOSHONE GROUP.

BY WHITMAN CROSS. [1]

A recent discussion as to the origin and definition of the term Laramie, by A. C. Veatch,[2] calls attention once more to a vexed question in American stratigraphic nomenclature. The original observations, by Mr. Veatch and others, which have led to this discussion of terminology are certainly of great significance and must receive full recognition, but they do not justify, in my opinion, the proposition made by Mr. Veatch for the future use of the term Laramie. Another course will be advocated in the following pages.

Mr. Veatch announces the discovery of an "unconformity which in the vicinity of Carbon (Wyoming) and to the southeast separates all the Laramie beds studied by the Hayden and King parties from the underlying Cretaceous." The unconformity may, he believes, involve the "whole sedimentary series of the region, or over 20,000 feet of strata." This discovery and others recently made in Wyoming and Colorado[3] demonstrates that the similar unconformities hitherto known in Colorado and Montana are not of such local

[1] Published with permission of the Director, U. S. Geological Survey.

[2] On the Origin and Definition of the Geologic term Laramie. Amer. Jour. Sci., 4th ser., Vol. XXIV, 1907, pp. 18–22. Jour. Geol., Vol. XV, 1907, pp. 526–549.

[3] Veatch, A. C.: Coal and Oil in Southern Uinta County (Wyo.), U. S. Geol. Survey, Bull. 285, Contributions to Economic Geology, 1905, pp. 332, 335.

Veatch, A. C.: Coal Fields of East-Central Carbon County (Wyo.), U. S.

significance as some geologists and paleontologists have been inclined to assume. The new observations are of special interest as affecting beds of the Laramie Plains, from which a considerable portion of the supposed "true Laramie" flora has been obtained. The point emphasized by Mr. Veatch in the cited articles is one of nomenclature—as to the importance of the newly discovered stratigraphic relations of the Carbon section in determining what shall be the future use of the term Laramie. He attaches first importance to those relations, while I wish to express my conviction that they are, under the circumstances of this case, of subordinate importance.

Mr. Veatch believes it necessary to tie the definition of a geologic formation to a type section and argues that the geographic name applied to the formation should refer to that type section. While it is no doubt desirable to follow these rules wherever practicable, it is unfortunately a fact, of common experience to geologists, particularly to those working in the western United States, that in many cases the name most closely connected with the locality of a key section is preoccupied as a formation name or is unsuited to such use; and in some instances there is no name attached to the type locality. The real essentials for an adequate definition of a formation appear to me to be: clearly expressed stratigraphic relations, a statement of lithologic character and paleontologic data, and reference to type sections, the more the better. It is fortunate if the name can refer to a completely typical locality. If, however, the definition of a formation is clear as to stratigraphic relations and the unit with those relations is a natural one, the name becomes in time more intimately connected with the definition than with the strata of any locality, for the first known sections are not always the best. A term thus becomes denotive rather than connotive. The requirement that the name should be derived from "the type locality" becomes unreasonable and impracticable when the unit named is a

Geol. Survey, Bull. 316, Contributions to Economic Geology, 1906, Part II, Coal, Lignite and Peat (M. R. Campbell in charge), pp. 246, 250.

Schultz, A. R.: Coal fields in a portion of central Uinta County (Wyo.), Ibid., p. 214.

Gale, H. S.: Coal Fields of the Danforth Hills and Grand Hogback, in Northwestern Colorado, Ibid., p. 267.

Veatch, A. C.: Geography and Geology of a Portion of Southwestern Wyoming, etc., U. S. Geol. Survey, Prof. Paper No. 56, 1907.

large formation or a group not completely represented at any one locality. Such was and is the case with the "Laramie Group."

As to the origin of the term Laramie Mr. Veatch points out that Clarence King, who proposed the name and defined its application, was very careful in the choice of appropriate geographic names for formations. That is undoubtedly true in a general way, still, King was not working under any rule such as that now prevailing in the U. S. Geological Survey. Much space is given by Mr. Veatch to establishing by citations the exact application of the name Laramie Plains in the seventies, and to showing that the sections of "Laramie" beds examined by the Hayden and King survey geologists were probably all above the unconformity seen at Carbon. His conclusion is that "the type locality of the Laramie is Carbon, on the Laramie Plains."[4] If the term Laramie had been in fact proposed especially for strata of the Laramie Plains, or even for a formation known by King and Hayden only in the zone traversed by the Union Pacific Railroad or the Fortieth Parallel in Wyoming, it is probable that many stratigraphers would agree with Mr. Veatch in his sweeping conclusion that: "strictly considered, the term Laramie, therefore, can appropriately be applied only to the beds above the great unconformity," whatever they might think of the new restriction "and below the Fort Union."[5] But the name was not so proposed. It was introduced into literature and defined by King as a compromise term for beds known to be widely distributed from Montana to New Mexico. The statement made by King is very clear as to the desire of Hayden and himself to have a name which each could use for a great series of supposedly conformable beds, without prejudice as to age. Laramie was practically proposed as a synonym for "Lignitic," but not as an exact one, for that term had been very broadly used by Hayden and others. Mr. Veatch thinks that "if merely a general term without a type locality had been desired, the term Lignitic, exactly defined for the area involved, would have served all purposes.[6] That is possibly true, if King and Hayden had thought so, and been willing to use it, but they wisely adopted another course.

There is not the slightest doubt as to the fundamental stratigraphic

[4] Amer. Jour. Sci., 4th ser., Vol. XXIV, 1907, p. 20.
[5] Ibid. [6] Ibid.

relations which King and Hayden thought characteristic of the Laramie. Mr. Veatch has shown this by ample quotations from the definition of the former. In all statements quoted and in others which might be cited the relations most strongly emphasized in regard to the Laramie is its *conformity with the underlying Cretaceous beds.* King believed the Laramie to be Cretaceous; Hayden thought it transitional between Cretaceous and Tertiary. King believed that Mesozoic sedimentation ended by reason of a great Rocky Mountain revolution and that the Laramie was separated from the lowest Eocene beds, erroneously supposed by him to be the Wasatch, by a marked unconformity. Hayden thought that Laramie and Wasatch were essentially conformable.

The essence of King's definition is contained in the sentence: "accordingly . . . . it was amicably agreed between us [King and Hayden] that this series should receive the group name of Laramie, and that it should be held to include that series of beds which conformably overlies the Fox Hill."[7] "There is no difference between us as to the conformity of the Laramie group with the underlying Fox Hill."[8] There is no reference to the Carbon or any other section of Laramie beds as typical. The name would appear to have been chosen because it was deemed the best one derivable from the zone covered both by the King and Hayden surveys, and not because of a type section. It was undoubtedly believed that the Carbon section illustrated, but in common with many others, the fundamental relation of conformity with the underlying Cretaceous.

Hayden's last statement of his position was in the introduction to Lesquereux's Tertiary Flora, as follows:

"The facts as we understand them at the present time would seem to warrant this general division, viz: a marine series, Cretaceous; gradually passing up into a brackish water series, Laramie; gradually passing up into a purely fresh water series, Wasatch."[9] He regarded it probable that the Wasatch and Fort Union beds were identical, in part at least.

The Laramie of King's conception was a natural stratigraphic unit with a well defined base to be found in many places but with

[7] U. S. Geol. Expl. of 40th Parallel, Vol. I, Systematic Geology, 1878, p. 331.
[8] Ibid., p. 348.
[9] U. S. Geol. and Geog. Survey of the Ter., Mon. VII, 1878, p. v.

an upper theoretical limit which might nowhere be represented, owing to the assumed pre-Tertiary erosion. It was to embrace the upper group of conformable Cretaceous sediments, deposited in brackish or fresh waters during gradual continental uplift. A long period of non-deposition and great erosion in the Rocky Mountain region was assumed by King and by other stratigraphers and paleontologists of thirty years ago to mark the interval between Cretaceous and Eocene sedimentation. Hayden's view as to the age of the Laramie was largely due to Lesquereux's opinion that the flora was Tertiary, but, as the quotation above given shows, he thought of the Laramie in its fundamental stratigraphic relation as the brackish water deposit succeeding the marine Cretaceous through gradual uplift.

Although the Laramie was simple in its essential definition and conception, the strata referred to it included local deposits as well as those of wide distribution, and knowledge concerning some of these beds was very meager and untrustworthy when the group was established. It is a most natural result of detailed studies during the last thirty years that several formations at the top of the group assumed to have the relations embodied in King's definition, have been found to possess other relations. But there is still a large formation or group answering to the fundamental part of King's definition, and to such beds it seems to me both most natural and most expedient to apply the term Laramie in future. In the Laramie Plains there are, according to Veatch, 6,500 feet of conformable Cretaceous beds above the Montana marine strata and below the break at the base of the Carbon beds. The geographic term is thus still appropriate, even if the Carbon section be excluded from the Laramie. The term has now been so widely applied and for such a long time that it appears to me unwise to drop it even if there should prove to be no true Laramie beds on the Laramie Plains, as Veatch uses that designation.

Among the districts named by King as exhibiting Laramie beds in representative manner is the eastern foot hill zone of the Front Range in Colorado, where they were known also to geologists of the Hayden Survey. It was in this region that Eldridge and myself discovered that the section referred to the Laramie by both Hayden and King consisted of two parts: a lower one, conformable with the

marine Cretaceous, and thus corresponding to the principal element of King's definition, and an upper portion exhibiting relations at variance with that definition. With the recognition of the Arapahoe and Denver formations, separated in time from the Laramie of the conformable series by an epoch of uplift and great erosion, came the necessity of revising the application of the term Laramie. The Arapahoe and Denver beds were at first considered to be the earliest deposits of the Eocene series.[10] Taking them from the Laramie made no change, I think, in the definition of the latter as the uppermost member of the conformable Cretaceous series in the Rocky Mountain region, although Mr. Veatch considers it "redefinition."

Soon after the recognition of the Arapahoe and Denver formations other deposits of nearly synchronous origin were discovered in discordant relations with the Cretaceous section, a notable instance being the Livingston beds of Montana. It was also found by Marsh and Hatcher that the horned dinosaurs and associated vertebrates, the so-called "Ceratops fauna," occurred in Converse County, Wyoming, in strata which appeared to occupy the position of the Laramie, in conformity with the marine Cretaceous. The presence of the same fauna in the Arapahoe and Denver beds led many geologists and paleontologists to the belief that the latter must also be of Cretaceous age, and that the breaks below the Arapahoe and Livingston beds were of local importance.

In 1892 I reviewed the accumulated evidence concerning the importance of the Arapahoe and Denver beds and deposits correlated with them by virtue of unconformity or fossil evidence and in conclusion advocated:—

"The restriction of the term Laramie, *in accordance with its original definition*, to the series of conformable beds succeeding the marine Montana Cretaceous, and the grouping of the post-Laramie lake beds described, with their demonstrated equivalents, in another series to which a comprehensive name shall eventually be given."[11]

This course had previously been proposed by R. C. Hills.[12] In

[10] Cross, Whitman: The Denver Tertiary Formation. Amer. Jour. Sci., (3), Vol. XXXVII, 1889, pp. 261–282.

[11] "Post-Laramie Deposits of Colorado." Amer. Jour. Sci., (3), Vol. XLIV, 1892, p. 41.

[12] Orographic and Structural Features of Rocky Mountain Geology. Proc. Colo. Sci. Soc., Vol. III, 1890, p. 397.

the monograph on the Denver Basin[13] the terms Laramie and Post-Laramie were again used with this significance.

If it be conceded that the interests of stratigraphic nomenclature will be best subserved by retaining the term Laramie for the beds of the conformable Cretaceous section above the Montana group it is plain that the nomenclature of the younger formations, usually separated from the Laramie by stratigraphic break or unconformity, which were included through misapprehension by King and others in the original Laramie, should also be considered in this connection. It is still my belief that the use of a new group term for these formations will greatly assist in clarifying the situation. The tentative term Post-Laramie has but imperfectly served the purpose intended, and is clearly unsuitable for permanent use. It appears to be left for me to finally propose this new term.

The uplift that terminated deposition of the conformable Cretaceous section was, as it seems to me, in the first degree epeirogenic, affecting the Rocky Mountain region from Montana to southern Colorado, with every probability that its influence was equally marked far beyond the limits named, especially to the north and to the south. Certain facts of observation, such as the great angular unconformities below the Livingston and Carbon beds and the stratigraphic break of equal magnitude below the Arapahoe formation, may be interpreted to indicate that pronounced orogenic uplifts of as yet undetermined amount and extent were imposed upon the greater movement. Such comparatively restricted uplifts have occurred at various times and in different districts throughout the Tertiary period. That the movement was not one of continuous uplift may be almost taken for granted. Subsidence doubtless occurred but there is no evidence of true marine conditions ensuing after the Laramie epoch, as there was after the Judith River. If subsidence produced brackish water conditions in post-Laramie time it must have been of but local extent.

Succeeding or in part synchronous with the Rocky Mountain uplift there was erosion and resultant deposition in many basins or on the slopes of the rising land. For such of these more or less

[13] Geology of the Denver Basin, Colorado, by S. F. Emmons, Whitman Cross and G. H. Eldridge. Mon. XXVII, U. S. Geol. Survey, 1896.

distinctly local deposits as may now be preserved it is proposed to provide a group name.

As the beds in question are genetically connected with the uplift which gave rise to the Rocky Mountains and have a wide range through the mountain province it would be most appropriate if the group name could refer to these relations. But the use of Rocky Mountain as the name of a Carboniferous quartzite, by Dowling,[14] precludes the application of this term in another sense. The State names Montana, Wyoming and Colorado, and all the other geographic names of more than local significance which might be considered appropriate for this purpose appear to be already in use as stratigraphic terms. Believing that it would be a misfortune to adopt a purely local term for this great group of deposits, I have followed the personal suggestion of Dr. F. H. Knowlton and selected an Indian name connected with the larger part of the Rocky Mountain province. The map published by the Bureau of Ethnology illustrating the distribution of the great linguistic families of North American Indians shows the district once occupied by the Shoshonean family to embrace the greater part of the Rocky Mountain area, with a part of the great Basin. The mountains were especially the land of the Utes and Shoshones, two tribes of this family. With this broad derivation it is proposed to apply the term Shoshone Group to the deposits which unconformably succeed the Laramie and to their equivalents, and which are overlain by the Fort Union or Wasatch beds, when they are present.

It is to be clearly understood that the name Shoshone refers to no typical locality or district but rather to a province. It has no connection with the Pliocene Shoshone Lake of King, the deposits of which he called the Humboldt Group. In manner of derivation the term is directly comparable with "Algonkian," which comes from Algonquian, the name of another linguistic family of Indians, and of the province they inhabited.

Laramie and Shoshone beds may be easily separated, under the broad general definitions thus far used, where angular unconformity exists between them or where a corresponding stratigraphic break can be identified by lithologic or paleontologic evidence. One

[14] Dowling, D. B.: Report on the Cascade Coal Basin, Alberta, Canada Geological Survey, 1907, p. 9.

or the other of these conditions exists in many localities that have been closely studied and may possibly be realized throughout the area in which the Shoshone beds now occur. But there is at least a theoretical possibility that in some places now represented by exposures deposition was continuous from the marine Cretaceous to the Fort Union epoch. In such places Laramie and Shoshone strata come together in conformity or a transitional formation must be created. It should be kept in mind while considering the subject that this situation is not peculiar to the boundary between Laramie and Shoshone beds but may arise in any case where it is desired to separate strata preceding from those formed during or immediately after a great uplift.

The line to be drawn between Laramie and Shoshone in a series of conformable and consecutive deposits must be determined at some future time, when such a series is definitely known. The criterion for the distinction may be a lithologic or paleontologic change, or as is more probable, some arbitrarily selected feature. At the present time, it seems to me that the difficulty of distinguishing between Laramie and Shoshone beds is either a general theoretical one, or a local and practical one due to a lack of knowledge concerning the true relations and paleontologic contents of the strata in some special district.

The characterization of the difficulty as perhaps largely theoretical rests on the following consideration: The uplift terminating the widespread Laramie sedimentation doubtless caused at first a relatively small landmass, or perhaps several of them. Denudation of such land areas must have begun at once; erosion and deposition, either continental or submarine, were, indeed, accompaniments of uplift. But as larger and larger tracts gained some notable elevation erosion must have quickly removed a great part of the most recent deposits, if not all of them. The whole of the Rocky Mountain province may thus have been denuded of the beds which would constitute a transition series if preserved. In this case a complete section must be looked for in outlying areas which were but little elevated during the Shoshone epoch. On the Great Plains side it is clear that such beds can be found only in quite restricted districts, owing to Tertiary erosions or a mantle of later deposits. On the west, too, the areas within which transition beds can exist are few.

The idea of transitional deposits is, of course, not new. Numerous sections have been thought to represent consecutive sedimentation but the investigations of the last twenty years have shown breaks in many such sections, while in no case has a transitional series been established. The Hayden survey geologists believed that Laramie and Wasatch beds were, in some places at least, connected by an unbroken series of strata. Aside from apparent conformity the existence of certain species of fresh water shells in both Laramie and Wasatch has been taken as evidence of continuity of deposition. Dr. C. A. White, whose observations during the Hayden survey were of much weight in influencing the opinion of his colleagues, again expressed this idea while reviewing the relations of the Laramie to the Denver and Arapahoe formations.[15] The presence of identical fresh water species in the Laramie and Wasatch of any given section does not, however, prove the continuity of conditions at the site of that section during the whole time involved.

In the light of observations at Golden, Carbon, and many other localities, apparent conformity between the Laramie and beds above it cannot be regarded as proof of continuous sedimentation. The only evidence which can show conformity to mean continuity of deposition in this case would appear to be gradual change in fauna or flora of the epoch in question. This evidence has not been furnished at any locality.

Referring only to the established facts of the Denver district, a section of some other region, supposed to represent continuous sedimentation between the Laramie and Fort Union epochs, must contain beds representing:—

1. The long interval of uplift and erosion preceding the Arapahoe deposition.
2. The Arapahoe.
3. The interval of erosion and volcanic eruption preceding the Denver.
4. The Denver.
5. Interval between the Denver and Fort Union,

No section even approximating such a record has been established.

[15] The North American Mesozoic. Vice-Presidential address, Proc. A.A.A.S., Vol. XXXVIII, 1889, p. 14.

The Laramie may be defined as a formation of brackish or fresh-water sandstones and shales, usually quartzose and coal-bearing, which constitute the uppermost division of the conformable, consecutive, and widespread series of the upper Cretaceous in the Rocky Mountain and adjacent regions. It rests upon the Montana marine group. The only upper limit now definitely known is a stratigraphic break, above which comes, normally, some formation of the Shoshone group.

Should a series of sediments be discovered connecting in unbroken sequence the Laramie and the lowest recognizable Shoshone formations, the boundary between them must be established at least for that section, on the basis of facts which cannot be anticipated.

By this definition the Laramie is inseparably connected with the great Cretaceous section below it, as in the conceptions of King, Hayden, and perhaps all of the earlier observers. It was presumably coextensive with the Montana beds and represents conditions which had existed locally during the Judith River epoch in Montana.

While the Laramie was originally so widespread, its distribution as now preserved, is a matter of much uncertainty. Veatch reports 6500 feet of Laramie strata below the horizon marking the break at the base of the Carbon beds and no doubt other developments of the Laramie occur in Wyoming, though recent investigations make it necessary to refer many supposed Laramie exposures of that State to the Shoshone group, and to study carefully all sections before making assignments.

The Laramie is exhibited in its typical relations in the Denver basin and northward along the base of the Front Range. It there rests conformably on the Fox Hills (Eldridge) and is succeeded by a stratigraphic break representing a long period of erosion, as demonstrated by the materials of the basal conglomerate of the Arapahoe formation. The remaining Laramie of the Denver basin varies from 600 to 1200 feet in thickness. The greater part of the known Laramie flora has been found in this district in the coal measures near the base of the formation.

Further discussion of Laramie distribution seems inadvisable at this time for the reason that the information gathered by many parties of the U. S. Geological Survey engaged in studying the coal measures of the Rocky Mountain region, under direction of M. R. Campbell, cannot as yet be utilized.

The Shoshone group may be defined as embracing the lacustrine, fluviatile or terrestrial deposits, composed of detritus from the rising land area of the Rocky Mountain province, formed between the Laramie and Fort Union epochs. The group embraces beds which have been commonly referred to as "Post-Laramie" or "Upper Laramie" in the literature of recent years. Dana, in his Manual of Geology, used the alternative terms "Upper Laramie" and "Denver Group," the latter being an inadmissible and confusing application of Denver in a second, comprehensive sense. The name "Post-Laramie" was proposed by me, as already pointed out, for the formations now included in the Shoshone Group.

Among the formations which may now be specified, on published data, as belonging to the Shoshone group are the Arapahoe, Denver, Middle Park, and Animas beds of Colorado; the Carbon and Evanston beds of Wyoming; the Livingston beds of Montana. The Converse County "Ceratops beds" of Wyoming and the Hell Creek beds of Montana belong to this group, according to Barnum Brown,[16] who calls them "Post-Laramie."

Many of the formations of the Shoshone Group appear to have been quite restricted in area. At least, they are now isolated and correlation is as yet rather tentative. It is not yet known that the Arapahoe beds of the Denver Basin, or any other particular deposit, represent the earliest of these local formations. There is reason to correlate, more or less closely, the Denver, Middle Park, Animas, and Livingston beds, which consist largely of similar volcanic debris and contain similar floras or faunas. But it cannot be assumed that volcanic eruption was coextensive with the uplift of this period nor that it did not begin during the Laramie; hence it is probable that formations consisting of non-volcanic material were deposited in some districts during the Denver epoch, and there may be volcanic material in some Laramie strata. It is plain that before complete correlations of permanent value can be made among the Shoshone formations the stratigraphic relations must be thoroughly examined, the fauna and flora of each local deposit must be carefully studied in the light of stratigraphic evidence, and all elements brought into harmony. Such investigation will necessarily take many years.

[16] The Hell Creek Beds of the Upper Cretaceous of Montana. Bull. Amer. Mus. Nat. Hist., Vol. XXIII, 1907, pp. 823–845.

Except for the brackish water forms of the Laramie fossils have not been cited in this discussion as characterizing the Laramie or Shoshone beds, although it seems certain that it will be possible, eventually to discriminate between them quite sharply in most cases by means of their fossil remains. It has always been an unfortunate feature in discussions of the Laramie question that there has been so little positive knowledge and so much assumption as to the true stratigraphic relations of fossil-bearing beds. At this time, when so many investigations are in progress, yielding abundant new material and revealing errors or deficiencies in earlier work, it seems best for the stratigrapher to regard the true significance of paleontologic data as imperfectly established, and I prefer to place the responsibility for characterizing the faunas and floras of the Laramie or Shoshone beds with the paleontologists. A few general statements may be made in illustration of the present situation.

Fossil plants are widely distributed in all formations concerned. Without reviewing the early literature of the so-called "Laramie flora," which was made to include plants actually occurring at various horizons between the Dakota and Miocene, it may be recalled that Ward's Synopsis of the Laramie Flora,[17] published in 1885, was characterized by Newberry as "really and only an important contribution to our knowledge of the Fort Union flora."[18] Newberry further maintained that the Laramie (including beds here called the Shoshone Group) and Fort Union floras were totally distinct. Knowlton has endorsed Newberry's view as to the essentially distinctive character of the Fort Union flora,[19] and, through study of many new collections, partly gathered in person, he is now in a position to affirm that opinion. By Mr. Knowlton's courtesy I am permitted to refer here to the fact, shown by recent collections, that the Fort Union flora ranges downward into the "Hell Creek beds." The most important collection on which this statement rests was made by Barnum Brown, the plants being in direct association with the

[17] Ward, Lester F.: Synopsis of the Flora of the Laramie Group, U. S. Geol. Survey, 6 Ann. Rep., 188, pp. 399–557.

[18] Newberry, J. S.: The Laramie Group, Bull. Geol. Soc. Am., Vol. I, 1890, p. 525.

[19] Knowlton, F. H.: Notes on a Few Fossil Plants from the Fort Union Group of Montana, etc., Proc. U. S. Nat. Mus., Vol. XVI, 1893, pp. 33–36.

huge dinosaurs. The flora of the Fort Union group now known to Mr. Knowlton embraces about 500 species.

The discovery of the Fort Union flora in association with the vertebrate fauna of the Hell Creek beds raises several highly important questions, such as the relative value of plants and dinosaurs in determining the age of the Fort Union. A discussion of these questions and a comparison of the Fort Union, Shoshone and Laramie floras will be given in a forthcoming paper by Mr. Knowlton.

The Shoshone flora known to Mr. Knowlton now embraces about 300 speecies, 200 of which occur in the Arapahoe and Denver beds. The known flora of undisputed Laramie beds of Colorado contains 80 species. It is sufficient to say here that the Shoshone flora is distinctly intermediate in character between those of the Laramie and Fort Union and is easily distinguished from either, according to Mr. Knowlton.

The invertebrate fauna of the Laramie contains both fresh and brackish water forms. The latter belong to *Ostrea*, *Corbula*, *Corbicula*, *Anomia*, etc., and are identical with or nearly related to forms also known in brackish water deposits of the Montana group, as at Coalville, Utah, and Point of Rocks, Wyoming, and in Judith River beds. Such forms are rarely found, I believe, in the Shoshone beds; so rarely that there must arise in each case a query as to the significance of the presence of these forms. Does it necessarily imply a subsidence permitting a recurrence of brackish water conditions, or may the forms in question have adapted themselves to fresh water environment? The intimate association of brackish and fresh water forms above the Laramie may well raise the latter question in any case.

The remarkable vertebrate fauna occurring in beds referred to the Laramie in a general way by paleontologists has until recently been a hindrance rather than a help to the stratigrapher engaged in studying the geologic development of the Rocky Mountain region at the close of the Mesozoic era. During the years in which Marsh was engaged in describing in rapid succession the wonderful horned dinosaurs and associated forms "from the Laramie of Colorado," Wyoming, or Montana he came to speak of the "Ceratops beds" and the "Ceratops fauna" collectively, minimizing almost to the degree of ignoring, the importance of stratigraphic and other evidence showing that the vertebrates he grouped together so closely came

from several formations which were clearly not synchronous deposits.

It would appear to be self-evident that the vertebrate life must have undergone marked evolution during the series of orogenic disturbances characterizing the Laramie and Shoshone epochs. Hatcher, who took up the study of the Ceratops fauna, after Marsh, realized the importance of careful stratigraphic examination, and before his lamented death laid the foundation for the phylogenetic study of the "Laramie" vertebrates which alone can make them of diagnostic value in determining stratigraphic relations. The investigation of the Judith River beds of Montana by Hatcher and Stanton in 1903 demonstrated that they belong in the Montana Group. The "Ceratops fauna" was thus carried below the Laramie, and Hatcher, instituting such comparisons as were possible, announced the general conclusion as regards the vertebrates, that

> In every case where any group of the fauna has been studied from sufficient material, it has been found to be represented by distinctly older and more primitive types than the related forms from the Laramie.[20]

In harmony with this view are the opinions of Stanton concerning the invertebrate fauna and of Knowlton on the flora, to be found in the same publication.

Vertebrate remains have been obtained in the Laramie beds (as here defined) in but very few localities. The most important fossil to be referred to here is the *Agathaumas silvestris* Cope from Black Buttes, Wyoming. This form is represented by skeletal parts and cannot therefore be satisfactorily compared with most of the other Ceratops forms, which are known only from cranial parts. The recent review of the phylogeny of the Ceratopsia by Lull[21] places *Agathaumas silvestris* by itself as a form much older than *Triceratops* of the Converse County beds. This view agrees with the reference of the Black Buttes beds to the Laramie by Stanton on the evidence of brackish water forms believed to occur shortly above the Agathaumas horizon, but conflicts in some measure with the close

[20] T. W. Stanton and J. B. Hatcher: Geology and Paleontology of the Judith River Beds with a Chapter on the Fossil Plants by F. H. Knowlton. U. S. Geol. Survey, Bull. 257, 1905, p. 103.

[21] The Ceratopsia, by J. B. Hatcher, Mon. XLIX, U. S. Geol. Surv., edited and completed by R. S. Lull, 1907, Part II by Lull, Phyolgeny, etc., p. 161.

correlation of Black Buttes and Converse County beds suggested by the similarity of their freshwater faunas and the floras.[22]

Barnum Brown correlates the Converse County and Hell Creek beds on the basis of unconformable relations to marine Cretaceous, lithologic character, vertebrate and invertebrate fauna, flora, and position relative to Fort Union beds. He also calls them "Post-Laramie" and extends the correlation to the Denver beds because of the Triceratops fauna in the latter.[23] The Triceratops is described by Hatcher and Lull as the most highly differentiated form of the horned dinosaurs known. It was apparently the last of the race.

The mammals associated with the Triceratops fauna in Converse County, whose Jurassic affinities were so strongly emphasized by Marsh, must manifestly be studied as to their relations to the forms of the Torrejon and Puerco, before their significance can be determined.

The facts recited seem to me to indicate clearly that when the distribution of fossils of all kinds in the Laramie and several Shoshone formations is more completely known and the phylogeny worked out, it will be found that each formation has its distinctive fauna and flora which can be utilized with certainty in correlating newly discovered deposits of obscure relations.

In the preceding discussion I have avoided the question as to the age of the Shoshone beds, whether Cretaceous or Eocene. I desire now to urge their reference to the Eocene. The Denver beds were originally referred by me to the Eocene, but the great weight attached to the Mesozoic affinities of the vertebrate fauna by paleontologists led to a tentative acquiescence in the assignment of the Arapahoe and Denver formations to the Cretaceous, in the Denver monograph. In that volume I reviewed various aspects of the question and can add but little to what was there said. The main point seems to be that the Laramie and Shoshone beds belong to a transition series between the Cretaceous and Eocene and that whatever break occurs between any two formations is possibly bridged over by deposits of some other locality. The Laramie is related to the Judith River and other brackish water formations of the Montana Cretaceous,

[22] Stanton and Knowlton, Bull. Geol. Soc. Amer., Vol. VII, 1898.

[23] The Hell Creek Beds of the Upper Cretaceous of Montana. Bull. Amer. Mus. Nat. Hist., Vol. XXIII, 1907, pp. 823–845.

the Shoshone to the great succession of Tertiary local deposits. The retreat of marine waters and the decided uplift of a large continental area marked the appropriate boundary between Cretaceous and Eocene from the stratigraphic side. The plant life seems to show no special reason for drawing the line at any other horizon.

The argument most effectively used for including the Shoshone beds in the Cretaceous has come from the vertebrate remains of that group. The Mesozoic affinities of that fauna are said to be so pronounced that paleontologists have been unwilling to consider the proposition of referring beds containing that fauna to the Eocene. The intimate relations of the fauna to its ancestors are not surprising and as a large part of the fauna became extinct in Shoshone time the absence of a comparable line of descendants is easily comprehended, but the stratigrapher naturally raises the question—Why is the extinction of the huge vertebrates of the Shoshone epoch to be considered as determining the Mesozoic-Cenozoic line? A quarter of a century ago it was the common belief of stratigraphers and paleontologists that the "great Rocky Mountain revolution" so changed conditions of environment affecting the living forms of the time that the Mesozoic vertebrate fauna in particular could no longer exist. Little was then known of this revolution and yet an almost catastrophic influence of the uplift upon life was assumed as natural. Now that the change from marine to permanent continental conditions is known to have been marked by oscillations and the vertebrate fauna is shown to have survived the very changes once assumed to have been fatal to it the cause of extinction becomes a mystery, yet is held to have the same great significance formerly assigned to it. This conclusion is surely open to question.

The little mammals found in the Converse County beds have been charged with exterminating the huge dinosaurs, but Lull rejects this hypothesis and reverts to orogenic movement as the cause.[24] But there is at present no available evidence to show a movement of any unusual importance between the Denver and Fort Union epochs.

It has been suggested by Peale that the extinction of vertebrate faunas in the Miocene and Pliocene periods was due to widespread showers of volcanic ashes and the same cause has recently been

[24] The Ceratopsia, U. S. Geol. Surv. Mon. XLIX, p.

brought forward by Scott to account for the extinction of the Miocene fauna of Patagonia. If the disappearance of the Ceratopsia and associated reptilian forms may possibly have been due to the great volcanic outbursts of the Shoshone epoch, it is nevertheless true that no ash beds have been found in which their remains occur in perfect condition, as is the case in the other instances referred to. The Denver beds are for the most part not ash beds. It is of course possible that such beds were eroded before the Fort Union epoch, but this explanation is certainly as yet merely a speculation.

Where a gradual change takes place from one set of conditions to another various groups of animals and plants of the earlier period will adjust themselves with varying rapidity and success to the conditions of the later time, and some may disappear through the lack of the power of adjustment. The forms which survive longest are manifestly not those which mark the change in conditions. The vertebrate fauna can logically be used to limit the Cretaceous of the Rocky Mountain province only on the basis of a time correlation through those forms with some well established section elsewhere. As far as I know there is no such section on the American continent. Certain marked resemblances have been pointed out between the Ceratops fauna and that of the Gosau formation in Austria, which, after much discussion has been referred to the uppermost Cretaceous. But it is of much importance in citing this resemblance to know whether it is the Triceratops fauna of the Shoshone group, the forms of the Judith River Cretaceous, or possibly a more primitive fauna, which is most closely related to that of the Gosau beds.

The question as to where the Cretaceous-Eocene line shall be drawn in the Rocky Mountain province is one to be decided on broad grounds and in closing I wish to quote the philosophical views of Dr. C. A. White, a biologist, paleontologist, and stratigrapher, expressed in regard to this very question nearly 20 years ago, after discussing the evidence of the Arapahoe and Denver beds. Referring to precise determinations of the age of formations solely on fossil evidence, Dr. White remarks:

> Those paleontologists who make this unwarranted application of their science to systematic geology, all use the scheme of classification that has been established for Europe, and use it as if it were of infallible application to all other parts of the world, and also as if it were already absolutely

perfected for that continent. While I have no inclination to question the general accuracy of the European scheme of classification for that continent, I do not hesitate to express the opinion that it is not of infallible application to other parts of the world, except as to its larger divisions, and that even in this respect it will need modification. That is, I hold that investigation of the formations which are found upon any given continent or great division of the earth's surface ought to be prosecuted, first, with relation to one another, and second, with reference to their ultimate, not immediate, correlation with those of other continents or divisions.[25]

[25] Vice-Presidential address, The North American Mesozoic, Proc. A.A.A.S., Vol. XXXVIII, 1889, pp. 225–226.

PROCEEDINGS

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. XI, No. 2, PP. 47-178 APRIL 28, 1909

STUDIES IN THE AMERICAN BUPRESTIDÆ.

BY THOS. L. CASEY.

It would seem that but few sections of the Coleoptera have been so neglected, or so superficially investigated with a view to scientifically defining and grouping the genera, as the Buprestidæ. The conspicuous and brilliant metallic coloration prevailing among the species, doubtless led the early authors to define the majority of them from their salient external characters alone, and generally in few words, so that the determinative literature is inadequate and frequently misleading. These remarks apply, however, more especially to the first few groups of genera as they occur in America, for some careful and undoubtedly useful work has been accomplished in subsequent parts of our series, for example in the genera *Chrysobothris*, *Acmæodera* and *Agrilus* by Dr. G. H. Horn and Mr. H. C. Fall.

Alluding to the neglect during the past fifty years of that part of the family which forms the subject of the present essay, it will suffice to state that only a comparatively small proportion of the specific and subspecific forms in our cabinets have been defined, that the genus *Chalcophora* has been constituted in our lists during all this time of two notably distinct genera, that the three species assigned to *Hippomelas* belong in reality to three different genera, two of which are not at all closely allied, and, finally, that *Buprestis* is separated from the earlier genera by *Dicerca* and *Pœcilonota*, which differ conspicuously in antennal structure as will appear below. This general lack of interest in the taxonomic treatment of the family is apparently due, in some measure at least, to actual absence of structural plasticity, the entire under surface of the body being unusually fixed and con-

stant throughout, so that even Lacordaire, generally so happy in his choice of primary characters, has, seemingly in despair, seized upon a few antennal features for major group division, without testing them with sufficient thoroughness; the result is that the grouping suggested by that author, especially that founded upon variations in the ridge above the antennal foveæ and in the pores and fossæ of the outer antennal joints, is not satisfactory, as indeed remarked by LeConte in his monograph of the family. At the same time the group characters adopted by LeConte are also valueless to a great degree, for it is not apparent that the front is narrowed by antennal insertion to any greater degree in *Chrysobothris* than in *Gyascutus*, and the nature of the meso-metasternal suture, although very important, completely fails as a group character in the sense intended by that author, while the differences in prosternal conformation are too feeble, inconstant and illusory to serve any useful purpose. It is perhaps also due in part to this lack of evident organic structural diversity, that early mistakes in generic assignment were so frequently made by systematists; but it is difficult to comprehend, even under this assumption, the original referring of what we now know as *Gyascutus planicosta* and *obliteratus*, as well as many exotic species, to the genus *Chalcophora*.

It has been impracticable for me to survey the entire family with sufficient thoroughness to definitely pronounce upon primary group division, if there be any worthy of adoption, and the genera here reviewed are therefore arranged in close succession in a single statement and without tribal delimitation. The principal generic characters assumed relate almost wholly to antennal and elytral structure, but, for more closely related genera, diverse characters of the front, pronotum and tarsi have proved to be of more or less utility. There are two sufficiently distinct types of antennal structure among the genera having smoothly anchylosed sterna, and, if found to be of general application in the family at large, there is no reason why they should not form the basis of major group or tribal division. In the first group we might suggest *Hippomelas* and allied genera, having a terminal antennal process, as one tribal group, *Psiloptera*, *Spinthoptera* and probably others now confounded with *Psiloptera*, as another, *Chalcophora* and related forms as a third and *Buprestis* with its immediate allies as still another, and, in the second division, which is probably by far the larger, *Dicerca*, with related genera, should be

considered a special tribe based upon the position of the antennal fossæ and distinguished from others, such as *Chrysobothris*, by the form of the elytral bases, degree of separation of the eyes and other characters. Many genera were unnecessarily rejected by Lacordaire, presumably because of deficiency in structural peculiarities affecting those special organs usually looked to elsewhere, or in diversification of the sclerites of the under surface, overlooking the fact, of which we here have sufficient proof, that our criteria for generic definition should vary to fit the conditions of the particular section of the Coleopterous series that we may have under consideration. In this case elytral and antennal structure become of paramount importance from the generic viewpoint, although in many other sections of the order they may be wholly unimportant.

Messrs. Warren Knaus, H. F. Wickham and Chas. W. Leng have generously permitted me to acquire duplicate material from their collections, and this, together with a considerable series in my own cabinet collected by Dunn, Levette and others, gives me a very fair representation of the species. I also have to thank Mr. Champion for a transcription of Ollivier's diagnosis of *Buprestis viridula*. In order to study the laws of intraspecific variation I obtained extensive series collected by Mr. A. H. Manee, at Southern Pines, North Carolina, consisting of about sixty-five specimens of *Buprestis ornata* and some twenty-five examples each of *B. apricans* and *Dicerca obscura*. These have been of some utility in several efforts to decide whether or not two closely allied uniques might represent different species, for the laws of variation applying to a few species are very apt to apply to all those in the same group of genera. The secondary sexual characters at the apex of the abdomen are remarkably inconstant within rather broad limits and cannot be employed, as a rule, in defining allied species, and punctuation and general sculpture are also variable in some parts of the series to a rather unusual degree; but the formation of the elytral apices is usually rather constant. So it required a large amount of study to become sufficiently familiar with the subject to attempt the definite separation of specific and subspecific forms. Probably I have made some mistakes which future knowledge will rectify.[1]

[1]This paper is the gradual outgrowth of an original intention on the part of the writer, to describe, merely in an isolated manner, a few species of *Gyascutus*.

The genera here considered may be defined as follows:—

Mesosternum and metasternum anchylosed, the suture obsolete or very fine.....2

Mesosternum separated from the metasternum by a distinct cleft.....14

2—Outer antennal joints more or less obliquely truncate beneath, always more rapidly or abruptly narrowed basally, and usually with sensitive setigerous pores in addition to the fossæ, the latter in a few cases wholly obsolete.....3

Outer antennal joints enlarged within apically, or more typically serriform, not more rapidly or abruptly narrowed basally, usually without aggregated sensitive pores but always having an intero-terminal sensory fossa; antennæ shorter and more compact as a rule.....10

3—Last antennal joint with a terminal process, wanting apparently only in the male of *Hippomelas;* sensory fossæ terminal, diversely developed and sometimes obsolete; pronotum never sulcate. Sonoran faunal regions.....4

Last antennal joint without trace of terminal process in either sex.....6

4—Last antennal joint of the male without evident terminal process; body moderately stout to narrow and subcuneate, convex, more feebly and evenly sculptured, the sides of the prothorax more evenly converging from base to apex and frequently nearly straight; tarsi variable. [Type *Buprestis saginata* Mann.].....**Hippomelas**

Last antennal joint having a distinct terminal process in both sexes; sculpture of the integuments deeper and more irregular.....5

5—Pronotum with the basal bead never entire but always interrupted medially, where it joins the raised median smooth line; tarsi more slender and elongate, the basal joint of the posterior almost always longer than the next two combined; sculpture moderately diversified. [Type *Chalcophora planicosta* Lec.] ..... **Gyascutus**

Pronotum with the basal bead strong, even and entire, not obliterated at the middle; tarsi shorter and thicker as a rule though variable, the basal joint of the posterior not as long as the next two combined; sculpture rough though more uniform, that of the pronotum almost as in *Spinthoptera.* [Type *Chalcophora cælata* Lec.] ..... **Stictocera**

6—Outer antennal joints with lateral as well as apical sensory fossæ. Body more or less parallel, the apical part of the elytra regularly ogival as a rule and narrowly truncate and bispinulose at the apices; pronotum wholly devoid of basal beading, not sulcate though sometimes in part feebly, longitudinally impressed medially; elytra with impressed series of coarse punctures, and, in addition, scattered finely punctulate and puberulent shallow areolæ, which are usually bright metallic in coloration; prosternum bisulcate, transversely truncate anteriorly; basal segment of the abdomen feebly flattened to deeply sulcate; tarsi thick, the first joint of the posterior but little longer than the second. Sonoran and Neotropical regions. [Type *Psiloptera valens* Lec.]. **Spinthoptera**

Outer antennal joints with the sensory fossæ single and intero-terminal, very rarely obsolete.....7

7—Elytra very irregularly sculptured; pronotum always sulcate; epistoma unusually narrowly and deeply emarginate.....8

Elytra with regular sculpture, never having the large, uneven and interrupting depressions of the preceding group; pronotum generally without a median sulcus though sometimes impressed along the median line; epistoma more broadly and feebly sinuate as usual; legs slender. Holarctic faunal region.....9

8—Pronotum bisulcate, the median line more or less evidently costuliform; elytra with deep irregular depressions, the side margins never more than feebly serrulate posteriorly, the apex generally obtusely angulate; antennæ with the setigerous pores scattered and perforate, the sensory fossa obsolete; labrum corneous; mentum very transverse, truncate, wholly corneous; prosternum bisulcate. Holarctic regions. [Type *Buprestis mariana* Linn.]..... **Chalcophora**

Pronotum unisulcate; antennæ rather thick, the outer joints with close-set impressed setigerous pores and with well developed intero-apical sensory fossæ, the latter irregular in form; labrum coriaceous; mentum less transverse, trapezoidal, corneous in more than basal half, the apical part coriaceous; elytra irregularly punctured, very unevenly costulate and with very large and shallow interrupting areolæ, the lateral edges strongly serrate posteriorly, the apex not truncate; prosternum and first ventral impressed along the median line. Nearctic regions. [Type *Buprestis campestris* Say].....**Texania**

9—Scutellum large, the remaining characters nearly as in *Buprestis*, the elytra regularly striate. Europe. [Type *Buprestis austriaca* Linn.]. *** Eurythyrea**

Scutellum small; elytra striate; labrum generally wholly coriaceous and pale in color but becoming corneous and metallic basally in some aberrant species; elytral apices rounded or truncate, sometimes bispinulose, the sides not serrulate posteriorly; prosternum convex or flattened along the middle; first ventral convex to deeply sulcate; basal joint of the hind tarsi more or less considerably elongate. Holarctic regions. [Type *B. octoguttata* Linn.]..... **Buprestis**

Elytra not striate but regularly costate, with densely cribrate and broadly concave intervales, without trace of serial punctures; labrum always corneous and metallic basally; prosternum impressed and punctured along the middle; elytra rounded or truncate at tip. Nearctic regions. [Type *Ancylocheira lauta* Lec.]..... Cypriacis

Elytra densely and subevenly cribrate, without striæ, but having regular series of large perforate punctures; remaining characters nearly as in *Cypriacis*. Atlantic Nearctic regions. [Type *Buprestis decora* Fabr.]..... Stereosa

10—Hind coxæ strongly dilated within as usual, their hind margin thence strongly oblique to the sides; antennal fossæ antero-internal, small and

rounded; eyes with their inner margins oblique as usual; tarsi longer; body not cuneiform.....11

Hind coxæ but slightly dilated within, their posterior edge thence transverse to the sides of the body; eyes parallel within; antero-terminal fossæ of the outer antennal joints large and irregular, the joints also with a small lateral fossa in addition; body subcuneate in form.....13

11—Pronotum more closely punctate or depressed along the median line; elytra roughly sculptured, more or less prolonged at tip, not or scarcely serrate at the sides posteriorly; antennæ inserted in larger depressions under more or less pronounced oblique elevations of the front. Holarctic regions. [Type *Buprestis œnea* Linn.].....**Dicerca**

Pronotum subelevated and impunctate along the median line; elytra less roughly sculptured and usually with more distinct striation.....12

12—Antennæ inserted under oblique prominences somewhat as in *Dicerca;* elytra more or less feebly produced at tip, not or scarcely serrulate at the sides, the apices truncate or sinuate and generally bispinulose; surface with sombre coloration. Holarctic regions. [Type *Buprestis variolosa* Payk.].....**Pœcilonota**

Antennæ inserted in exposed foramina, the supra-antennal ridges obsolete; elytra not produced at tip, feebly serrulate at the sides posteriorly, the apices more or less truncate and multispiculose; integuments with vivid metallic coloration. Europe. [Type *Buprestis festiva* Linn.]. ***Lampra**

13—Antennæ inserted in small frontal foramina, very short and compact; pronotum feebly impressed medially toward base, otherwise almost evenly convex; scutellum small; elytra subevenly cribrate and with very faint subconvex smoother lines, the sides serrate posteriorly and at the narrowly rounded apex, which is not at all produced; tarsi very short. Sonoran regions. [Type *Halecia gentilis* Horn].....**Anataxis**

14—Scutellum small as usual but distinct and normal.....15

Scutellum obsolete; elytra without striation.....16

15—Antennæ inserted in small foramina under very small, feeble and inconspicuous ridges, short, compact, the joints nearly as in *Dicerca* but more convex and with dense sensitive pores beneath, the sensory fossæ intero-terminal, distinct and circular, the last joint with a strong terminal process as in *Gyascutus;* body small, subcylindric, the eyes widely separated, with their inner margins but slightly converging upward; prothorax subparallel and broadly rounded at the sides, faintly impressed along a part of the median line; legs slender; tarsi short; hind coxæ dilated internally as usual; first ventral suture distinct, rectilinear throughout; elytra feebly serrulate at the sides and finely striato-punctate. California. [Type *N. cupreofusca* n. sp.].....**Nanularia**

Antennæ inserted in very small and widely separated foramina, which have their upper edges horizontally acute but not ridged, very slender, the outer joints elongate and much as in *Buprestis,* sparsely punctate, more closely and subrugulosely beneath, with very small rounded intero-

terminal sensory fossa; labrum well developed, sinuato-truncate; epistoma unusually deeply and not broadly emarginate; body small, slender; eyes with the inner margins distinctly converging upward as usual; prothorax feebly trapezoidal with nearly straight sides, trisulcate; elytra without trace of serrulation at the sides, sinuate and bidenticulate at the apices, obscurely and imperfectly striate and with uneven and undefined subimpressed areolæ; prosternum not sulcate; first ventral convex, the first suture fine but distinct, straight; legs long and very slender. Atlantic regions. [Type *Buprestis elongata* Lap.-Gory]. ..... **Cinyra**

16—Antennæ inserted in small exposed foramina, not within a cavity and without superior ridge though having a small polished and sculptureless spot adjoining each above and becoming more prominent along the upper margin of the foramina, their outer joints strongly serrate and triangular, with their lower margins very oblique and more converging basally, having dense asperate sensitive pores beneath anteriorly and a large intero-apical sensory fossa, the last joint narrow and elongate-oval; eyes widely separated, their inner margins slightly converging upward; epistomal margin narrowly, deeply sinuate medially; labrum as in *Cypriacis*, coriaceous but having basally two large dense and metallic areas which are very narrowly separated medially; maxillary palpi very slender; mentum sinuate at apex, corneous and densely cribrate; pronotum uneven, with a short compressed and prominent ridge at each side behind the middle of the lateral margin and a small deep cavity before the middle of the base; scutellum wholly obsolete; elytra oblong, wider than the prothorax, cribrate, without trace of striæ and very uneven, scarcely at all serrulate at the sides, the tips obtuse, rounded; prosternum densely sculptured throughout, not impressed, the abruptly narrowed apex not attaining the metasternum, the side pieces of the mesosternum separated, however, by a deep cleft; basal segment of the abdomen apparently free or nearly so, the first suture similar to the others and rectilinear; legs slender, the basal joint of the hind tarsi greatly elongated; hind coxæ strongly oblique as usual. Pacific coast to Gulf of Mexico. [Type *T. blondeli* Mars.]. ..... **Trachykele**

The usual position of *Dicerça*, interpolated between *Hippomelas* and *Buprestis*, dates apparently from the work of Lacordaire, who drew attention to the similarity in antennal insertion and form of the supra-antennal ridges to those of *Psiloptera;* but the marked dissimilarity of the antennæ themselves seems to the writer a far more important consideration and necessitates the removal of *Dicerca* and *Pœcilonota* from the vicinity of *Hippomelas*, *Psiloptera* and *Buprestis*, to a closer association with *Chrysobothris*. The European *Eurythyrea* Sol., and *Lampra* Spin., are introduced above for comparison and greater completeness; they are distinguished by the prefixed asterisk. There can be but little question that *Lampra* ought to be considered a genus dis-

tinct from *Pœcilonota* and not a subgenus. *Anataxis*, proposed for *Halecia gentilis*, is not closely related to *Dicerca* or *Pœcilonota*, but I can imagine no better place for it than that assigned in the table. It was placed in *Agœocera*, by Waterhouse, but on examining the figure given by Laporte and Gory for *Anthaxia gigas*, the type of *Agœocera*, I cannot perceive the least serration of the sides of the elytra and, besides, the pronotal and elytral structure is so different that I venture to propose for *gentilis* a separate genus. This species is entered twice in the Kerremans Catalogue, once under *Agœocera* and again under *Halecia*. The genus *Trachykele*, of Marseul, is very aberrant, not only in general facies and absence of scutellum, but in the virtually free basal segment of the abdomen. It is quite probable that *Buprestis lecontei* Lap.–Gory, constitutes a genus different from that founded upon such species as *blondeli* and *opulenta*.

The delimitation of species in this group of genera, and indeed throughout the Buprestidæ, is rather more difficult and uncertain than usual, because of erratic variation in many of the elements generally relied upon for the definition of species. Kerremans alludes to this in the introduction to his general catalogue of the family, and intimates that there may possibly be no such reality in nature as species or genera, or even higher groups, and that it may be all a matter of individual opinion. The expression, "opinionative species," is frequently employed in alluding to those which are maintained or reduced from time to time through the idiosyncrasies of writers, though rather meaningless after all, because of the impracticability of standardizing human intelligence; but, on the strength of his expressed doubts and apprehensions, the author quoted has had recourse to a wholesale system of "lumping," which appears to me not fully justified. Because of deficiency in material I have not always been able to make up my mind definitely as to species, having had to rely more on general habitus than anything else in a number of cases. Those forms which are consequently to some extent doubtful to me as species are inscribed as subspecies in the various tables, but, because of the undesirability of trinomials, these subspecies should be quoted under two names only when referred to verbally or in text; they would not have been named at all if there were not a very strong probability of true specific value in every case. In some parts of the series I have united and separated forms many times before coming to a

conclusion, final as far as apparently permissible from the incomplete material at hand. Kirby's species were all collected from three to ten hundred miles north of our northern boundaries and some of them are unquestionably different from our own; the attempt to force some of our forms to bear the Kirbyan names has given rise to several mistakes. The *Buprestis viridula*, of Ollivier, described from Carolina, is a Philippine species of *Dicercomorpha*. *Gyascutus californicus*, of Horn, is assumed to form part of the genus *Nanularia*, though in that species the last antennal joint is specially described as obtuse at apex, so that this reference is somewhat hypothetical. If *californicus* is not assignable to *Nanularia*, however, I can suggest no other place for it, as, apparently, it can be neither a *Gyascutus* nor a *Hippomelas*.

Hippomelas Lap.-Gory.

The species of this genus are more elongate and subcylindric as a rule than in *Gyascutus* and *Stictocera*, and of much smoother and more feebly sculptured surface; they, however, occasionally become rather stout in form, as in the type, which was named *saginatus* by Mannerheim; this species is not represented in my collection at present. The coloration is usually black and frequently without trace of metallic lustre, but is occasionally bright and metallic, particularly in *mexicanus* and related species of southern Mexico, and also in the second subgenus, defined below. The head and eyes are large, the frontal surface roughly sculptured as usual, descending at the sides in a more punctate and pubescent slope or depression to the inner margin of the eyes, the epistoma broadly, feebly sinuate, the antennæ moderately long and compressed, the outer joints with dense sensitive punctures, except above, and having an irregular and somewhat inconstant or vestigial apical sensory fossa near the margin of the articular foramen, and they are inserted under strong oblique frontal ridges. The prosternum is not impressed though feebly flattened, the mesosternum wholly divided, the meso-metasternal suture fine and sometimes barely traceable, the first ventral convex medially and the legs variable subgenerically. There are two subgenera as follows:—

Tarsi shorter and thicker, the basal joint never as long as the two following combined; abdomen with the basal segment shorter, behind the coxæ more or less evidently shorter than the second, the first suture sinuate medially as usual though almost obliterated.....**Hippomelas**

Tarsi longer and more slender, the basal joint fully as long as the next two or longer, as in *Gyascutus;* abdomen with the basal segment a little longer, the first suture similar but better marked..... **Prasinalia**

The latter of these subgenera seems to be peculiar to the fauna of Arizona and the adjacent parts of California, where it replaces *Hippomelas,* which is widely diffused from our southern boundaries to southern Mexico.

Hippomelas in sp.

Legs very thick, the tarsi unusually short, the basal joint of the posterior but little longer than the second. Body moderately narrow, convex, subcylindric, cupreous in lustre, the elytra more æneous, the epipleuræ and sides of the under surface becoming greenish; head (♂) much more depressed throughout the frontal surface and vertex than in any other species, feebly concave, hairy, more finely and uniformly sculptured and green from the occiput to the strong antennal ridges; outer antennal joints parallel; prothorax two-fifths wider than long, moderately trapezoidal, the sides straight; apex feebly arcuate except laterally, the base broadly bisinuate; surface moderately strongly, subevenly and sparsely punctate, more closely laterally and with feebly marked and more convex vacant spaces throughout, the lateral margin green; scutellum small, transverse; elytra slightly wider than the prothorax and three and one-half times as long, the sides feebly converging from the humeri to about apical third, thence rounding and with long, very feeble serrules to the apices, which are narrowly and deeply emarginate and briefly bidentate; surface even, with barely impressed striæ of fine close punctures, becoming larger and closely confused at the sides; intervals scarcely punctate, somewhat creased; under surface sparsely punctate, polished, bright coppery, the legs and lateral parts unusually pubescent. Length 23.0 mm.; width 7.5 mm. Mexico (Guerrero). ***brevipes** n. sp.

Legs less thick, the tarsi less abbreviated, the basal joint of the posterior almost as long as the next two combined as a rule..... 2

2—Body stouter in form, always black or blackish and seldom with noticeable metallic lustre. Sonoran regions..... 3

Body narrower, decidedly slender though convex and subcylindric, bright metallic in lustre; third antennal joint much shorter, but little longer than the fourth. Southern Mexico..... 6

3—Elytra with very feeble æneous or greenish-metallic lustre 4

Elytra deep black or piceous-black, without trace of metallic lustre 5

4—Form elongate-oval, convex, stout, moderately shining, the hairs of the elytra very short and sparse, dense and longer as usual at the finely punctate basal margin, also unequally on the head, the legs very sparsely pubescent; head large, with large irregular elevated smooth areas which are separated by æneous depressions, the latter densely and rather finely punctate; antennæ moderate, the third joint unusually elongate; pro-

thorax three-fourths wider than long, the sides broadly rounded, more strongly converging anteriorly, the basal angles somewhat prominent; apical margin broadly arcuate except laterally, the base sinuate laterally; surface rugose laterally, and, less distinctly, apically, rather finely, remotely punctate medially, the interspaces laterally with dense æneous punctures in vermiculate series; scutellum transversely oval; elytra not evidently wider than the prothorax, narrowed slightly to near apical third, the sides thence rounding and feebly serrulate to the feebly emarginate and bidenticulate tips; surface convex throughout, striato-punctate nearly as in *brevipes;* under surface shining, black and æneous, the abdomen strongly, rather sparsely æneo-punctate, convex, notably ascending posteriorly. Length 28.0–29.0 mm.; width 10.0–10.3 mm. Western Texas.....**grossus** n. sp.

A—Nearly similar to the preceding but shorter, the prothorax somewhat shorter, more strongly punctured, less narrowed anteriorly, the head relatively still larger; elytra shorter, more obtuse behind, the series of punctures scarcely at all impressed and the punctuation laterally less confused and scarcely more close-set than toward the suture; tibiæ shorter, more outwardly expanded at apex and notably more densely setulose throughout. Length 26.5 mm.; width 9.5 mm. Western Texas.....**robustus** n. subsp.

Form narrower and more elongate, smaller in size, subcylindrically convex. shining, the head large, in great part æneous, densely punctured and pubescent, the smooth irregular areas strongly elevated; antennæ strongly compressed as usual, the third joint slightly less elongate; eyes large and prominent; prothorax deep black, but little more than one-half wider than long, the sides feebly converging, broadly, feebly and subevenly arcuate from base to apex, the latter feebly arcuate; base deeply sinuate laterally, the angles not at all everted; surface deeply vermicularly rugose, with the intervals æneo-punctate, coarsely punctate apically, less coarsely and sparsely medially and basally; scutellum tumid, transversely oval; elytra but little wider than the prothorax, formed nearly as in *grossus* and similarly sculptured, with widely spaced and distinct punctures in uneven single series along the intervals, greenish-metallic in lustre, the sides apically rather strongly and acutely serrulate, the apex approximately bidentate as usual; under surface in great part æneous, the abdomen strongly, more closely and irregularly punctured, less strongly ascending posteriorly than in *grossus;* tibiæ not densely but strongly albido-setulose. Length 25.0 mm.; width 7.8 mm. Arizona (Tucson).....**serrulatus** n. sp.

Form elongate, convex, much smaller in size than *grossus*, blackish-æneous in color, the pubescence sparse and extremely short; prothorax one-half wider than long, slightly narrowed anteriorly, the sides broadly rounded, the posterior angles acute; elytra finely striato-punctate, the intervals sparsely punctate. Length 18.8–25.0 mm. Texas (Laredo to Ringgold Barracks). [=*Buprestis sphenicus* Lec.]..... **sphenicus** Lec.

5—Body rather short, stout, the male narrower and with more cuneate elytra, deep black, slightly shining, subglabrous as usual; head moderately

large, less elevated between the eyes than in the preceding species, rugose and with greenish punctures, pubescent, more concave anteriorly in the male; eyes large, prominent; antennæ extending nearly to the base of the prothorax (♂) or evidently shorter (♀); prothorax trapezoidal, three-fourths to four-fifths wider than long, the sides distinctly arcuate, becoming feebly sinuate basally, rugosely æneo-punctate, smoother and sparsely punctate medially and toward base; scutellum less transverse and more quadrate than in the preceding species; elytra scarcely wider than the prothorax, of the usual form, scarcely at all serrulate at the sides behind, with the usual apical sinuation, the surface notably flattened toward apex, the punctured series more or less confused or irregular except toward apex, where they become deeper, excepting four pairs of striæ on each elytron, which are regular throughout; under surface black and ænescent, the abdomen coarsely and rugosely but not densely punctate; legs moderate, the hind tibiæ more gradually and distinctly thickened from base to apex in the male, the fifth ventral truncate in both sexes but with the marginal gutter deeper and more abrupt in the male. Length 23.0–27.0 mm.; width 8.3–10.0 mm. Southern Arizona..... **planicauda** n. sp.

Body parallel and more convex, deep black, somewhat shining; head relatively rather small, nearly as in *planicauda*, the eyes large and prominent; third antennal joint a little more than twice as long as wide; prothorax feebly trapezoidal, three-fourths wider than long, the sides broadly and feebly arcuate, becoming straight toward base, the surface coarsely but rather sparsely punctate, becoming æneo-punctate and rugose laterally and apically; scutellum scarcely one-half wider than long, oval, broadly impressed; elytra barely wider than the prothorax, parallel and straight at the sides to apical third, thence gradually rounding to the emarginate apices, not at all serrulate except feebly very near the tip; surface not notably depressed posteriorly, sculptured as in *planicauda* though very much more sparsely and less conspicuously, the only regular series, except the sutural as in *planicauda*, being in four pairs; under surface black and æneous, the abdomen rugosely punctate and with large flattened punctureless patches laterally. *Male* with the apex of the fifth ventral transversely excavated, the posterior truncate edge broadly, angularly lobed toward the middle. Length 20.0 mm.; width 7.0 mm. Arizona (Nogales). **cylindricus** n. sp.

6—Pronotum somewhat irregularly sculptured, generally with rounded punctureless areas anteriorly; body moderately narrow, cupreous, the elytra greenish-metallic, parallel, feebly striato-punctate, the rounding sides posteriorly evidently serrulate, the surface without dense pubescence at base. Length 20.0 mm.; width 6.5 mm. Mexico.
***mexicanus** Lap.-Gory

Prasinalia n. subgen.

Hind tarsus as long as the tibia. Body elongate, cuneate, æneous-green, shining; epistoma truncate; head intricato-rugose, the antennæ very long, nearly one-half longer than the head and prothorax, the latter slightly wider than long, narrowed anteriorly, the sides nearly straight, truncate in front, "trisinuate" at base, the hind angles acute, not everted; surface coarsely, and, at the sides, confluently punctate; elytra narrow, convex, gradually narrowing from base to apex, the tips bidentate, the surface rather coarsely and irregularly striato-punctate; under surface finely and densely punctate, paler in color, the prosternum polished and violaceous; hind tarsi compressed, the first joint as long as the two following combined. Length 18.8 mm. California (Owen's Valley). [=*Gyascutus cuneatus* Horn].

cuneatus Horn

Hind tarsus distinctly shorter than the tibia, though slender and subcompressed..... 2

2—Body narrow, the elytra unevenly cuneate, rather convex, polished, bright metallic green above and beneath, the prosternum cuprascent, the posterior margins of the ventral segments steel-blue; head with the vertex elevated, the ocular slopes abruptly descending from longitudinal polished impunctate areas along the sides, the median parts more irregularly rugose, the epistoma very feebly and broadly sinuate; antennæ extending to basal fourth of the prothorax, the third joint equal in length to the fourth, the eleventh with a short terminal process; prothorax trapezoidal, with the sides but very feebly arcuate, less than one-half wider than long, the apex arcuato-truncate, the base broadly sinuate laterally and with a small feeble sinus at the scutellum; surface moderately and sparsely punctate, more coarsely and coalescently so laterally, the basal angles acute; scutellum small, only slightly transverse; elytra not evidently wider than the prothorax, feebly narrowed to near apical third, then more strongly to the acutely ogival apex, the sides posteriorly serrulate, the apices emarginate; surface strongly and closely, and, toward the sides and apices, confusedly punctate, the punctured striæ evident however and regular except near the sides, somewhat impressed; under surface finely but not very closely punctate, the prosternum medially polished and with a few punctures scattered along the median line. Length 19.0 mm.; width 6.0 mm. Arizona (Florence)..... **angustus** n. sp.

Body larger and much stouter, similar in lustre and coloration, except that the ventral segments are not margined with blue, the entire abdominal surface irregularly clouded with metallic cupreous and green; head nearly similar, except that the elevated polished areas parallel to the eyes are not so well defined and are covered with coarse sparse punctures; antennæ similar, the eleventh joint with a short terminal process; prothorax similar but more transverse, with the sides more arcuate, becoming more evidently sinuate basally, the basal margin at the scutellum not evidently sinuate and the surface broadly impressed

medially, broadly flattened toward base; elytra as wide as the prothorax, very feebly narrowed to near apical third, then much more rapidly and with the sides serrulate to the emarginate apices, the punctures everywhere well separated, the punctured series wholly unimpressed and almost regular though rather inconspicuous; under surface nearly as in *angustus*, the abdominal punctures fine, feebler and more unevenly distributed. Length 24.0 mm.; width 7.5 mm. Southern California. ..... **metallicus** n. sp.

If the same sexual difference in the antennæ obtains in *Prasinalia* as in *Hippomelas*, the types of both *angustus* and *metallicus* are females; but I can scarcely imagine so great a sexual divergence in the antennæ, and especially in the hind tarsi, as equality of either of them with *cuneatus* would imply, assuming the type of that species to be a male. The synonymy of *mexicanus* with *saginatus*, usually maintained, is I think wholly without basis of fact. There is a specimen before me, from Guerrero, that I have assigned to *mexicanus*, though it is more æneous throughout above and lacks the rounded punctureless spaces on the pronotum. There is no material from the lower Rio Grande valley in my collection at present, so it is only possible to utilize the characters given in the original description for *sphenicus* Lec. It is without much doubt different from any of the more western forms above described. *Brevipes* is almost subgenerically different from the remainder of *Hippomelas* and is placed first as being at one of the extremes in tarsal structure; the fifth ventral of its male is not transversely excavated at tip, though having the edge laminate; it is very broadly truncate at apex, with two small, widely separated and nearly circular emarginations.

Gyascutus Lec.

In this genus the body is convex, though less elongate and more oval than in *Hippomelas*, and the head is relatively much smaller; the surface sculpture is far rougher as a rule and the finely pubescent areas which, during life become thickly coated with a loose whitish farinaceiform material, are more extensive, particularly at the sides of the under surface and at the base and along the depressions of the elytra; the finer sculpture and longer pubescence of these areas serve to retain the powdery coating more securely. The general structure is almost as in *Hippomelas*, though the prothorax is always strongly rounding at the sides and more narrowed anteriorly and the hind coxæ are less

dilated internally, their posterior edge being less oblique. The sexual characters are much the same, the fifth ventral being more or less similarly truncate and transversely impressed in both sexes, sometimes with a minute tooth at each side of the truncature. The basal joint of the hind tarsi is frequently much longer than the next two combined, the epistoma broadly sinuato-truncate, the elytra invariably bispiculose at tip and the coloration of the body always metallic. The species are numerous, those known thus far being the following:—

Pronotum finely and densely punctate between the smooth elevations even medially; elytra with finer and denser punctures in a longitudinal sublateral area; coloration generally greenish-metallic.....2

Pronotum sparsely and generally more coarsely punctate medially and basally, the elytral sculpture more even, without a clearly demarcated sublateral area of much finer and denser punctuation; size smaller as a rule, the coloration generally coppery.....11

2—Elytra rapidly narrowed from base to apex, the latter relatively acute. Body rather stout, convex, shining, obscure greenish-metallic throughout, the depressions rather closely but briefly pubescent; head with large confused polished rugæ, except broadly along the eyes and in front, the depressions densely punctate, ænescent and densely pubescent; prothorax about two-thirds wider than long, trapezoidal, the sides strongly arcuate, converging and straighter anteriorly, sinuate toward the prominent and acute basal angles, the base broadly sinuate laterally and very broadly and feebly at the scutellum; apex broadly, feebly arcuate medially; surface with numerous polished elevations, except in the apical transverse impression, all the depressions densely punctate; scutellum slightly transverse; elytra at the humeri much wider than the prothorax, the sides feebly arcuate; surface of each with three polished, somewhat ragged costæ, the interval of the second and third broad and unusually finely, densely punctate; striation only traceable between the polished sutural elevation and the first costa; under surface unequally punctate, finely and densely toward the bases of the abdominal segments and on the hind coxæ; prosternum narrowly and feebly impressed and punctate along the middle; hind tarsi very slender though evidently shorter than the tibiæ. Length 21.5–23.5 mm.; width 7.8–9.0 mm. California (Yuma). [=*Chalcophora planicosta* Lec.]..... **planicosta** Lec.

Elytra not rapidly narrowed from base to apex, at the humeri less notably broader than the prothorax as a rule.....3

3—Eyes convex and notably prominent as in *planicosta*.....4

Eyes feebly convex, not at all prominent, continuing the general outline curve of the head.....10

4—Elevated polished spaces of the pronotum very numerous and conspicuous.....5

Elevated pronotal spaces very small and few in number, widely scattered; sculpture and subsutural striation of the elytra aberrant.....9

5—Elytra distinctly subcostate, cuprascent. Body moderately stout and convex, shining, the pubescence of the upper surface and head unusually short, also fine, short and close beneath; head and pronotum bright æneous, the former closely and subevenly rugose, except near the eyes and on the occiput, the inter-rugal punctures coarse and not dense; antennæ (♂) extending rather beyond the base of the prothorax, the latter three-fifths wider than long, very slightly narrower than the elytra, of the usual form, the basal angles distinctly everted and acute; scutellar sinuation feeble; surface with strong but very irregular polished elevations, continuous along the median line, the interstitial punctures rather small and dense; elytra just visibly narrowed and with nearly straight sides to apical two-fifths, thence obliquely to the rather acute apex; surface with the three broad costæ of *planicosta* very evident but still more ragged and broken, the striæ, except the sutural and scutellar, scarcely traceable; punctures close, finer and denser laterally. Length 20.0 mm.; width 7.7 mm. Arizona (Bill William's Fork),—F. H. Snow.....**snowi** n. sp.

Elytra with the costæ never more than traceable; coloration generally more greenish.....6

6—Form narrower and subparallel, the sinus of the elytral apices broader than usual.....7

Form very broadly suboval.....8

7—Lustre moderately shining, greenish-æneous; pubescence of the elytra short but rather abundant, subvittate; head subcupreous, unusually densely pubescent, rather finely, very densely punctate throughout, the median line carinate medially, the elevated spots very few in number and inconspicuous; antennæ (♂) extending slightly beyond the base of the prothorax, unusually dilated from the base of the fourth joint; prothorax three-fourths wider than long, the sides broadly rounding, evidently more so medially, the basal angles prominent; surface with strong and confused through isolated elevated spaces, the punctures of the interspaces strong, dense and cribrate; elytra between three and four times as long as the prothorax and a little wider, the dorsal humeral swelling pronounced; surface striated, suturally, the costæ evident but only feebly convex, not elevated, the surface laterally deeply and very densely cribrate; under surface greenish-æneous, finely, densely punctate except medially. Length 23.5 mm.; width 8.8 mm. Arizona.....**cribriceps** n. sp.

Lustre strongly shining, greenish, sometimes with a faint æneous tinge; pubescence less abundant, very short; head metallic-green, confusedly rugose, the punctuation of the interspaces coarse, close but much less extensive than the smooth rugosities, the pubescence much sparser than in *cribriceps;* antennæ not so broad at the fourth joint; prothorax nearly similar but with the small punctures of the interspaces not so dense or deeply cribrate; elytra but little wider than the prothorax,

the sides straight and parallel to apical two-fifths, thence rapidly rounded and oblique to the rather obtuse apex, the humeral swelling not conspicuous; disk without costæ, their positions indicated by greater convexity and sparser punctures of the surface, which is evidently striate suturally, finely and only moderately closely punctate even sublaterally, the two apical spines unusually developed. Length 15.7–21.0 mm.; width 5.7–7.8 mm. New Mexico (Demming).

pistorius n. sp.

Lustre moderately shining, obscure greenish-metallic, the surface more convex than in either of the preceding species and with the head decidedly smaller, the large polished rugosities more extensive than the punctuation; antennæ (♂) with the third joint barely as long as the fourth, the latter and succeeding joints moderately compressed, parallel except basally; prothorax two-thirds wider than long, of the usual form, much narrowed anteriorly, the basal angles abruptly everted, acute and very prominent; surface covered with strong polished confused elevations, the punctures of the interspaces rather coarse, fine along the basal margin; elytra subparallel, the sides nearly straight for three-fifths, thence rounding, oblique, and becoming nearly straight to the apex; surface nearly even and almost equally convex throughout, the sublateral punctures not very close-set; striæ obliterated, except the sutural and three more visible double striæ on each, also a fourth visible apically near the sides and more tumid; under surface irregularly and, for the most part, finely and closely punctate. Length 20.0 mm.; width 7.3 mm. Arizona (Winslow),—H. F. Wickham.

acutangulus n. sp.

8—Surface metallic-green with feeble æneous tinge, only moderately shining; pubescence ashy as usual, rather distinct, feebly subvittate on the elytra; head nearly as in *pistorius* but with fewer rugæ and greater extent of dense punctures, particularly before the middle, closely and conspicuously pubescent; antennæ (♂) nearly as in *pistorius* but with the third joint much more elongate, being decidedly longer than the fourth; prothorax short, nearly four-fifths wider than long, rounded at the sides, unusually narrowed but with arcuate sides to the apex, the basal angles unusually feebly everted; surface nearly as in *pistorius;* elytra evidently wider than the prothorax, the sides very feebly converging and feebly arcuate for three-fifths, thence slightly more arcuate and gradually strongly convergent but arcuate to the tip; surface nearly as in *pistorius;* under surface more unevenly punctate. Length 22.5 mm.; width 8.7 mm. Arizona.....**pimalicus** n. sp.

Surface much more polished and pale brassy-green in color, generally not at all cupreous, feebly pubescent, the pubescence inconspicuous and scarcely at all vittate on the elytra; head in great part coarsely and closely rugose, rather sparsely pubescent; antennæ (♂) with the third joint slender but scarcely as long as the fourth; prothorax very transverse (♀) or much less so (♂), the sides more arcuate but rather less converging anteriorly than in *pimalicus*, the hind angles much more prominently everted and acute; surface nearly similar, except that the

punctures are finer, less dense and more inconspicuous medially toward base; elytra almost evenly convex, without trace of costæ except feebly toward tip, the surface evidently though finely striate and more coarsely sculptured in about inner half, the fine punctures sublaterally not close-set and rather uneven; outline nearly as in *pimalicus;* abdominal segments finely and densely punctate only toward base. Length 19.3–24.5 mm.; width 7.0–10.2 mm. Utah (St. George),—H. F. Wickham. **amplus** n. sp.

A—Body more elongate, bright brassy-cupreous in color; head nearly similarly rugose but more finely, closely punctate toward the eyes and on the occiput; prothorax twice as wide as long, nearly as in *amplus* but wider at base, the basal angles not so acute or everted but extending sensibly beyond the elytral humeri; elytra more elongate, with the sides very rounding and converging posteriorly, very much more gradually so than in *amplus*, the surface less rugose. Length 23.5 mm.; width 9.0 mm. Utah (St. George),—H. F. Wickham..... **ærata** n. subsp.

9—Very stout, elongate-oval in form, convex, only moderately shining, bronzy-æneous in color, the pubescence of the elytra very short, sparse, evenly distributed, without trace of vittate appearance; head not densely pubescent, about equally rugose and densely punctate; antennæ (♀) attaining about basal third of the pronotum, the prothorax large, but little narrower than the elytra, two-thirds wider than long, the sides subevenly rounded, becoming strongly convergent anteriorly, the basal angles everted and acute; surface with the median line, which is irregularly enlarged anteriorly, and a few small scattered spots elevated and smooth, the major part of the surface, however, rather coarsely, deeply and densely cribrate; elytra with the sides just visibly converging and slightly arcuate for three-fifths, then rather rapidly rounding, becoming oblique and feebly arcuate to the apex; surface subequally and densely punctate throughout, the striæ especially evident in four pairs on each, the first pair not evenly arcuate to the tip but becoming more strongly and externally arcuate in about apical fourth; under surface in great part finely though not densely punctate, very briefly and inconspicuously pubescent. Length 24.5 mm.; width 9.8 mm. Utah (St. George), —H. F. Wickham..... **egregius** n. sp.

10—Elytra with obsolescent smooth costæ or very evident vestiges of disintegrated costulation, the surfaces between the very feeble elevations somewhat concave and finely, densely punctate except suturally; body moderately stout, parallel, rather convex, greenish or viridiæneous to feebly cuprascent and rather shining, the pubescence distinct and somewhat longer than usual; head rather smaller than usual, the eyes brown in all examples examined, the front about equally rugose and finely, densely punctate; antennæ moderate, the third joint barely as long as the fourth (♂) or a little longer(♀); prothorax two-thirds wider than long, narrowed anteriorly, arcuate at the sides, the basal angles very variable in prominence and eversion; surface with finer, dense punctures and large irregular polished elevations, the me-

dian line broadly and irregularly convex and smooth, more or less evidently bifurcating anteriorly; elytra but little wider than the prothorax, the sides just visibly converging for three-fifths, then rounding and arcuately converging to the tip, the striation evident suturally; under surface finely, densely punctate except medially, the abdominal segments coarsely and sparsely so apically as usual. Length 16.0–23.0 mm.; width 5.5–8.5 mm. Western Texas (abundant near El Paso). [=*Chalcophora obliterata* Lec.]..... **obliteratus** Lec.

Elytra without trace of the principal costules of *obliteratus*, evenly convex and more broadly, subevenly striate, with coarsely broken interspaces in inner half of each, the surface thence to near the sides concave and closely punctate though much more coarsely and less densely than in *obliteratus;* size smaller, the form more slender, shining, brassy-green to dark green in color; head generally with three lines of coarse polished broken rugæ, the remainder densely and finely punctate; antennæ moderate; prothorax nearly similar but shorter, the apical margin generally more angulate at the middle, the basal angles acute and slightly everted, the scutellar sinus broad and very feeble; elytra nearly as in *obliteratus* in general form, the under surface unequally punctured as usual. Length 14.7–17.0 mm.; width 5.0–6.1 mm. Southeastern Arizona..... **fidelis** n. sp.

11—Eyes with their inner margins strongly converging upward as usual; basal angles of the prothorax prominent and acutely everted.....12

Eyes with their inner margins but feebly converging upward, the basal thoracic angles not everted.....17

12—Prothorax very evidently narrower at apex than at base 13

Prothorax about as wide at apex as at base; body very small in size.....16

13—Body fusoid, the head not or but little wider than the base of an elytron in either sex.....14

Body subcylindric, the head notably wider than the base of an elytron....15

14—Form very stout, convex, rather shining, deep cupreous in color, the ashy pubescence short but distinct, evidently vittate on the elytra; head unevenly punctate, finely along the eyes, for the most part, however, coarsely and confusedly rugose; eyes large and slightly prominent; antennæ short (♀), with the third joint much longer than the fourth, the remaining joints strongly serrate; prothorax two-thirds wider than long, strongly narrowed anteriorly, rounded at the sides, the basal angles only slightly everted; surface with strong and irregular elevations, with densely punctate interstices laterally, coarsely, rather sparsely and unevenly punctate medially and basally, the scutellar sinus very broad and feeble; elytra evidently less than twice as long as wide, but little wider than the prothorax, of the usual subparallel form, obliquely narrowed posteriorly, the surface throughout subequally convex and rugose and unevenly, not densely punctate, with the striation more or less evident though deeper suturally; fine punctures of the under surface less dense than in the preceding section, the pu-

bescence very short and inconspicuous. Length (♀) 20.0 mm.; width 7.8 mm. Texas (near El Paso)..... **obesus** n. sp.

A—Body nearly similar in general form but much narrower and with less widely separated eyes;—allowing for differences in sex prevailing elsewhere,—and differing also most obviously in being wholly æneous-green, without trace of the strong cupreous color of *obesus;* elytra similarly narrowly and deeply sinuate at the tips and strongly bispiculose, the very short pubescence even more evidently arranged in broad and moderately definite vittæ. Length (♂) 17.5 mm.; width 6.5 mm. Texas (El Paso)..... **æneoviridis** n. subsp.

Form rather stout though evidently less so than in the preceding, cupreo-æneous to deep coppery-red, shining, the pubescence very short and sparse, not vittate on the elytra; head rather concave anteriorly, densely punctate, more or less rugose posteriorly on the vertex; eyes much less prominent, their outline continuing that of the head, becoming more longitudinal posteriorly, pale brown with fine black margin in all the numerous examples at hand; antennæ nearly as in *obesus* but more slender; prothorax nearly as in *obesus* but less narrowed anteriorly and with the basal angles more strongly everted and acute, the scutellar sinus a little deeper and more angular; elytra nearly similar throughout though a little more elongate, almost twice as long as wide (♂) or somewhat shorter (♀); under surface nearly similar and with numerous coarse perforate punctures along the middle of the prosternum and densely throughout the width anteriorly. Length (♂) 12.5–16.5, (♀) 13.3–17.5 mm.; width (♂) 4.0–6.2, (♀) 4.6–6.8 mm. Southeastern Arizona..... **compactus** n. sp.

A—Body nearly as in *compactus* but larger and more oblong, bright cupreous, the head slightly larger and with the eyes still more widely separated; prothorax nearly similarly sculptured but more transverse; elytra more evidently oblique at the sides in apical third, the pubescence less uniformly distributed, being rather obviously in single lines but without the broader vittæ of *obesus* and *æneoviridis.* Length (♀) 19.0 mm.; width 7.1 mm. Southeastern Arizona. **solidus** n. subsp.

Form moderately robust, reddish or coppery-bronze, moderately shining; prothorax with the sides moderately arcuate, the disk convex, coarsely punctured, somewhat tuberculate at the sides from confluence of the punctures but without distinct callosities; scutellum small, oval; elytra densely and deeply punctate, the punctures near the apex less confused and having a slight tendency to form striæ; body beneath more shining than above, moderately densely punctured but smoother along the median line; prosternum very coarsely punctured in front, the process smooth, with a row of coarse deep punctures so closely placed as to resemble a groove. Length 15.0–19.0 mm. North Carolina (near Wilmington),—fide G. H. Horn..... **carolinensis** Horn

15—Body rather narrowly, subcylindrically convex, shining, cupreous, the pubescence short but very evident, not vittate on the elytra; head for

the most part coarsely, closely and confusedly rugose, finely punctate along the eyes, only slightly concave anteriorly, the eyes nearly as in *compactus* but slightly more prominent, the antennæ nearly similar (♂); prothorax much narrower, not quite one-half wider than long, otherwise similar, only moderately narrowed anteriorly, with the apex but very feebly arcuate medially, the basal angles only feebly subeverted, the scutellar sinus feeble; surface similar but more coarsely as well as more sparsely punctured medially; elytra not quite twice as long as wide, evidently wider than the prothorax, the posterior obliquity slighter and more gradually formed, the surface sculpture almost similar but becoming more rugose laterally; under surface polished, brighter coppery-red, the fine punctures nowhere dense; prosternum with the very coarse perforations widely and irregularly spaced along the middle. Length 15.0 mm.; width 5.6 mm. New Mexico.

cylindrinus n. sp.

16—Form very narrowly suboval, moderately convex, shining, bright bronze above, feebly cuprascent beneath, the pubescence very short, sparse and inconspicuous, not vittate on the elytra; head punctate and also with flattened and confused smooth spaces, only feebly concave anteriorly; eyes and antennæ nearly as in *compactus;* prothorax scarcely more than one-half wider than long, the sides subparallel, feebly arcuate medially, rather abruptly and subsinuately convergent near the apex, the basal angles not at all everted; surface coarsely, confluently punctate laterally, finely and sparsely so and basally depressed medially and with two divaricately oblique impressions from the middle of the base; scutellum very small; elytra uniformly convex and sparsely punctate and rugulose throughout, the striæ fine, distinct but not impressed suturally, a submarginal costule evident for a short distance near the middle; under surface not finely, rather sparsely and subrugulosely punctate laterally; anterior tibiæ (♂) feebly arcuate, scarcely serrate, the middle tibiæ almost straight. Length 9.2 mm.; width 3.0 mm. Southeastern Arizona..... **debilis** n. sp.

Form more elongate and subcuneiform, shining, deep coppery-red; head and antennæ (♂) nearly as in *debilis;* prothorax rather less than one-half wider than long, the sides broadly rounded, very gradually converging anteriorly to the apex, which is very slightly narrower than the base, feebly prominent medially, the basal angles very slightly everted, acute, the scutellar sinus unusually deep and distinct; surface broadly depressed basally but not bi-impressed, coarsely, confluently punctate laterally, very sparsely medially; elytra more elongate, much more than twice as long as wide, evenly convex, finely, very sparsely punctured and sparsely rugulose throughout, the striation barely evident even suturally; under surface not densely, subrugulosely punctured laterally; anterior tibiæ (♂) distinctly arcuate and remotely serrulate within, the middle tibiæ also arcuate though more feebly, but serrulate within, only near the tip; posterior tibiæ nearly straight. Length 11.0 mm.; width 3.5 mm. Southeastern Arizona,—G. W. Dunn.

tenuis n. sp.

17—Form and coloration nearly as in *compactus* but much smaller, metallic-purplish, shining, the pubescence fine, short and sparse; head coarsely, unevenly and confluently punctate; antennæ (♀) unusually short; prothorax moderately transverse, convex, narrowed anteriorly, irregularly and coarsely punctate, the punctures confluent laterally with large rugosities, the broad median space simply irregularly and rather sparsely punctate; hind angles right; elytra of the usual form, having small irregular smooth places and also finely punctate, the punctures somewhat regularly serial suturally but confused laterally and apically, where they become somewhat transversely confluent though still not dense; meso- and metasternal side-pieces not coarsely but subconfluently punctate; abdomen rather finely, subrugosely punctured at the sides; anterior tibiæ very slightly arcuate, the intermediate and posterior nearly straight. Length 11.5–13.0 mm. Utah (Chadburn's Ranch)..... **juniperinus** Wick.

The sexual characters in this genus are feeble, and, although the male is generally a little smaller and narrower than the female—sometimes notably so, the readiest way to distinguish the sexes is by the structure of the antennæ, all the joints being elongate in the male, the outer ones becoming rapidly shorter in the female. The anterior, and sometimes also the intermediate, tibiæ are arcuate, being more or less serrulate within in the male, but the anterior are simply more or less bent in the female. My cotype of *juniperinus*, very kindly sent to me by Prof. Wickham, is a female measuring 11.5 by 4.0 mm. in size; the species is peculiar in having the internal margins of the eyes so feebly converging posteriorly, this character having been first noticed by the original describer. The locality of *carolinensis* Horn, is open to the gravest doubt, especially when we consider its perfectly normal type of form, coloration and sculpture. I am of the opinion that no species of *Gyascutus* occurs beyond the desert Sonoran provinces. On comparing *compactus* with what purported to be a specimen of *carolinensis* in the LeConte cabinet, I found the latter to be very similar, though rather less robust and with the scant pubescence more vittate in arrangement on the elytra. In comparison with *Hippomelas*, *Stictocera* and *Spinthoptera*, where individual stature appears to be rather constant, the body in *Gyascutus* frequently varies enormously in size within specific limits; individuals are usually abundant when they occur at all. In the first section of the genus the broad and densely punctate impression along the apical thoracic margin is much more developed and abruptly defined than in the second section.

Stictocera n. gen.

While similar to *Gyascutus* in general organization, the comparatively few species of this genus differ in several important structural features. The hind coxæ, for example, are more rapidly though gradually expanded internally as in *Hippomelas*, and the tarsi also are nearly as in the latter genus. In the pronotum *Stictocera* differs very much from either *Gyascutus* or *Hippomelas*, having the surface even in general convexity, as in the latter, but with a different type of sculpture and without the smooth irregular callus along the median line so very general in the former, so that the elevated basal margin, which distinguishes the genus from all its associates, is entire and not discontinuous at the middle. The species are frequently of large size, comprising the largest Buprestids of this country, and sometimes of very broad elongate-oval convex form, though also occurring narrower and more parallel. The antennæ are strongly compressed, subparallel and densely punctate distally, the outer joints with the apical margin finer than in *Hippomelas* and with the edge sharply defined, the surface internally obliquely merging into the general surface of the joint, the sensory fossa sharply defined, elongate-oval or feebly reniform and near the articulatory foramen. The elytra are evenly convex, uniformly though rugosely sculptured and obscurely striate, as in the second group of *Gyascutus*, the sides seldom very evidently serrulate posteriorly and the apex distinctly bispinulose. The species may be distinguished as follows:—

Basal joint of the hind tarsi but little longer than the second. Head brassy-punctate, with elevated reticulate lines; prothorax with deep punctate æneous rugæ, less densely sculptured than in *Gyascutus obliteratus*, the polished elevations cyaneous, narrowed anteriorly, the sides broadly rounded, the surface transversely impressed at apex, the base trisinuate, the posterior angles acute; elytra striato-punctate, transversely and sparsely but deeply rugose, the sides subserrate posteriorly; surface "almost constantly with a large brassy patch on each elytron."—[fide Waterhouse]; under surface æneous, densely punctate and pubescent; pectus and posterior segments of the abdomen coarsely punctate, shining, variegated with bluish reflections. Length 23.3 mm. Mexico (Ures, in the State of Sonora). [=*Chalcophora cælata* Lec.]. . **cælata** Lec.

Basal joint of the hind tarsi much longer than the second, though distinctly shorter than the next two combined 2

2—Form broadly suboval when well developed, varying greatly in size, shining, dark steel-blue, the depressions brassy; pubescence short,

sparse, evenly distributed on the elytra, coarse and erect, longer and dense in isolated patches on the under surface; head more densely pubescent, with large irregular smooth rugæ, finely, densely punctate along the eyes and in an angulate anterior area; eyes large, prominent, brown in all examples at hand; antennæ not quite attaining the base of the prothorax (♀) or longer (♂), the third joint subequal in length to the fourth; prothorax about twice as wide as long, four-fifths wider than the head, strongly narrowed anteriorly, the sides arcuate, the basal angles everted and acute, the scutellar sinus broad and deep; surface somewhat flattened medially toward base, vermicularly eroded and punctate, the low flat smooth areas large, becoming strongly elevated laterally; elytra distinctly wider than the prothorax, barely twice as long as wide, the sides moderately converging for three-fifths, thence oblique and but slightly arcuate to the apex; surface subuniform throughout, the striæ moderately distinct almost to the sides, the intervals much interrupted by subquadrate spots of greater convexity; abdominal segments steel-blue, very coarsely, unevenly and remotely viridi-punctate, finely, densely punctate only near their bases laterally. Length 21.0–31.0 mm.; width 7.2–12.6 mm. Texas (near El Paso). **pollens** n. sp.

Form narrower and subparallel, similarly convex and with the same coloration, lustre and sculpture; head and eyes nearly similar, except that the latter are rather more strongly convex and decidedly less widely separated; antennæ parallel and strongly compressed, the lower part of joints four to eleven pale in color as usual and with the lower margin rectilinearly truncate except basally, differing very markedly in the sexes, as in *Gyascutus*, extending well beyond the base of the prothorax (♂) or failing to attain the base by a corresponding amount (♀); prothorax not so transverse as in *pollens* but otherwise similar; elytra narrower and more parallel, about twice as long as wide, slightly wider than the prothorax, the sides arcuately converging in apical two-fifths, with sculpture and sparse erect setæ as in *pollens*, the under surface nearly similar; anterior tibiæ (♂) slightly bent and with a few very minute serrules within apically, the intermediate more strongly serrulate apically but almost straight. Length 22.0–26.0 mm.; width 8.0–9.7 mm. Arizona (Tuçson),—H. F. Wickham... **laticornis** n. sp.

The single very small male of *pollens* in my series has the anterior tibiæ evenly bowed but with the inner subapical serrules almost completely obsolete, the intermediate distinctly arcuate, though less strongly, but with the inner subspiniform serrules from behind the middle to the apex much stronger. *Laticornis* differs from *pollens*, not only in its narrower form and smaller size on the average, but in its more convex and rather less widely separated eyes, with their inner margins somewhat more strongly converging upward and also in its evidently less transverse prothorax. The apex of the last

abdominal segment is thick, truncate and transversely excavated throughout the width of the truncature in both sexes.

Spinthoptera n. gen.

The genus *Psiloptera*, of Solier, having as its type the South American *attenuata*, of Fabricius, as amplified by Lacordaire became very composite and indefinite in its scope, a number of generic types being included by him which have since been separated and held to be amply valid, such as *Perotis*, *Polybothris*, *Hippomelas* and *Ectinogonia*. Thus simplified *Psiloptera* has been continued by various authors without much further amputation of members, and I have ventured here to detach those forms having the prosternum truncate anteriorly and not medially prolonged and the elytra studded with shallow, finely punctate and pubescent metallic areolæ, under the generic name *Spinthoptera*. General facies, completely ignored by Lacordaire, is of itself in reality the most important structural character prevailing in this group of genera and is more decisive than modifications of special organs, of which there are very few. In fact the genera might be termed opinionative, in the same sense that species not characterized by striking structural differences in special organs are usually called opinionative species. To maintain that either species or genera are less real for being of such an opinionative nature is not justifiable; it merely necessitates greater intelligence and experience in specifically delimiting such series of individuals, or in aggregating such groups of species to form genera, with a greater attendant risk of mistakes; but after all, in the search for truth, which alone should be the ultimate aim, errors of judgment are practically unavoidable at times.

We note in this genus a departure in several structural features from those of the three preceding genera, aside from the special and peculiar modification of the antennæ common to all the Psilopterids. There is, for example, no terminal antennal process; the prosternum, instead of being punctured or feebly impressed along the middle, is remotely bisulculate, and the first abdominal segment, instead of being uniformly convex medially, is here either flattened or sulcate. We should note also an entire absence of the raised basal margin of the pronotum and ante-scutellar sinuation of the Hippomelids, the constant presence of two small perforate ante-scutellar discal punctures, wholly unsuggested in the Hippomelids but forcefully remindful of

Dicerca, and the frequent posterior prolongation of the elytra in *Psiloptera,* also betraying an obscure bond of affinity with that genus and presumably signifying derivation from a common primitive stock. The striation of the elytra is much more developed and obvious than in the Hippomelids, the hind coxæ rapidly dilated within as in *Hippomelas* and *Stictocera,* the outer antennal joints much compressed, rectilinearly truncate beneath as in those genera and wholly differing from *Dicerca,* densely punctulate along their obliquely flattened lower edges and with sensory fossæ lateral and linear in form, as well as one terminal, which is narrow, deep and oblique. The hind tarsi are thick, with the three basal joints progressively diminishing very slightly in length; sexual differences are virtually unobservable. The species and subspecies of our fauna may be outlined as follows:—

Prothorax widest at or near the middle; elytra arcuately narrowing posteriorly and more or less obtuse.....2

Prothorax widest at base.....6

2—Prothorax rounded at the sides; first ventral segment merely flattened along the median line.....3

Prothorax angulate at the sides at or slightly behind the middle; first ventral segment deeply sulcate along the median line.....5

3—Antennæ metallic blue or greenish throughout. Body large in size, stout, convex, shining, dark steel-blue, the impressions bright greenish-æneous, subglabrous, the elytral areolæ densely punctate and having short decumbent pubescence, the irregular sparse vestiture of the under surface longer, decumbent, arranged in sparse radiating clusters of three or four hairs each from the very coarse transverse punctures, especially of the abdomen; head very coarsely rugose throughout, the antennæ short, but little longer than the head in either sex, slightly more apically attenuated in the male; eyes large though only moderately prominent, widely separated; prothorax barely twice as wide as long, widest behind the middle, the sides broadly, subevenly rounded, becoming gradually more convergent apically and feebly so and slightly sinuate basally, the basal angles right; apex feebly arcuate except laterally, the base very broadly lobed, sometimes subangularly; surface convex anteriorly and laterally, more flattened basally and with a distinct subquadrate impression at the middle near the base; punctures very coarse and irregular, generally sparce medially, very unevenly and vermicularly confluent laterally; scutellum small, rounded; elytra but little wider than the prothorax, not quite twice as long as wide, parallel, gradually rounding at the sides and obliquely, subarcuately narrowed in apical two-fifths to the apices, the latter narrowly truncate, sometimes obliquely with the sutural angle more prominent; punctures large, impressed, arranged in regular series which are slightly impressed,

not much more so laterally, the finely punctate shallow areolæ rather small in size, frequently subtransversely coalescent; prosternum densely, coarsely punctate, broadly polished and impunctate along the middle; legs blue, the femora frequently subviolaceous. Length 26.0–28.8 mm.; width 10.2-11.6 mm. Texas (El Paso) ..... **convexa** n sp.

Antennæ probably metallic blue in color but not described, the body nearly as in *convexa* but with the prothorax very much more transverse, the form stout, the color dark steel-blue, the head and prothorax with greenish-brassy punctures, the latter unequally punctate, at the middle basally broadly foveate, almost three times as wide as long, broader before the base, the sides anteriorly strongly rounded, posteriorly sinuate, the hind angles right; elytra with punctured striæ, the intervals with many quadrate spaces, which are impressed, greenish-brassy, granulate and pubescent, at the apex obliquely subtruncate, the sutural angles rather prominent; under surface densely and coarsely viridi-punctate; prosternum bisulcate. Length 22.5–28.7 mm. Texas (Eagle Pass,—LeConte). [=*Psiloptera valens* Lec.].... **valens** Lec.

Antennæ non-metallic, except sometimes feebly toward base.....4

4—Body stout, parallel and convex, nearly as in *convexa* and *valens* in coloration, lustre and sculpture throughout, the eyes larger, much more prominent and less widely separated than in the former; antennæ similar but deep black, becoming faintly bluish toward base; prothorax shorter than in *convexa*, apparently somewhat more than twice as wide as long and of a different outline, being more anteriorly inflated and widest before the middle laterally, more sinuate basally, the angles similar, the basal impression more extended anteriorly, obsolescent beyond the middle; elytra nearly similar but scarcely more than three-fourths longer than wide, the apical truncature oblique, angularly acute and prominent suturally, the æneous areolæ larger, the punctures of the series toward the suture smaller; under surface nearly similar, the tibiæ rather more closely punctate and pubescent, the abdomen with large and uniform dense patches of pubescence laterally. Length 23.5–24.5 mm.; width 9.2–9.8 mm. Western Texas (locality unrecorded)..... **ocularis** n. sp.

Body more slender, parallel, convex, very much smaller in size, shining, almost similarly sculptured; head small, black, with coarse æneous rugæ, the eyes moderate, not notably prominent; antennæ short, piceous-black throughout; prothorax black, convex, three-fourths wider than long, only moderately and gradually narrowed anteriorly, widest near basal third, the sides very broadly rounded, becoming sinuate only at the basal angles, the surface deeply and rather abruptly impressed at the middle basally, the punctures very coarse, not close, ænescent and irregular; elytra blackish-blue, in form and sculpture nearly as in the preceding species, the apices more narrowly and obliquely truncate; under surface nearly similar, except that the more densely and evenly pubescent sublateral patches of the abdomen are much more finely and feebly sculptured; legs and tarsi more slender, blue, the femora

very coarsely punctate, partially greenish basally. Length 15.7–16.2 mm.; width 5.4–5.9 mm. Texas (locality unrecorded) . . . . **parva** n. sp.

Body nearly as in *parva* but larger and stouter and differing from any of the preceding in the shining blue and coppery iridescence of the elytra, parallel, convex; head rather small, the eyes convex and prominent, brown in all specimens at hand, widely separated, the front with strong confused cupreo-æneous rugæ; antennæ shining, sometimes with faint greenish-black reflection, bluish toward base; prothorax not quite twice as wide as long, widest well behind the middle, nearly as in *convexa*, the median basal impression stronger and extending further anteriorly, generally evanescent beyond the middle, the smooth areas blue-black, the remainder æneous; elytra nearly as in the preceding species but with much larger and more coalescent cupreous areolæ, which are more coarsely and densely punctate, slightly opaque and with short, less conspicuous pubescence, deeper laterally, where they produce a more rugose appearance; apices narrowly and very obliquely sinuato-truncate, the truncature sometimes difficult to trace; under surface with the densely pubescent patches of the abdomen much more finely and densely sculptured than in *convexa* or *ocularis* but more nearly as in *parva;* legs bluish or bronzed, the femora, and the tibiæ less evidently, deeper blue apically. Length 19.4–21.5 mm.; width 7.0–8.0 mm. Northern Texas and Kansas. [=*Dicerca woodhousei* Lec.] . . . . . **woodhousei** Lec.

5—Form oblong, stout, moderately convex, the pronotum much less strongly so anteriorly and laterally than in the preceding group and more gradually and strongly flattened throughout the width basally, but not or scarcely impressed at the middle subbasally, the two ante-scutellar punctures thereby rendered very obvious, blue-black, shining, the depressions throughout brilliant viridi-æneous; head strongly, vermicularly rugose and coarsely punctured, the eyes large and strongly convex, widely separated, the antennæ and legs as in *convexa*, bright violaceous-blue; prothorax somewhat more than twice as wide as long, broadly angulate at the sides, widest distinctly behind the middle, where the width is evidently greater than at base, the converging sides nearly straight from angulation to apex, feebly sinuate basally, the basal angles acute; surface with coarse æneous punctures, sparse and unevenly distributed, becoming densely and very irregularly aggregated laterally; elytra nearly as in *convexa* but not so convex, the feeble oblique apical truncature variable, sometimes transverse; punctures strong, arranged in coarse impressed series deeper laterally, the depressed areas brilliantly shining, densely, rather finely punctate and moderately pubescent, very variable in extent, generally isolated, sometimes larger and in great part subtransversely confluent; sulcus of the first ventral abrupt and deep, evanescent near the hind margin though in very variable degree, generally narrower, deeper and longer (♂) or rapidly shallow with more posteriorly flaring sides (♀). Length 22.0–31.0 mm.; width 8.0–11.7 mm. Arizona. **arizonica** n. sp.

Form nearly as in "*Dicerca divaricata*" but without elytral prolongation

and more convex, black, shining above, the under surface bright cupreous; depressions of the upper surface cupreous; head cupreous, the front feebly depressed medially, coarsely sculptured; antennæ short, obscure cupreous; prothorax convex, twice as wide as long, apparently widest slightly behind the middle, the sides subangulate, converging anteriorly, sinuate basally, the basal angles right; surface coarsely, sparsely and irregularly punctate, the punctures more crowded laterally, longitudinally and feebly impressed along the middle, with a narrow smoother median line; elytra gradually narrowing to the apices, the latter obliquely truncate, with the outer angle dentiform; serial punctures becoming transversely confluent laterad, producing a rugose appearance, the intervals with a few punctures and some impressed punctured bright cupreous spots; under surface coarsely and more or less confluently punctate, the prosternum as usual; first ventral sulcate medially, the sulcus abruptly defined; femora cupreous, the tibiæ black above with coarse greenish punctures, greenish-cupreous on the sides, the tarsi obscurely cupreous. Length 16.5–22.0 mm. Texas (Brownsville). [=*Psiloptera cupreopunctata* S.]. **cupreopunctata** Schaef.

6—Form stout, steel-blue, the head and pronotum variegated with viridiæneous punctures, the pronotum unequally punctate, broadly impressed "foveato" in the middle at base; prothorax almost twice as wide as long, narrowed anteriorly, the sides at the middle obtusely angulate, thence feebly subsinuate to the base, the basal angles right; elytra with punctured striæ, the intervals with quadrate impressed spaces, which are granulate, pubescent and greenish-golden in color, very variable in extent as in *arizonica*, obliquely feebly truncate at apex; under surface densely and coarsely viridi-punctate, the prosternum bisulcate. Length 26.5–31.3 mm. Mexico (Ures, in the State of Sonora). [=*Psiloptera webbi* Lec.]. ..... **webbi** Lec.

Form short, stout and very convex, only moderately shining, blackish-bronze above with metallic green depressions; under surface dull viridi-æneous laterally, deep and brilliant metallic roseate along the middle, very bright on the polished sterna, dull on the abdomen; head very coarsely, rugosely punctate, the antennal ridges unusually strong; eyes prominent; antennæ black, very feebly bronzed, with the lateral sensory fossæ small and rounded or oval, not linear as in the preceding species; prothorax glabrous, about twice as wide as long, the sides rapidly converging from base to apex, feebly angulate behind basal third, thence straight to the apex, slightly sinuate in less than basal third, the angles slightly less than right; surface coarsely, sparsely but irregularly æneo-punctate, more densely laterally, where there are some elevated smooth areas, very feebly and indefinitely impressed toward the middle of the base, the two punctures very evident; elytra but little wider than the prothorax, the sides parallel and straight for nearly three-fifths, thence gradually oblique, becoming very feebly sinuate near the apices, which are rather broadly and obliquely truncate, with the outer spine rather strong; surface with suturally feebly, laterally strongly, impressed series of coarse punctures, becoming contiguous

and foveiform laterally, also with deeply impressed, finely, densely punctate and puberulent green areolæ, which become obsolete in about inner half, except posteriorly, where they extend to the suture through small in size; intervals punctureless; under surface closely, coarsely and irregularly sculptured, the sterna broadly smooth along the middle, the first ventral narrowly and deeply sulcate; legs bronzed, the femora with a feebly rose-colored reflection apically. Length 22.0 mm.; width 8.5 mm. Panama (Taboga Island)..... ***insularis** n. sp.

Some of the above species, notably those of the *valens* series, appear to resemble the Mexican *drummondi* Lap.-Gory, in general form and sculpture, but the figure of that species seems to indicate a broader and more arcuate basal pronotal impression, and, as our forms constitute several allied species, I assume that none of them is actually synonymous with *drummondi*. It is impossible to imagine any reason whatever for assigning such mutually distinct species as *webbi, valens* and *woodhousei* to *drummondi* as varieties, and it is still more preposterous to consider them synonyms. The structure of the base of the abdomen seems, among other features, to have been wholly overlooked in distinguishing species of the *webbi* and *valens* type. In *valens* the prothorax is undoubtedly very much shorter and more inflated at the sides than in *convexa*, but the statement by LeConte that it is nearly three times as wide as long is doubtless far overdrawn.[2] In *ocularis* the prothorax is more transverse than in *convexa* and is more anteriorly dilated, the eyes and antennæ also being notably different from those of *convexa* in prominence and color, but, as these points are not mentioned by LeConte in regard to *valens*, further observation will be necessary before deciding definitely the kinship of *ocularis* and

[2] This proportional width of the prothorax is very deceptive. I have recently measured with dividers the width in terms of length, in cases where the prothorax certainly seemed to be beyond doubt more than twice as wide as long, as in *Spinthoptera ocularis*, for example, and the result proves that, even in such cases, it comes far short of actually being even as much as twice as wide as long. The comparative statements given in the descriptions of the present paper, as well as all others of the writer, are not based upon instrumental measurements, but are simply the ratios as they appear to his eye. The deception is due, in most part at least, to the shape of the apex, base and side margins, for if we had before us a geometric rectangle of the actual extreme dimensions, there would be much less trouble in realizing the true ratio. This goes to prove the necessity for stating the true dimensions of all the parts of an animal in linear units, as advocated by the writer many years ago, if we desire to record a description of the greatest possible value for purposes of comparison.

valens. It is distinctly stated by LeConte that the prothorax of *webbi* is wider at the base than at any other place, but Mr. Schaeffer seems to have mistaken this to be "wider at base than at apex," which of course is very evidently true of every species of the genus; I have assumed, however, that in *cupreopunctata* the greatest thoracic width is at or near the middle. I have been unable to identify *insularis* with any species of the Biologia and conclude therefore that it is as yet unrecorded in the literature of the subject; it seems to resemble *hirtomaculata* Hbst., somewhat, but that species is described by Gory as being slightly depressed, with the prothorax lightly pubescent laterally.

Chalcophora Solier.

Although in this genus the general habitus is wholly unlike that of the preceding genera, the affinity may in reality not be so remote as appears, for the two prosternal sulci are present as in *Spinthoptera*, though deeper and much more approximate. This and the following differ from any others of the genera here considered in having the epistoma more narrowed and much more abruptly and deeply emarginate, and the supra-antennal ridge, so prominent in the preceding genera, is here obsolete and replaced by a broad feeble rugose swelling of the surface. The antennæ in *Chalcophora* are slender, with elongate and sparsely punctate outer joints, which appear to be wholly devoid of sensory fossæ terminal or otherwise, being the only genus of this section of the family, coming under my observation, in which some trace at least of terminal fossæ cannot be discerned; the terminal joint is evenly oval and without suspicion of apical process. The pronotum is constantly broadly though feebly sulcate, the sulcus longitudinally divided by a slightly elevated obtuse smoother line, the scutellum small, the elytra gradually narrowed behind, entire at tip, not or but feebly serrulate at the sides posteriorly and with the sutural angle sometimes spiniform; their sculpture is peculiarly uneven, with large and finely punctate, more metallic depressions and polished lines and elevations, both having a generally though unevenly longitudinal arrangement. The legs are rather slender, the male tibiæ without any striking sexual modifications, the first ventral impressed or sulcate and the basal joint of the hind tarsi at least as long as the two following combined. The male modification of the abdominal apex is more

pronounced than in any other genus except *Texania*, and consists of a deep, abrupt and angular emargination, not suggested at all in the female. The male also has the median parts of the sterna more impressed and hairy than in the female as a rule, a character suggesting *Buprestis* and other following genera. The species are rather numerous and may be separated by the following characters:—

Subsutural groove of the elytra abbreviated, attaining basal third or fourth; body more sombre in coloration, though similarly shining; basal sulcus of the abdomen glabrous in both sexes 2

Subsutural groove continuing to the base of the elytra though shallow and sometimes subinterrupted near the base; lustre of the body more brightly æneous or cupreous as a rule; basal sulcus of the abdomen, as well as the sterna, more pubescent in the male.....8

2—Sutural angles of the elytra distinctly dentate or spinulose; males not rare 3

Sutural angles not prolonged though sometimes feebly subprominent; males apparently much less abundant than the females.....4

3—Depressions of the elytra finely, densely and evenly punctulate, shining, blackish-æneous, the depressions less shining and more cupreous; under surface obscure æneous and partially cinereo-pubescent; head well developed, unevenly, moderately punctate, with a very large deep frontal impression which is narrowed posteriorly along the median line; eyes rather prominent; antennæ not extending to the base of the prothorax even in the male; prothorax rather transverse, fully two-thirds wider than long, the sides broadly rounded anteriorly, sometimes prominent and occasionally distinctly angulate (♀), parallel toward base and generally nearly straight; surface broadly, roughly and unevenly sculptured and biimpressed laterally, the two punctate sulci very feeble, the elevations smooth; scutellum small; elytra scarcely more than three-fourths longer than wide, the sides parallel, obliquely and arcuately converging in apical two-fifths and more or less visibly serrulate, the subsutural groove rather feebly concave, the second constricted and subinterrupted at and behind the middle, the sublateral carina nearly entire, the next distinct before the middle, uniting with the submarginal behind the humeri; under surface smooth, with small patches of fine close punctures. Length (♂) 20.0–22.5, (♀) 25.0–28.5 mm.; width (♂) 6.9–7.5, (♀) 8.6–9.7 mm. Atlantic region,—Massachusetts to Florida. [=*novæ-boracensis* Fitch, *Buprestis virginiensis* Drury, *virginica* Say and Harris, *virginiaca* Gmel., and *cupreomaculata* Goeze].....**virginiensis** Drury

A—Nearly similar to *virginiensis* but more elongate and with the second elytral sulcus more interrupted at the middle, blacker in color, very shining, the under surface duller cupreo-æneous; head nearly similar but more coarsely, sparsely punctate, the eyes less convex; prothorax much less transverse, but little more than one-half wider than long,

the sides almost evenly and broadly arcuate, gradually converging anteriorly, parallel and straight basally, the surface rather more deeply impressed at the sides behind the middle, the median sulci extremely shallow and obsolescent; elytra similar but notably more elongate, the gradually converging and evenly arcuate sides posteriorly even more evidently serrulate; basal sulcus of the abdomen extending beyond the middle of the second segment. Length (♂) 27.0 mm.; width 8.5 mm. Florida..... **obliterata** n. subsp.

Depressions of the elytra more coarsely and subrugosely punctate, the head less developed; body nearly as in *virginiensis* but with relatively smaller head and prothorax and rather more coppery lustre; head almost similarly sculptured, the excavation rather narrower, the eyes a little less prominent; prothorax nearly similar in outline and sculpture but somewhat more transverse, the sides broadly rounded and converging anteriorly (♂) or more subangulate anteriorly (♀), parallel and nearly straight basally; elytra much more evidently wider than the prothorax, otherwise nearly similar; under surface more coppery in lustre. Length (♂) 21.0–22.0 mm.; width 7.2–7.7 mm. Wisconsin (Bayfield),—H. F. Wickham..... **lacustris** Lec.

A—Nearly as in *lacustris* but with the head (♂) relatively still smaller and with a much narrower and feebler frontal excavation along the middle; prothorax still more transverse, swollen and rounded at the sides anteriorly, the sides parallel but broadly sinuate basally, the basal angles more acute; surface almost similarly sculptured; elytra less decidedly wider than the prothorax but otherwise nearly similar, the coppery depressions still more coarsely punctato-rugose and very much more strikingly so than in *virginiensis;* under surface nearly similar, cupreo-æneous. Length (♂) 22.0 mm.; width 7.8 mm. Massachusetts..... **brevicollis** n. subsp.

4—First ventral scarcely more than flattened medially. Body very elongate, moderately convex, shining, black, the elytral depressions faintly bronzed, beneath feebly cupreous in lustre; head moderate, coarsely, irregularly and not closely punctate, the excavation broad anteriorly, narrow and deep along the median line posteriorly; eyes large but unusually feebly convex; prothorax two-thirds wider than long, the sides broadly rounded and gradually convergent anteriorly, parallel and somewhat sinuate basally, the basal angles unusually prominent; surface with the usual sculpture, the median impression very shallow, with the dividing ridge unusually narrow; elytra evidently wider than the prothorax, nearly twice as long as wide, the sides posteriorly unusually gradually convergent, becoming nearly straight before the broadly rounded apical angles, the sutural angle sharp and a little less than right, not at all produced; surface sculptured nearly as in *virginiensis;* under surface nearly as in that species but with the pubescence everywhere very short and inconspicuous, the coarse punctures not so large. Length (♀) 27.0 mm.; width 8.3 mm. Honduras.

***hondurasica** n. sp.

First ventral distinctly sulcate along the middle as usual; sides of the pro-

thorax anteriorly more or less distinctly angulate or prominently and narrowly rounded, especially in the female.....5

5—Elytral depressions not or but slightly rugose, having fine dense punctures nearly as in *virginiensis*.....6

Elytral depressions with larger, somewhat separated punctures, giving a much more coarsely rugulose appearance.....7

6—Elytra posteriorly more gradually obliquely narrowed, with the sides only very feebly arcuate; females only at hand. Body very elongate, moderately convex, shining, black, the depressions and the under surface bright cupreous; head well developed, irregularly punctate; an area along the eyes, much wider than in *hondurasica* and a little wider than in *virginiensis*, finely, densely sculptured, the frontal pit deep and nearly as in the latter; eyes smaller and still more remotely separated; prothorax nearly as in *virginiensis*, except that the median densely punctate impression is broader and somewhat shallower and the dividing median line very much wider and less convex; elytra nearly as in *virginiensis* but much more elongate, about twice as long as wide, the sides posteriorly with more obsolete or scarcely traceable serrulation, the apical angles broadly rounded, thence narrowly subtransverse to the suture; under surface with the usual moderately coarse, sparse punctures, with lateral patches of fine, dense and more metallic punctuation, the ashy hairs not conspicuous though rather long. Length (♀) 26.5–28.5 mm.; width 9.0–9.8 mm. California. [=*Buprestis angulicollis* Lec.].....**angulicollis** Lec.

A—Nearly as in *angulicollis* but rather narrower and more convex, more sombre in coloration, the depressions dull subcupreous or bronzed, the under surface black, with feebly cupreous and finely punctured areas; prothorax less transverse, with less obvious anterior angulation at the sides, as in *angulicollis* very slightly wider at the angulation than at base, with the intervening sides tending to bisinuation; elytra nearly similar but with the sculpture of the depressions evidently less fine. Length (♀) 24.5–26.5 mm.; width 8.5–9.0 mm. Colorado (Boulder Co.).....**montana** n. subsp.

Elytra posteriorly more rapidly converging and rounded at the sides, or, evidently more obtuse. Body somewhat broader in form and rather less convex, shining, black, the depressions of the upper surface bronzed, the lower surface less brightly cupreous; head nearly similar, the eyes not prominent; prothorax more transverse, much more abruptly prominent at the sides at apical third (♀) or not very markedly so (♂), the general surface more flattened basally, the sculpture nearly similar; elytra similar in general sculpture but with the raised polished spaces larger and less abruptly defined and the sides more deeply sinuate at about two-fifths from the base, much less than twice as long as wide; metasternum more concave in both sexes, with unusually long and coarse white hairs in the male. Length (♂, ♀) 24.0–28.0 mm.; width 8.5–10.0 mm. Washington State and Idaho (Fort Cœur d'Alene).....**oregonensis** Fitch

7—Body broad and only moderately convex, shining, black, the depressions obscurely cupreous, beneath dull cupreous; polished black areas with feeble cupreous reflection; head as in *virginiensis*, except that the antennæ are shorter and thicker than in the female of that species, the outer joints much less elongate; prothorax more transverse, very prominent laterally, and much wider than at base at about apical third, the sides thence converging and bisinuate to the base; surface sculptured in general as in that species, the depressions much more coarsely rugose and the median smooth line broader, the basal callus at lateral fourth much larger and more conspicuous; elytra broader, the converging sides posteriorly more rounded, with scarcely a trace of serrulation, the sculpture having the same general arrangement but with the elevations feebler and less sharply defined; under surface with the usual sculpture. Length (♀) 28.0 mm.; width 10.0 mm. Florida..... **prominens** n. sp.

8—Smooth polished areas of the elytra but feebly elevated and less abruptly formed, in some parts dilated, the general sculpture nearly as in *virginiensis*.....9

Smooth areas very abruptly formed, higher and linear in form throughout; sutural angle of the elytra never prolonged or dentiform; antennæ thicker; elytra very evidently wider than the prothorax; species more boreal in habitat.....10

9—Form narrower and more elongate than in *virginiensis*, moderately convex, polished, generally with strong golden-æneous lustre throughout above and beneath but occasionally black and without much metallic lustre; head well developed, unevenly punctured and rugose, the deep frontal sulcus not dilated anteriorly; eyes moderate, slightly prominent, the antennæ slender; prothorax but little more than one-half wider than long, the sides parallel and nearly straight, gradually broadly rounding and very moderately converging anteriorly; surface sculpture as usual, except that the median smooth line is very broad and feebly convex; elytra about twice as long as wide, but little wider than the prothorax, the sides very gradually converging and feebly arcuate posteriorly, the apex unusually narrow, with the sutural angles strongly prolonged and spiculiform; surface with the smooth convex parts together much exceeding in area the depressions, the latter finely and for the most part densely punctate; sutural sulcus becoming subobliterated basally; under surface with the pubescence of the finely and densely punctate areas very distinct, ashy white. Length (♂) 22.7–24.0, (♀) 24.0–28.0 mm.; width (♂) 7.5–8.2, (♀) 7.7–9.2 mm. Southern Atlantic States. [= *Buprestis georgiana* Lec., and *liberta* Lap.-Gory nec Germ.]. **georgiana** Lec.

Form and sculpture nearly as in *georgiana* but narrower, the æneous lustre varied with clouds of metallic bluish-green toward the sides of the elytra, the under surface bright subcupreous; head nearly similar, the eyes much less convex; prothorax trapezoidal, barely one-half wider than long, the sides distinctly converging and nearly straight from base to apex, very feebly arcuate anteriorly, the sculpture nearly similar; elytra in form and sculpture nearly as in *georgiana* but more evidently wider than the pro-

thorax and with the sutural angles at apex not in the least prolonged or dentiform, the apices very narrowly oblique; under surface nearly similar, except that the densely punctate areas are much less pubescent and the angular emargination of the last ventral in the male narrower, acute, with its sides straight and not of a bluntly ogival form as in that species. Length (♂) 22.5 mm.; width 7.0 mm. Southern Atlantic States ..... **iridescens** n. sp.

10—Head well developed, the eyes convex and rather prominent.....11

Head notably small, the eyes continuing its generally rounded outline; body smaller in size than in any other species.....13

11—Depressions of the elytra strongly, closely punctured and also rugose; elytra narrowing posteriorly from slightly behind the middle, with the sides evenly and very evidently arcuate to the moderately obtuse tips. Body elongate-suboval, more convex than usual, coppery in lustre, the elevations blackish, the under surface shining, cupreous; head densely punctate, also with some smooth rugæ on its two large convexities, the latter separated by a broad and moderately deep groove; prothorax three-fifths wider than long, the sides parallel and somewhat sinuate, obtusely, subangularly rounded before the middle and thence strongly converging to the apex; sculpture nearly as in *georgiana* but with the sublateral impression behind the middle much shallower and more diffuse, the sublateral basal callus feeble; elytra about twice as long as wide, notably convex, the sides feebly serrulate posteriorly, the apices rounded; under surface in great part finely, rather closely but not densely punctate, the pubescence inconspicuous, polished and coarsely, sparsely punctate medially as usual. Length (♀) 26.0 mm.; width 9.0 mm. Pennsylvania..... **fortis** Lec.

Depressions of the elytra rather more finely, densely punctate, not so rugose; elytra narrowing posteriorly in about apical third, with the oblique sides nearly straight toward tip, the apices transverse suturally.....12

12—Body rather broad, moderately convex, dull cupreous, the raised parts black, the under surface brilliant æneo-cupreous; head nearly as in *fortis;* prothorax relatively smaller, one-half wider than long, nearly similar in form and sculpture, except that the sides are less prominently rounded before the middle, sometimes very evenly rounded from behind the middle to the apex; elytra evidently less than twice as long as wide, nearly as in *fortis* but less convex, the apex almost similarly obtuse; under surface nearly similar, except that the fine punctures laterally are denser, Length (♂) 23.0–25.0 mm.; width 8.0–8.8 mm. Canada (Ontario)..... **laurentica** n. sp.

Body broad, moderately convex, the depressions of the upper surface bright cupreous-red, the raised parts black; head and prothorax relatively smaller than in the preceding, the former nearly similar, the antennæ notably thick, the subapical joints (♀) but little longer than wide; prothorax smaller, shorter and more transverse, three-fifths wider than long, nearly as in the two preceding, except that the parallel sides are apt to be somewhat bisinuate behind the apical converging and rounding parts

and the sublateral impression and basal callus more pronounced; elytra distinctly less than twice as long as wide, much wider than the prothorax, the apex more acute than in either of the preceding, the sculpture similar; under surface with the sublateral areas of fine dense punctures smaller and more irregular among the smooth patches, and with the whitish pubescence much denser and more conspicuous, as usual decumbent but having also longer and more erect sparse hairs intermingled. Length (♀) 21.0 mm.; width 7.7 mm. Canada (eastern Ontario). [=*Buprestis liberta* Germ., and *borealis* Lap.-Gory].
liberta Germ.

13—Form somewhat as in *liberta* but narrower and more convex, the depressions duller cupreous-red, the elevations black, the under surface bright cupreous; head scarcely more than half as wide as the prothorax, less coarsely and more densely cupreo-punctate than in *liberta*, with narrower rugæ, the sulcus similar; antennæ (♀) less stout, the subapical joints much longer than wide; prothorax similarly transverse, relatively still smaller, the sides parallel and obsoletely bisinuate, gradually strongly rounding and convergent from near the middle to the apex; sculpture nearly similar; elytra nearly similar throughout but still notably wider than the prothorax, the sides before the middle more deeply sinuous, the depressions similarly finely, densely punctate and nearly even; under surface with similarly isolated patches of dense fine punctures, which however are only feebly and very inconspicuously pubescent. Length (♀) 18.0 mm.; width 6.8 mm. New York (northern).....**parviceps** n. sp.

It will be observed that in the above statement some ten American species are considered valid, together with several subspecies, while, in the general catalogue of the Buprestidæ, Captain Kerremans has listed only three, since *fulleri* belongs to *Texania* and not to *Chalcophora*. This considerable increase of species, so material in fact that it may be criticized as unwarranted, is due principally to two causes: first to the fact that a number of species, long established, have been hastily and erroneously suppressed in the catalogue mentioned, *angulicollis* and *oregonensis*, for example, having the elytra proportionally much more elongate than *virginiensis* and without the sutural spine of that species, being abundantly distinct and not synonyms as there enrolled. Then again a number of forms have been discovered since the genus was investigated by LeConte about fifty years ago, so that it is believed the actual increase of synonymy will at least not prove burdensome.

The prothorax in *Chalcophora* is generally more prominent or subangulate at the sides before the middle in the female than in the male, as plainly observable in a series of *virginiensis* before me, in

some individuals of which the sides are not even notably prominent in anterior rotundity, while in others there is a distinct angulation; the character is, at best, rather inconstant and unreliable as a specific criterion. The synonym *obscura* Fitch, recorded originally by LeConte under *virginiensis*, and later repeated by Kerremans in the form "*obscurata*," I have been unable to find in the quoted article by Dr. Fitch. There is, to be sure, a variety suggested by that author in the running text of his article, but it is not *obscura*, and, being unrecognizable, it were better that it lapse and be not perpetuated in synonymy.

Texania n. gen.

The more densely punctate antennal joints, forming one of the structural differences between this genus and *Chalcophora*, was noted without further comment by LeConte, but that author failed to observe the large and well developed antero-internal sensory fossa of the outer joints, which are wholly obsolete in that genus; this, with the character mentioned, alone necessitates the generic separation from *Chalcophora* of *Buprestis campestris* and other allied forms. In addition, however, there are three other distinctive structural characters of importance distinguishing the two genera. The first of these supplemental characters relates to the general sculpture of the upper surface of the body, the pronotum having a narrower, deeper and undivided median sulcus, and the more coarsely punctato-rugulose elytra have very shallow, irregularly rounded areolæ, more or less interrupting the continuity of a few fine uneven longitudinal nervures. The second differential character results from the complete coalescence or disappearance of the prosternal sulci of *Chalcophora*, to form a feeble pubescent impression in the male or simply a flattened surface in the female, and the third refers to the very strong and acute serration of the sides of the elytra posteriorly, which, however, is not always so developed as in the type, becoming much feebler, though always distinct, in such species as *fulleri* and *bisinuata*. At the same time, the affinity of *Texania* with *Chalcophora* is strongly expressed by the general structure of the head and prothorax, as well as by the form of the triangular incisure at the abdominal apex of the male. Kerremans separated a genus *Chalcophorella* from the European representatives of *Chalcophora*, but, from all information available at present,

it cannot be identical with *Texania,* although seemingly a valid genus and not a subgenus of *Chalcophora.*

The species known to me are not very numerous and may be distinguished as follows:—

Species of smaller size and narrower form, the pronotal sulcus narrow and deep, the serration of the elytral margins posteriorly very strong and conspicuous..... 2

Species of large size, broader and more depressed form, the pronotal sulcus broad and shallow, the elytral serration much feebler.....3

2—Body narrow, elongate, moderately convex, shining, with feeble obscure greenish lustre, nearly glabrous, the under surface brighter cupreous and with stiff, sparse and inconspicuous decumbent hairs; head rather small, the front nearly flat, coarsely and confusedly punctate and rugose, the median line finely grooved, with a small oval pit between the posterior parts of the eyes, the latter moderately prominent; antennæ not attaining the thoracic base in either sex; prothorax trapezoidal, from a little less (♂) to somewhat more (♀) than one-half wider than long, the sides sensibly converging and feebly, subevenly arcuate throughout, the basal angles slightly everted, acute and prominent; surface with the sulcus entire, deep and acutely excavated, confusedly punctured and rugose broadly toward the sides, with a deep sublateral impression behind the middle, the basal margin very feebly sinuate at the scutellum, the latter very small, rounded; elytra slightly wider than the prothorax, a little more than twice as long as wide, parallel, the sides gradually rounding and converging behind in more than apical two-fifths, the conjoined apex feebly emarginate at the suture, the apices very narrowly sinuato-truncate; surface coarsely, feebly, unevenly punctato-rugose, with obscure longitudinal striæ between the pronounced nervures, the areolæ finely but sparsely punctate and shining; sterna and first ventral throughout deeply impressed (♂) or flattened to feebly concave (♀), the last ventral in the former with a large equilatero-triangular emargination, the under surface of the last dorsal appearing beyond the incisure, flat, densely punctate, puberulent and with a finely and strongly beaded free edge; legs and coxæ nearly as in *Chalcophora.* Length 22.0–24.0 mm.; width 6.7–7.8 mm. Missouri, Kentucky and Indiana. [= *Buprestis campestris* Say and *substrigosa* Lap.-Gory].....**campestris** Say

Body slightly broader, similarly convex, rather less shining, greenish in lustre, with short hairs particularly evident posteriorly, the under surface cupreous, with brilliant green reflection along the median parts of the sterna, the pubescence more evident than in *campestris,* the punctures laterally, as in that species, small and subevenly distributed, not in dense patches as in *Chalcophora;* head slightly larger but otherwise nearly as in *campestris,* though more evidently and broadly concave toward the median line throughout; prothorax more transverse, the sides nearly parallel for three-fifths from the base, there broadly

rounded and thence strongly converging and nearly straight to the apex, the median sulcus wider, less acute at the bottom, the sublateral impression much more feeble and more diffuse; elytra nearly similar in form and sculpture but more densely and rugosely punctate throughout, especially in the areolæ, the apices narrowly but more obliquely truncate, the sutural angle prominent and acute; male sexual characters similar; tarsi more metallic green in lustre. Length (♂) 23.0 mm.; width 7.2 mm. Pennsylvania ..... **serriger** n. sp.

3—Form oblong, depressed, dark bronze above, feebly shining and sparsely pubescent in patches; head coarsely punctate, deeply, longitudinally grooved; prothorax broader than long, the sides obtusely angulate medially, oblique anteriorly, subparallel behind, feebly sinuate before the hind angles, which are moderately prominent; apex feebly emarginate, the base bisinuate; surface with a broad vague channel medially and a moderately deep longitudinal impression sublaterally, coarsely rugulose at the sides, smoother medially; elytra oblong, depressed, parallel, gradually narrowed and moderately serrate at the sides in apical third, the apex obtuse; surface with four vague nervures, the latter with thickened spaces which surround large but very vague foveæ [areolæ], the nervures feebly shining, the intervals opaque, rugulose, sparsely punctured and with very short pubescence; under surface similar in color to the upper, irregularly and coarsely punctate, with spots of denser and finer punctuation. Length 27.5 mm. Texas. [= *Chalcophora fulleri* Horn] ..... **fulleri** Horn

Form stout, very moderately convex and not very shining, with a pronounced metallic green lustre above, each puncture with an extremely small hair, which is more developed in the male; under surface cupreous and polished along the middle, greenish and duller laterally, the punctures fine and dense laterally, with numerous small smooth patches, the pubescence extremely minute and inconspicuous (♀) or longer, dense and very distinct (♂); head moderate, densely and coarsely punctato-rugose, narrowly excavated along the median line, with a small deep fovea nearly as in *campestris;* antennæ apparently longer in the female than in the male but not attaining the thoracic base; eyes moderately prominent; prothorax fully two-thirds wider than long, the sides parallel and evenly bisinuate to well before the middle, there obtusely angulate and thence strongly convergent and straight to the apex; base but feebly impressed at the scutellum; surface finely, sparsely punctate medially, coarsely and rugosely laterally, the median sulcus very broad, deeper and more densely punctulate anteriorly, becoming gradually obsolete basally, with the median line deeper just before the basal margin, the large sublateral impression, just behind the middle, feeble and indefinite; elytra about twice as long as wide, evidently wider than the prothorax, parallel, the sides rapidly converging, arcuate and slightly serrate in apical third, the apices cupreous, narrowly oblique, with the sutural angle produced and acute; surface somewhat finely, closely punctato-rugose throughout and similarly so and equally shining and puberulent in and outside of the areolæ, the nervures not as prominent

as in *campestris*, the sexual characters of the under surface nearly similar. Length (♂, ♀) 25.0–30.0 mm.; width 8.5–10.8 mm. Texas.
bisinuata n. sp.

Form broader and less parallel than in *campestris*, the size larger, the pronotal sulcus broader and more shallow, visible for only three-fourths of the length and having a slightly flattened elevation near the anterior margin; prothorax more "triangular," the elytra more dilated. Louisiana (near New Orleans). [= *Chalcophora langeri* Chev.].. **langeri** Chev.

The species *langeri* Chev., is of rather uncertain tenure; the few lines of description given above are drawn from information furnished LeConte by Chevrolat himself and printed in the Monograph of the former author. It apparently cannot be the species described above under the name *bisinuata*, neither does it seem to be the *fulleri* of Horn. The description of the prothorax as triangular is rather indefinite, fitting *campestris* better than any other, but the characterization of the thoracic sulcus will not at all apply to that species.[3] I have therefore appended it provisionally as above and until further material from Louisiana can be collected, for as yet we certainly do not know all concerning the fauna of that section of the country. There are probably a number of species of *Texania* in Texas and territory immediately adjacent, which region appears to be its proper centre of dispersal. All the species of *Texania* seem to be more or less rare in collections.

Buprestis Linn.

Ancylocheira Esch.; *Anoplis* Kirby.

The species of this genus are properly holarctic in range, some tropical and Australian forms now attached belonging in reality to other genera; they are numerous and troublesome to separate with certitude, because of considerable variation in form, size and sculpture within specific limits; many of them also are rare or local. It is possible, however, by careful study of large series, to become sufficiently familiar with the laws of intraspecific variation, to be tolerably sure in

[3] Such evidence as we have shows beyond doubt that *langeri* is a species of the *fulleri* type, and that the probability is that the expression "prothorax more triangular" refers to the very patent fact that the sides of the prothorax are more angulate than in *campestris*. It may be therefore that either *fulleri* or *bisinuata* is a synonym of *langeri*. Or perhaps both *fulleri*, which I have not seen, and *bisinuata* may prove to be varietal forms or synonyms of *langeri*.

the taxonomic assignment of those forms represented by single examples, although of course mistakes under these circumstances may readily occur. Difficulties of this kind, nevertheless, scarcely warrant such carelessly sweeping opinions as that put forth by Crotch, in surmising that all the immaculate forms allied to *maculativentris,* constitute a single species, for this is certainly very far from being true. It is also most improbable that there can be the transitions between *lineata* and *maculipennis* hinted at by LeConte, as apparently proved, at any rate, by the large series at hand.

The genus *Buprestis,* as represented by *octoguttata,* which was suggested by Kerremans as the type to be definitively adopted and to which no valid objection can apparently be advanced, includes a wide range of bodily habitus, but the elytra are regularly striate throughout, without the faintest indication of such irregularities as the depressions or areolæ of the preceding genera, and this would seem to be the most important general distinguishing character of *Buprestis* within this group having the outer antennal joints elongate, more narrowed toward base, inferiorly punctate and with a distinct antero-internal sensory fossa. The frontal margin is always broadly sinuato-truncate, the antennæ inserted in triangular cavities which are generally accentuated internally by the moderate though clearly defined oblique ridges; the latter, however, become obsolete in *langi, rufipes* and related forms. The labrum is usually wholly pale and coriaceous, but in *langi* and allies it becomes partially corneous and metallic in lustre; it seemed at first as though this disparity in labral structure might form the basis for subgeneric division, but as it would have placed two such very similar species as *rufipes* and *elongata* in different subgenera, it evidently fails to have any such value. The pronotum generally has a smooth and punctureless, more or less embossed median line, but in *langi* and other similar forms it is wholly devoid of this character, the surface being feebly impressed and more punctured along the median line. The prosternum and first ventral segment may be impressed to strongly sulcate, or without trace of impression and with pronounced even convexity. The legs are slender, the basal joint of the hind tarsi more or less considerably elongate, and the anterior tibiæ of the male may have a strong reflexed spine internally near the tip or betray no vestige of any such structure. The abdominal apex is more or less truncate in both sexes, though, as

in *confluenta*, sometimes more deeply sinuate in the male, but these secondary characters are very inconstant and liable to mislead, so that they are generally not referred to in the descriptions. The integuments are always virtually glabrous, shining and frequently metallic in coloration, though sometimes deep black, some species being among the more lugubrious of this highly metallic family; some are maculate with flavate in diverse patterns and others unicolorous.

The species and subspecies represented in my collection, or assignable with some degree of certainty from published descriptions, may be identified by the following tabular statement:—

Male with the anterior tibiæ deeply sinuate within beyond the middle and with a strong reflexed subapical spine internally; pronotum never impressed along the median line.....2

Male with the anterior tibiæ unmodified; pronotum frequently impressed along the middle.....29

2—Prosternum flattened, sometimes feebly impressed along the median line, the first ventral segment always sulcate medially.....3

Prosternum broadly, evenly convex, the first ventral never more than feebly impressed along the middle; elytra with finely comminuted maculation, the striæ and intervals subuniform throughout the width.....28

3—Elytra each with two brick-red vittae, sometimes more or less disintegrated, the inner much abbreviated. Body elongate-fusiform, convex, black, generally with feebly æneous or cupreous reflection, less marked on the elytra; head about as wide as the thoracic apex, rather finely, densely punctate, less densely and more coarsely anteriorly and in a posterior interocular tumescent transverse area, having (♂) an anterior arcuate and irregular and a post-median transverse pale fascia, or (♀) usually two or four small apical and two juxta-ocular spots; antennæ slender; prothorax nearly three-fourths wider than long, strongly trapezoidal, the sides nearly straight, sometimes slightly inflated basally, generally linearly pale at the lateral and apical margins toward the angles, rather coarsely, subevenly and not very densely punctate, with a slight impression before the scutellum; elytra but little wider than the prothorax, three-fourths longer than wide, the sides gradually rounding and oblique in posterior two-fifths, the apices transversely truncate with spiculate inner and outer angles, the truncature also feebly and irregularly microspiculose; striæ moderate, finely punctate, the intervals but feebly convex, more coarsely punctate, almost uniform throughout, the fourth and especially the sixth notably broader basally and more punctate; under surface shining, distinctly punctate, the last ventral with a small red spot near each anterior angle. Length 12.2–17.0 mm.; width 4.8–6.7 mm. North Carolina, Florida and Louisiana.....**lineata** Fabr.

Elytra each with four flavate spots arranged longitudinally and subequally

spaced, the spots not interrupted in continuity by the striæ, though sometimes divided and forming two or three spots, one or all of which may become obsolete, the two or three anterior spots frequently united between themselves longitudinally and internally.....4

Elytra each with four large flavate spots or narrower bands, which are discontinuous, being interrupted at the striæ; abdomen with four series of pale spots, generally obsolete in the males.....11

Elytra immaculate.....16

4—Body smaller, more fusiform, the prothorax subevenly trapezoidal and almost evenly punctate, nearly as in *lineata*, the elytral apices truncate, feebly spiculose and bidentate, the strial intervals nearly flat and almost equal. Atlantic regions..... 5

Body larger, more elongate, the prothorax trapezoidal but strongly swollen at the sides basally and with more irregular sculpture; elytra evenly truncate at tip, with the outer angle obtuse to feebly dentate; elytral intervals alternately strongly convex. Western North America.....9

5—Second and third spots of the elytra when present always strongly and outwardly diverging, approximate and generally united at their bases.6

Second and third elytral spots nearly transverse, widely separated longitudinally even internally, the spots generally large, fully formed and not at all comminuted.....8

6—Larger as a rule or stouter and with a larger head, more southern in habitat, the ante-coxal plate of the metasternum generally bimaculate medially. Rather stout, convex, shining, black with feeble æneous lustre; head (♀) well developed, rather coarsely, somewhat unevenly punctate, the eyes moderate, widely separated, bordered internally with orange-red, which becomes transverse superiorly, the front also with two anterior spots and a central detached vitta of the same color; antennæ slender, not attaining the thoracic base; prothorax three-fifths wider than long, evenly trapezoidal with straight sides, the apex transverse, broadly arcuate medially, the base bisinuate as usual; punctures rather coarse, unevenly sparse medially, closer laterally; scutellum rounded, flat, polished and metallic; elytra less than twice as long as wide, the sides gradually rounded and oblique posteriorly, though feebly arcuate, to the apical truncature, the striæ strong, closely punctate, the intervals more coarsely punctate, nearly flat, alternately narrower with a single series of punctures and slightly broader with the punctures somewhat closer and more confused; flavate spots small and much disintegrated; abdomen coarsely, closely and conspicuously punctate, the basal sulcus rather deep, continuing virtually to the segmental apex, the last segment with a transverse orange-red spot at each side near the base. Length (♀) 15.0 mm.; width 5.85 mm. Florida.
maculipennis Lap.-Gory

A—Similar to *maculipennis* but narrower and relatively more elongate, the head (♀) fully as developed, with rather prominent eyes, the lower flavate margin along the latter interrupted at the middle and not extending upward as far as the middle of the eyes, also with two

small frontal spots, the posterior spots seldom and only sporadically indicated, the antero-inferior thoracic and two anterior marginal transverse spots of the prosternum less developed; elytra narrower, with similarly small, sparse and very broken pale maculation; under surface with bright metallic lustre, the abdominal punctures rather strong but sparser, the orange-red spot at each side of the last segment more posteriorly oblique inwardly, sometimes almost obsolete. Length (♀) 12.7–13.5 mm.; width 4.8–5.4 mm. North Carolina (Southern Pines)..... **deficiens** n. subsp.

B—Form shorter, stouter and less convex, not so shining or metallic above, the under surface dark subcupreous; flavate border of the eyes (♀) extending upward to the middle of their inner margins, without other pale frontal marking in the type; prothorax nearly as in *maculipennis*, the elytra shorter and broader, two-thirds longer than wide, the flavate spots large, solid and complete, the first and second united, the external part of the latter curving forward externally, enveloping the humeral callus and virtually attaining the base, the third touching the second internally and similarly strongly though posteriorly oblique, the fourth small and subapical; abdomen nearly as in the two preceding but less strongly punctate, the lateral spot of the last segment obsolescent. Length (♀) 14.0 mm.; width 5.9 mm. Virginia (Cape Henry)..... **fusiformis** n. subsp.

Smaller and more boreal in habitat, the head notably smaller in size, the ante-coxal plate of the metasternum apparently very seldom maculate with paler tint.....7

7—Abdomen narrowly and rather deeply sulcate at base as usual, with smaller, sparser punctuation; pronotum without well defined and more convex impunctate areas. Body narrowly fusoid, convex, shining, feebly subæneous; head rather small, the eyes not very prominent, the lower yellow stripe along the eyes terminating at their lower third (♀) or with this border ascending to the upper part of the eyes, bisinuate within and transversely, inwardly prolonged at its upper end, with a large anterior anchor-shaped spot (♂); prothorax nearly as in *deficiens* but more transverse, the elytra nearly as in *maculipennis*, with the flavate spots more or less disintegrated; abdomen with the transverse lateral spot frequently wholly obsolete. Length (♂, ♀) 9.5.–14.0 mm.; width 3.8–5.5 mm. Massachusetts, Pennsylvania (Hazleton) and Indiana..... **inconstans** Mels.

A—Form more evenly fusoid, the head (♀) still rather smaller, with the inferior yellow line along the eyes and two small anterior spots; prothorax similar, except that the sides are more converging from base to apex; elytra similarly striate but with the sides posteriorly more evenly arcuate to the truncature and not straight or even feebly sinuate, as they generally are in *inconstans;* maculation more complete, nearly as in *fusiformis;* abdomen more finely and feebly punctate, the ante-coxal plate of the metasternum feebly bimaculate in the type. Length (♀) 12.2 mm.; width 5.0 mm. Michigan.
scripta n. subsp.

Abdomen at base narrowly, very feebly impressed along the flattened median line and coarsely, very densely and conspicuously punctured throughout; pronotum with some distinct impunctate callous areas. Body very small, narrowly fusoid and convex, colored and sculptured otherwise as in *inconstans*, the head (♀) very small, with the eyes not prominent, having a small pale spot adjoining the lower limb of the eyes; prothorax shorter and more transverse, at base nearly twice as wide as long, the ante-scutellar impression unusually deep and very distinct; elytra as in *inconstans*, the sides arcuate posteriorly to the truncature; last ventral without trace of maculation in the type. Length (♀) 10.7 mm.; width 4.2 mm. New York (Adirondack Mts.)..... **reducta** n. sp.

8—More elongate, fusiform and less convex than in the preceding forms, the maculation orange-red; head (♀) as in *inconstans*, or (♂), with the entire anterior part solidly pale, excepting two small black points, the pale area deeply, angularly biemarginate posteriorly; prothorax nearly to quite twice as wide as long, almost as in *inconstans;* elytra gradually becoming oblique posteriorly but with the sides feebly arcuate to the truncature, striate nearly as in *inconstans*, but with the punctures of the intervals less coarse, the second interval from the side margins more prominently convex; abdomen sulcate as usual at base, not very coarsely but strongly, moderately closely punctate, the spots of the last segment very strongly, inwardly oblique. Length (♂, ♀) 11.0–14.5 mm.; width 4.2–5.6 mm. Michigan and Missouri.
leporina n. sp.

9—Body black-bronzed, polished; under surface with a few pale decumbent hairs; head confluently punctured, with several irregular confluent smooth spaces; labial palpi, spot on the mandibles, labrum, lower margin of the eyes and some frontal spots yellow; prothorax bisinuate at apex and base, coarsely punctate, with several smooth spaces, the lateral margin except basally, and part of the apical margin yellow; elytra slightly furrowed, the furrows punctured, the intervals alternately convex and plane, the sutural interval convex, forked at base, the flat intervals most punctured but the convex the more coarsely; surface with three equidistant and irregular yellow spots, arranged longitudinally, and, nearer the base on the second ridge, there is a line of confluent yellow dots; apices truncate; abdomen having a triangular orange-colored spot at the sides of each segment, those on the last segment larger and irregular, the coxæ also and under sides of the thighs are partly of the same color. Length 15.0–16.0 mm. British-America (Latitude 65° and in the Rocky Mountains).....**nuttalli** Kirby

Body black; abdomen with two widely separated series of small pale spots at each side; coxæ and femora only extremely rarely exhibiting any paler maculation.....10

10—Form oblong-oval, moderately convex, deep black, without metallic coloration above, feebly metallic beneath; head wholly bright orange, with two rounded central black spots arranged transversely, the posterior line of the pale area, between the upper limits of the eyes, with a large median transverse sinus, the punctures generally well separated

(♂), or more densely and irregularly punctate, black, with orange maculation along the eyes and with two or three small anterior spots (♀); prothorax trapezoidal, swollen laterally toward base, three-fourths wider than long, the anterior and lateral margins near the apical angles pale (♂), or with merely a spot under the angles pale (♀); surface rather coarsely, sparsely punctate, with several large irregular smooth areas sublaterally and a broadly smooth median line, finely striate subbasally; elytra three-fourths longer than wide, the sides parallel and nearly straight for two-thirds, thence oblique, becoming nearly straight to the apices, which are simply transversely truncate (♀), or obliquely so with the sutural angles more prominent (♂); surface with deep but finely and very obscurely punctate striæ, the intervals strongly convex and very sparsely, not coarsely punctate, alternately only slightly more so, except the sixth and eighth which are decidedly less convex and more punctate though not densely, the former greatly broadening over the humeral swelling, the reddish-flavate spots two and three alone well developed, vaguely subquadrate and feebly, divaricately oblique outwardly, the first spot small, more internal and generally comminuted, the fourth small and sometimes obsolete; under surface sparsely pubescent, variably punctate, the abdomen deeply sulcate basally, the four spots of the fourth segment subequidistant (♀), or with the two median very approximate (♂). Length 16.5–18.5 mm. width 6.4–6.9 mm. New Mexico (unrecorded locality and Fort Wingate) ..... **alternans** Lec.

A—Form nearly as in *alternans* but much larger, with the elytra more gradually narrowed and more produced posteriorly, the eyes rather less prominent, the prothorax more inflated and rounded laterally in nearly basal half, the sides thence more converging and straighter to the apex. Length (♀) 20.0 mm.; width 7.7 mm. Arizona (Walnut). ..... **conicicauda** n. subsp.

Form much more cuneate and more elongate, similarly convex, the upper surface generally with a faint greenish-metallic lustre; head (♂, ♀) respectively as in *alternans*, except that the transverse posterior margin of the solid bimigronotate pale area of the former has a very small deep median sinus; antennæ (♂) scarcely attaining the thoracic base; eyes but slightly prominent; prothorax less transverse but otherwise nearly similar, with a much stronger impression before the scutellum; elytra generally more sinuate at the sides near the middle, gradually oblique posteriorly and slightly arcuate to the apical truncature, the outer angle more obtuse, blunt; surface nearly as in *alternans* but with the reddish-flavate pale spots much more developed, all four distinct, the first and second generally united and sometimes also the outwardly and divaricately but notably more strongly oblique second and third spots; abdomen deeply sulcate at base, finely and sparsely to rather strongly and more closely punctate, the pale spots frequently, and especially in the male, wholly obsolete, excepting two rather large and irregular on the last segment. Length 16.7–18.7 mm.; width 5.9–7.0 mm. California to Washington State. [=*Ancylocheira dilatata* Motsch., i litt.?].

læviventris Lec.

A—Similar to *læviventris*, except that the abdominal surface is not polished but feebly alutaceous, the hind coxæ not uniformly black but with a transverse pale discal spot, and the large spots of the last segment not full and vaguely triangular but transverse, each with a slender vitta proceeding from the side posteriorly and extending parallel to the sides almost to the tip; prothorax more strongly and abruptly swollen at the sides in basal half. Length (♀) 21.0 mm.; width 8.0 mm. Washington State..... **pugetana** n. subsp.

11—Pronotum strongly impressed near each side just behind the middle. Body oblong-elongate, rather feebly convex, black, without distinct metallic lustre, the under surface with short sparse hairs; head densely punctato-rugulose, sparsely pubescent, with a narrow elongate callus medially and a fine stria thence to the base, the eyes moderate; front with anterior as well as juxta-ocular pale spots in both sexes; antennæ unusually thick; prothorax very nearly twice as wide as long, the sides inflated and strongly, evenly rounded in basal half, thence straight and converging to the apex, the latter and base strongly bisinuate; surface with the margins near the apical angles and a small elongate spot near the basal pale, the punctures coarse, close, dense and rugulose laterally, the four smooth vittæ very pronounced, the impression within as well as without the sublateral irregular vittæ distinct, the median vitta strongly striate along the middle except apically, the two anterior callous spots large and well defined; elytra parallel, the sides gradually rounding posteriorly to the wholly unextended apices, which are truncate and usually bidenticulate, the surface with the alternate intervals perfectly flat, subopaque, finely and densely punctate, or very convex, polished, not more coarsely but very sparsely punctate, the four pale fasciæ broken into small elongate spots on the ridges; under surface with small pale spots on the prosternum, met-episternum, coxæ and along the under side of the femora; abdomen strongly punctate, sulcate at base, wholly immaculate (♂), or with a series of very small red dots along each lateral margin (♀). Length 17.5–20.0 mm.; width 6.8–7.7 mm. New Mexico..... **diruptans** n. sp.

Pronotum not or feebly impressed sublaterally, the sides strongly swollen basally, thence converging and almost straight to the apex; elytra with the intervals equally polished throughout, the flatter and more convex not so unequal and sparsely, subsimilarly punctate, the pale fasciæ more developed, attenuate outwardly and interrupted only at the striæ, the second tending to curve forward anteriorly at the sides; apices always truncate, bispiculose and frequently very feebly, irregularly undulate; under surface with small pale spots on the sterna and coxæ and sometimes on the under side of the femora.....12

12—Elytra unusually prominent at the sides near basal fourth and thence strongly sinuate to behind the middle; male with two small convexities in the apical margin of the second ventral, the median part of the segment flattened, with the coarse dense punctures streaming obliquely toward the two inequalities. Body black, without metallic lustre; head (♂) not coarsely but closely punctate, with a median and two

rather distinct oblique smooth lines, the median line of the occiput broadly smooth and concave; anterior half of the front yellow, with a posterior spur at the middle and two small anterior black points, also with a more posterior oblique spot near each eye, the latter large but not prominent; antennæ rather slender; prothorax small, moderately transverse, the sides arcuate basally, the apex broadly prominent and arcuate, only very feebly sinuate laterally; surface coarsely, closely punctate, with pale margins and impunctate areas as in *diruptans*, the sublateral smooth vitta partially interrupted by a small deep foveiform impression; elytra much wider than the prothorax, strongly cuneate from the base, broadly rounded and subprominent laterally behind the middle, the sides thence rapidly oblique, becoming subsinuate to the apex; under surface strongly punctate; femora and abdomen without pale spots, except a small one at each side of the last segment. Length (♂) 17.0 mm.; width 6.3 mm. Washington State (Tacoma).

contorta n. sp.

Elytra subparallel, not very prominent subbasally and but feebly sinuate laterally, the second ventral unmodified in the male.....13

13—Basal inflated part of the prothorax with the sides broadly rounded. Pacific regions.....14

Basal inflation more abrupt, angulate or tumescent, the head, pronotum and under surface more cupreous. Atlantic regions.....15

14—Form oblong, parallel, only moderately convex, shining, colored as in *contorta* and with the general characters similar, except that the head and prothorax are relatively larger (♂), the latter almost as wide as the elytra, the head nearly similar in sculpture and ornamentation, except that the upper pale spots near the eyes are less oblique and less posterior; eyes rather small and not at all prominent; prothorax with the apical margin even more strongly and prominently arcuate medially, the callous smooth areas similar, the small impression on the outer side of the sublateral vitta less marked; sides near the base less broadly prominent than in the two following forms; elytra but three-fourths longer than wide, very rapidly oblique behind in less than apical third; under surface strongly but not densely punctate, shining, with the usual sternal and coxal pale spots, the femora with an elongate pale spot beneath, the abdomen with a pale spot at each side of the basal sulcus and another transverse at each side of the last segment. Length (♂) 17.8 mm.; width 7.4 mm. California.....**gravidula** n. sp.

A—Nearly as in *gravidula* throughout though a little narrower, the head (♂) with larger and much more prominent eyes, the median line and two lateral discal spots smooth, the pale area confined to the entire apical margin, running along the eyes from above the middle to the base of the head beneath, the median posteriad pale spur long; prothorax similar; elytra more elongate, more gradually and less strongly oblique at the sides posteriorly in apical two-fifths, feebly arcuate even near the apices; under surface nearly similar, the femora and abdomen without pale spots, except a slender oblique line at each side of the

last segment; basal joint of the hind tarsi long as usual in this group, almost as long as the next three combined. Length (♂) 17.8 mm.; width 6.8 mm. Washington State..... **torva** n. subsp.

B—Nearly as in *torva* but still more elongate, the elytra nearly twice as long as wide, with the sides similarly gradually rounding and oblique in posterior two-fifths but becoming nearly straight to very feebly sinuate near the apices; head (♀) as in *gravidula*, having the anterior margin throughout the width, sometimes broken into four spots, pale; prothorax as in that form but with feebler indication of impression interrupting the sublateral smooth vittæ; elytra sculptured as in *torva*, the flatter intervals rather more punctate than in *gravidula;* abdomen with the four lines of pale spots well developed (♀), with numerous pale spots on the sterna and coxæ and one on the under side of the femora, the spots of the two inner abdominal lines larger than those of the marginal lines. Length (♀) 17.3–19.7 mm.; width 6.2–7.8 mm. Colorado (Boulder Co.).. **boulderensis** n. subsp.

15—Form nearly as in the preceding, the size much smaller, the coloration and sculpture almost similar; head (♂) densely punctate, the callous areas very small and inconspicuous, the occiput impressed along the median line; front yellow in anterior half, except a sinus above each antenna and generally two rounded discal points, the yellow area with a short posteriad median prolongation, the spot near the upper part of each eye distinct to wholly obsolete; eyes somewhat prominent; prothorax with the sides at two-fifths from the base subangularly protuberant, the apical margin broadly bisinuate; sculpture and ornamentation as in *gravidula*, except that the impression near the outer smooth vitta is wholly obsolete; elytra as in the preceding forms gradually oblique at the sides posteriorly, sometimes feebly sinuate toward the apices; under surface and sometimes the femora inferiorly spotted with flavate as in the preceding; abdomen strongly punctate, narrowly sulcate at base, generally with a pale spot at each side of the sulcus, the other spots nearly obsolete (♂), the single spot at the centre of the fourth segment, forming the apex of the two inner series, generally visible, the last segment with a biramose spot at each side, which is however frequently wholly obsolete. Length (♂) 13.5–16.7 mm.; width 5.0 6.0 mm. Lake Superior (Duluth and Bayfield)..... **flavopicta** n. sp.

Form notably narrower and relatively somewhat more convex, the pale broken fasciæ of the elytra larger, almost always longitudinally confluent near the suture; general coloration and sculpture similar; head smaller, less densely punctate and not so evidently pubescent, similarly ornamented; prothorax similar but less transverse, the sides less angularly tumid and at basal third, thence to the base frequently with an intermediate sinus; elytra somewhat more produced at tip, with the sides toward the apices more evidently sinuate, the apical truncature transverse as usual, finely bidenticulate; under surface nearly similar but with less evident ashy hairs, the abdomen more sparsely and evidently less strongly punctate as a rule. Length (♂) 13.5–14.2 mm.; width 4.8–5.2 mm. Pennsylvania and New York to Michigan.

consularis Lap.-Gory

16—Abdomen with four series of pale spots; body convex and fusiform, generally with rather distinct green or violaceous metallic lustre..... 17

Abdomen with a single series of pale spots at each side.....21

17—Pronotum strongly declivous laterally, the side margins and apical angles not visible from above. Form elongate, convex, the lustre polished, feebly violaceous, more evidently so beneath; head strongly and not very densely punctate, the median line narrowly smooth anteriorly but without other callous spots, the eyes (♀) margined internally throughout with an internally bisinuate red border, the front also with two anterior elongate red spots; eyes rather prominent; antennæ moderate; prothorax three-fourths wider than long, unusually parallel, the medially subprominent apex fully three-fourths as wide as the base, the sides evenly converging from base to apex, evenly and feebly arcuate; surface evenly convex, with an oval orange spot at the sides of the apex, coarsely, generally sparsely and unevenly punctate, having sublateral areas and the median line impunctate, the latter with a small deep basal puncture; elytra but little wider than the prothorax, twice as long as wide, parallel, the sides very gradually rounding and converging in apical two-fifths, the apices rounded, transverse toward the suture, the latter scarcely prolonged; surface with the intervals alternately wider, moderately convex and sparsely punctate and narrower, flatter and more closely punctate; under surface strongly punctate, the abdomen less densely, shining, wholly immaculate excepting two small rounded red spots at each side of segments two to four and one transverse near each side of the fifth, sulcate basally. Length (♀) 17.8 mm.; width 6.8 mm. Colorado (?)—Cab. Levette.

rubronotans n. sp.

Pronotum not strongly declivous laterally, the side margins and apical angles visible from above.....18

18—Prothorax much narrower than the elytra, the sides not continuous. Body less convex, polished, the anterior parts feebly, the elytra strongly metallic green, the under surface violaceous; head (♀) as in the preceding but with the eyes less prominent and with more developed pale orange marking, the latter completely enclosing the front except at the middle posteriorly; prothorax two-thirds wider than long, trapezoidal, the sides evenly converging throughout, very feebly arcuate except apically, the margins antero-laterally orange-red; surface coarsely, closely, unevenly punctate, tumid submedially near each side, with but few small irregular callous spots, the median line uneven, impunctate, feebly striate medially toward base but without distinct subbasal puncture; elytra three-fourths longer than wide, two-fifths wider than the prothorax, the sides feebly converging and broadly sinuate, becoming somewhat gradually rounded and oblique, then nearly straight to the rounded apices, the sutural angle dentate; surface nearly as in the preceding but with much less unequal intervals either in width or in their generally feeble convexity; under surface less punctate, the polished abdomen finely and sparsely so, the spots orange, those of the

inner series large and transverse, the external small but uniting with the inner on the subapical segments, those of the last segment very large, extending nearly to the apex but not transversely confluent. Length (♀) 16.8 mm.; width 6.8 mm. Montana....**adonea** n. sp.

Prothorax at base almost as wide as the elytra, the sides almost a prolongation of those of the latter, which are similarly rounded or obtuse at tip, with the sutural angle dentiform; surface shining, greenish to violaceous metallic, the anterior thoracic angles pale as usual.....19

19—Abdomen polished, very finely and sparsely punctate. Body nearly as in *adonea;* head (♀) sparsely, irregularly punctate, solidly pale between the entire inner margins of the eyes, excepting the small antennal sinuses and two large and two minute discal central spots, the transverse hind margin of the pale area with a quadrate median emargination; eyes moderate; prothorax evenly trapezoidal, with the sides nearly straight or very faintly biarcuate, the apex rather prominently rounded medially; surface broadly tumid sublaterally except near the apex, coarsely, rather closely and irregularly punctate, with but small and badly defined smooth spots, the median line impunctate but not tumid, unipunctate basally; elytra three-fourths longer than wide, nearly as in *adonea* but with more evidently unequal intervals; orange spots of the inner and outer abdominal series moderate, generally transversely united, those of the last segment transverse but not meeting medially and each prolonged posteriorly along the margin for a short distance. Length (♀) 17.0 mm.; width 6.9 mm. Utah (Stockton)...**histrio** n. sp.

Abdomen more closely, more or less strongly and conspicuously punctate though somewhat variably so as usual.....20

20—Form rather broad, only moderately convex, shining, dull metallic green to violaceous; head (♀) strongly but not very densely punctate, the back part of the front between the upper part of the eyes less punctate and medially feebly impressed, the front surrounded broadly with orange-yellow, which is sometimes solid excepting two median spots; eyes feebly convex, not prominent; prothorax trapezoidal, two-thirds wider than long, the sides broadly, very feebly biarcuate; surface almost evenly convex, rather coarsely but unevenly punctate, with the usual impunctate areas sublaterally and a smooth median line, which is frequently striatulate along the middle posteriorly, the fovea subobsolete; elytra evidently less than twice as long as wide, parallel, rather rapidly rounding and oblique at the sides in apical two-fifths, the apices rounded, becoming transverse suturally, the sutural angle dentiform; surface with the intervals strongly alternating in convexity, sparsely and very inconspicuously punctate throughout, the subhumeral marginal cavity deep; under surface strongly, moderately coarsely and closely punctate, immaculate except the abdomen, where the four series of yellow spots are well developed, the two lateral transversely confluent subapically, the two large spots of the last segment not attaining each other medially. Length (♀) 18.0–19.5 mm.; width 6.8–7.4 mm. New Mexico (Fort Wingate), Colorado (Salida), Arizona (Grand Canyon of the Colorado) and Idaho (Cœur d'Alene—the color brighter æneous) . . **subornata** Lec.

A—Nearly as in *subornata* but more elongate, more convex, with less unequally convex elytral intervals and with the sides of the elytra much more gradually rounding posteriorly and thence more gradually oblique and more evidently arcuate to the apices, the latter broadly rounding, very oblique thence to the strongly dentate sutural angles; head and prothorax nearly similar, except that the latter is less transverse, the elytra more elongate; abdomen similarly deeply sulcate along the median line of the first segment, coarsely, densely and very conspicuously punctate throughout, the spots as in *subornata* but deeper orange-red in color. Length (♀) 18.5 mm.; width 6.9 mm. Colorado (Boulder Co.)..... **punctiventris** n. subsp.

Form narrower than in *subornata* but only slightly more convex, shining, obscurely violaceous; head (♀) strongly but rather sparsely, irregularly punctate, similarly ornamented, the eyes rather more convex; prothorax nearly as in *subornata*, the punctures similarly sparse and irregular but smaller medially, the sides broadly arcuate in basal half, thence nearly straight or less arcuate to the apex, the punctures becoming relatively coarser and denser near the sides than in *subornata;* scutellum oblong, parallel, flat; elytra nearly twice as long as wide, almost as in *subornata*, except that the surface is more punctured, the punctures less fine; abdomen distinctly punctured but much less coarsely or closely than in the two preceding forms, the spots small, red, those of the lateral pairs not approaching each other transversely, the two of the last segment very different, being transverse, not at all ramate posteriorly along the margin and uniting on the median line to form a single transverse fascia. Length (♀) 17.2 mm.; width 6.5 mm. Kansas..... **violescens** n. sp.

21—Form nearly as in the preceding, elongate, fusoid and notably convex; elytra strongly longitudinally undulated medially 22

Form more parallel and notably less convex; integuments black, never with the marked metallic lustre of the preceding section, the elytra more even and less undulated.....23

22—Body black-bronzed, punctured, glossy; head with a levigated elevation in the centre between the eyes, channeled behind, marked with two yellow spots beneath on the cheeks, a triangular one adjacent to the eyes on the inner side and two dots of the same color between them; prothorax coarsely punctate, with smooth spaces, the discal one longitudinal, with an ante-scutellar impression; sides converging at the base of the prothorax; anterior angles with a yellow stripe; elytra strongly furrowed, with numerous very minute punctures in the furrows, rounded at apex; interstices with scattered punctures, those of striæ 2–3, 4–5 and 8–9 elevated so as to form an obtuse ridge; four last ventral segments of abdomen having on each side a reddish-yellow spot, those on the last segment being the largest and most irregular; anus with two distinct lateral teeth. Length 18.5 mm. British America (Latitude 54°,—Kirby, and one specimen without more exact locality than "B. A." received from Chas. W. Leng); Washington State.
rusticorum Kirby

Body nearly as in *rusticorum*, of the same color, the head, anterior thoracic angles and abdomen similarly spotted, except that on the first there are no frontal dots; the prothorax however is differently shaped, being somewhat constricted anteriorly, with the sides toward base rounded; it is also channeled [referring without much doubt to the impressed stria, frequently observable toward base in many species]; the sculpture of the elytra is similar but they are more attenuated and truncated at the end, as in *rustica*, and armed with three minute denticles. Length 15.5 mm. British America (Cumberland House, Lat. 54°).
paganorum Kirby

Body much smaller and narrower than in *rusticorum*, polished, brighter bronzed, greenish or subcupreous; head moderate, densely punctate, with median and subposterior levigated spaces; eyes only moderately convex; prothorax three-fourths wider than long to nearly twice as wide as long, trapezoidal, the sides more or less inflated and broadly arcuate in rather more than basal half, the surface almost evenly convex, strongly but very unevenly punctate, coarsely and densely so laterally, more sparsely and less coarsely medially, with large sublateral smooth spaces and a distinct smooth median line which is generally finely, briefly striate at base; elytra but little wider than the prothorax, nearly twice as long as wide, gradually strongly oblique at the sides in apical third, the apices transversely truncate, the truncature sometimes irregular or finely spiculose, the outer angle obtuse, never dentiform; under surface strongly, closely punctate; lateral spots of the penultimate ventral segments very small and frequently subobsolete, those of the last segment obliquely linear, sometimes also posteriorly ramate along the margins but never meeting on the median line. Length (♂, ♀) 14.0–16.0 mm.; width 5.0–5.9 mm. New Hampshire, Vermont, Michigan, Wisconsin (Bayfield), South Dakota and Manitoba. [=*sexnotata* Lap.-Gory]..... **maculativentris** Say

23—Pale spots well developed at the sides of all the ventral segments as in the preceding group.....24

Pale spots wanting or greatly reduced at the sides of the abdomen, except on the last segment, where they are correspondingly more conspicuous, forming a large transverse red fascia..... 27

24—Prothorax very strongly narrowed anteriorly, the apex not more than two-thirds as wide as the maximum width. Body elongate, convex, black, the pronotum with very feeble cupreo-violaceous lustre; head (♀) densely punctate, the intercular surface in great part coarsely rugose, with the entire frontal margin, enclosing two black points and emitting a long posterior medial spur, pale yellow; also with a suboblique and more orange spot at the upper part of each eye, the eyes not prominent; antennæ rather long, extending fully to the thoracic base; prothorax nearly twice as wide as long, widest behind the middle, the sides evenly and strongly arcuate, becoming gradually very convergent and less arcuate anteriorly; surface with the usual antero-lateral yellow vitta, almost evenly convex, coarsely, densely

but unevenly punctate, with sublateral smooth spaces and a narrow and uneven impunctate median line; elytra long, but little wider than the thoracic disk, twice as long as wide, the subparallel sides very gradually rounding and oblique posteriorly, the apices rounded, with the sutural angle scarcely at all prominent; surface with the intervals alternatingly feebly and strongly convex, moderately punctate, rather coarsely and closely so and subrugose laterally; abdomen deeply and abruptly sulcate basally, rather strongly but sparsely punctate, the yellow spots distinct and subequal on every segment, larger and transverse though separated on the fifth. Length (♀) 19.5 mm.; width 7.0 mm. New Mexico (Cloudcroft) ..... **acomana** n. sp.

Prothorax not so strongly narrowed and less rounded on the sides, the apex three-fourths to four-fifths as wide as the maximum width; elytral apices similar 25

25—Elytra oblique at the sides in fully apical two-fifths, more prolonged apically, the eyes rather more prominent. Body oblong, rather depressed, deep black; head (♀) coarsely rugose, with a large median area somewhat depressed and with a short callous median line, finely and densely punctate, the front with four anterior pale spots; epistoma medially unusually deeply sinuate; antennæ rather thick; prothorax short, almost twice as wide as long, the sides converging, evenly and moderately arcuate from just before the base to the apex, rounding in slightly at base; apex and base broadly bisinuate; surface coarsely and irregularly punctured as usual, the smooth median line with a striaform impression at base; scutellum longer than wide, metallic; elytra not quite twice as long as wide, scarcely at all wider than the prothorax, with the usual nearly flat, alternating with convex, intervals, the flat ones much the broader; punctures fine and sparse; abdomen rather strongly and closely punctate but not coarsely, the basal sulcus moderate, not quite attaining the apex of the first ventral; spots red, those of the fifth segment transversely subquadrate, widely separated. Length (♀) 18.0 mm.; width 7.0 mm. Kansas.... **morosa** n. sp

Elytra generally oblique in about apical third; eyes not prominent..... 26

26—Form rather more elongate and scarcely so depressed, black, sometimes with very faint greenish or violaceous lustre either on the elytra or pronotum, the former frequently dark piceous; head nearly as in *morosa* but with more yellow maculation, this sometimes solidly surrounding the median parts of the front though broadly open behind, the epistoma less deeply sinuate, the antennæ rather longer; prothorax much less transverse, three-fourths wider than long, the sides frequently a little more rounding basally, the sculpture coarse, nearly similar; elytra nearly similar, though a little more elongate and more evidently wider than the prothorax, the punctures larger, closer and much more conspicuous especially laterally; abdomen as in *morosa*, the pale spots of the last segment rarely coalescent transversely; male apparently very rare. Length (♀) 17.0–20.0 mm.; width 6.6–7.8 mm. Colorado,—Cab. Levette..... **fusca** n. sp.

A—Nearly as in *fusca* but shorter and more oblong, the head smaller but otherwise nearly similar, the eyes not at all prominent, the central punctuation less fine and rather less crowded, the antennæ somewhat thicker; prothorax more transverse, not quite twice as wide as long, the sides broadly, subevenly rounded, more converging but still arcuate anteriorly, the punctures rather sparser; scutellum rounded; elytra shorter, evidently less than twice as long as wide and not very evidently wider than the prothorax, otherwise similar; abdomen as in *fusca* but somewhat less strongly and decidedly sparsely punctate, the lateral yellow spots smaller throughout. Length (♀) 17.0 mm.; width 6.7 mm. Montana ..... **sublivida** n. subsp.

Form nearly as in *fusca* but much smaller in size, shining black, the pronotum sometimes violaceous; head nearly similar but with less evident and much smaller central punctate area, the front yellow (♂), excepting two large posterior areas, or with the yellow area more contracted and broken into spots (♀); eyes slightly convex; antennæ rather long; prothorax nearly twice as wide as long to distinctly less; the sides sometimes slightly prominent near basal third but generally almost even; surface less coarsely and more densely punctate than in *morosa* though smilarly irregular, slightly impressed sublaterally behind the middle; scutellum rounded; elytra not quite twice as long as wide, but little wider than the prothorax as a rule, sculptured as in *fusca*, with almost equally distinct punctuation though rather less strongly alternating intervals; abdomen shining, alutaceous, strongly, rather closely punctate, the orange lateral spots distinct, subequal, those of the fifth segment somewhat obliquely transverse, moderate, basal sulcus strong, the second segment also sometimes slightly impressed medially. Length (♂, ♀) 14.0–17.0 mm.; width 5.2–6.8 mm. Colorado (Boulder Co. and Ouray) and New Mexico (Albuquerque and Cloudcroft). **caliginosa** n. sp.

27—Pronotum with four rounded impressions near the base, one on each side of the basal sublateral callus. Head rather small, densely punctate and somewhat impressed medially on the front, with several small smooth patches and with well developed yellow maculation, the eyes not prominent; antennæ rather slender; prothorax small, two-thirds wider than long, widest at basal third, where the sides are prominently rounded, thence rather strongly converging anteriorly and less strongly posteriorly and nearly straight; apex and base bisinuate; surface coarsely punctate, densely laterally, the sublateral smooth spots prominent, the smooth median line irregular, feebly striate basally; elytra almost a third wider than the prothorax, less than twice as long as wide, parallel, oblique but rounded at the sides in apical third, the apices truncate but with obtuse angles; surface with the equal intervals slightly alternating in convexity, the punctures sparse as usual but strong and distinct; abdomen strongly, rather closely punctate, narrowly sulcate at base; segments two to four each with a small lateral spot, the fifth with a large entire fascia which is sinuate at the middle of its anterior margin, arcuato-truncate at tip, with rounded angles. Length (♀) 16.7 mm.; width 6.5 mm. Montana ..... **nigricans** n. sp.

Pronotum with a deep foveiform impression at each side of the median line before the middle but otherwise not distinctly impressed. Surface shining, greenish-black; head (♂) coarsely, densely punctate and partially impunctate, the entire space between the eyes yellow-orange, except a large median anteriorly and deeply incised black spot; eyes large but not prominent; antennæ slender; prothorax short, almost twice as wide as long, only moderately narrowed anteriorly, the sides subevenly rounded, a little more so basally, widest at about basal third; surface strongly, sparsely punctate, densely so laterally, the sublateral smooth spots coalescent, not prominent, with traces of the subbasal depressions of the preceding; anterior sides and lateral third of the apical margin pale; elytra nearly as in *nigricans* but only very slightly wider than the prothorax, the apices subtruncate and with feeble minute irregularities but with the outer angle obtusely rounded; surface strongly but not closely punctate, the intervals alternatingly rather wide, moderately convex, less polished and feebly rugose and narrower, strongly convex, smooth, less punctate and very lustrous, the arrangement very regular throughout the width; abdomen deeply sulcate basally, strongly, rather closely punctate, the third and fourth segments each with a very small red dot laterally, the fifth with two large transverse red spots, the apex evenly and distinctly sinuate with simple angles. Length (♂) 18.5 mm.; width 6.9 mm. British Columbia (Golden) ..... **lyrata** n. sp.

Pronotum without evident impressions. Body large and elongate, shining, black or greenish-black to faintly violaceous in lustre; head nearly as in *lyrata*, sometimes with a larger finely and densely punctate medial area, the pale area surrounding the interocular surface nearly similar and frequently as well developed in the female as in the male; prothorax larger, much less transverse, generally but little narrower at base than at basal third, the sides more even thence to the apex, nearly straight or feebly arcuate, sometimes feebly biarcuate, but, in the male, sometimes subangularly prominent behind basal third; surface more densely punctate, with the sublateral smooth areas usually large though not prominent; elytra but little wider than the prothorax, generally fully twice as long as wide, the apices truncate to arcuato-truncate, nearly even, the sutural angle unusually evident for this section; surface nearly as in *lyrata* but less strongly punctate, the wider intervals more nearly flat and not so rugulose, the narrower less convex; abdomen strongly but not very coarsely, closely punctate, sulcate at base, the fifth segment with a large and generally entire transverse red fascia, the two or three preceding also sometimes with a small red dot at each side, the fifth broadly sinuate at tip (♂), or arcuato-truncate with obtuse angles (♀); females abundant, the male rare. Length (♂) 15.0, (♀) 18.0–23.0 mm.; width (♂) 5.8, (♀) 7.0–8.8 mm.; dimensions of one ♀ 23.0 by 8.3 mm., of another ♀ 22.0 by 8.8 mm.. Oregon, Idaho (Cœur d'Alene), Washington State and Vancouver Island). [=*rusticorum* Lec. nec Kirby]. ..... **adducta** n. sp.

28—Form moderately elongate and subdepressed, vivid green above, the

elytra violaceous blue to green, varying with angle of light, thickly and uniformly, finely spotted with fulvous yellow, the spots more or less transversely confluent, a transverse band behind apical third, which is continued broadly on the suture to the apex, devoid of spots; under surface (♀) coppery with greenish reflection, without paler maculation, or (♂) having the median parts from the head to near the apex of the first ventral pale yellow, with a small yellow spot at each side of the fifth ventral; head (♀) without pale spots, rather coarsely, densely punctate, the eyes rather prominent, or (♂) very densely and more finely punctate; prothorax two-thirds wider than long, the sides evenly converging, almost evenly and moderately arcuate from base to apex; surface even, evenly convex, without impunctate areas, the smooth median line interrupted anteriorly, the punctures coarse, very dense laterally; elytra but little wider than the prothorax, parallel, nearly twice as long as wide, the sides gradually oblique in more than apical third, the apices obliquely rounded, the sutural angle not at all prominent; surface with equal, moderately convex, finely and sparsely punctate intervals, the striæ closely and evidently punctate; abdomen very finely, sparsely punctate, the first segment narrowly flattened along the median line. Length (♀) 16.0 mm.; width 5.7 mm. Kansas (Edmond),—Warren Knaus. [=*confluens* Lec.] ..... **confluenta** Say

A—Nearly as in *confluenta* throughout, the arcuate elytral band free from maculæ not prolonged posteriorly on the suture, the prothorax shorter, with the lateral punctures still more confluent, the impunctate median line entire, the side margins with a pale point at the apical angles and another near the base; head (♂) finely, very densely punctate and much more pubescent; last ventral (♂) with an entire transverse pale fascia from side to side near the base, the punctures stronger than in the female of *confluenta* and less sparse. Length (♂) 14.7 mm.; width 5.0 mm. Texas ..... **tessellata** n. subsp.

29—Elytral striæ more or less fine, with small, even, less close-set punctures. Atlantic regions, extending westward nearly to the Rocky Mts 30

Elytral striæ sulciform, densely and more confusedly crenate, the intervals relatively narrow; median line of the pronotum generally more impressed. Pacific regions, extending eastward in the north as far as Lake Superior 34

30—Body very elongate, in great part pale beneath, the legs at least in part pale, the elytra each with an anterior vitta from the basal margin 31

Body less elongate, without paler areas beneath, the legs always black with more or less metallic lustre, the elytra variously maculate with yellow .. 32

31—Legs entirely pale in color. Body only moderately convex, shining, metallic green, the anterior parts frequently bluish to æneous; lateral parts of the sterna metallic green, the remainder of the under surface variegated with yellow and brownish-red, the latter prevailing on the abdomen, the former forming a broad but broken axial vitta from the head to the middle of the abdomen, apparently in both sexes, the sides

of the body beneath also with yellow spots, forming a broad fascia on the last ventral; head moderate, the eyes rather prominent, the front without pale spots, coarsely, closely punctate, with a prominent smooth callus along the median line centrally; antennæ slender, pale brown; prothorax two-thirds wider than long, but little narrower at apex than at base, the former truncate, the latter bisinuate; sides evenly, feebly arcuate; surface evenly convex, coarsely, not densely punctate, without smooth spots or median line but with a small fovea before the scutellum, the hypomera pale, the latter tint sometimes spreading more or less broadly to the dorsal surface; elytra about two and one-half times as long as wide, only just visibly wider than the prothorax, very gradually rounded and narrowed posteriorly behind the middle, the apices rather broadly sinuate and strongly bispiculose, each with a yellow vitta from just beyond the middle of the base for two-fifths or more, a transverse discal fascia at apical two-fifths and another still more posterior, the apices also pale; striæ impressed, punctulate, the intervals equal, moderately convex, becoming flat basally, finely, sparsely punctate; under surface finely, sparsely punctate, more strongly and closely laterally. Length (♂, ♀) 17.5–21.0 mm.; width 5.4–6.7 mm. Pennsylvania, Indiana, Kentucky, Louisiana and Kansas..... **rufipes** Fabr.

A—Similar to *rufipes* but much larger and stouter, the head more developed, with the front much more convex, the eyes fully as large but not prominent, their contour following the general outline; scutellum equally well developed, flat, rounded; elytra with the sides much more rounding and converging posteriorly, the sinuate apices relatively narrower though strongly bispiculose. Length 23.0 mm.; width 7.4 mm. One specimen labeled "Cal." in Cab. Levette, but probably in error..... **virens** n. subsp.

Legs black and metallic bluish-green, the femora pale, with the upper side, a lateral streak and the tip metallic black, the anterior pale only on the under surface in basal two-thirds. Body rather less slender, shining, black to greenish-black, the under surface in great part pale; head coarsely, densely punctate, with a few callous smooth spots, a large, posteriorly cuneate median pale spot at apex and another at the lower part of each eye, the latter not at all prominent; antennæ black with feeble metallic lustre; prothorax as in *rufipes*, the sides broadly pale, with a dark vitta on the hypomera; scutellum very much smaller; elytra as in *rufipes* but less elongate and evidently wider than the prothorax, very gradually and arcuately narrowed posteriorly to the apices, which are briefly produced and each rather wide, deeply, obliquely sinuate, the external angles strongly spiculate, the sutural much produced and acute, similarly striate, the intervals not distinctly punctate, each elytron with a narrow reddish vitta from the humeral angles over the callus to two-fifths from the base at outer third, a small discal spot just behind the middle, another larger, more transverse and lateral at apical fourth and a small longitudinal dash near the suture between the last and the apices, the latter not pale; under surface completely

impunctate, except some very fine sparse asperate punctules laterally, in great part pale, each abdominal segment with a very large irregular pale fascia which is sometimes medially interrupted, the fifth wholly pale, except the tip and the lateral basal angles. Length 20.0 mm.; width 6.5 mm. One specimen from Cab. Levette labeled "N. Y.," but more probably from Colorado. ..... **elongata** n. sp.

32—Elytra each with three large discal pale spots, the anterior elongate, oblong or oval and not attaining the base, the second transverse, at three-fifths, extending nearly from suture to side margin, the third feebly oblique, discal and near the apex. Body subparallel, rather depressed, brassy-green, the elytra somewhat more obscure, the under surface green with cupreous reflection; head strongly, densely punctured, without callous spots even medially; antennæ black, but feebly metallic; prothorax three-fourths wider than long, the apex but slightly narrower than the base, the sides subevenly, feebly arcuate; surface without pale maculation of any kind above or beneath, coarsely and not very closely punctate, without smooth or impressed line, with a small ante-scutellar puncture; scutellum small, subtransverse, oval; elytra twice as long as wide, distinctly wider than the prothorax, parallel, arcuately narrowed behind, the apices sinuate and strongly, acutely bidentate; surface finely striate, the striæ as in *fasciata*, punctate, the punctures more visible viewed obliquely from the side than from the suture, the intervals nearly flat, equal, finely and remotely punctate; abdomen finely punctate, densely so laterally. Length 11.3 mm.; width 4.0 mm. Michigan ..... **sexplagiata** Lec.

Elytra each with a conspicuous irregular pale fascia at three-fifths and a small oblique subapical spot, also sometimes a small discal pale spot at two-fifths from the base..... 33

33—Sides of the prothorax incurvate at base and feebly swollen basally, but thence moderately converging and nearly straight to the apex. Body oblong-elongate, moderately convex, polished, cupreous, generally more greenish anteriorly, sometimes obscure throughout, the under surface bright cupreous to greenish or even violaceous in the dark forms; head strongly but very unevenly punctate, the eyes prominent; prothorax nearly twice as wide as long, the apex about four-fifths as wide as the base, broadly, subevenly sinuate, the base feebly bisinuate; surface coarsely, sparsely punctate, more closely laterally, feebly to not at all impressed along the middle, generally with a small sublateral rounded impression, the ante-scutellar fovea conspicuous; scutellum moderate, variable; elytra slightly more than twice as long as wide, just visibly wider than the prothorax, parallel, arcuately narrowed behind, the apices sinuate and strongly bispiculose; striæ rather strong, evenly and closely punctate, the punctures on the inner slope of the grooves, the intervals nearly flat though slightly inclined sutureward, extremely minutely, remotely punctulate; abdomen with the basal segment very faintly and indefinitely impressed along the middle, finely, not very closely punctate, more strongly, densely so laterally; basal joint of the hind tarsi unusually short, very much shorter than the

next two combined. Length 14.8–15.7 mm.; width 5.2–6.0 mm. Dakota, Wisconsin (Bayfield) and Indiana..... **fulgens** n. sp.

Sides of the prothorax evenly converging and distinctly arcuate from a short and very feeble though abrupt basal swelling to the apex, not evidently incurvate at base; subapical spot of the elytra very much more oblique. Body more elongate in form, brilliant and pure green in color, becoming subæneous beneath, maculate nearly as in *fulgens* but with the post-median fascia generally fuller and less irregular; head strongly and closely but somewhat irregularly punctate, the eyes moderately prominent; antennæ piceous-black, with feeble metallic reflection; prothorax almost twice as wide as long to evidently less, more or less feebly impressed along the median line, strongly and subequally but not very closely punctate throughout, with a small and feeble sublateral impression at basal third; scutellum rather small, subquadrate but variable as usual; elytra slightly more than twice as long as wide, evidently wider than the prothorax, parallel, the sides gradually rounding and converging in apical third, the apices, striæ and punctuation nearly as in *fulgens;* a small ante-median spot sometimes present but frequently wholly obsolete; all the spots, as in *fulgens*, surrounded by a black clouded border; abdomen punctulate nearly as in *fulgens*, the lateral punctures similarly larger and rather dense, only slightly more asperulate. Length 14.2–17.5 mm.; width 5.2–6.4 mm. Pennsylvania, New York and Ontario (Sudbury). [= *sexmaculata* Hbst., and *lherminieri* Chev..... **fasciata** Fabr.

A—Similar but more elongate, bright cupreo-æneous above and below, with feeble greenish reflection at the sides of the elytra, the latter similarly maculate and sculptured; head nearly similarly sculptured; prothorax less transverse, three-fourths wider than long, equally strongly but much more densely punctured throughout, feebly impressed medially toward base; elytra nearly two and one-half times as long as wide the sides more gradually rounding and converging behind and less oblique than in *fasciata*, the apices similar; abdomen similarly punctulate, the first segment more strongly impressed along the middle though indefinitely as in *fasciata*. Length 16.2 mm.; width 5.7 mm. Michigan ..... **fortunata** n. subsp.

34—Elytra each with three large and distinct pale spots, one near basal third and sometimes extending to the base, another behind the middle and the third near the apex, the apices always sinuate and acutely bidentate, the pronotum more or less evidently impressed along the middle.....35

Elytra immaculate or having sporadically a small spot near three-fifths and another still smaller near the apex.....39

35—Anterior pale spot extending obliquely to the base and enveloping the humeral callus. Body elongate, brassy-green; head purplish, punctate, the front carinate; prothorax one-half wider than long, punctured, the sides subparallel, the base bisinuate; elytra purplish, the basal pale spot including a dark spot on the humeral callus, the spot at about one-

third from the apex transverse, not attaining the suture but extending to the margin, the subapical extending nearly to the suture and dilated along the margin, the spots reddish-yellow in color; striæ deep, punctate, the intervals sparsely punctate; antennæ testaceous, the first joint æenescent. Length 15.0 mm. Washington State (Steilacoom). **gibbsi** Lec.

Anterior pale spot wholly discal like the others, never extending to the base; antennæ always black, with more or less æneous or greenish metallic lustre throughout.....36

36—Subapical spot of the elytra very oblique, the anterior spot nearer the side margin than the suture. Body brilliant and pure green, becoming faintly æneous medially beneath, slender; head very densely, subuniformly punctate; eyes prominent; prothorax four-fifths wider than long, the sides parallel and straight to beyond the middle, there rounding and distinctly convergent to the apex, the latter broadly sinuate, feebly arcuate medially; surface bluish centrally, coarsely, closely punctate, confluently so laterally; elytra nearly two and one-half times as long as wide, a fifth wider than the prothorax, parallel, the sides rounding and becoming oblique in apical third, the striæ deep, coarse, finely, confusedly punctate, the intervals not quite twice as wide as the striæ, remotely punctulate, not very convex; anterior spot moderate, rounded, almost twice as far from the suture as from the side, the second transverse, irregular, not attaining either suture or sides, the third not attaining the sides or suture; abdomen with the basal segment not at all impressed, finely punctate, densely so laterally; legs slender. Length 13.5 mm.; width 4.5 mm. California..... **bistrinotata** n. sp.

Subapical pale spot only moderately oblique, the anterior on the median line.....37

37—Prothorax apparently parallel, the sides evenly and distinctly arcuate. Body very slender, slightly convex, colored as in *bistrinotata;* head small, densely punctate, with a small central æneous callus not suggested in the preceding; eyes prominent; prothorax short, very nearly twice as wide as long, strongly but sparsely punctured, more closely in the medial depressed line and more coarsely as well as densely laterally, with a deep rounded sublateral impression behind basal third, the apex but little narrower than the base; scutellum rounded, convex, smooth; elytra fully two and one-half times as long as wide, between five and six times as long as the prothorax and nearly a third wider, nearly as in the preceding but more broadly sinuate at the tips; intervals narrower and more convex, the spots all discal, not attaining suture or sides; abdomen finely, more sparsely punctate, the basal segment very faintly impressed along the middle, the fifth segment truncate and feebly bidenticulate at apex in the male. Length 12.5 mm.; width 4.1 mm. California..... **angusta** n. sp.

Prothorax similarly distinctly narrower than the elytra but with the sides converging from base to apex, broadly arcuate basally, becoming straighter anteriorly or evenly arcuate throughout.....38

38—Sides of the prothorax evenly arcuate from base to apex. Body very elongate, moderately convex, shining, viridescent, with very strong cupreous lustre, the under surface brilliant cupreous-red medially and throughout the abdomen, viridescent laterally and with unusually long ashy pubescence; head very densely and confluently but subuniformly punctate, the eyes large and prominent; prothorax three-fifths wider than long, the apex decidedly narrower than the base, obsoletely bisinuately truncate; surface strongly, closely punctate, densely and more coarsely so laterally, with the impression large, shallow and diffuse, the median line broadly but strongly impressed throughout; elytra between four and five times as long as the prothorax and a fourth wider, parallel, the sides rounding and converging behind in apical third, the apices sinuate and acutely bidentate; sculpture as in *bistrinotata* but with the punctures of the inner of the two confused series of the striæ more distinct; anterior pale luteous spot large, longer than wide and anteriorly pointed, the second large, almost rounded, the third broad, attaining neither suture nor sides; abdomen with the basal segment feebly flattened medially, the punctures fine but strong, dense laterally, the fifth segment broadly, angularly emarginate at tip in the male. Length 16.0 mm.; width 5.2 mm. Oregon (Newport),—H. F. Wickham..... **callida** n. sp.

Sides of the prothorax gradually more arcuate basally. Body less elongate, parallel, subdepressed, shining, green, sometimes with very evident cupreous lustre, cupreous beneath on the abdomen, otherwise green laterally; head densely, confluently punctate, the eyes prominent, pale in examples at hand; prothorax shorter, three-fourths wider than long, the apex much narrower than the base; surface broadly impressed medially, strongly, rather closely punctate, subconfluently so laterally, without evident impression; base with a small truncate and abruptly formed lobe at the scutellum, which is not at all evident in *callida*, the ante-scutellar puncture distinct; scutellum small, rounded, variable; elytra as in *callida* though shorter, but little more than twice as long as wide, the sides more arcuate to the tips, which are sinuate and bispiculose as usual; sculpture and maculation nearly similar, as is also the punctuation of the under surface, the anterior spot much smaller, the post-median more transverse; apex of the fifth ventral transversely truncate in the male. Length 14.5–15.5 mm.; width 5.0–5.6 mm. California..... **fastidiosa** n. sp.

A—General characters relating to form, coloration, maculation and sculpture as in *fastidiosa*, the eyes still more prominent; prothorax notably shorter and more evidently narrower than the elytra, almost twice as wide as long and rather more sinuate at apex, but otherwise similar; elytra even more rounded on the converging sides in apical third, the sinus of the apices very much narrower than in any other form of this group; abdomen much less cupreous and only faintly so medially, broadly green laterally. Length 13.0 mm., width 4.6 mm. California..... **mediocris** n. subsp.

39—Elytral apices more broadly and frequently obliquely sinuato-truncate

at tip, with the outer angle strongly dentiform, the sutural acutely prominent 40

Elytral apices much narrower, feebly sinuato-truncate, with the outer angle obtuse, sometimes almost rounded, the sutural acute though seldom very noticeably prominent 42

40—Prothorax but little narrower than the elytra. Body elongate, slightly convex, shining, green, sometimes with decided cupreolate reflection, except the abdomen and median parts of the under surface anteriorly, which are brightly polished and cupreous; head rather small, densely, subconfluently punctate and somewhat rugulose, the eyes not very prominent; antennæ black with metallic lustre; prothorax two-thirds or more wider than long, the sides strongly converging anteriorly, more rounded basally; surface strongly and unevenly but rather sparsely punctate, confluently so in places laterally, broadly and very feebly impressed along the middle, the ante-scutellar puncture very small or obsolete; elytra rather evidently more than twice as long as wide, parallel, the sides gradually rounding in apical third to the apices, coarsely furrowed, the furrows confusedly crenate; intervals narrow, remotely punctulate, generally wholly immaculate but occasionally having each a small spot near apical third and a minute subapical dot; abdomen very minutely, sparsely punctate, less finely, closely so laterally. Length 16.0–19.2 mm.; width 5.2–6.3 mm. California and Oregon,—abundant ..... **crenata** n. sp. (Mots., i. litt.?)

A—Form and coloration throughout as in *crenata*, the head similar but relatively a little larger; prothorax differing very obviously, being smaller and less convex, shorter and more transverse, the sides less inflated basally, the central portions bluish and the sublateral rounded impressions notably more posterior in position; elytra nearly similar throughout but more distinctly wider than the prothorax; under surface similarly minutely and remotely punctulate, with broadly convex prosternum and transversely truncate fifth ventral. Length 16.5 mm.; width 5.9 mm. California (Yreka) .... **seditiosa** n. subsp.

Prothorax much narrower than the elytra 41

41—Size large, notably depressed, viridi-cupreous, in great part bright cupreous beneath, the external marginal line of the elytra finely cupreous; head small, strongly, coalescently punctato-rugose, the eyes large but not prominent; antennæ black, metallic basally; prothorax two-thirds wider than long, the sides arcuate, converging anteriorly, the apex much narrower than the base, broadly sinuate; disk a little wider just behind the middle than at base, broadly and feebly impressed medially except toward apex, the subbasal foveola very feeble, the sublateral rounded impression behind the middle strong; punctures deep and rather coarse, moderately close, coarser, and crowded laterally; basal angles right; elytra a little more than twice as long as wide, almost a fourth wider than the prothorax, sculptured as in the preceding, not maculate; under surface almost similar, the first segment feebly flattened along the middle; legs slender, the basal joint of the hind tarsi not quite as long as the

next two combined. Length (♀) 19.5 mm.; width 6.8 mm. Washington State (Tacoma)..... **levicceps** n. sp.

Size much smaller, shining, almost pure vivid green above, the under surface, except laterally, and the abdomen æneo-cupreolate; head relatively somewhat larger, strongly, confluently punctate, the eyes moderate, not noticeably prominent; antennæ black, with the metallic lustre greatly diminishing apically; prothorax nearly four-fifths wider than long, almost parallel, the sides but feebly arcuate though more rounding and converging anteriorly, the apex less evidently narrower than the base; surface strongly punctate, densely laterally, with four small rounded impressions, one on each side of the broadly and feebly impressed median line just before the middle, the others in the usual sublateral position but feebler than in the preceding; elytra slightly more than twice as long as wide, the sides more rectilinearly oblique apically, five times as long as the prothorax and almost a third wider, sculptured as in the preceding, immaculate; under surface similar, the fifth ventral in the male rather narrowly truncate at tip, the truncature very faintly bisinuate. Length (♂) 15.3 mm.; width 5.3 mm. California,—Cab. Levette..... **depressa** n. sp.

42—Body beneath coarsely punctured; elytra cupreous at the sides. Form elongate-oval, subdepressed; head moderately densely punctate, brilliant green in color changing to cupreous; prothorax broader than long, narrower in front, the sides very feebly arcuate; surface moderately convex, with rather coarse punctures, which are more densely placed at the sides, brilliant cupreous in color; elytra at base wider than the prothorax, oblong-oval, the apex feebly attenuate, the tips feebly emarginate, with the sutural angle acute and slightly prolonged; surface striate, the intervals equal, moderately convex and sparsely punctate, the coloration diversified, brilliant blue along the suture, shading to green, with the margin cupreous; under surface very densely punctured at the sides of the metasternum and abdomen, brilliant cupreous in color with green reflection; prosternum and first ventral not sulcate. Length 15.0 mm. California (Owen's Valley) and Oregon.....**connexa** Horn

Body beneath finely punctured, more closely and strongly laterally as usual; elytra sometimes suffusedly cupreolate but never with distinct cupreous side margins.....43

43—Species of the Pacific coast regions.....44

Species of the far interior of the continent.....45

44—Prothorax but slightly narrowed anteriorly, the sides almost parallel; upper surface pure brilliant green, the under surface cupreolate as usual. Body depressed, very shining; head very densely and confluently but almost evenly punctate, the eyes not prominent; prothorax fully three-fourths wider than long, the sides nearly straight and parallel, gradually more rounding and converging anteriorly; surface coarsely punctate, confluently so laterally, feebly impressed on the median line, the sublateral rounded impression behind the middle

very deep and conspicuous; elytra between two and three times as long as wide, almost a third wider than the prothorax, straight and parallel at the sides, the latter gradually oblique and becoming straight in apical two-fifths, the sutural angle not prolonged though acute; surface deeply crenato-sulcate as usual, with a small pale spot only slightly behind the middle and another at apical sixth; under surface finely, sparsely punctate, rather closely and strongly so laterally. Length 15.0 mm.; width 5.2 mm. British Columbia (Stickine Riv.),—H. F. Wickham. **viridimicans** n. sp.

Prothorax much narrower at apex than at base, the sides converging and almost evenly arcuate throughout; upper surface golden-green. Body oblong, depressed; head and disk of the prothorax cœrulescent, [the form of the latter assumed as above]; head rugose, the pronotum deeply punctate; elytra densely costate, the interstices [grooves] rugulose; apex truncate, unarmed. Length 17.0 mm.; width 6.0 mm. Alaska (Sitka)..... **langi** Mann.

A—Bright golden-green; head and prothorax thickly punctured, the latter with an impressed longitudinal line; elytra with deeply impressed punctured lines, having a purplish tinge on each side in front, full four times the length of the prothorax, cupreo-bivittate; abdomen with a short gilded band on the fore border of each segment, the tip cupreous. Length 18.0 mm. Vancouver Island.. **ornata** Walker

B—Elongate, parallel, feebly convex, cuprascent above, the pronotum more brilliant cupreous, the sutural and basal regions of the elytra greener; under surface throughout highly burnished, deep and rich coppery-red, with faint greenish tinge near the sides anteriorly; head coarsely, confluently punctate, the eyes prominent, black; antennæ coppery-red basally; prothorax not more than three-fifths wider than long, the sides rather more rounded basally than usual and more incurvate at base; surface broadly and only very faintly impressed along the middle, with the sublateral impressions wholly obsolete, the strong punctures rather sparse, coarser, very deep and dense laterally; elytra about two and one-half times as long as wide, nearly five times as long as the prothorax but only slightly wider, the sides gradually rounding and converging in apical third to the narrowly sinuato-truncate apices, the sutural angle very acute but not much prolonged; surface with very coarse, confusedly cribrato-punctate grooves, which are about as wide as the remotely punctulate intervals, immaculate, suffusedly cupreolate; under surface finely, sparsely punctate, minutely so medially; femora unusually minutely, sparsely punctulate. Length 16.0 mm.; width 5.8 mm. Vancouver Island (Nanaimo),—H. F. Wickham..... **incolumis** n. subsp.

C—Similar to the last but more elongate and rather more depressed, green, the elytra suffusedly cupreolate, the under surface bright coppery-red, more broadly and evidently green toward the sides anteriorly; head very densely but less coarsely punctate, the eyes smaller and less prominent; prothorax nearly similar, except that the median line

is strongly impressed throughout; elytra similar though relatively broader, nearly a fourth wider than the prothorax and each with very small pale points near apical third and seventh or eighth; under surface with the fine punctures a little stronger. Length 17.0 mm.; width 6.0 mm. Oregon ..... **oregona** n. subsp.

D—Still more depressed, polished, green with cupreous lustre, the elytra cupreous, with the broad sutural regions green; under surface as in *oregona;* head and eyes as in that form, the prothorax also similar though a little shorter, with dense sublateral areas of smaller punctures than in *oregona;* scutellum a little larger; elytra shorter though more than twice as long as wide, a little wider behind the middle than at base, a third wider than the prothorax, the sides more rapidly rounding and oblique posteriorly and becoming more rectilinear than in either of the preceding and in nearly apical two-fifths; surface less coarsely sulcate, the grooves more finely though confusedly punctate, the intervals wider, nearly flat, still more finely and remotely punctate than in the two preceding, each with a small pale spot only a little behind the middle and another near apical eighth; under surface somewhat less finely punctate, the femora more evidently. Length 16.0 mm; width 5.8 mm, British Columbia (Golden)..... **obliqua** n. subsp.

45—Sides of the prothorax evenly and unusually strongly rounded, becoming strongly convergent and gradually straighter anteriorly before about the middle. Body above very deep and uniform bluish-green throughout, the under surface green to bluish, with faint æneous reflection laterally on the abdomen only; head not coarsely, very densely and coalescently punctate, with the median line somewhat elevated but not smooth; eyes not prominent; antennæ black; prothorax much shorter than in any other allied species, fully twice as wide as long, the apex much narrower than the base, broadly and almost evenly sinuate, the base sinuate only near each side; surface scarcely visibly impressed medially, the basal fovea distinct, the sublateral rounded and densely sculptured impression rather small; surface strongly punctured, closely but not very confluently so laterally; scutellum small, elongate; elytra long, two and one-half times as long as wide, only very slightly wider than the prothorax, the sides almost rectilinearly oblique in more than apical third, the narrow apices very feebly sinuato-truncate; surface with the deep, densely and confusedly punctate sulci as wide as the intervals, sometimes with purplish-blue clouds and occasionally with small post-median pale spots as usual; under surface medially minutely and sparsely punctate. Length 15.5 mm.; width 5.2 mm. New Mexico. **patruelis** n. sp.

Sides of the prothorax parallel and nearly straight, gradually rounding and moderately convergent anteriorly from near the middle.....46

46—Form elongate, subdepressed, uniform deep green though not very bright above, brighter and with some æneous reflection beneath; head small, very densely, confluently punctate, the eyes prominent,

black in all examples at hand; prothorax short, very nearly twice as wide as long, feebly impressed along the middle, the subbasal fovea well developed, the sublateral impressions feeble (♂), or deep and conspicuous (♀), also sometimes with two additional submedial feeble impressions in the former, which are obsolete in the latter, sex, where however a small oblique impression is visible near the base at lateral fourth; punctures strong, unevenly dense laterally; elytra shorter than in *patruelis* though much more than twice as long as wide, much more distinctly wider than the prothorax, with a tendency to post-medial inflation, the sides behind obliquely and subrectilinearly converging, the apices very feebly sinuate and with broadly rounded or obtuse external angles; surface nearly as in *patruelis*, generally immaculate but occasionally with small post-median spots, especially in the female; under surface similar. Length 13.5–16.0 mm.; width 4.7–6.0 mm. Colorado (Boulder Co.).....**graminea** n. sp.

Form less elongate, similarly depressed, deep and uniform more brilliant green above, cupreous and shining beneath, becoming greenish at the sides anteriorly; legs bright green; head finely, very densely, subuniformly punctato-rugulose; eyes prominent, pale; prothorax as in *graminea* but rather more narrowed anteriorly, the apex deeply and evenly sinuate; surface narrowly, feebly impressed along the median line and with a strong rounded impression toward each side at basal third, strongly punctate, coarsely and very confluently so laterally; disk cœrulescent medially, as also in a broad area along the elytral suture disappearing toward tip; elytra scarcely more than twice as long as wide, about a fourth wider than the prothorax, somewhat abruptly, strongly, subrectilinearly narrowed in nearly apical two-fifths; surface with the sulci not quite so coarse but confusedly and closely punctate, the intervals much wider than the sulci, finely, remotely punctate, each elytron with a transverse sinuous pale spot and a small and very oblique subapical spot nearly as in *fasciata*, the spots surrounded by a black clouded border; punctures of the under surface stronger than in the preceding species but not conspicuous; basal segment of the abdomen very faintly impressed medially as usual in this section. Length 14.7 mm.; width 5.5 mm. Lake Superior (Isle Royale).....**saturata** n. sp.

"Elytra like *aurulenta;* prothorax flattened, side margin thickened, disk with a broad dorsal stripe, and oblique space each side smooth; prothorax and under surface thinly clothed with long soft white hair. California,—Coll. Mniszech."....**villosa** Lec.

Some of the synonymy suggested by Crotch and since perpetuated in catalogues, is of so extraordinary a nature that it is difficult to account for it as a deliberately formulated scientific opinion; perhaps the most completely untenable of these suggestions is that which unites such diverse forms as *langi* and *sexplagiata* with *fasciata*. The species described under the name *connexa*, by G. H. Horn, is only

tentatively placed in the above table, for the remarks appended to the original description are so ambiguous that it is quite impossible to state anything definite concerning its relationships. The author at first places it in a group with *gibbsi* and *confluenta,* which are altogether dissimilar species, and he finally states that it has elytra somewhat as in *adjecta,* which is certainly not to be inferred from the language of the description; *adjecta* having no striæ in the usual acceptation of that term. The *villosa,* of LeConte, is appended in the complete language of the original description. The species is really not described, for while the few remarks concerning the prothorax would seem to signify alliance with *Buprestis* proper, as here limited, the elytra are said to resemble those of *aurulenta.* The name *aurulenta* Linn., has been until recently applied to two very different species, so that it is impossible to determine whether LeConte had in mind *ornata* Fab., or his own *lauta.* The locality "California" appears furthermore to be very doubtful.

The species near *maculipennis* are difficult to separate and my results are not given with entire confidence, the only opinion that can be held with certainty being that a number of distinct species are generally confused in our collections. The original descriptions of Kirby's species are alone utilized for the characters given in the above diagnoses. *Nuttalli,* by the maculation of the coxæ, may be allied more closely to *consularis* than to *alternans,* but the abdominal spots, ranged in a single series at each side, shows that is different from either. The inflation of the basal part of the prothorax in *nuttalli* is assumed, as no mention of such a character is made by Kirby. Of *rusticorum* I have two specimens; the outline is evenly fusiform and the sides of the trapezoidal prothorax are inwardly arcuate basally, which may account for the rather ambiguous language of the original diagnosis; the under surface is strongly and closely punctate and the elytral apices are obtusely subtruncate or apparently almost broadly rounded; the last ventral in these two females is truncate at apex, the sides of the truncature feebly subdenticulate, but this is a variable character. There can be little or no doubt that these specimens represent the true *rusticorum* and it differs considerably from those following it in the table, such as *fusca* and *adducta,* which have generally been assumed to represent the species. *Paganorum* seems to be very closely allied to *rusticorum* and may be merely a subspecies. I have assumed to

represent *consularis* a species not very common in the eastern States; the description of Laporte de Castelnau and Gory is evidently taken from an unusually large female, but the language "elytres très-épineuses à l'extrémité" is not strictly true of any example of the *consularis* group coming under my observation. The drawing also shows that the elytra are more prolonged at tip than in any that I have seen.

Elongata, of the above table, is evidently allied to the Mexican *variegata*, differing in the arrangement of the elytral spots, in its more obscure coloration, and, more especially, in its much more strongly punctured pronotum; it is also allied to *catoxantha* Lap.-Gory, differing essentially in having the elytral vitta proceed from the humeral angles and not from the "milieu de leur base." The names *dilatata* and *crenata* Mots., (*Ancylocheira*), quoted by LeConte (Proc. Ac. Phil., 1873, p. 331), appear to be unpublished; at any rate, I have carefully searched through four large volumes of Motschulsky's almost complete octavo papers without being able to find them, and they do not appear in the Munich Catalogue or in the special catalogue of the Buprestidæ by Kerremans. *Ornata*, of Walker, is wholly unrecognizable but may be a subspecies of the very insufficiently described *langi*, of Mannerheim. There can be no doubt whatever of the reality of many species allied both to *langi* and *gibbsi*, although the pale antennæ of the latter constitute a very exceptional character. *Langi* is probably a local species and the common California form, with broadly sinuato-truncate and acutely bidentate elytral apices, named *crenata* in the table, is undoubtedly different.

The species described by Harris under the names *Buprestis geranii* and *characteristica*, belong respectively to the genera *Acmæodera* and *Chrysobothris*. *Buprestis aurulenta*, of Linné, which has given rise to so much trouble and uncertainty, having been identified with *decora*, *lauta* and *impedita*, of the following subgenera, has seemingly at length found a definite resting place as a European species and may therefore be removed from our lists.

Subgenus **Cypriacis** nov.

The body here becomes, as a rule, rather more oblong, with the prothorax somewhat less trapezoidal than in *Buprestis* proper, and the

pronotum uniformly impressed or sulcate along the middle. The labrum is more chitinous and metallic in its basal parts, but, aside from this, there is very little in the structure of the sclerites or organs of the body to distinguish it as a separate group. The complete absence of true elytral striæ and the substitution therefor of a few longitudinal ribs, separated by wide and uniformly punctured or rugulose intervales, is evidently a result of advanced evolution through Buprestid species of the *langi* type, the latter having evenly and closely sulcate elytra, with the sulci densely and confusedly punctato-rugose; and the impressed median line of the pronotum, incipiently evident in those forms, becomes here still more developed as an external feature. We have only to imagine the coarse sulci of *langi* to be greatly expanded, coincidently with the suppression of the alternate ridges, to evolve the typical forms of this group, traceable indeed in intermediate stages through such species as *adjecta*, *brevis* and *intricata*. But the true striation of typical *Buprestis* has so completely disappeared that the group would seem to require separation as a subgenus, and, if the intermediate forms above mentioned, which are however much more closely related to typical *Cypriacis*, as exemplified in *lauta*, than to any species of true *Buprestis*, were to become extinct, the differences would certainly be of full generic import. The species are generally of vivid green or bluish-green metallic coloration, with abruptly cupreous elytral side margins as a rule, though occasionally dull coppery-brown throughout. Those known thus far may be characterized as follows:—

Elytral costæ convex, their summits polished and impunctate. Pacific regions to Lake Superior.....2

Elytral costæ flat, punctured. Atlantic regions.....13

2—Intervales between the costæ each with a feeble secondary ridge, that between the sutural ridge and the first normal costa strong and subsimilar to the latter.....3

Intervales uniformly concave, densely and uniformly sculptured throughout.5

3—Elytral suture not at all cupreous. Body short, stout and convex, moderately shining, green, the head, lateral and apical parts of the pronotum and side margins of the elytra cupreous; remainder of the elytra, less noticeable sublaterally and basally, with dark purplish-blue reflection; under surface throughout of a bright metallic magenta; head strongly but rather sparsely punctate, more finely, densely so basally; eyes moderate, the antennæ slender, dark piceous; prothorax strongly

trapezoidal, with evenly and moderately arcuate sides, about twice as wide as long, the surface very moderately impressed along the median line, strongly, not densely punctate, coarsely and in part subconfluently so laterally; base gradually prominent medially; elytra three-fourths longer than wide, scarcely wider than the prothorax, the sutural and next two ridges strong, separated by narrow sulci, the intermediate ridges elsewhere low and smooth, the depressed lines rugose; apices narrowly sinuate and bidenticulate; under surface minutely, sparsely punctate, the prosternum flat medially, entering the metasternum for a considerable distance, the first ventral convex; legs slender, the basal joint of the hind tarsi equal in length to the next two. Length 13.8 mm.; width 5.8 mm. Vancouver Island ((Nanaimo),—H. F. Wickham ..... **brevis** n. sp.

Elytral suture cupreous or subæneous, as well as the side margins..... 4

4—Body rather stout, above bright brassy-green, densely punctured, the under surface bright coppery tinged with green, moderately punctate, the prosternum broadly impressed between the coxæ and not hairy; head uniformly punctured; prothorax "almost three times as wide as long"(!), narrowed anteriorly, broadly rounded at the sides, cuprascent, broadly canaliculate; elytra at the sides broadly, at the suture narrowly, cupreous, each with four discal costæ and one, scutellar, united with the sutural, all smooth and shining, also with another costa, almost entire, between the elevated suture and the normal first discal costa; interstitial concave lines densely punctate, the apices subemarginate. Length 15.0 mm.; width 6.3 mm. Washington State (near Fort Vancouver) ..... **adjecta** Lec.

Body oblong-suboval, rather feebly convex, moderately shining, metallic green, the central parts of the pronotum and a broad median part of each elytron nearly from base to apex, deep indigo-blue, the elytral suture narrowly cuprascent, shading into green, the side margin more broadly brassy-green becoming cupreous posteriorly; under surface pale cupreous, with feebler greenish reflection; head very densely punctured throughout, with some small irregular smooth areas, the eyes not prominent; antennæ black, with more or less cupreous reflection; prothorax not quite twice as wide as long, the sides moderately converging and nearly straight to well before the middle, then strongly rounding and convergent to the apex; surface barely at all impressed along the median line, broadly, longitudinally impressed near each side, coarsely punctured, very densely almost throughout laterally; elytra about twice as long as wide, scarcely wider than the prothorax, the sides parallel, rounding and converging in rather less than apical third, the apices broadly rounded, not at all sinuate, the sutural angle right, not prominent; juxta-sutural supplemental ridge much narrower than the first normal costa though almost equally elevated; intermediate ridges low, narrowly smooth, the sublateral ridge very strongly elevated and conspicuous, the concave intervals strongly, transversely rugose; under surface finely, not densely but rather strongly punctate, the prosternum simply flattened medially, punctate anteriorly, more acuminate

posteriorly than in *brevis* but scarcely at all entering the metasternum; first ventral strongly convex medially; legs short, slender, the first joint of the hind tarsi rather longer than the next two. Length 18.5 mm.; width 7.2 mm. New Mexico..... **intricata** n. sp.

5—Third of the true elytral costæ very short 6

Third costa long, extending to between apical third and sixth.....7

6—Form strongly depressed, the pronotum feebly impressed along the middle. Body oblong, gradually attenuate posteriorly, above obscure and dark in color, the head and sides of the upper surface more or less cupreous, the bottoms of the elytral rugosities bluish-metallic; beneath not very shining, densely sculptured and cupreous; head finely, very densely punctured, with long and conspicuous pubescence, the eyes rather prominent; antennæ nigro-metallescent; prothorax four-fifths wider than long, the sides rather strongly convergent and nearly straight, becoming arcuate and more strongly convergent only near the apex; base broadly and feebly arcuate, faintly sinuate laterally; surface convex, with moderate metallic punctures which are coalescent in small groups, dense laterally and also dense but smaller in the faint median depression; scutellum oblong, concave, cupreous; elytra nearly twice as long as wide, slightly wider than the prothorax, the parallel sides becoming gradually broadly rounded behind three-fifths, and thence feebly convergent and nearly straight to the rather narrow apices, which are rounded externally and not at all sinuate, the sutural angles right, not prolonged; surface notably depressed, with the usual convex costæ strong, the third abbreviated a little behind the middle, the sublateral very much elevated and conspicuous, the intermediate surfaces coarsely, confusedly reticulato-rugose; under surface rather finely but densely punctate and conspicuously pubescent throughout, the prosternum broadly concave and densely sculptured and hairy, the first ventral convex medially. Length (♂) 13.4 mm.; width 5.3 mm. Lake Superior (Whitefish Point)..... **lateralis** n. sp.

Form convex, the pronotum deeply canaliculate. Body rather broad, above obscure brassy-green; prothorax coarsely and densely punctate, narrowed anteriorly, the sides at the middle almost angulate, posteriorly sinuate; elytra densely and rugosely punctate, the suture, a scutellar costule, the margins and four discal costæ on each strongly elevated and smooth, the third discal costa greatly abbreviated; apices somewhat prolonged, truncate; under surface brassy-green. Length 15.5 mm. Lake Superior ..... **sulcicollis** Lec.

7—Under surface of the body duller cupreous, obscure or blackish toward the median line. Body large, oblong, moderately convex, the head and pronotum bright cupreous, the latter suffused with greenish on the central parts; elytra deep vivid green, the sutural ridges and the lateral margins, including the fourth costa, bright cupreous; head rather pubescent, coarsely, deeply punctate, the punctures longitudinally confluent and compressed, a small central region depressed and finely, densely punctured and more greenish; eyes not prominent; antennæ

black; prothorax four-fifths wider than long, the sides feebly converging and straight to about the middle, there gradually rounding and more convergent to the apex, the latter but feebly sinuate; surface very coarsely punctured, sparsely so medially and sublaterally, more densely and confluently broadly near lateral fourth and near the sides, the median line distinctly impressed and finely, densely punctate; scutellum small, oblong; elytra not evidently wider than the prothorax, less than twice as long as wide, parallel, obliquely subrectilinear at the sides in fully apical third, the apices broadly rounded, the sutural angles almost obtuse; sculpture as in *lauta* though somewhat coarser; under surface sparsely pubescent, finely, not closely punctate, the prosternum broadly concave, strongly, sparsely punctate, not more pubescent, the concavity anterior becoming obsolescent posteriorly; apices of the ventral segments cupreous-red throughout the width. Length 20.8 mm.; width 8.0 mm. Mexico (Chihuahua),—C. H. T. Townsend. . ***fabulosa** n. sp.

Under surface bright cupreous throughout.....8

Under surface pale green, sometimes with faintly ænescent reflection toward the median line, or bright bronze throughout.....10

8—Sides of the elytra posteriorly evenly rounding and converging to the apices. Body elongate-suboval, the elytra frequently feebly inflated subposteriorly, moderately convex, bright pale green to golden-green, sometimes darker greenish-blue, the anterior parts with more or less cupreous lustre, the elytral suture and side-margins bright-cupreous; head densely, confluently punctate, with a more depressed and more finely and densely punctured central spot which is longitudinally divided by a raised median line, subglabrous (♀), or very much more finely and densely punctate throughout and conspicuously pubescent (♂); eyes larger and more prominent in the latter; prothorax nearly twice as wide as long, the sides nearly parallel as a rule to about the middle, there rounding and more converging to the apex, sometimes converging throughout; surface well impressed along the middle, moderately and not closely or confluently punctate medially, irregularly, densely so laterally; elytra three-fourths longer than wide, evidently wider than the prothorax, the apices broadly rounded, the sutural angle frequently minutely dentate; surface with the four discal ribs well developed, the intervales evenly and densely cribrate; under surface rather finely but strongly, not closely punctate, sparsely and feebly pubescent (♀), or conspicuously so (♂), the abdomen more closely punctured in the latter; prosternum more or less narrowly and distinctly impressed and punctured along the median line. Length 14.0–18.0 mm.; width 5.6–7.3 mm. Oregon to British Columbia and Vancouver Island. [=*Ancylocheira lauta* Lec.]..... **lauta** Lec.

A—Similar to *lauta* in coloration and sculpture but smaller and narrower in form, the prothorax but little narrower than the elytra, the sides almost evenly converging and arcuate from base to apex; elytra and under surface as in *lauta*, except that the apices in the former are narrowly truncate; head in the male similarly densely punctured

and hairy. Length 14.0–15.2 mm.; width 5.6–6.0 mm. Oregon. [Fort Vancouver,—LeConte] ..... **radians** Lec.

Sides of the elytra oblique posteriorly, becoming straight or feebly sinuate before the tips 9

9—Body rather stout, moderately convex, colored throughout as in *lauta;* head (♀) as in that species, except that the central more densely sculptured divided spot is not so clearly marked; prothorax four-fifths wider than long, the sides scarcely converging and nearly straight to well beyond the middle, there rounding and rapidly converging to the apex, sensibly incurvate at base; apex subtruncate, broadly bisinuate, the base also evenly bisinuate; surface with scarcely a vestige of impression along the middle but with a small impression before the scutellum, the punctures coarser than in *lauta* and coalescent in short sinuous lines medially, coarser and densely coalescent laterally; scutellum broader, quadrate; elytra shorter, rapidly oblique at the sides in apical two-fifths, the oblique sides straight, the apices broadly rounded, becoming transverse suturally, the sutural angle right and rather blunt; surface as in *lauta*, the costæ well elevated but with the intervales more unevenly though similarly densely cribrate; under surface finely, remotely punctate medially, rather strongly and closely so laterally, the prosternum flat and smooth, with an obsoletely subimpressed punctate median line. Length 15.3 mm.; width 6.0 mm. Colorado (Boulder Co.). **æmula** n. sp.

Body much narrower, smaller than *lauta* but with similar coloration and sculpture, except that the green on the elytra is replaced by deep greenish-blue; head (♂) similarly finely, very densely punctate and pubescent, the eyes larger and more prominent than in the female; prothorax as in *lauta* but with the sides becoming less parallel behind the middle though straight, not at all incurvate at base as they are in *æmula;* punctures for the most part isolated or simply crowded as in *lauta;* elytra but little wider than the prothorax, as in *lauta* but about twice as long as wide, the sides becoming oblique in apical third and feebly subsinuate just before the apices, which are broadly subtruncate, the external angles right but rounded, the truncature anteriorly oblique suturally, feebly undulated and with the sutural angle rather strongly spiculate; sculpture as in *lauta*, except that the intervales are still more densely cribrate, almost opaque; under surface as in *lauta* but more strongly and closely punctured than in the male of that species. Length (♂) 14.2 mm.; width 5.2 mm. Washington State (Tacoma).

tacomæ n. sp.

Body rather stouter, coloration nearly as in *lauta* throughout, excepting a broad bluish-green streak on each elytron; head nearly as in *æmula;* prothorax three-fourths wider than long, the sides converging and straight from the base nearly to apical third, there rounding and more convergent to the apex; surface narrowly impressed and finely, densely punctate on the median line anteriorly; punctures isolated, rather sparse, moderate in size, coarse and unevenly confluent laterally; elytra evidently wider than the prothorax, the converging sides posteriorly

becoming feebly sinuate before the tips, which are as in *tacomæ*, but with the outer angle more broadly rounded and more even and transverse suturally; costæ much more feeble than in any of the preceding forms, becoming very low at a little before the centre of each elytron, where the punctures extend almost across them, the intervales densely, subevenly cribrate as in *lauta;* under surface punctured nearly as in *lauta* but more coarsely and densely so toward the sides, the prosternum rather narrowly and deeply impressed along the median line. Length (♀) 16.5 mm.; width 6.2 mm. Idaho (Cœur d'Alene)..**nupta** n. sp.

10—Pronotum with coarse punctures coalescent in short isolated irregular series on the median parts, densely but irregularly confluent laterally; general coloration of the upper surface as in *lauta*.....11

Pronotum with much smaller but deep perforate punctures, not evidently confluent in short series medially, very dense laterally; coloration of the upper surface dull cupreous, the elytra medially broadly cupreo-viridescent.....12

11—Body oblong, moderately convex, rather stout, the anterior parts more or less cupreous; elytra with bright cupreous inner and outer margins, the remainder bluish-green, the ribs frequently deep indigo; head with longitudinal rugulation caused by the compressed coalescent punctures, with a central green divided spot of dense punctures; eyes not at all prominent (♀), pale in all examples at hand; prothorax two-thirds wider than long, the sides broadly arcuate, becoming parallel basally, more convergent anteriorly, sometimes slightly sinuate just behind the apex, the latter truncate, broadly and evenly bisinuate; surface broadly and distinctly impressed along the middle; elytra evidently inflated behind the middle and nearly one-half wider than the prothorax to evidently less, scarcely three-fourths longer than wide, the oblique sides posteriorly becoming almost straight, the apices broadly rounded, transverse toward the suture, where the angle is sometimes distinctly spiculose; surface sculptured nearly as in *lauta;* under surface more strongly punctured, usually coarsely and very densely toward the sides; prosternum deeply impressed and densely punctate along the median line; females abundant; males rare as usual in this group. Length (♀) 16.5–17.5 mm.; width 6.5–7.0 mm. California....**venusta** n. sp.

Body larger and much more elongate, rather more convex, deep green, the anterior parts with but little cupreous lustre, the inner and outer margins of the elytra cupreous; head as in the preceding but with the median line more strongly elevated centrally; eyes not at all prominent, rather small; antennæ black, metallic basally; prothorax two-thirds wider than long, the sides parallel and subsinuate in nearly basal half, thence moderately convergent and almost straight to the apex, which is truncate, with the sinuations obsolescent; surface broadly, moderately impressed and scarcely more finely though more thickly punctured along the middle, rather pubescent at the sides; elytra almost twice as long as wide, evidently wider than the prothorax, the converging sides posteriorly not becoming quite straight, the apices very broadly rounded,

becoming somewhat oblique and straight toward the minutely denticulate sutural angles; surface with the costæ rather more acutely elevated than usual, the concave intervales much more coarsely, confusedly and densely cribrate than in *lauta;* under surface plentifully pubescent, the prosternum narrowly and deeply sulcate, the abdomen not closely but rather strongly punctate, more strongly but not densely so laterally, the general color pale green, ænescent along the median line. Length 19.5 mm.; width 7.3 mm. New Mexico..... **prospera** n. sp.

12—Form elongate, subparallel, rather convex; under surface bright bronze, broadly greenish laterally except on the abdomen; head closely, perforately punctate, the punctures compressed and partially confluent longitudinally, the central densely punctate spot ill-defined, divided by an elevated line; eyes moderate, pale, only slightly prominent; prothorax only three-fifths wider than long, the sides converging and broadly, subevenly arcuate from base to apex; surface scarcely at all impressed along the middle but noticeably so at the base, the punctures much coarser laterally than medially, though not very confluent; scutellum subquadrate, rather well developed; elytra four-fifths longer than wide, a third wider than the prothorax, not at all inflated behind the middle but rather widest across the humeral swellings, the sides very gradually rounding in apical two-fifths, becoming not quite straight at the apices, which are clearly truncate though with the outer angle obtuse, the sutural angles denticulate; costæ rather low and broadly convex, the intervales with the dense and crowded punctures regular but unusually deep; prosternum impressed and strongly punctate medially; abdomen finely, remotely punctate, becoming coarsely, shallowly and very densely so laterally. Length (♀) 18.0 mm.; width 6.5 mm. Oregon..... **affinis** n. sp.

Form nearly similar, the coloration similar, except that the under surface is less bronzed and the median parts of the elytra more bluish-green; head more finely and densely punctate, the punctures compressed, the median line fine, elevated; eyes nearly similar; prothorax shorter, two-thirds wider than long, similar in form, the apex bisinuously truncate; surface distinctly impressed anteriorly and more finely, densely punctate along the middle but scarcely impressed posteriorly, the punctures generally close-set, extremely dense laterally, with a less punctate longitudinal area basally near lateral fifth or sixth; scutellum much smaller, oblong; elytra a little shorter, the sides more rapidly and arcuately converging behind, becoming subsinuate before the angles, which are rounded, the apices thence transverse to the denticulate sutural angles; surface sculpture nearly as in the preceding but with more elevated costæ, the cribration rather less coarse; under surface more strongly, less sparsely punctate, the punctures coarse and densely crowded laterally; prosternum finely, deeply grooved along the middle, elsewhere medially impunctate as usual. Length (♀) 16.5 mm.; width 6.0 mm. California (Yreka)..... **adulans** n. sp.

13—Body rather stout and shorter, of less sombre coloration, the median parts of the elytra always more or less greenish or bluish. Obscure

cupreous, the anterior parts with greenish patches, the elytra with the broad sutural and marginal cupreous stripes suffusedly and gradually disappearing internally, sometimes obliterating the medial blue or green area by the resulting greenish-æneous tint; under surface cupreous; head with densely compressed and longitudinally confluent punctures, rather coarse (♀) or fine (♂), with a divided and more densely sculptured central spot, the surface feebly pubescent (♀), or densely and conspicuously so (♂); prothorax two-thirds to four-fifths wider than long, trapezoidal, the sides but slightly arcuate; surface only feebly impressed along the median line, strongly, sparsely punctured medially and in a sublateral tumescent area toward base, elsewhere densely punctate; elytra but little wider than the prothorax, sometimes decidedly inflated behind the middle, two-thirds or more longer than wide, the sides oblique posteriorly, the apices broadly rounded, becoming transverse toward the feebly denticulate sutural angles; surface with the low flat costæ distinctly and rather closely but irregularly punctate, the intervales very densely and evenly cribrate; under surface pubescent and rather closely punctured (♂), or subglabrous and more sparsely and finely punctate (♀), the prosternum impressed and punctured medially. Length 14.3–17.0 mm.; width 5.3–7.0 mm. New York, Ontario, Michigan and Lake Superior (Bayfield and Whitefish Point) ..... **impedita** Say

Body much more elongate and more parallel as a rule, always dark coppery-brown, the median line of the elytra seldom with any decided greenish tinge 14

14—Elytra gradually narrowed from but slightly behind the middle to the apices, which are transversely truncate. Body elongate-suboval, moderately convex, rather shining, dark brown with feeble cupreous-red lustre, more pronounced on the elytral costæ, the under surface bright cupreous; head (♀) as in the preceding, the eyes only moderate in size and but slightly convex; prothorax two-thirds wider than long, strongly trapezoidal, the sides broadly arcuate, becoming subsinuate broadly toward base, the basal angles somewhat acute from above; surface only very obsoletely impressed though more densely punctate along the middle; punctures coarse and deep, disposed as in the preceding; elytra fully four-fifths longer than wide, behind the middle two-fifths wider than the prothorax, the external angles at apex obtuse but not rounded, the sutural scarcely denticulate; surface with low flat punctured costæ, the intervales more coarsely and confusedly cribrate than in the preceding, the second and third decidedly greenish in tinge; under surface evidently though sparsely pubescent, finely, sparsely punctate, more strongly but not densely so toward the sides of the abdomen, the prosternum impressed and closely punctured along the middle. Length (♀) 17.2 mm.; width 6.4 mm. Ontario (Georgian Bay). **canadensis** n. sp.

Elytra more abruptly narrowed behind in barely apical third, the sides scarcely becoming straight near the apices; intervales of the elytra never greenish 15

15—Elytral apices rounded. Body oblong, rather more convex, sometimes feebly inflated behind the middle, slightly shining, dark coppery-brown, duller laterally than medially; head as usual in the preceding species, with dense compressed punctures and fine central carina; prothorax three-fourths or more wider than long, the sides straighter and more parallel in basal, more converging in apical, half, sculptured as in the preceding but more closely throughout, the apex similarly feebly bisinuously truncate; scutellum elongate, subquadrate, impressed, cupreous; elytra three-fourths or more longer than wide, from very evidently to at least two-fifths wider than the prothorax, the apex transverse at the suture, broadly rounded externally, the sutural angles right; surface with the low flat costæ punctured, closely and coarsely so externally, the intervales very densely, not very coarsely cribrate; under surface bright cupreous, the sculpture nearly as in *canadensis*. Length 13.0–18.0 mm.; width 4.8–6.8 mm. Pennsylvania to Ontario . . **obscura** n. sp.

Elytral apices narrower, truncate to sinuato-truncate and more or less evidently bidenticulate. Body more elongate and parallel, relatively narrower and somewhat less convex, dark coppery-brown to blackish; head a little larger than in *obscura*, with dense compressed punctures which are rather coarse and subglabrous (♀), or finer and moderately pubescent (♂), with a median densely punctate depressed area divided by the central carina and generally green in color; eyes only moderate in size but prominent, generally black; prothorax almost twice as wide as long, the sides as a rule strongly converging in apical, nearly parallel and straighter in basal, half, the surface scarcely at all or very feebly impressed along the middle, the sculpture as in *canadensis* but closer throughout, the lustre generally more cupreous laterally; scutellum broader, cupreous, concave; elytra four-fifths longer than wide, but slightly wider than the prothorax, seldom at all inflated behind the middle, the sculpture nearly as in *obscura* though rather coarser; under surface not cupreous but bronzed, the abdomen rather closely punctate throughout and somewhat more strongly so than in *obscura*. Length 13.5–18.8 mm.; width 4.7–6.7 mm. North Carolina, Alabama and Louisiana. . . . . **striata** Fabr.

Several of the above species are represented by series sufficiently full to show clearly the extent of specific variation. This is perhaps most evident in the form of the prothorax, which may be subprominently rounded at the sides to evenly trapezoidal with feebly and evenly arcuate sides, within specific limits, also in the degree of inflation of the elytra, which are often notably wider behind the middle than at the humeri. The form of the elytral apices, on the other hand, seems to be one of the more constant characters, and, on the whole, the most useful in characterizing certain species which resemble each other superficially. The species described by Say under the

name *impedita* was wrongfully united with *striata* by LeConte; it is an abundantly valid species.

Subgenus **Stereosa** nov.

This section of *Buprestis* is very limited in extent. The general habitus of the species, involving among other features the somewhat greater convexity of the body, is quite different from that prevailing in either of the preceding subgenera, and it is this that prompts me to give them a distinctive subgeneric name. The general anatomical characters are as in *Cypriacis*, but the elytra have no vestige of regular discal costæ and but feeble traces of impressed striæ, in the usual sense, but instead there are series of large perforate punctures, the general surface being closely, deeply and confusedly but evenly cribrate with smaller punctures. The prothorax is trapezoidal and seldom has any trace of the impressed median line so developed in *Cypriacis* and in some of the less typical forms of true *Buprestis*, but the ante-scutellar impression or deep puncture is generally evident. The basal joint of the hind tarsi is similarly variable in elongation. The four species known thus far may be described as follows:—

Elytra narrowly but abruptly sinuato-truncate and feebly bidenticulate at apex. Body narrowly elongate-oval, convex, moderately shining, greenish-subcupreous, the elytra generally bright green, with the suture and external margins cupreous, frequently with a broad and ill-defined median vitta on each of a dense indigo blue and again at times suffused with cupreous almost throughout; under surface vivid green to bright cupreous; head very densely compresso-punctate, the central dense spot not very constant; eyes rather small and not very prominent; antennæ of the usual form, black; prothorax two-thirds or more wider than long, the sides converging from base to apex and nearly straight; apex truncate, very obsoletely bisinuate, the base broadly but more evidently; surface strongly but not closely punctate, the punctures smaller and denser in patches sublaterally, a median impunctate line sometimes evident but never entire; elytra slightly wider than the prothorax, almost twice as long as wide, the sides rounding and converging in about apical third; surface subevenly convex, the small punctures not densely crowded, rather sparse suturally, the larger perforations of the series moderate but variable in size and well separated; under surface finely, closely punctured, sparsely along the middle, the punctures toward the sides of the abdomen not at all crowded; prosternum flattened, finely, densely punctate and sometimes feebly impressed; head and under surface but slightly more hairy in the male. Length

(♂) 11.3–14.6, (♀) 15.2–16.7 mm.; width (♂) 3.9–5.0, (♀) 5.2–6.0 mm. North Carolina to Arkansas and Louisiana. [=*salisburyensis* Weber] ..... **decora** Fabr.

Elytra rounded at tip, the sutural angles acute and more or less prominent. 2

2—Coloration nearly as in the preceding, bright and metallic, with the elytral suture and side margins cupreous. Form shorter and relatively stouter than in *decora*, generally paler and more uniform brassy-green, the elytra sometimes broadly suffused with darker, though usually greenish-blue; under surface bright cupreous; head smaller; similarly sculptured though more coarsely in the female, where there are some irregular smooth spots; prothorax similar but more rounded at the sides and more longitudinally convex, sometimes with vestiges of an impressed and more punctate median line, the punctures still coarser, not dense and more evenly disposed; elytra only two-thirds or more longer than wide, slightly wider than the prothorax, almost similarly formed, the serial perforations coarser, the punctures similar though relatively smaller and more apt to be distributed in a single line on some of the intervals, owing to the coarser serial punctures; under surface as in *decora*, the relative hairiness of these parts and of the head of the male and female similar. Length 12.0–13.6 mm.; width 4.5–5.5 mm. New Jersey and New York ..... **ultramarina** Say

Coloration nearly uniform and more sombre, the elytra without cupreous suture or margins 3

3—Form oblong-oval, moderately convex, dull or feebly shining, obscure cupreous-brown, the anterior parts brighter but with the more elevated portions black (♀), or with the elytra obscure green (♂); under surface bright cupreous throughout, with greenish reflections; head very densely compresso-punctate, more coarsely so and less hairy in the female, the median line carinate centrally; eyes moderate, not very prominent; prothorax trapezoidal with feebly arcuate sides, three-fifths wider than long, with a rather pronounced groove along the apical margin laterally; punctures strong, sparse medially, where there is a nearly entire impunctate line in the female but not in the single male at hand, dense and confluent near the sides; scutellum oblong, depressed on the disk, with a median elevation; elytra three-fourths or more longer than wide, evidently wider than the prothorax, the oblique sides in apical third almost straight (♂), to decidedly arcuate throughout (♀), the surface even, except a sublateral ridge which is obsolete basally and feeble (♂), or very pronounced (♀), the serial perforations rather coarse, more or less elongate, the cribration dense, becoming very crowded laterally; under surface finely punctate, sparsely so (♀), or more densely and more pubescent (♂). Length 16.0–18.0 mm.; width 5.8–7.0 mm. Alabama (Grand Bay) ..... **cribripennis** n. sp.

Form more elongate and rather more convex, dark and uniform bronze-brown above, more cuprascent anteriorly, bright cupreous throughout beneath; head more densely and uniformly compresso-punctate, the eyes decidedly smaller and less convex, not at all prominent; prothorax

similar in form but rather more closely punctate, the punctures similarly uneven in distribution; scutellum nearly similar, cupreous; elytra nearly twice as long as wide, rather coarsely but not quite so densely cribrate, more notably sparsely so toward the suture, the punctures of the series coarse, deep and perforate; sublateral ridge less prominent; under surface somewhat more strongly and less sparsely punctate, more strongly but not very closely so laterally; male and female apparently with but slight structural differences. Length 18.0–22.0 mm.; width 7.0–7.8 mm. North Carolina; also one specimen labeled "Cal." but no doubt erroneously. [=*bosci* Lap.-Gory]..... **apricans** Hbst.

The sublateral ridge of the elytra varies in prominence in this section very much as in *Cypriacis,* where it is very strong and imparts a very characteristic facies in such species as *lateralis* and *intricata* and feeble in *fabulosa* and *brevis*; here it is almost obsolete in *decora* but pronounced in *apricans* and especially in the female of *cribripennis.* This ridge is seldom very prominent in *Buprestis* proper, though generally traceable. All the species of this section are locally distributed in pine regions and therefore generally rare, though abundant enough within their proper environments. *Ultramarina* seldom seems to have a coloration wholly warranting its name, the bright surface generally being of a more golden-green color than in *decora;* it seems to be decidedly rare.

Dicerca Esch.

This genus, though so different in general habitus, is related closely to *Buprestis* in most of its general organization, excepting in antennal structure and the very much shorter basal joint of the hind tarsi; it differs otherwise principally in its rough and irregular surface sculpture, prolongation of the elytral apices, which however becomes obsolete or nearly so in some species and occurs sporadically in other parts of the family, as for instance in *Psiloptera* and in *Buprestis consularis,* and, finally, in the male and female characters at the apex of the abdomen, which, though of a markedly different kind, are similarly inconstant within specific limits and therefore unreliable as a specific criterion. The broadly and feebly sinuato-truncate and sublobate anterior margin of the prosternum is a rather more striking feature than in *Buprestis,* but the prosternal process, the mesosternum and the metasternum are virtually similar and the meso-metasternal suture is very fine, the two surfaces being similarly anchylosed and not

departing noticeably in structure from the corresponding parts in *Psiloptera* and *Gyascutus*, as we are led to suppose from the group divisions made by LeConte in his monograph of the American species of the family.

The male does not differ much from the female in superficial characters, but the sterna are apt to be more impressed and punctate and more hairy in the former, where the apex of the fifth ventral is transversely, rectangularly emarginate as a rule, with the median part of the notch briefly and broadly produced in a truncate lobe. In the female the apex is more acuminate and is narrowly and deeply emarginate, generally with a slender tooth projecting from the bottom of the sinus, sometimes as far posteriorly as the lateral lobes; this tooth may, however, be well developed to wholly obsolete within specific limits and the sinus itself may be broader or narrower. In the male the intermediate tibiæ generally have on the inner side an obtuse tooth, which occasionally becomes a slender erect process as in *horni*. The coloration of the body is brassy or bronzed to dull cupreous as a rule, but is sometimes deep black throughout and without metallic lustre of any kind.

The species are very numerous in subarctic North America and are assignable to a considerable number of distinct groups, for the most part recognized and clearly characterized by LeConte; these groups may be briefly indicated as follows:—

Prosternum flattened, concave or sulcate.....2

Prosternum convex.....10

2—Prothorax not constricted basally or arcuately inflated before the middle.....3

Prothorax shorter and more transverse as a rule, sinuously narrowed basally behind the more or less marked anterior inflation, the pronotum generally more uneven in sculpture.....7

3—Intermediate tibiæ not dentate in the male though sometimes obtusely swollen or subangulate within.....4

Intermediate tibiæ of the male with a strong obtuse internal tooth..... 5

Intermediate tibiæ of the male with a slender erect serrulate process internally 6

4—Elytra obliquely and gradually narrowed posteriorly, the sides usually becoming feebly sinuate before the apices, which, however, are not prolonged; they are deeply sinuate and acutely bidenticulate; pronotum never obviously canaliculate.....Group I

Elytra with the tips similarly sinuate and bidenticulate but prolonged; pronotum deeply canaliculate.....Group II

5—Elytra as in Group II but with the greatly prolonged apices entire. Group III

6—Elytra more strongly, arcuately narrowed behind, the apices rather abruptly but only very briefly prolonged and broadly obtuse. Group IV

7—Prosternum and last ventral segment not bicostate; elytral apices moderately prolonged.....8

Prosternum with two smooth and strongly elevated costæ, the fifth ventral bicostulate..... 9

8—Elytral apices entire.....Group V

Elytral apices sinuate and acutely bidenticulate; front with a callous band between the eyes..... Group VI

9—Elytral apices markedly prolonged, rounded; metasternum strongly sulcate.....Group VII

10—Body in form and sculpture somewhat as in the *obscura* group; elytra obliquely attenuate, not prolonged, the tips obtuse; intermediate tibiæ not dentate.....Group VIII

Although these groups differ among themselves to a very noticeable extent in general appearance and sculpture, I am not prepared at present to assign any very great taxonomic weight to their differential characters. The convex prosternum of *mutica* Lec., constituting group VIII of the table, seems at first very important, but in comparing *Buprestis confluenta* and *læviventris*, corresponding differences are observable in even more marked degree. It will be noted that I have been compelled to make some changes in the grouping proposed by LeConte.

Group I—Type *obscura* Fabr.

The species of this group are numerous and require unusual care in discrimination. The hurried and superficial manner in which they have been hitherto surveyed may be sufficiently inferred from the statement made by Crotch (Pr. Acad. Phil., 1873, p. 85) regarding his inability to distinguish *lurida* from *obscura*, two species altogether different, not only in general appearance, form of the prothorax and relative prominence of the eyes, but by the very much more marked internal swelling of the middle tibiæ in the male of the former; they are in fact representative species of the two principal sections into which this group may be divided, as shown by the following table:—

Eyes prominent; intermediate tibiæ of the male not or only very feebly swollen internally.....2

Eyes not at all prominent, the intermediate male tibiæ more or less distinctly swollen or angulate internally; prothorax sinuate at apex throughout...9

2—Prothorax evenly narrowed from base to apex, the latter sinuate as usual. 3

Prothorax parallel, the sides rounding and converging anteriorly to the apex 4

3—Surface feebly convex, very roughly sculptured; body broad, oblong-oval, rather shining, dull cupreous, with the elevations black; under surface blackish and obscure cupreous; head roughly sculptured, with uneven callosities, which tend to form a transverse band between the eyes, the latter only moderately prominent (♀), or strongly so (♂); prothorax one-half to three-fourths wider than long, the sides feebly arcuate, sometimes feebly subprominent before the middle; surface finely, sparsely punctate, with a more strongly impressed medial subapical area, coarsely and confluently punctate laterally, with sublateral line of broken callous spots and an impression near lateral fifth behind the middle; ante-scutellar cavity distinct, single; scutellum small; elytra scarcely wider than the base of the prothorax, three-fourths or more longer than wide, the oblique sides posteriorly becoming evidently sinuate before the tips, which are more broadly sinuate than in any other species of the group, strongly bispiculose; surface densely punctate, sparsely and finely near the suture, generally with evident rows of coarser punctures, the alternate intervals with elongated and conspicuous irregular raised polished black areas; under surface coarsely, rugosely punctate, the pectoral channel much broader, more evenly concave and densely sculptured and hairy in the male than in the female as usual. Length 13.5–18.3 mm.; width 4.7–6.6 mm. Virginia (Norfolk) and North Carolina (Southern Pines) to Florida.[= *Buprestis obscura* Fabr., *baltimorensis* Hbst., and *consimilis* and *pruinosa* Gory].
obscura Fabr.

Surface evidently more convex and smoother, form more elongate, still darker in coloration, with more æneous than cupreous lustre; head coarsely, very densely but more evenly punctato-rugose, without very marked callous spots, the pubescence longer and much more conspicuous; eyes more widely separated; prothorax nearly similar in form but rather less transverse, the sides evenly and feebly arcuate throughout; surface much more even and more evenly punctate, rather closely so, with similar anterior punctured area and basal pit medially, the punctures relatively less coarse and more evenly dense and confluent laterally, not impressed sublaterally behind the middle; scutellum larger; elytra similar though rather more elongate, the sculpture of the same general nature but less coarse and more even, the callous spots smaller, less elevated and much less conspicuous; sides posteriorly becoming straight and not sinuate toward the tips, which are much more narrowly and normally sinuate and bidenticulate; under surface nearly similar. Length (♀) 18.8 mm.; width 6.3 mm. Texas.
indurata n. sp.

4—Apex of the prothorax subtruncate, broadly sinuate laterally, the median part arcuate, with a small median sinuation. Body very much smaller, oblong, feebly inflated behind the middle, rather convex, moderately shining, dull æneous above, more cuprascent beneath; head densely, moderately coarsely punctato-rugose, with a transverse callous spot centrally, the pubescence short, not conspicuous; antennæ cupreous, sparsely hairy; prothorax three-fifths wider than long, the parallel sides nearly straight to within an unusually short distance of the apex, there rather abruptly rounded and convergent to the apex; surface confluently and coarsely punctate laterally, less coarsely, rather sparsely medially, where the median line is feebly impressed before the middle and rather more punctured, the ante-scutellar pit bipunctate; near lateral fourth before the middle and at base there is a small irregular callous area and behind the middle a large vague suboblique impressed region; scutellum very small; elytra with the basal margin slightly wider than the prothorax, not quite twice as long as wide, the gradually rounding oblique sides in apical two-fifths becoming barely perceptibly sinuate near the emarginate tips, which are strongly bispiculose; surface densely and unevenly punctate, less densely so suturally, the impressed striæ distinct suturally but only finely punctate, the raised elongate spots, separating the usual subdepressed areas of denser and finer punctuation, moderately developed; under surface rugosely punctate, the median tooth of the apical sinus (♀) unusually broad and parabolic in form, the two notches very small. Length (♀) 14.0 mm.; width 5.0 mm. Wisconsin..... **truncata** n. sp.

Apex of the prothorax broadly, subevenly sinuate as usual.....5

5—Sides of the elytra posteriorly very gradually rounding and oblique, becoming straight or barely perceptibly and very broadly sinuate before the emarginate apices; body small in size..... 6

Sides of the elytra more rapidly converging posteriorly, becoming very obviously sinuate before the apices; body larger and stouter.....8

6—Elytra unusually elongate, more than twice as long as wide, with the punctures everywhere distinct, close but not confluent laterally. Body slender, convex, shining, feebly cupreous above and beneath, the elevations blackish; head coarsely, densely punctato-rugose, with a transverse central callus, the pubescence evident; prothorax one-half wider than long, the sides straight and parallel to apical third, there rounding and convergent to the apex; surface somewhat tumid medially, feebly, obliquely impressed near the base at about lateral fourth, with coarse crowded punctures and some small and very irregular callous spots laterally, the median parts sparsely but strongly punctured, the ante-scutellar pit not evident; elytra at base very slightly wider than the prothorax; surface unevenly and feebly striate, not so roughly sculptured as usual, the elongated callous spots only slightly elevated, the areas of dense punctures well defined and conspicuous; under surface coarsely punctato-rugose, the pectus (♀) narrowly and deeply, the first ventral unusually distinctly but broadly, sulcate, the fifth ventral with a

short blunt median tooth at apex. Length (♀) 15.7 mm.; width 4.9 mm. New Hampshire (Hampton)..... **gracilis** n. sp.

Elytra less elongate, twice as long as wide or less, with the coarse punctures laterally very uneven and confluent as usual.....7

7—Body oblong, moderately stout and convex, sometimes feebly inflated behind the middle, moderately shining, obscure æneous, somewhat cupreous beneath; head nearly as in *gracilis*, the prothorax similar but shorter and more transverse, with the parallel sides in basal two-thirds generally, straight but sometimes faintly sinuous; surface not evidently tumescent medially and with the ante-scutellar pit evident, sometimes bipunctate; elytra narrowing behind in about apical third, roughly sculptured, with the patches of dense punctures large and very obvious, the elongate callous spots strong; under surface (♀) nearly similar, with the impression of the first ventral rather distinct, the median tooth of the apical sinus longer and acute or finely aciculate; male with the sternal channels broader, concave, densely sculptured and more hairy. Length 13.8–16.0 mm.; width 4.8–5.7 mm. Kansas to Pennsylvania..... **porcatula** n. sp.

Body narrower anteriorly, the elytra rather strongly inflated, convex, nearly similar in coloration, lustre and sculpture, except that the densely punctate patches of the elytra are less impressed, more confused and less definite; head nearly similar though much smaller; prothorax three-fifths wider than long, slightly inflated before the middle, with broadly rounded sides, the latter evidently sinuate in nearly basal half, the basal angles less than right; elytra behind the middle fully a fourth wider than the prothorax, twice as long as wide, the sides broadly arcuate, gradually converging behind in fully apical two-fifths, the apices narrower than in *porcatula* and more semicircularly sinuate; female with distinct sternal and abdominal axial impressions, the fifth ventral with a small shallow apical sinus, the median tooth and lateral lobes very short, the former obtuse. Length (♀) 14.0 mm.; width 4.7 mm. Florida (Marion Co.)..... **innocua** n. sp.

8—Form oblong-oval, convex, shining, obscure æneous, brighter cupreo-æneous beneath; head coarsely, densely punctato-rugose, with a small transverse central callous spot, the hairs very small and inconspicuous; eyes unusually large and prominent; antennæ but little longer than the head, cupreous; prothorax large, but little more than one-half wider than long, the sides broadly rounding and converging anteriorly, becoming parallel from before the middle and also evidently sinuate basally; surface rather closely, moderately punctate along the middle, especially in the anterior feebly impressed area, the punctures gradually coarser and close laterally, becoming coarse and crowded near the sides, with a sublateral line of irregular callus but not evidently impressed near the base, the ante-scutellar pit small though deep; elytra but little wider than the prothorax, fully twice as long as wide, faintly inflated subposteriorly, narrowing in apical third; surface not very rough, with coarse and very confluent irregular punctures laterally, without evident series of punctures, the punctured patches moderate, the callous spots

large though feeble, cariniform near the semicircularly emarginate apices; under surface (♀) deeply impressed throughout the sterna and first ventral, the sinus of the fifth deep, with the median tooth long, very slender and aciculate. Length (♀) 16.8 mm.; width 5.9 mm. Indiana..... **sagax** n. sp.

Form nearly similar, shining, obscure to bright cupreous above, not brighter beneath; head nearly similar but without so distinct a central callus, subglabrous, the eyes relatively not quite so large or prominent though more so than usual; prothorax similar but broadly rounding at the sides and more gradually narrowing anteriorly from only a little before the middle, the sides parallel and subsinuate behind the middle; surface sculptured as in *sagax* but with the medial feebly impressed and densely punctate subapical spot shorter and better defined, and with large diffuse oblique sublateral impressions of the disk behind the middle; scutellum similarly distinct, rounded; elytra very evidently more than twice as long as wide, not so inflated behind the middle, more strongly though similarly sculptured, the densely punctate areas deeper, the callous spots stronger, especially in the sublateral series behind the middle; there are also more or less evident, scarcely impressed series of coarser punctures; under surface (♀) nearly similar, except that the medial tooth of the apical sinus, though variable in length, is truncate at tip, sometimes broadly so. Length (♀) 17.5 mm.; width 6.0–6.3 mm. Florida. **floridæ** n. sp.

9—Oblique sides of the elytra posteriorly becoming straight or virtually so toward the apices. Grayish-brassy in color; prothorax shorter than wide, narrowed anteriorly, the sides broadly rounded, subparallel behind the middle, the surface roughly punctate, confluently toward the sides, sparsely at the middle, with an obsolete and nearly smooth vitta near each side, the median line somewhat impressed, more densely punctate, the channel being more evident than in *obscura;* elytra rugosely punctate, the striæ toward the suture and apex more strongly punctured, the intervals variegated with irregular elevated black spaces, more irregular than in *obscura*, being rather portions left between confluent punctures than oblong areas, the apices gradually attenuate, not at all prolonged, bidentate. Length 15.0 mm. (♀). Pennsylvania. **soror** Lec.

A—Cupreous, the elevations greenish-black; under surface obscure cupreous-red; head coarsely, very densely punctate, with callous spots in a general broad transverse line between the eyes and above the middle of the front; prothorax three-fifths wider than long, the sides straight and parallel, gradually rounding and converging to the apex from a little before the middle, the surface almost evenly but only moderately convex, coarsely, densely punctured laterally, with numerous smooth, very irregular raised spaces, more finely, sparsely so medially, with the densely punctate median line impressed anteriorly but not elsewhere; ante-scutellar pit diffused on the margin; elytra more than twice as long as wide, but little wider than the prothorax, gradually narrowing behind in fully apical two-fifths, the

convex surface more even than usual, with impressed punctured striæ almost even and visible nearly to the sides, the densely punctured spots small and not impressed, the black spots feebly elevated, generally small but occasionally large and oblong, the punctuation not very rugose though dense, except near the suture; under surface (♀) channeled along the axial line as usual, the apical sinus with a long slender aciculate tooth. Length (♀) 16.0 mm.; width 5.8 mm. New York (Buffalo)..... **regularis** n. subsp.

Oblique sides of the elytra toward tip becoming more or less evidently sinuate, the tips thus appearing as though very slightly prolonged....10

10—Elytra not noticeably inflated subposteriorly, relatively more elongate.11

Elytra more or less conspicuously inflated, being decidedly wider behind the middle than at base.....12

11—Form elongate, rather convex, moderately shining, obscure æneous, feebly cuprascent beneath; head coarsely, densely punctate and rugulose, the central callus obvious; prothorax nearly two-thirds wider than long, the sides rounding and converging anteriorly, parallel and broadly, feebly sinuate from before the middle to the base; surface subevenly convex, coarsely, densely punctured laterally, with callous spots near the sides medially and others, very variable, in a sublateral line especially visible before the middle and at base; median parts rather finely, sparsely punctate, the anterior punctured area but very feebly impressed, the basal pit evident, sometimes bipunctate; scutellum longitudinally sulcate as a rule; elytra but little wider than the prothorax, distinctly more than twice as long as wide, subparallel, the sides gradually rounding and converging in apical two-fifths and gradually sinuate near the strongly bidenticulate apices, which seem to be slightly prolonged; surface coarsely, very rugosely and confluently punctate laterally, the punctured series broken but evident, the raised spaces very irregular and the punctate areolæ not well defined; under surface as usual, the median tooth in the apical sinus of the fifth ventral (♀) long and acutely aciculate. Length (♀) 17.5–18.2 mm.; width 5.7–6.1 mm. Indiana and Illinois (northern).... **levettei** n. sp.

Form narrower and still more convex, glittering and bright æneous, varied with small subcupreous patches, the raised parts greenish-black; under surface cupreous, dull laterally due to the coarse confluent sculpture, polished and viridiæneous medially; head very coarsely, confluently punctato-rugose, with small callous spots; antennæ a little longer than the head, bright cupreo-æneous; prothorax shorter, three-fourths wider than long, the sides broadly arcuate and gradually moderately converging anteriorly, becoming subparallel and feebly sinuate only behind the middle; surface very coarsely, densely punctate and with numerous very irregular ramifying callous spots laterally, sparsely and more finely punctate medially and nearly as in *levettei*; elytra more than twice as long as wide, barely at all wider than the prothorax, the sides very gradually rounding and converging from only slightly behind the middle, more feebly and broadly sinuate toward the strongly bispicu-

lose apices than in the preceding; surface less rugosely though coarsely and rather confluently punctate laterally, the punctured striæ fine but evident suturally, the dark spots elongate and numerous but only feebly elevated, the punctured areolæ very irregular but distinct, sometimes with more greenish-metallic lustre; under surface (♀) deeply sulcate along the prosternum, the metasternum flat, the medial tooth of the apical sinus long, slender and aciculate. Length (♀) 16.0 mm.; width 5.5 mm. Illinois (southern) ..... **gaudens** n. sp.

12—Body elongate and rather narrow, convex, gradually inflated posteriorly, slightly shining, dark cupreous, obscure above, brighter when living; head rather small, densely, moderately coarsely punctured, generally with a V-shaped central callus; prothorax two-thirds wider than long, the sides broadly rounded and moderately converging before, becoming parallel and broadly sinuate behind, the middle; surface broadly, indefinitely impressed sublaterally behind the middle, densely but only moderately coarsely punctate and with irregular callous spots laterally, sparsely and finely punctate medially, the subapical spot scarcely impressed, the basal pit variable, generally small but sometimes double; elytra at base but little wider than the prothorax, gradually broader posteriorly, and, behind the middle, evidently wider than at base, the sides thence very gradually rounding and converging, becoming sinuate before the sharply bidenticulate apices; surface unusually rough, the cupreous areolæ more deeply impressed, the raised spots numerous and prominent; under surface deeply impressed along the axial line nearly to the apex of the first ventral. Length 15.0–17.0 mm.; width 4.9–5.8 mm. New York to Florida. [=*indistincta* Mels.]. . **lurida** Fabr.

Body nearly as in *lurida* in general coloration and moderate lustre but more parallel and relatively stouter, less dilated posteriorly; head less densely punctate, the callous spots similarly very irregular in a transverse interocular region; prothorax larger and much less transverse, barely one-half wider than long, similar otherwise, except that the anterior densely punctate medial spot is more impressed and the areas of dense punctuation at each side of the sublateral line of callus anteriorly are more impressed, causing the vittæ to be more prominent; elytra more rapidly attenuate posteriorly, scarcely more than twice as long as wide, but slightly inflated behind the middle, the surface very much smoother than in *lurida* and with the punctured series very distinct and entire nearly to lateral third; sides only slightly sinuate before the apices; under surface (♀) nearly similar, except that the sinus of the fifth ventral is shallower, with the median tooth shorter, triangular. Length (♀) 17.0 mm ; width 5.9 mm. Texas..... **seriata** n. sp.

Body shorter than in either of the preceding, shining, æneous, the head and sides of the pronotum cuprascent, the entire under surface more brilliant cupreous; head coarsely, densely punctate, with a broadly V-shaped central callus, including a depressed area; there is also a transverse band of irregular callous spots between the antennæ; prothorax nearly as in *lurida* but with the oblique impressions behind the middle still stronger; elytra scarcely twice as long as wide, moderately inflated

behind the middle, where they are a third wider than the prothorax, the sides rather rapidly rounding and converging posteriorly, becoming only broadly and very moderately sinuate near the apices; surface very densely but not very coarsely punctato-rugose laterally, very uneven, the punctured areolæ much impressed, the striæ indistinct and much broken, the callous areas moderately elevated, finely cariniform near the apices; under surface (♀) as usual, the median tooth of the apical sinus long and slender but obtuse at apex. Length (♀) 15.0 mm.; width 5.5 mm. Iowa.....**erosa** n. sp.

Obscura is represented before me by a large series, holding very homogeneously to the characters above stated; cabinet specimens are generally dark and obscure in coloration, but the appearance of fresh examples is markedly different, owing to a pale grayish-metallic bloom which is destroyed unless the utmost care be taken in handling them; it is probably one of these specimens that served as the type of *pruinosa*. The integuments of the body are so thick and hard that a pin is to be inserted only by using great force; *lurida* and allied species are not so heavily armored. *Soror* is compared with *obscura* by LeConte, and is declared to be identical by Crotch, though the form of the prothorax seems to approximate more closely to that of the *lurida* type; nothing is stated by the describer regarding the relative size or prominence of the eyes, and I have therefore had to assume that the species will enter the second section of the group. It is entirely possible, however, that this is a mistake and that it is more related to *porcatula*, in which event *regularis* will become a true species.

Group II—Type *pugionata* Germ.

This group agrees with the last in nearly all of its characters, including the unmodified middle tibiæ of the male and the deeply sinuate and acutely bidenticulate elytral apices, but here, the latter are more prolonged and the pronotum differs in having a pronounced median impressed channel and subentire smooth sublateral callous vittæ, imparting a distinctly different habitus to this part of the body. In *pugionata*, the elytral tips are as much prolonged as in the next group. The only two known species are the following:—

Form elongate, the surface golden-brassy in lustre; head densely punctate, with a V-shaped central callus and two on the occiput separated by a moderate channel; prothorax shorter than wide, moderately narrowed anteriorly, the sides anteriorly broadly rounded, the surface conflu-

ently punctate, trisulcate and marked with four smooth elevated vittæ; elytra densely punctate, the sutural stria distinct, the suture elevated; alternate intervals with elongate smooth elevated spaces, the sides posteriorly oblique and gradually converging [becoming sinuate], the tips slightly prolonged and bidentate; under surface coppery, densely and coarsely punctured at the sides, nearly smooth or sparsely punctured at the middle; prosternum deeply, the first ventral moderately, sulcate, the metasternum almost flat; male with the last ventral tridentate, the medial tooth short and broadly truncate, the middle tibiæ straight and unmodified; female with the medial tooth of the apical sinus acute. Length 15.0 mm. Alabama to Pennsylvania. [=*pugionata* Lap.-Gory nec Germ.] ..... **lepida** Lec.

Form moderately elongate, much smaller, convex, shining, somewhat obscure coppery above, brighter cupreous beneath; head rather small, very coarsely but not so densely punctato-rugose, with large irregular central callous spaces; eyes rather small but prominent; prothorax short, three-fourths wider than long, the sides feebly arcuate and moderately converging before the middle, subparallel and feebly sinuate basally, the apex feebly sinuate; surface with a densely punctured median channel, with the ridges broad, nearly flat and sparsely punctate, thence to the sides coarsely, confluently punctate, with a more or less incomplete and narrower callous vitta, and some smaller callous spaces still nearer the sides; elytra barely wider than the prothorax, much more than twice as long as wide, the sides gradually rounding and converging from slightly behind the middle, becoming broadly sinuate, the tips greatly produced as in the next group, deeply sinuate and bispiculose, the surface uneven, with series of small punctures suturally, rather coarsely, densely and unevenly punctate laterally, the alternate intervals with strongly elevated but very irregular, elongate and smooth greenish-black spaces, the finely punctured areolæ rather distinct; under surface axially grooved, more strongly in the male, in which the middle tibiæ are unmodified, the median lobe of the apical emargination moderately broad, truncate, the medial tooth of the female sinus long and slender. Length 11.0–12.0 mm.; width 3.6–4.0 mm. Massachusetts. [=*Buprestis pugionata* Germ. (nec Lap.-Gory)].
pugionata Germ.

In regard to *lepida* Lec., which I have been unable to examine, it is stated by Crotch (l. c. p. 87) that the prothorax is longer than wide, but, though perhaps unusually elongate, it certainly cannot even be so long as wide, as indeed definitely so stated by LeConte.

Group III—Type *divaricata* Say.

In this group the elytra are more prolonged at apex than in any other, this character giving the species a habitus which is altogether distinctive. It is the largest group of the genus and comprises a wide

range of sculpture and outline, so that there ought not to be much difficulty in recognizing the various forms, which are in great part as yet undescribed. I have restored two of Melsheimer's species, believing them to be valid, almost as distinctly so in fact as *prolongata*, of LeConte, but *caudata*, of that author, which has been viewed with suspicion, is one of the more aberrant forms of the group, indicating the quality of observational work hitherto put upon them. There may be some mistakes in my interpretations, owing to paucity of material, but the large series of *divaricata* before me, gives a very good idea of such variation as may legitimately be anticipated, so that I do not think there will prove to be any considerable amount of actual synonymy. The species and subspecies may be defined as follows:—

Body of an elongate-oval, convex form, the elytra gradually rounding and converging behind from only slightly behind the middle; coloration generally cupreous above and beneath; species confined apparently to the extreme northeastern regions and not at present known to occur to the westward of New England 2

Body oblong-elongate and more parallel, the elytra rounding less gradually at the sides posteriorly and from a point always well behind the middle. 8

2—Elytral prolongation more or less abruptly formed, with its sides becoming parallel for some distance before the apex 3

Elytral prolongation gradually formed and more acuminate, not parallel even at the tip; species very small in size 7

3—Prothorax broadly angulate or angularly rounded at the sides well behind the middle 4

Prothorax obtusely subprominent at about the middle of the sides, the latter not sharply angulate 6

4—Series of punctures on the elytra not evident even toward the suture. Body moderately elongate, shining, dark and obscure in color above, the punctures and depressions deep cupreous; under surface and legs obscure cupreous; head coarsely, densely punctato-rugose, the central callus small and inconspicuous; eyes relatively small, only moderately convex and not noticeably prominent; prothorax three-fifths wider than long, the sides very feebly convergent and sinuate for two-fifths, there broadly but rather sharply angulate and thence more convergent and nearly straight to the apex, which is broadly sinuate as usual; surface sparsely punctate medially, impressed and more punctured on the median line to behind the middle, coarsely and densely so, with numerous uneven callous spots irregularly disposed, broadly toward the sides, with two strong deep punctures before the scutellum; elytra slightly wider than the prothorax, more than twice as long as wide, strongly, unevenly punctured, loosely suturally, very densely laterally, with numerous small and moderately elevated, very irregular and ramify-

ing black areas, the slightly depressed cupreous areolæ small, well defined, finely and closely punctate; prolongation cupreous; under surface and femora coarsely, closely and rugosely punctate, the axial line smoother and impressed as usual, the fifth ventral (♀) binigrocostulate medially, the median tooth of the apical sinus acute but broad at base, triangular. Length (♀) 16.0 mm.; width 5.4 mm. Massachusetts. **abrupta** n. sp.

Series of fine punctures, which are rather remotely spaced, rather distinct on the elytra except laterally, the series unimpressed.....5

5—Body short and rather stout, convex, only moderately shining, cupreous, with obscure or blackish elevations, the under surface dark cupreous; head coarsely, densely punctate, canaliculate posteriorly, with numerous longitudinal rugæ centrally, the eyes moderate in size but very convex and extremely prominent, deep black in the type; prothorax fully three-fourths wider than long, the sides parallel and deeply sinuate for a little more than a third, there broadly but very sharply angulate and thence strongly converging and straight to the apex; surface broadly impressed and more closely punctate throughout the length on the median line, with a large basal impression containing two deep punctures, coarsely, deeply, subconfluently punctate and with scattered irregular callous spots laterally, feebly impressed sublaterally behind the middle; elytra nearly as in the preceding but shorter, only a little more than twice as long as wide, the surface uneven, irregularly sculptured, very densely laterally, the raised spots feebler, the cupreous areolæ almost similar, the prolongation shorter and broader; under surface nearly similar, the black ridges of the fifth ventral feebler and less approximate. Length (♂) 15.0 mm.; width 5.2 mm. New Hampshire (Hampton).....**biangulata** n. sp.

Body elongate-oval, convex, shining, dull cupreous, the elytra obscure greenish throughout though varied by feeble subænescent reflections, the prolongation not different in color; under surface dark cupreous; head coarsely, unevenly rugose and punctate, with a depression before the central callus; eyes rather well developed, somewhat prominent; prothorax barely three-fifths wider than long, the sides subangularly prominent slightly behind the middle, thence subparallel and feebly sinuate to the base and converging and broadly arcuate to the apex; surface canaliculate and densely punctured before the middle and simply more closely punctate posteriorly on the median line, the basal pit large, deep and single, the sculpture otherwise nearly as in the preceding; elytra aberrant, similar to *abrupta* in form though more gradually attenuate, but almost uniformly punctate, without densely punctate cupreous areolæ and with the raised spots feeble, small and few in number; punctured series unimpressed and scarcely traceable, except near the suture; under surface nearly as in *abrupta*. Length (♀) 17.0 mm.; width 5.8 mm. Massachusetts..... **inflatula** n. sp.

6—Form elongate-oval, convex, rather shining, cupreous with the elevations black, brighter cupreous beneath; head coarsely, very densely but subevenly punctato-rugose, the eyes moderately convex and rather

prominent; prothorax fully three-fourths wider than long, the sides obtusely but subangularly prominent at the middle, thence sul parallel and feebly sinuate to the base and converging and feebly arcuate to the apex, the median line obsoletely impressed, deeply so anteriorly and with a very feeble elongate central callus, densely punctate anteriorly, the basal fovea deep, single or double; punctures laterally coarse, deep and confluent, with few irregular callous spots near the sides but with more forming an irregular broken vitta at lateral fourth, the impressions obsolete; elytra scarcely wider than the prothorax (♂), or slightly wider (♀), much more than twice as long as wide, the prolongation generally very abruptly formed and parallel, broader than usual though rather longer than wide; surface strongly, almost uniformly punctate, densely and rugosely at the sides, with numerous callous spots, which are elongate and regular suturally but elsewhere small, very irregular and ramifying transversely and longitudinally, the areolæ not well defined and not more finely punctate; under surface as usual. Length 14.2–19.0 mm.; width 4.7–6.4 mm. Massachusetts. **pisciformis** n. sp.

A—Similar to the preceding but narrower, paler and brighter cupreous, the elytra with the elevations more uniformly elongate and regular throughout and the sides more gradually converging posteriorly, with the prolongations much less abrupt, more extended and very noticeably narrower in form, brighter cupreous in color; eyes more prominent, especially in the male. Length 16.5–17.2 mm.; width 5.3–5.8 mm. Massachusetts ..... **longicauda** n. subsp.

7—Body moderately stout, convex, shining, cupreous with black elevations, dark cupreous beneath; head moderately coarsely, very densely and subevenly punctate, with a small transverse central callus, the eyes rather small, moderately prominent; prothorax two-thirds wider than long, the sides converging and broadly rounded anteriorly, gradually becoming parallel and sinuate behind the middle; surface feebly impressed and more punctured along the middle, deeply and more narrowly impressed anteriorly, the two ante-scutellar punctures conspicuous; punctures laterally only moderately coarse, crowded but not confluent, with callous spaces and sublateral broken vitta nearly as in the preceding, the impression obsolete; elytra at base wider than the prothorax, the humeral angles well exposed; sides parallel, gradually rounding and converging posteriorly from about the middle, becoming broadly, feebly sinuate to the tip of the unusually acuminate prolongations, the latter strongly carinate medially on the disk; surface much as in the preceding species, the series of fine punctures readily traceable suturally; under surface as usual. Length (♂) 13.2 mm.; width 4.5 mm. Massachusetts..... **cupreola** n. sp.

A—Similar to the preceding but narrower and more elongate, the head a little smaller, more coarsely, confusedly punctate, with the ramifying interspaces broader and more ruguliform; eyes nearly similar but scarcely so prominent; prothorax shorter and broader, not impressed along the median line except anteriorly and more coarsely and

confusedly, densely punctured laterally, with the callous spots more diffused; elytra at base much less evidently wider than the prothorax, the sides still more gradually converging posteriorly, and, from a little behind the middle, the surface nearly similar but with the black elevations more numerous, irregular and confused, except near the suture, the small and clearly defined, cupreous areolæ deeper. Length (♂) 13.0 mm.; width 4.3 mm. Massachusetts..... **filiola** n. subsp.

8—Prothorax narrowed gradually from base to apex. Form moderately stout, convex, shining, cupreous with the smooth parts blackish above, rather dull cupreous beneath; head confusedly and densely punctato-rugose, more or less impressed along the median line throughout, with a central interrupting callus; eyes moderately prominent; prothorax at base three-fourths wider than long, with the sides slightly prominent behind the middle; surface feebly impressed and closely punctate along the median line, more deeply anteriorly, the two basal punctures strong; punctures laterally only moderately coarse, very dense on each side of the sublateral ragged line of callus, coarser and very dense with much mingled callus near the sides; elytra not evidently wider than the base of the prothorax, twice as long as wide to the base of the cauda, the sides gradually rounding and converging in apical two-fifths, the prolongations gradual, becoming parallel and strongly divaricate; surface densely, rugosely punctured laterally, finely, sparsely so suturally, without distinct punctured series except feebly near the suture and without distinct finely punctured areolæ, the black spots only feebly elevated, elongate suturally but small and irregularly ramifying elsewhere; female with the medial terminal tooth short, broad and triangular. Length (♀) 18.4 mm.; width 6.2 mm. Pennsylvania.
caudata Lec.

Prothorax subparallel and generally slightly sinuate at the sides behind the middle.....9

Prothorax evidently though gradually narrowed basally, the width at the base more or less obviously less than at the middle, where the sides are more or less inflated though rounded.....19

9—Sides of the prothorax obtusely but sharply angulate at the middle. Body stout, convex, partially shining, black with the punctures green anteriorly, the elytra, except suturally and throughout the width basally, dull cupreous and green intermingled, the elevations black as usual; under surface in great part black, the punctures cupreous; head confusedly but not very densely punctate, with numerous small isolated callous spots which are very irregular in form, the eyes rather small but prominent; prothorax three-fourths wider than long, the sides sinuate in basal, converging and nearly straight in apical, half, sparsely punctate medially, with a small apical punctate impression and a closely double basal pit, the punctures laterally not very coarse and everywhere isolated, mingled with much black callous area; surface unimpressed; elytra not wider than the prothorax, between two and three times as long as wide, the sides gradually rounding and converging in posterior two-fifths, the prolongation gradually formed but

long and becoming parallel apically, obtuse, each with a strong, anteriorly bifurcating carina; surface almost even, with but very few scarcely elevated and almost evenly oblong smooth spots, strongly, coalescently punctate laterally and with even, unimpressed series of punctures, nine in number, only the extreme lateral series being indistinct; under surface rugose as usual, deeply sulcate along the entire axial line to the tip of the first ventral. Length (♂) 20.0 mm.; width 6.4 mm. Pennsylvania (Allegheny).....**subæqualis** n. sp.

Sides of the prothorax sometimes slightly prominent medially, but always rounded from a dorsal viewpoint.....10

10—Body above deep and uniform blue-black throughout, moderately slender and convex, rather dull in lustre; head very densely, uniformly punctato-rugulose, impressed along the median line throughout; eyes prominent, moderate in size; antennæ piceous-black basally, not metallic; prothorax three-fourths wider than long, the sides angularly prominent at the middle, parallel and feebly sinuate to the base, moderately converging and barely arcuate to the apex; surface with a large oval impressed and punctate area before the middle, flattened and less punctate thence to the deep single basal pit, laterally coarsely and very densely punctate, obliquely, deeply impressed behind the middle, with a small prominent callus before the middle and another at base in the same sublateral line, also a small submedian callus near the lateral margin; elytra slightly wider than the prothorax, between two and three times as long as wide, the sides gradually rounding and converging in apical two-fifths, rather abruptly sinuate at the base of the prolongations, which are short, broad and parallel, separated by a large acute notch; surface almost even, coarsely punctured except near the suture, very densely laterally, the striæ very distinct and impressed to beyond the median line, the callous spots small and very few in number, feeble, the areolæ few in number, and, behind the middle, large, shallow, less coarsely but not at all finely punctate and not metallic; under surface very deeply sulcate along the axial line. Length (♂) 18.5 mm.; width 6.0 mm. New York (Adirondack Mts.),—J. F. Kemp..**nigra** n. sp.

Body above metallic æneous, bright to obscure, sometimes moderately cuprascent.....11

11—Sides of the elytra more strongly rounding and converging behind, the prolongations rather abruptly formed and short, parallel.....12

Sides of the elytra more gradually rounding and converging through a longer distance posteriorly, the prolongations very gradually formed, longer and more acuminate.....15

12—Elytral striæ strong and distinct, sometimes nearly to the sides but not sulciform.....13

Elytral striæ very fine, sometimes traceable only to the median line 14

13—Body rather stout, moderately convex, shining, æneo-cupreous, the under surface slightly more intense in color; head coarsely, very densely punctato-rugose, with sparse callous spots, more or less impressed along the median line; eyes only moderately prominent; antennæ

æneo-cupreous; prothorax four-fifths wider than long, the sides obtusely subprominent at the middle, thence strongly converging and evidently arcuate anteriorly, and parallel and broadly sinuate basally; surface rather more punctured but not or only feebly impressed along the middle, except the constant and distinct impressed spot near the apex, the basal pit single or double, toward the sides strongly, obliquely impressed behind the middle, the impression generally deep and conspicuous, the punctures coarse and dense, with the usual callous spots very irregular; elytra nearly as in *nigra* in outline, the prolongation not quite as long as wide in its parallel part as a rule, obtuse at the tips but with the sutural angle sometimes acutely produced; surface rather rough, coarsely, densely punctured laterally, finely and sparsely near the suture, the striæ rather coarse, not much impressed but visible sometimes throughout the width, strongly punctured; callous spots strong, elongate suturally, smaller and ramifying elsewhere; areolæ not very well defined and not much less coarsely punctured; under surface as usual, the axial sulcus stronger in the male, and, on the prosternum, broader, more concave and more pubescent; medial apical tooth (♀) short, broad and triangular but variable as usual. Length 17.0–20.5 mm.; width 5.6–6.8 mm. New York, Pennsylvania, Indiana, Illinois, Kentucky and Wisconsin (Bayfield). [=*Buprestis divaricata* Say and *D. dubia* Mels.; also *Buprestis acuminata* Lap.-Gory nec Pall.(*acuminata* Pall., is European)]..... **divaricata** Say

A—Similar in general form and size but very dark and obscure æneous, obscurely cuprascent beneath, more shining, the head more coarsely rugose, the eyes a little larger and more prominent, the pronotum more coarsely punctured laterally, with larger and very irregular smooth spaces and the impressions obsolete, the median parts except anteriorly very remotely punctate, not at all impressed behind the middle, the basal pit similar; elytra with the punctures everywhere well separated and almost to the side margins, where, however, they become more or less transversely coalescent, the striæ obvious and impressed. Length (♀) 19.0 mm.; width 6.1 mm. New York (Buffalo)..... **limula** n. subsp.

B—Similar in general form but smaller and more slender, rather less bright and darker æneous, the under surface cupreous, with much metallic green lustre medially; head with the depressed medial spot bright green; eyes similar; prothorax similar but with the sides obtusely angulate at the middle, the converging sides thence to the apex straight; surface less impressed behind the middle, with the sculpture toward the sides much coarser; elytra similar but more elongate, the surface very much more coarsely and confluently punctato-rugose, except near the suture, the impressed striæ evident almost throughout the width, the black smooth spots small but strongly elevated, widely separated; two ridges of the fifth ventral strong as usual in this group. Length (♀) 16.5 mm.; width 5.2 mm. Indiana..... **incisa** n. subsp.

Body less stout and more convex, shining, dark æneous with black spots as

usual, more cupreous and greenish beneath; head nearly as in *divaricata* but with the eyes relatively a little larger and less widely separated; prothorax similar but with the sides anteriorly more convergent and nearly straight, posteriorly much less sinuate, the sculpture more even and with the post-median impressions much more feeble; elytra nearly as in *divaricata* throughout but with the prolongation, though similarly abrupt, still shorter, the parallel part nearly twice as wide as long; punctuation distinct and clear-cut but as usual coarse and confluent laterally, the striæ less coarse though very distinct to beyond the median line; under surface and sexual characters similar, except that the two ridges of the fifth ventral are shorter, more apical and very closely approximate, separated only by a narrow groove,—a very variable feature however. Length (♀) 17.0 mm.; width 5.8 mm. New York (Buffalo)..... **parumpunctata** Mels.

14—Form rather stout and convex, rough in sculpture, moderately shining, largely æneo-cupreous above with many small green clouds in the depressed areas of the elytra, the entire frontal margins and labrum also bright green; under surface cupreous and bright green, the legs green with feeble cupreous reflection; head very coarsely rugose, more finely punctato-rugose anteriorly, the eyes only moderately convex and not prominent; prothorax nearly as in *divaricata* but less closely sculptured throughout, obliquely though moderately biimpressed behind the middle; elytra but little wider than the prothorax, almost as in *divaricata* in outline and in the broad, obtuse and rather abruptly formed prolongation, but differing in its fine and finely punctate striation which is not visible much beyond the median line, the black callous spots numerous and strongly elevated, the depressed areolæ large, confused, with the close punctures coarse but smaller than the others; under surface rugose, nearly smooth and impressed along the axial line as usual but not obviously less rugose along the middle of the abdomen; median abdominal tooth (♀) rather long and slender. Length (♀) 18.2 mm.; width 6.2 mm. Ohio..... **aurichalcea** Mels.

Form somewhat similar but smaller and with relatively smaller head and prothorax, darker and more uniform æneo-cupreous above and but moderately shining, cupreous with some green glints beneath; head less coarsely, densely punctato-rugose, with a better defined and depressed, more finely punctate central spot, which is viridi-æneous as well as the labrum and the median apical parts of the front; eyes moderately large and more prominent; prothorax three-fourths wider than long, the sides subparallel, very broadly arcuate, gradually moderately converging anteriorly and becoming sinuate in only basal third, the surface less coarsely rugose, though closely punctured laterally and similarly unimpressed along the middle except very feebly anteriorly, the basal puncture small and deep, the oblique impressions diffuse and moderate; elytra evidently wider than the prothorax, similar in outline but with the obtuse prolongation narrower and relatively a little longer, though with the parallel part not longer than wide, similarly subabruptly formed; surface more uniform and less rugose, the fine and finely punc-

tured striæ visible to some extent throughout the width, the lateral margins much more brilliantly metallic æneous and green than the remainder of the disk, the elevations moderate, the areolæ not well defined and not densely punctate, except those behind the middle; under surface similarly rugose and sulcate, the prosternal sulcus broadly concave but only moderately pubescent in the male. Length (♂) 15.8 mm.; width 5.2 mm. Vermont (Bennington Co.)... **æstiva** n. sp.

15—Elytral striæ fine. Body rather narrow, convex and shining, obscure æneo-cupreous, the under surface brighter, cupreous; head densely and confusedly compresso-rugose, with a broad entire median impressed line, the eyes moderately prominent; prothorax fully four-fifths wider than long, the sides rather prominently rounded at the middle, thence converging and feebly arcuate to the apex and parallel and broadly sinuate to the base; surface not impressed medially, except narrowly and rather deeply anteriorly, the basal pit deep, only very widely and diffusely subimpressed laterally behind the middle, coarsely, closely punctate and confusedly rugose; elytra slightly more than twice as long as wide, just visibly wider than the prothorax, the sides gradually rounding and converging in posterior two-fifths, becoming but very feebly and broadly sinuate, the prolongation rather short and broad but altogether gradual in formation, obtusely truncate, not becoming parallel at tip; surface coarsely and almost regularly punctured, coalescently so toward the sides, the callous spots moderately convex, few in number and widely separated; areolæ wanting; fifth ventral (♀) closely bicostate, the median apical tooth small but acute. Length (♀) 15.5 mm.; width 5.1 mm. New Hampshire (Hampton).. **rustica** n. sp.

Elytral striæ coarse.....16

16—Pronotum more or less evidently and generally deeply, obliquely impressed sublaterally behind the middle.....17

Pronotum without oblique impressions behind the middle.....18

17—Form subparallel, moderately broad and convex, rather shining, obscure cupreous, darker beneath; head coarsely, confluently and very densely but somewhat evenly punctato-rugose, feebly depressed along the middle, the eyes only moderately prominent; prothorax nearly as in the preceding but with the sides more deeply sinuate basally, the base somewhat narrower than the middle; surface more or less impressed and closely punctate throughout the length medially, rather deeply, confusedly and coarsely punctato-rugose laterally; elytra slightly wider than the prothorax and evidently more than twice as long as wide, sometimes feebly inflated subposteriorly, the sides very gradually rounding and obliquely converging in apical two-fifths, the prolongation moderately wide, obtuse, gradually formed, the incisure distinct and deep but narrow; surface coarsely sulcate except laterally, the sulci coarsely punctate, the intervals convex, the sublateral interval posteriorly more prominent than usual, the sculpture densely confused laterally, the callous spots moderate and rather few in number, the areolæ not well defined except suturally and posteriorly; under surface as usual, the apical tooth (♀) small but very aciculate, sometimes wholly want-

ing, the sinus then becoming narrower. Length 15.7–20.5 mm.; width 5.2–6.7 mm. Michigan, Indiana, New York (Adirondacks) and New Hampshire..... **subcuprea** n. sp.

A—Similar to the preceding but in the male narrower and more parallel, the elytra not wider than the prothorax, narrowing more rapidly in about apical third and drawn out at apex to a narrower but similarly gradual prolongation, the prosternal channel wider than in *subcuprea* (♂), leaving much narrower lateral ridges, the metasternum also with an evidently broader and less posteriorly attenuated furrow. Length (♂) 17.7 mm.; width 5.4 mm. New Hampshire. **pertinax** n. subsp.

Form slightly stouter, convex, shining, grayish-metallic, not at all cupreous above though bronzed beneath; head nearly as in *subcuprea* but more impressed along the median line almost throughout, the eyes only moderately developed, somewhat prominent; prothorax less transverse though rather more than three-fourths wider than long, nearly similar in outline though much less sinuate at the sides basally; surface deeply but not very broadly sulcate along the median line, the sulcus more closely punctured as usual, very coarsely, extremely densely and confusedly punctured laterally, with an occasional callous spot, the oblique impressions not so deep as in the preceding; elytra somewhat more inflated, and, behind the middle, fully a fourth wider than the prothorax, the sides very gradually rounding behind, becoming similarly gradually and broadly sinuate to the tip of the moderate prolongation, which is more broadly obtuse at apex; surface with rather coarse subsulciform series of coarse punctures, the sculpture dense and very confused laterally, the subsutural carina posteriorly sharply defined but elsewhere with very confused and irregular elevated spots and having but few well defined areolæ; under surface as usual in this group, the medial apical tooth (♀) very short and broad, triangular. Length (♀) 20.5 mm.; width 6.8 mm. Colorado..... **sulcatula** n. sp.

18—Body larger, stout and convex, moderately shining, obscure bronze, brighter beneath; head very coarsely and confusedly rugose, with a broadly impressed median line interrupted centrally by a V-shaped callus; eyes well developed but rather feebly convex, scarcely at all prominent; prothorax nearly as in the preceding but relatively smaller, the sides behind the middle parallel and deeply sinuate nearly as in *subcuprea*, the surface not impressed though more plentifully punctate along the middle, except the usual subapical spot, the basal pit with sloping posterior surface, the sculpture laterally very much confused, being a mixture of coarse and dense punctures and large ramifying callous areas; elytra at base distinctly wider than the prothorax, the sides nearly straight, gradually rounding and converging in posterior two-fifths, the gradually formed cuprascent prolongation unusually short and broad, with the sutural angles minutely aciculate; surface with distinct close-set punctures which are only partially confused near the sides, the black callous spots numerous and strongly elevated, giving a coarsely rugose general surface, the series not much impressed but

very evident except laterally, coarsely punctured suturally, the areolæ not well defined; under surface coarsely rugose, smoother and channeled axially as usual, the apex of the fifth ventral (♀) with the sinus small, the lateral lobes very broad and the median tooth broadly triangular. Length (♀) 20.0 mm.; width 6.7 mm. Vancouver Island (Victoria) ..... **vancouveri** n. sp.

Body rather small in size and less stout, moderately convex, shining, obscure brassy-bronze in color, brighter beneath; head densely, moderately coarsely and subevenly punctato-rugose, with a central depression before a small transverse callus; eyes rather small and not very prominent; prothorax fully four-fifths wider than long, the sides broadly, subevenly arcuate and converging from slightly behind the middle to the apex, parallel and sinuate in but little more than basal third; surface not or scarcely impressed medially, except narrowly so anteriorly, the basal pit triangular and deep, densely, coarsely and confusedly punctate laterally, with a few callous spots; elytra but slightly wider than the prothorax, parallel, gradually and broadly rounding and converging in apical two-fifths, the prolongation gradually formed, attenuate and rather long; surface with rather coarse striæ which are visible almost throughout, the striæ only feebly impressed but coarsely and unusually distinctly punctured, the sculpture coarse, dense and confused laterally, the callous spots almost wanting before, moderately conspicuous behind, the middle, the areolæ not defined; under surface rugose and axially sulcate, the last ventral (♂) with the deep emargination transversely rectilinear at the bottom, the lobe occupying the entire width. Length (♂) 15.5 mm.; width 5.0 mm. Wisconsin. **angusticauda** n. sp.

19—Pronotum not impressed along the median line except anteriorly....20

Pronotum more or less deeply sulcate throughout along the middle.....21

20—Form rather narrow, elongate and parallel, moderately convex, shining, obscure gray-metallic in lustre, scarcely bronzed beneath; head coarsely, confusedly compresso-punctate, feebly but unequally impressed along the middle, the eyes well developed and prominent; prothorax nearly twice as wide as long, the sides prominent, almost obtusely angulate at the middle, where the width is but slightly greater than at base, thence gradually converging and feebly arcuate to the apex, broadly sinuate basally; surface obliquely impressed sublaterally behind the middle, coarsely, confusedly punctato-rugose laterally, with a definite callous spot only before and behind the impression; elytra nearly two and one-half times as long as wide, barely wider than the prothorax, the sides very gradually rounding and converging in apical two-fifths, becoming gradually and broadly sinuate, the prolongation long, somewhat attenuate and cuprascent, the surface unevenly sulcate, the elevations only moderate in number and prominence, the foveolæ rather small and definite posteriorly but not more finely punctate; under surface rugose and deeply sulcate axially, the last ventral (♀) with the apical sinus but little wider than deep, the tooth gradually and very finely aciculate. Length (♀) 19.0 mm.; width 6.0 mm. Wisconsin (Bayfield),—H. F. Wickham..... **subargentea** n. sp.

Form much stouter, convex, subinflated posteriorly, rather dull, blackish with the depressions very obscure æneous above, the under surface very obscure æneo-cupreous and black; head densely compresso-rugose, impressed along the middle, the eyes smaller and only moderately prominent; prothorax strongly, subangularly prominent at the sides just before the middle, thence strongly, arcuately narrowing to the apex, less strongly so with feebly sinuate sides to the base, very nearly twice as wide as long, the surface deeply, obliquely impressed behind the middle sublaterally and also with a deep rounded impression before the middle at each side of the median tumid surface, coarsely, densely and confusedly punctato-rugose laterally; elytra slightly wider than the prothorax, the sides gradually rounding and then rather rapidly converging in apical two-fifths, the prolongation narrow, moderate in length but not abruptly formed; surface rugose laterally, coarsely punctato-sulcate thence suturally, the surface sublaterally with the elevations bordering the large areolæ posteriorly unusually strong, giving a feebly undulated appearance; female with the terminal sinus narrow and as deep as wide, the tooth very small and broadly angulate, not extending posteriad through a fourth of its depth. Length (♀) 18.5 mm.; width 6.2 mm. Ontario ..... **severa** n. sp.

21—Thoracic sulcus narrow and better defined 22

Thoracic sulcus very broad, much dilated toward the base, less sharply defined at the sides and generally with a small central callus..... 24

22—Elytra with only a series of levigated spaces near the margin. General characters nearly as in *tenebrosa* (!) except that the pronotum has no levigated elevations and the impressions, except the median channel, which is better defined, more obsolete; elytra distinctly furrowed, especially near the suture, the furrows punctured; the attenuated apex of the elytra is longer than in *tenebrosa*, rather truncated and beneath is of a dark blue; the prosternum is linear and the base of the abdomen scarcely channeled; the teeth of the fifth ventral (♀) are longer than in *tenebrosa* and of a brilliant ruddy-copper. Length (♀) 15.5–18.0 mm. British America, (found in latitude 54° and at Cumberland House). [=*Stenuris tenebrica* Kirby]..... **tenebrica** Kirby

Elytra with levigated spaces almost throughout as usual..... 23

23—Color gray-metallic, often pruinose [as usual when fresh]; prothorax more than twice as wide as long, the sides anteriorly strongly rounded, posteriorly subsinuate, punctate, canaliculate, at each side behind the middle obliquely and deeply impressed; elytra deeply striate, the intervals with more obscure oblong spaces which are smooth and rather elevated, posteriorly obliquely attenuate, prolonged, the apices rounded, scarcely divaricate; beneath sparsely pubescent, axially sulcate as usual; last ventral of the male tolerably deeply emarginate at apex, sinuate; (♀) with the lateral teeth rounded, the medial acute. Length 19.2–21.2 mm. Lake Superior; [also British America]..... **prolongata** Lec.

A—Form more elongate and parallel, the elytra narrowing more rapidly behind in scarcely more than apical third, the prolongation long,

gradually formed and decidedly narrow; prothorax twice as wide as long, prominently inflated and rounded at about the middle, the sulcus evident but shallow, deeper anteriorly, the sublateral impressions deep, the surface laterally very confusedly but subevenly punctato-rugose; elytra parallel, not wider than the prothorax, more elongate, coarsely sulcate, the sulci coarsely punctate, obliterated only near the sides, the elevations small and not conspicuous, the sublateral interval posteriorly slightly more prominent and more or less broken as usual; apical sinus (♀) rather small, twice as wide as deep, the tooth rather long, slender and aciculate. Length (♂, ♀) 19.0–21.2 mm.; width 6.2–6.8 mm. British America ..... **longipennis** n. subsp.

Color obscure bronze, a little more coppery beneath though dark; body smaller, moderately convex, rather dull; head coarsely punctato-rugose, impressed along the middle, the eyes moderate, rather prominent; prothorax fully four-fifths wider than long, the sides evenly and broadly rounded, strongly converging anteriorly, feebly so and slightly sinuate basally; surface deeply sulcate, with a large deep basal pit, coarsely, densely and confusedly but almost evenly punctato-rugose laterally, the oblique impressions feeble but evident; elytra slightly wider than the prothorax, very gradually rounding and converging at the sides in apical two-fifths, the prolongation moderately wide, rather short and gradually formed, the median notch large and deep; surface very confusedly rugose throughout, the elevations numerous, small and irregular in form, the sulci only indicated by vague lineiform impressions, which are coarsely punctate but only definitely so near the suture; prosternum of the female with an unusually broadly concave rugose impression, rapidly narrowing posteriorly, the metasternum broadly concave, the first ventral impressed only anteriorly; medial tooth of the apical sinus rapidly, very finely aciculate. Length (♀) 16.0 mm.; width 5.6 mm. New York ..... **callosa** n. sp.

24—Form stout, rather convex, not very shining, dusky cupreous, brighter beneath; head coarsely, densely compresso-rugose, feebly impressed along the middle, the eyes moderate, prominent; prothorax nearly four-fifths wider than long, the sides prominently rounded rather behind the middle, thence strongly converging and slightly arcuate to the apex and feebly converging and very slightly sinuate to the base; surface with a broad and shallow, densely sculptured channel inclosing a small central callus and ending at base in a broad deep cavity, thence to the sides coarsely, very densely punctate, with about three callous spots, obliquely impressed behind the middle; elytra not evidently wider than the prothorax, only slightly more than twice as long as wide, gradually rounded and converging at the sides in apical two-fifths, the prolongation gradually formed but rather broad and short, the cleft narrow and deep; surface somewhat coarsely subsulcate almost throughout the width, the sulci rather coarsely and irregularly, not distinctly punctate, the elevations numerous and strong but for most part small and irregular, the depressed spots brighter metallic, strongly punctate; prosternum (♀) as broadly concave and roughly sculptured as in the

male of other species, the concavity limited only by a narrow ridge at each side, the median apical tooth triangular but finely aciculate. Length (♀) 17.5 mm.; width 6.2 mm. Lake Superior (Whitefish Point).....**rigida** n. sp.

Form very stout, moderately convex, the lustre feeble, deep black throughout above, feebly metallic at the side margins, bronzed beneath; head coarsely, densely and subevenly punctato-rugose, the eyes moderately developed but only slightly convex; prothorax in outline nearly as in *rigida* but with the lateral inflation at the middle, the sulcus not quite so broad but ending posteriorly in a similar large transverse cavity, the central callus prolonged posteriorly in a fine line; surface from the bounding ridges to the sides coarsely, very densely and confusedly but evenly punctato-rugose, without callous spots and not obliquely impressed behind the middle; elytra at least a third wider than the prothorax, scarcely more than twice as long as wide, the sides rather abruptly rounding and strongly converging posteriorly in more than apical two-fifths or from only slightly behind the middle, the prolongation gradually formed, not very long and somewhat finely acuminate; surface nearly even, with fine, unevenly punctured sulci throughout the width, densely rugulose laterally, the elevations small, few in number and inconspicuous; under surface (♀) with the prosternal concavity not quite so broad as in *rigida* and more coarsely sculptured, the ridges of the fifth ventral uniting at the apex, the latter narrow, wholly occupied by the shallow sinus, the lateral lobes acute, the median tooth narrowly triangular, very acute and extending beyond the lateral lobes. Length (♀) 19.0 mm.; width 6.8 mm. Ontario (Port Hope),—C. J. S. Bethune).....**tetrica** n. sp.

I have identified as *prolongata* Lec., a female specimen from an unrecorded locality in British America. It answers the description very well, except as to the proportions of the prothorax, the latter being evidently less than twice as wide as long, but this is unimportant, since the width in terms of length was habitually overdrawn by LeConte, as in the case for example of *Spinthoptera valens*, previously referred to. The elytra are somewhat inflated behind the middle, the sides gradually rounding and rather rapidly converging in more than apical two-fifths, the attenuated apex much prolonged and rather acuminate but gradually formed and very different from the same part in *divaricata* and allies, with which the species was united in complete synonymy by Kerremans. The above description of *prolongata* is wholly drawn from the characterization published by LeConte in his monograph (1859). If we admit that *tenebrica* Kirby, belongs to this group, and not near *tenebrosa*, of the next group, and the few published characters seem to warrant this assumption, it

must be closely allied to *prolongata* though probably a smaller species. The statement of Kirby that the elevated spots are only evident near the sides of the elytra, refers to the greater prominence observable, as a rule, in the submarginal interval behind the middle; this is particularly pronounced in certain species of *Buprestis*, as well, and is a general character, at least in this part of the family. *Longipennis* bears much the same relationship to *prolongata*, that *pertinax* does to *subcuprea*, and in both cases the subspecific type comes from the same locality as the species to which it is attached. In the latter case, the long and parallel-winged type of the assumably subordinate form, is a male, having besides some striking differences in the prosternal groove, so that I have given it subspecific rank provisionally. In the case of *longipennis*, however, the aberrant long-winged form is represented by both male and female. It may be that we have here evidences of true asexual dimorphism, but the material at hand is not sufficient to decide this at present. The general appearance of the subspecies in each case departs remarkably from that of the species, to a greater degree in fact than the general differences in facies distinguishing a number of allied though evidently distinct species. This is apparently therefore one of those puzzles that occasionally arise in taxonomic work, with incomplete material and in the absence of biologic evidence.

Group IV—Type *horni* Cr.

This is a small and very local group, peculiar to the Southern Pacific coast fauna. The only described species is the following:—

Form moderately stout, elongate-oval, not very convex or shining, obscure bronze above, with the margins of the pronotum and elytra and the occiput behind the eyes generally brighter or greenish, the under surface brighter cupreous; head coarsely punctato-rugose, strongly impressed along the median line throughout, rather more hairy in the male though sparsely, the eyes well developed and rather prominent; prothorax not quite twice as wide as long, the sides parallel and straight to the middle, there rounding and thence strongly converging to the apex, which is feebly sinuate; surface moderately impressed and more punctured along the median line, the impression with a feeble slender callus, coarsely, deeply and densely punctate with intermingled irregular callous spots from the broad and feebly tumescent ridges to each side and very broadly, diffusely impressed obliquely behind the middle, the basal pit deep, single; elytra barely at all inflated behind, twice as long as wide and only slightly wider than the prothorax, the sides grad-

ually rounding and converging in apical two-fifths, the short and broad prolongation rather abruptly formed, more cupreous and with the outer angles moderately rounded, the sutural feebly dentiform; surface sparsely pubescent, with moderate shallow, closely and coarsely punctate sulci in about inner half, densely, coarsely punctured, confluently so laterally, the callous spots strong but small and very sparse; under surface rugose, deeply sulcate along the axial line including the first ventral, the fifth with two vestigial ridges, the apex transversely emarginate (♂), or broadly and obtusely rounded (♀). Length 16.5–18.7 mm.; width 6.0–6.8 mm. California (Tulare Co.)..... **horni** Cr.

A—Similar but larger, stouter, more dusky and obscure in coloration, the head more coarsely rugose, the prothorax feebly inflated near the middle of the sides, the medial sulcus obsolescent, the punctures laterally denser and the anterior callus near lateral fourth much stronger; elytra nearly similar but with the outer angles of the prolongation much more broadly rounded; fifth ventral (♀) without trace of ridges and with the apex more acuminate and very narrowly rounded. Length (♀) 17.7 mm.; width 6.9 mm. California (Kaweah)..... **ampliata** n. subsp.

The variety, mentioned by Crotch, having the last ventral segment of the female tridentate at tip, I have not seen. It is probably a widely distinct species if the sexual characters are correctly stated.

Group V—Type *tenebrosa* Kirby.

The general habitus in this group differs greatly from that characterizing any of the preceding, the body being shorter and relatively broader, with the prothorax more transverse as a rule, generally inflated at the sides before the middle and with the surface much more unevenly impressed and sulcate. The elytra are more or less rapidly narrowed behind and briefly produced, the prolongation either narrow and acuminate as in *tenebrosa* and related species, or more broadly obtuse as in *crassicollis*, where it approaches the form described above in *horni*, but the apices are in all instances entire at tip. The species are rather numerous and more fully described by various early authors than in either the *obscura* or *divaricata* groups. After rather attentive study of the literature and of such material as is at hand, I would propose the following arrangement of those discovered thus far:—

Pronotal sulcus generally broader, densely punctate, having a small central callus by which it is in no measure interrupted; middle tibiæ of the male unmodified; head with an elevated transverse line between the eyes...2

Pronotal sulcus narrower, with a large central callus by which its continuity

is more or less completely interrupted; middle tibiæ of the male obtusely dentate within; head without a callous band between the eyes...7

2—Prothorax subparallel, only feebly inflated at the sides near apical third. Body elongate, subparallel, moderately convex, dull in lustre, dark brown or blackish and without evident metallic reflection above, similar beneath though more shining, nearly glabrous above, the head densely but not very coarsely punctato-rugose, with a strong callous transverse band between the eyes and two longitudinal callous areas at base; eyes moderate, not very prominent; prothorax three-fifths wider than long, the sides parallel and very feebly sinuate from the anterior inflation to the base, converging anteriorly; surface finely, densely punctate throughout, except the rather approximate medial ridges, and thence to the sides obliquely, though very moderately, impressed behind the middle and with an elongate anterior and small basal callus in a line nearer the medial ridges than the outer margin; central callus small and finely prolonged posteriorly; elytra distinctly wider than the prothorax, twice as long as wide, the sides parallel, gradually rounding and oblique in posterior two-fifths, becoming only very faintly sinuate near the obtusely acuminate apices, which are not evidently prolonged; surface finely, deeply, very closely and uniformly punctato-cribrate throughout, with series traceable to the sides of very coarse and well spaced perforate punctures, also having some elongate callous smooth lines on the alternate intervals, especially toward the suture; under surface not coarsely punctato-rugulose laterally, smooth and but feebly impressed axially, the male with the middle tibiæ unmodified, the apex of the fifth ventral with a shallow transverse emargination, the female with the apex narrowly and prominently rounded and entire. Length 11.0–13.7 mm.; width 4.0–4.8 mm. Massachusetts, Pennsylvania and District of Columbia. [=*Buprestis transversa* Say].....**punctulata** Schönh.

A—Similar to the above but larger and stouter, the head larger, with relatively smaller eyes, the transverse ridge finer and more acutely elevated but not quite so strong, the prothorax nearly similar but with the sublateral line of callus only narrowly interrupted or entire; sides of the elytra similarly oblique posteriorly but with the sinuation rather more obvious; prosternum of the male broadly, feebly concave and closely, coarsely punctured, scarcely at all hairy, the abdomen strongly punctured throughout. Length (♂) 14.8 mm.; width 5.6 mm. North Carolina (Southern Pines).....**pinorum** n. subsp.

Prothorax constricted and sinuate at the sides basally, broadly inflated before the middle.....3

3—Elytral apices rather broad and obtuse, not evidently prolonged, the form being nearly as in the preceding species. Body stout, oblong, moderately convex, feebly shining, dark cupreous-brown above, sometimes with small green areas and occasionally with the elytra almost entirely green, the under surface dark purplish-cupreous; head coarsely, densely punctato-rugose, with a sharply elevated transverse biangulate callous band between the eyes and two small approximate callous spots at base; eyes rather prominent; prothorax three-fourths wider than long,

very densely, uniformly punctured, with two strong median and two sublateral callous vittæ, the latter broadly interrupted by the concave impressions, also with a small central callus and an irregular elevation near each side margin; scutellum small, strongly transverse; elytra much wider than the prothorax, three-fourths longer than wide, the sides rather abruptly rounding and strongly oblique in apical third, becoming evidently sinuate near the tips, the latter transversely truncate, with the angles not at all rounded, the sutural slightly prominent; surface extremely densely, not coarsely punctate throughout, with unimpressed series of rather large but more or less obscure punctures though coarse and perforate in certain parts near the suture, the alternate intervals with moderately elevated and smooth elongate-oblong callous spots, varying greatly in size; under surface (♀) rather coarsely and subrugosely but not very densely punctate, the axial line only feebly impressed, the prosternum broadly, very feebly concave and coarsely, densely punctate throughout, the apex of the fifth ventral narrowly rounded, with two small deep approximate incisures, the median tooth parallel, truncate; male not at hand. Length 15.5–16.5 mm.; width 6.0–6.6 mm. Oregon and Washington State—eight specimens. [= *californica* Cr., i. litt.]..... **crassicollis** Lec.

A—Body larger, similar in general form, sculpture and coloration, the head relatively a little smaller, with less prominent eyes, the surface more confusedly and strongly rugose, the sides of the elytra more gradually rounding and less strongly oblique in apical two-fifths, the punctured series less distinct; under surface nearly similar; legs stout. Length (♀) 17.5 mm.; width 6.9 mm. Washington State..... **hesperica** n. subsp.

Elytral apices more gradually and finely attenuate, very narrow at tip and more or less evidently though but slightly prolonged.....4

4—Upper surface black, without metallic reflection, at least in *morio*.....5

Upper surface dark brown, with feeble subcupreous or æneous lustre, the under surface rather bright cupreous.....6

5—Body very much as in *divaricata* (!) but much smaller, the upper surface confluently punctured, with only the elevated parts glossy, the lower surface bronzed-copper and glossy; mouth and antennæ bronzed, the eyes black; front sculptured as in *divaricata;* prothorax uneven, with shallow impressions and a broad dorsal channel, distinctly bisinuate at base; surface with levigated elevations; scutellum very minute, impressed; elytra divaricate, suddenly attenuated at the apices, which are rounded and each with a single ridge; surface rough, with many concatenated and levigated irregular elevations, the sides of the apices bronzed; breast channeled, the first abdominal segment less conspicuously; prosternum nearly an isosceles triangle; abdominal apex with three short teeth. Length 15.5 mm. British America (latitude 65° and in the Rocky Mts.). [= *Stenuris tenebrosa* Kirby].
tenebrosa Kirby

Body oblong, rather stout, moderately convex, dull, deep black throughout

above, deep metallic magenta with feeble medial æneous reflection beneath; head not very coarsely, densely and unevenly punctato-rugose, with an uneven transverse callous band between the eyes and two uneven basal callous areas, the eyes moderately prominent, pale in the type; prothorax four-fifths wider than long, the sides strongly and subevenly arcuate, becoming about parallel for only a very short distance at base, widest slightly before the middle, the sulcus broadly concave, closely punctate and with a small central callus, the surface from the ridges to the sides very uneven, densely punctate and rugose, strongly impressed behind the middle, the exterior callous line broadly interrupted, the lateral ridge from the basal angles to the middle strong; scutellum whitish and coriaceous in the type, transverse, semicircularly rounded behind; elytra barely at all wider than the prothorax, four-fifths longer than wide, parallel, the sides gradually rounding and feebly oblique in posterior two-fifths, becoming scarcely at all sinuate toward the narrow apices, which are truncate with rounded angles, their discal carina not extending to the tip; surface not coarsely, very densely punctured laterally, sparsely so and in clusters suturally, with even series throughout the width of very large perforate punctures, which are not at all connected in the series by any kind of a stria; elevated spots few in number, small and with very irregular outline; under surface (♂) strongly punctato-rugulose, the prosternum broad and flat, very densely, coarsely punctured, the metasternum broadly concave and also densely punctured, the first ventral simply broadly flattened medially, the middle tibiæ unmodified, the fifth ventral with a shallow, broadly sinuate apical emargination, the angles acute. Length 15.0 mm.; width 5.5 mm. Lake Superior (Whitefish Point).....**morio** n. sp.

6—Form oblong, attenuate behind, moderately convex, not very stout, being somewhat as in *punctulata* in general form and sculpture; head densely and confusedly punctate, with a very irregular band of low callus between the eyes, the latter rather small and scarcely at all prominent; prothorax three-fourths wider than long, the sides evenly rounded and inflated anteriorly, becoming nearly straight and parallel in almost basal third; surface with the median ridges very narrow, strong, the inclosed sulcus deep, punctate, with a small central callus, the surface thence laterally very densely and confusedly but shallowly punctate, deeply impressed behind the middle interrupting the narrow line of callus, the submarginal ridge evident but very irregular; scutellum black, dull, transverse; elytra quite obviously wider than the prothorax, twice as long as wide, the parallel sides rather rapidly rounding and thence moderately oblique, becoming very broadly but distinctly sinuate to the narrowly and evidently prolonged apices, which are narrow and rounded at tip; surface punctured nearly as in *morio* and with series of perforate coarse punctures, which are however smaller and more compressed and only very obvious suturally, the raised spots more numerous and very irregular, mostly elongate and coarsely crenated at their sides by the punctures; under surface (♀) rugulosely punctate, the densely punctate prosternum flat, the fifth ventral gradually and acutely attenuate, with the apex very narrowly, subangularly

rounded and entire; male not at hand; Length 14.4 mm.; width 5.0 mm. Michigan (at Lake Superior). [=*lacustris* Lec. (fide Crotch)]. **lugubris** Lec.

A—Body nearly as in *lugubris* but more prolonged and more gradually attenuate posteriorly, the head nearly similar, the prothorax shorter and more transverse, nearly twice as wide as long, almost similar in outline and sculpture but with the two median ridges less elevated, the inclosed sulcus shallower, the central callus prolonged in a fine callous line to the base; elytra with the elongate callous spots more numerous, very irregularly crenulated along their sides by the coarse punctures, which are even more conspicuous than in *lugubris* but less perforate than in *morio*, the sides posteriorly very gradually converging to the narrow rounded apices but becoming only scarcely visibly sinuate; prosternum (♂) broad, just visibly concave and very densely punctate though scarsely hairy throughout; middle tibiæ unmodified, the fifth ventral with a shallow transverse emargination. Length (♂) 15.0 mm.; width 5.25 mm. Michigan (Whitefish Point, Lake Superior)..... **austera** n. subsp.

Form and size nearly as in *punctulata*, brassy-brown above; head dull cupreous, densely rugulose, slightly indented on the front and with a transverse interrupted polished callous line between the eyes; antennæ obtusely serrate, rich cupreous; prothorax transverse, slightly emarginate at apex, feebly bisinuate at base, where it is narrower than the base of the elytra, the posterior angles acute, the sides straight near the base, strongly dilated beyond the middle, dull cupreous, densely punctured, with four longitudinal polished black lines, the middle two entire, the outer interrupted before the middle or before an oblique fossula and appearing slightly again at base; there is also a narrow polished marginal line from the tip of the hind angles to near the middle of the lateral dilatation; scutellum transverse, black; elytra brassy-brown or black, densely punctate, with series of large remote punctures and many irregular linear black polished elevations; tip short, entire, the legs and under surface cupreous, shining, rugosely punctured, the post-pectus canaliculate. Length 14.0 mm.; width 6.0 mm. Virginia. [=*consobrina* Mels.]..... **dumolini** Lap.-Gory

Form nearly similar, æneous; prothorax twice as wide as long, strongly dilated at the sides, which are rounded anteriorly, sinuate posteriorly, roughly punctate, unequal, with a short carina at the posterior angles, callous spots at apex and base and two nearly smooth costæ, the dorsal sulcus broad and deep, with a small central callus; elytra punctured, the internal striæ coarsely punctate, the alternate intervals with elevated shining spaces, many of which are connected by elevated transverse rugæ, the tips briefly prolonged, rounded; under surface bright coppery, the prosternum flat, densely punctured, the metasternum feebly sulcate, and, like the unimpressed first ventral, sparsely punctate; male with the last ventral truncato-emarginate at apex, the middle tibiæ simple; female with the fifth ventral rounded at tip. Length 13.0–16.0 mm. Maine and New York. [=*tuberculata* Lec. nec Lap.-Gory]..... **distinguenda** Lap.-Gory

Form nearly similar, æneo-cinereous in color, the head, pronotum and elytra generally more or less suffused with green, the prothorax "more than twice as wide as long," the sides dilated and rounded, sinuate posteriorly, roughly punctate, unequal, with four shining elevated vittæ, the external subinterrupted, the dorsal sulcus "interrupted" by a "small" shining callus; elytra punctate, the internal striæ punctate, the alternate intervals with oblong shining elevated spaces, at apex slightly prolonged, the tips entire; prosternum broadly sulcate, subglabrous; male with the middle tibiæ unmodified, the fifth ventral truncato-emarginate at tip; female with the fifth ventral rounded and entire at tip. Length 15.0 mm. New York (near the city). [= *hilaris* Lec. and *manca* Lec. (fide Crotch)]..... **tuberculata** Lap.-Gory

7—Upper surface cupreous to dark cupreous-brown in color, the elytral apices narrowly acuminate.....8

Upper surface deep black throughout, without trace of metallic lustre, the elytral apices rather broadly obtuse.....12

8—Sides of the elytra rounding and rapidly converging posteriorly in about apical third.....9

Sides very gradually and broadly rounding and very gradually converging posteriorly from a point only slightly behind the middle.....11

9—Sides of the prothorax but feebly converging and sinuate basally. Body more elongate, moderately convex, shining beneath, bright cupreous throughout excepting the black elevations; head very unevenly, densely punctate and rugulose, coarsely and longitudinally rugose basally, the eyes rather well developed and prominent; prothorax three-fourths wider than long, the sides broadly and obtusely prominent before the middle, strongly converging anteriorly, becoming very feebly sinuate and moderately convergent toward base; surface densely punctate laterally, the ridges broadly convex and sparsely punctate, the deep included sulcus densely punctate, completely interrupted medially, the sublateral vitta broad, widely interrupted by the deep depression, the submarginal line of very irregular ramifying callus broad and extending throughout the length; elytra but little wider than the prothorax, fully twice as long as wide, the apices slightly prolonged, broadly rounded at the tip, the sides near them distinctly sinuate; surface rather finely, very densely punctate, the coarse serial punctures distinct only near the suture, the elevations elongate, numerous and strongly convex, shorter and more ramifying laterally; under surface (♀) punctato-rugose, the prosternum very feebly and broadly concave, coarsely, densely rugose, the fifth ventral moderately acuminate, rounded at tip, the latter with two small deep nicks separated by a quadrate ligula. Length 15.0 mm.; width 5.7 mm. Ontario (Sudbury).. **acerba** n. sp.

Sides of the prothorax more strongly though broadly constricted basally and broadly sinuate, the elytral tips more truncate.....10

10—Body moderate in size, dark subcupreous-brown to paler cupreous in color, always brighter beneath; head with some very coarse convex rugosities throughout, separated by densely crowded punctures, the

eyes moderate, rather convex; prothorax four-fifths wider than long, nearly as in the preceding but more narrowed and sinuate basally, the median parts tumid, broadly flattened, sparsely punctate, with a small deep punctured anterior impression and another which is gradually rather broadly inflated toward base; sculpture of the depressed lateral parts unusually coarsely, densely punctate; scutellum small, black, opaque, but little wider than long; elytra four-fifths longer than wide, rather evidently wider than the prothorax, the oblique sides posteriorly becoming obviously sinuate before the very briefly prolonged apices, which are obliquely truncate, with the outer angles only narrowly rounded; surface finely, very densely punctate, with rows of coarser punctures only evident suturally, where they are rather small though becoming very large along the callous spots, the latter numerous, strong and in large part transversely anastomosing; under surface (♀) rugose, the prosternum coarsely and rugosely punctured, broadly and rather deeply concave, the somewhat narrowly rounded apex of the fifth ventral having two minute and rather well separated nicks. Length 14.4 mm.; width 5.5 mm. New York (Lake George).

chrysea Mels.

A—Nearly similar in form, size and coloration, the head rather less coarsely but very irregularly punctured and rugose, more impressed along the median line, the eyes similar and generally rather prominent; prothorax and elytra nearly similar, the former sometimes nearly twice as wide as long and with an obvious deep median sulcus, which is evidently interrupted by a rounded callus, the elytral tips somewhat more prolonged, the sinuation of the sides toward them similarly very distinct; male with the axial groove of the under surface broad, deeply concave, densely sculptured and hairy, the femora also hairy beneath, the fifth ventral rectangularly emarginate, the middle tibiæ broadly, angularly dentate internally; female with the axial sulcus narrower, feebler, more coarsely and less densely sculptured and much less hairy, the fifth ventral nearly as in *chrysea*, the median tooth very variable in width. Length (♂, ♀) 13.8–16.7 mm.; width 5.0–6.0 mm. Lake Superior (south shore from Duluth to Whitefish Point). [= *tenebrosa* Lec. et Cr., nec Kirby].

bifoveata Lec.

B—Form nearly as in *bifoveata*, except that the eyes are relatively smaller and not at all prominent, the prothorax similar but with the sculpture of the depressed lateral parts much less coarse, very dense and more even, very nearly twice as wide as long; elytra similarly less than twice as long as wide but more inflated behind the middle, the sides behind more rapidly oblique, the apices less prolonged though similarly truncate at tip, the sinuation of the sides nearly as evident and the general sculpture of the surface finer, more shallow and still more confused; under surface (♀) nearly similar but with the nicks at the apex of the fifth ventral subobsolete. Length 14.7 mm.; width 5.5 mm. Michigan .....**mystica** n. subsp.

Body much larger and somewhat more parallel or with relatively larger

head and prothorax, obscurely bronzed, with black elevations, the under surface somewhat brighter bronze; head similarly confusedly compresso-rugose and impressed along the middle, the eyes well developed but only moderately convex; prothorax almost similar in form, with the interrupted sulcus as in *bifoveata*, the deep concavities and lateral callous areas nearly similar, the depressions rather more evenly punctate; scutellum small, opaque as usual; elytra scarcely wider than the prothorax and nearly twice as long as wide, the converging sides posteriorly becoming sinuate near the slightly prolonged apices, which are rather broader than in the preceding, arcuately truncate; surface with the series of coarse punctures more evident, though lost laterally, the callous polished spots equally or even more numerous but more irregular, the general surface decidedly more coarsely and confusedly rugose and uneven; under surface (♀) very coarsely rugose, the prosternum densely, very coarsely sculptured and nearly flat; metasternum broadly concave, the first ventral narrowly sulcate, obsoletely so posteriorly, the fifth ventral with the two deep notches more approximate than in the preceding species and subspecies. Length 17.0–19.0 mm.; width 6.25–6.9 mm. Colorado (Boulder Co.) to Montana.

montana n. sp.

11—Form narrower and more elongate than in the preceding species, rather convex, not more than feebly shining, dark coppery-red with black elevations above, brighter cupreous beneath; head coarsely, densely punctato-rugose, longitudinally impressed centrally, with two strong callous areas basally; eyes rather prominent; prothorax less transverse than in *bifoveata*, three-fourths wider than long, the sides prominent and rounded just before the middle, thence more converging and straighter to the apex and less converging and less sinuate basally than in that form, the surface similar but with the sculpture of the lateral depressions finer; elytra but slightly wider than the prothorax, fully twice as long as wide, very gradually and acutely attenuate posteriorly, the sides barely becoming at all sinuate, the apices truncate with rounded angles, the surface unusually finely, densely and evenly punctato-cribrate, the series of coarse punctures evident almost throughout, though deeper and more perforate suturally, the callous spots oblong, rather less numerous and not so strongly elevated; under surface (♀) nearly similar, the fifth ventral more acutely and gradually attenuated, with the apical notches approximate, the separating ligula narrow and parallel. Length 15.8 mm.; width 5.5 mm. Wisconsin (Bayfield),—H. F. Wickham..... **wickhami** n. sp.

12—Body moderately stout and convex, rather dull, black above, the elevations and almost the entire sutural region polished, the under surface more lustrous, rather bright cupreous throughout; head very coarsely, confusedly rugose, with a central and finely divided pit, the eyes rather small and scarcely at all prominent; prothorax four-fifths wider than long, nearly as in *bifoveata* in form and sculpture, except that instead of a median interrupted furrow, there is an anterior elongate and densely punctate pit, then a flat and sparsely punctate surface which is grad-

ually declivous posteriorly to the smaller transverse ante-scutellar cavity, the surface laterally strongly punctured and very uneven, with the outer smooth vittæ broadly interrupted by the usual large post-medial impressions; elytra but slightly wider than the prothorax, longer than in *bifoveata*, twice as long as wide, the sides similarly rapidly oblique in posterior third, becoming evidently sinuate near the broader and arcuato-truncate apices; general surface much more coarsely and unevenly punctato-rugose, the striæ rather impressed, visible throughout, coarsely punctured suturally, the elevations nearly similar, more coalescently diffused suturally, except behind the middle, the series on the sublateral interval posteriorly more than usually prominent and cariniform; under surface (♀) coarsely rugose, the prosternum broad, coarsely and rugosely sculptured, almost flat, with bluish-green lustre; metasternum deeply concave anteriorly; fifth ventral rather obtuse, the notches parallel-sided but unusually rounded, the ligula rounded at apex, parallel, the surface with more or less longitudinal rugosity and distinct indications of the usual two approximate medial ridges of preceding groups. Length 16.0 mm.; width 5.9 mm. Colorado..... **stolida** n. sp.

The synonymy in this group is almost hopelessly involved, owing to the brief and inadequate descriptions of the early authors, with wrongly quoted localities in several instances, leading thus to erroneous identifications on the part of LeConte and other subsequent writers. The trouble is accentuated by reason of the apparent rarity of many of the Atlantic coast species, so that my conclusions, as expressed above, were of necessity obtained by correlating information derived from a survey of the literature, with the assignments suggested in the Kerremans Catalogue and from a few of the published remarks of LeConte and Crotch. The species *dumolini*, *distinguenda* and *tuberculata*, of the table, are all unknown to me in nature and, in addition, much uncertainty has arisen from what appears to be an erroneous interpretation of *tenebrosa* by the authors just mentioned, who overlooked the facts, stated in the original description, that it is black and has a broad thoracic sulcus, the latter being a very important character in the present group and quite underestimated hitherto; but, at the same time, the head is said to be as in *divaricata*, that is, perhaps, without a transverse callous band; so we cannot make very positive statements concerning its identity. The name, as applied by those writers, refers to *chrysea* Mels., its subspecies and related species, forming the second section of the group, one of which was described by LeConte, under the name *bifoveata;* to this "olla-podrida" Crotch added what I hold to be the very dissimilar *crassicollis*,

having a transverse frontal callous band and broad thoracic sulcus but with the middle tibiæ of the male indeterminate, as the latter sex is unknown but apparently simple, since a California male was in all probability inadvertently named *californica* by Crotch, (Pr. Acad. Phil., 1873, p. 87). In any event *californica;* as a species, should be considered unpublished, as there is nothing written of it that could be termed a description, the only decisive character being its general stated resemblance to *tenebrosa*; but as several distinct species were confused by that author under the name *tenebrosa*, no one of which was in truth the Kirbyan species, we are unable to decide which form was alluded to in the comparison and the language is consequently ambiguous. I have assigned *californica* Cr., to *crassicollis* as a synonym and have omitted *sexualis* Cr. (l. c.) as the few words of the description do not admit of giving it a definite position among the others in the above table. Its rounded fifth ventral in the female shows that it is not in any way identical with the species described above as *crassicollis*, the abdominal apex there being distinctly tridentate, as mentioned by LeConte. My rather numerous examples of the latter all have the prothorax less transverse than stated by LeConte, and that author makes no allusion to the unusually elongate callous spots of the elytra, which are, however, noted by Crotch as a peculiarity of *sexualis*. It does not seem to be probable, in view of the localities of *crassicollis*, as mentioned by LeConte, that that species could be the same as the *montana*, of the above table, although the prothorax is shorter and relatively broader than in the form here identified as *crassicollis*.

Dumolini was described as coming from Senegal and *distinguenda* from the interior of Brazil, so that the failure of LeConte to identify them with our species was altogether pardonable, in the absence of sufficient familiarity with the general habitus of the fauna of those regions to betray to him their lack of harmony with their surroundings. I am by no means certain that *manca* Lec., is the same as *hilaris* but accept this disposition of it on the authority of Crotch; that *hilaris*, in any event, is the true *tuberculata*, of Laporte and Gory, seems to admit of very little doubt, on examining the originally published figure of the latter, and my description of *tuberculata* is taken from that of *hilaris* as given by LeConte. The latter author states that in *hilaris* and *manca*, the central thoracic callus "interrupts" the sulcus, but

the sexual characters are those of *lugubris* and some others having a broad uninterrupted sulcus.

It may be noted here that the only synonymy preserved in this paper is that referring to published species; the mere catalogue names of Melsheimer and Dejean are not given, on the ground that they ought not to be perpetuated.

Group VI—Type *americana* Hbst.

A small group resembling the preceding in the general form and rough sculpture of its members, and with the elytral apices similarly very slightly prolonged, but here the tips are deeply sinuate and bidenticulate, as in *obscura* and *pugionata*. The sexual characters of its two species differ as conspicuously as in the two sections of the *tenebrosa* group, indicating that the modifications of the intermediate tibiæ of the male in the second of the primary subdivisions of the genus is not so important as a group character as in the first. The two species may be described as follows:—

Body brassy-brown; head punctured, concave, with a transverse raised glabrous cranial line and two occipital callous spots, dull cupreous or brassy; prothorax rounded at the sides anteriorly, parallel posteriorly, unequal, roughly punctured, polished and punctate in the middle, with a vitta of three or four elevated polished black spots on each side between the middle and submargin, the vitta sometimes entire, and with a deep triangular impression in front of the scutellum, also a very shallow oblong impression behind the middle of the anterior margin, colored like the head; scutellum small, transversely linear; elytra striato-punctate, the punctures large and deeply impressed, the interstices finely chagrined, having also small and sparse sublinear polished black elevations; tips short, bidentate; under surface and legs dull cupreous, rugosely punctured, the pectus grooved, hairy; male with the middle tibiæ armed internally with a large tooth, the abdominal tip truncato-emarginate; fifth ventral of the female tridentate at tip, the middle tooth rounded apically. Length 16.0 mm.; width 6.0 mm. Pennsylvania and southward. [= *spreta* Lap.-Gory, *impressifrons* Mels. and *asperata* Lec. nec Lap.-Gory].....**americana** Hbst.

Body oblong-suboval, moderately convex, polished and sparsely pubescent, obscure æneous to viridi-æneous, bronzed beneath; head coarsely, very irregularly sculptured, impressed centrally before a transverse interocular line of callous areas, also with two approximate longitudinal occipital callous spots, the eyes only moderately convex; prothorax nearly twice as wide as long, the sides broadly rounded and moderately inflated, becoming not very converging and then parallel basally; surface very

unequal, the median line not or very feebly impressed but more distinctly so and densely punctate anteriorly and gradually more deeply to a broad pit basally, laterally very roughly, densely and coarsely punctate, with a sublateral callous vitta subinterrupted by a postmedian depression and with numerous irregular callosities along the side margins; elytra but little wider than the prothorax, twice as long as wide, parallel, the sides gradually rounding and oblique in scarcely more than apical third, becoming distinctly and rather abruptly sinuate at the apices, which are slightly prolonged, the tips deeply sinuate and acutely bispiculose; surface extremely rough and irregularly diversified with moderately coarsely and closely punctate depressed areas, large polished elevated anastomosing spots and larger serial punctures; along the side margins there are small oval areas of very dense white pubescence; under surface rugulose, not coarsely so on the abdomen, the axial line broadly smooth; male with the middle tibiæ unmodified, the prosternum narrowly and feebly impressed and punctured but not very pubescent along the middle, the metasternum flat, feebly, narrowly impressed along the median line, the fifth ventral rectangularly emarginate at apex, the notch with a short and very broad truncate lobe; female with a small sinus at the tip of the fifth ventral, from which projects a long slender truncate tooth, the surface of the segment with two vestigial and inconstant medial ridges. Length 13.0–15.8 mm.; width 4.6–5.8 mm. Massachusetts (Brookline), New York and Indiana. [=*asperata* Lap.-Gory, *molitor* Mels. and *spreta* Lec. nec Lap.-Gory].....**scobina** Chev.

The identification of *scobina* with *asperata* (Lap.-Gory nec Lec.), is given on the authority of the Kerremans Catalogue and that of *americana* Hbst., with *spreta* (Lap.-Gory nec Lec.) rests upon the conclusion of LeConte that, by the terms of its original description, it seems to resemble that species more than any other; but this surmise was marked as doubtful by that author. If it is not *spreta* it is most probably *chrysea* Mels., of the preceding group, but I have been unable to consult the original description, which, according to LeConte, is very ambiguous. At any rate some provision has to be made for it, as it was one of the first of our species to be made known in the literature of the subject and I adopt *spreta* as its synonym, because the weight of evidence seems to show that this disposition is most likely to be correct. The species is apparently rare and my description is compiled from those of Melsheimer and LeConte. *Scobina*, on the other hand, is rather abundant and my collection contains a good series. It seems to me unnecessary to propose two groups for these species, as suggested by LeConte, for they are apparently very much alike in everything but the male sexual characters. Crotch

gives no useful hints and does not even mention the names *scobina* and *americana* in his sketch of the genus.

Group VII—Type *pectorosa* Lec.

There is very little to be said at present concerning this group, as its single species is wholly unknown to me. The description given by LeConte may be stated as follows:—

Body blackish-æneous; prothorax more than twice as wide as long, the sides strongly dilated and rounded, briefly sinuate posteriorly, unequal, coarsely punctate, bicostate, the dorsal sulcus large; elytra rugose and densely punctate, the striæ foveately punctate, the alternate intervals with somewhat elevated smooth spaces, which are rather sparse, pronouncedly prolonged posteriorly and rounded at tip; under surface dark brassy, very coarsely punctured; prosternum with two smooth, strongly elevated costæ, the pectoral groove broad, deep and densely punctured; metasternum almost as strongly sulcate as the prosternum, sparsely punctured at the middle; first ventral broadly sulcate, sparsely punctured medially, the fifth with two narrow costæ, between which at the tip, is a very short and smaller one; the apex is truncate in the male and marked with four deep apical foveæ; middle tibiæ not modified in the male. Length 16.0 mm. Oregon..... **pectorosa** Lec.

Crotch gives no additional information concerning the unique male type of this species but places it, in his table, under the heading: "Apex of the elytra not produced, entire."

Group VIII—Type *mutica* Lec.

To this group also belongs a single species, represented thus far by a unique male specimen; it is described as follows:—

Form rather elongate, brassy-gray in color, the prothorax one-half wider than long, strongly narrowed before the middle and sinuate at the sides, strongly and, laterally, confluently punctate, dorsally canaliculate; elytra punctate, the internal striæ distinct, the intervals variegated with obscure spaces, the internal polished and sparsely punctate, posteriorly obliquely attenuate, not at all prolonged, the tips arcuately truncate; prosternum convex, sparsely punctate; metasternum and first ventral sulcate; male with the fifth ventral rectangularly emarginate, the notch with a short and broad, rectilinearly truncate tooth, the intermediate tibiæ straight and unmodified. Length 16.0 mm. New York (Brooklyn).....**mutica** Lec.

This species seems to have the general facies of *lurida*, in form and sculpture, but differs profoundly in its convex prosternum and entire elytral tips.

Pœcilonota Esch.

The species of this genus are much less numerous than those of *Dicerca* and present a distinctly different appearance, due to the more even and less convex surface, more regular and pronounced elytral striation and longer and more slender antennæ, especially noticeable in the joints following the second and differing in this way from *Lampra*, where the antennæ are very much as in *Dicerca*. The outer joints in *Pœcilonota* are, as in *Dicerca*, wholly devoid of dense punctures, but the sensory fossa is larger, oval and situated on the inner side of the apex of the serrature. In the present genus the median line of the pronotum is not impressed as in *Dicerca*, even near the apex, but is narrowly flattened, slightly elevated and abruptly impunctate; the scutellum is much larger, very transverse, strongly trapezoidal, with the hind angles more or less acutely prominent, the legs more slender and the basal joint of the hind tarsi more elongate. The elytral apices are generally rather abruptly, though briefly and narrowly, prolonged, the slender tips entire or sinuate and with denticulate angles, but this formation is far less constant within specific limits than in *Dicerca*, so that the nature of the elytral apices is not so trustworthy a criterion in the characterization of species, except when taken within rather wide limits. This plasticity in the form of the elytral tips is well illustrated by a specimen of *cupripes* before me, which, though a malformation, may have its origin partially in the general lack of stability of this part of the elytra. As a rule, the elytral tips of *cupripes* are simply rectilinearly truncate, but in the example alluded to the left elytron is normal, with its tip narrow and truncate, while the right elytron is abbreviated, not extending posteriorly as far as the left and has its tip broader, deeply and evenly sinuate and with acutely dentiform angles; this specimen is apparently not in the least abnormal otherwise.

One of the more pronounced characters distinguishing *Pœcilonota* from the general type form in *Dicerca*, resides in the prosternum, which in the former is broad and feebly, evenly convex as a rule, though depressed along the elevated side margins, and in this it resembles *Lampra*, but whether *Dicerca mutica* has a prosternum in any way similar or not, I am unable to state at present. The sexual characters are not very marked, the notch or sinus at the apex of the fifth ven-

tral usually being of similar nature in both sexes, and not medially dentate in either, but it is broader in the male in the majority of species, and the latter sex generally has the sterna more closely punctate and conspicuously pubescent. The known species may be outlined as follows:—

Abdominal apex deeply sinuato-emarginate in both sexes.....2

Abdominal apex deeply sinuate in the male, very feebly so in the female...4

Abdominal apex rounded.....5

2—Elytral apices very slender, evidently prolonged, the tips more or less sinuate and bidenticulate. Form narrowly oblong, more or less inflated posteriorly, obscure bronze above, with the elytra strongly and conspicuously cupreous at apex, the under surface cupreous, the legs bronzed with greenish-blue tarsi; head closely punctate, with large callous spaces medially toward base, the epistoma and labrum blue or green, the antennæ bluish; prothorax three-fifths wider than long, broadly rounded at the sides, gradually narrowed anteriorly, the apex subtruncate and evidently bisinuate; surface coarsely, closely punctured and rugose, with the smooth median line entire; scutellum cupreous, more or less impressed medially; elytra at base but little wider than the prothorax, though notably so behind the middle, the sides rounding and rapidly converging behind, becoming sinuate at the short and slender, somewhat divaricate apices; surface with impressed and closely punctured striæ, the intervals feebly convex, closely punctured and with irregular and black, smooth but not evidently more elevated spots; terminal notch of the abdomen (♀) but little wider than deep, the sterna sparsely punctate and subglabrous, the notch (♂) twice as wide but of the same depth, the sterna finely, closely punctate and with long conspicuous pubescence, the prosternum not so closely punctured as the metasternum, and broadly, feebly convex, though not by any means so strongly so as in the female. Length 11.4–15.2 mm.; width 4.0–5.7 mm. Canada, New York and (?) Texas.

erecta Lap.-Gory

Elytral apices not so slender, briefly prolonged, the tips bidentate. Body brassy-brown above; head slightly impressed, rugosely punctured; eyes yellowish-brown; prothorax equal, closely, rugosely punctured, the medial space glossy black, each side of which at the anterior margin there is a small black polished spot and a similar one at each side at the posterior margin; posterior angles right; scutellum transverse, concave; elytra punctato-striate with the first four striæ entire, the intervals rugosely punctured and with rows of oblong-quadrate glossy [black] spots, the lateral submargins transversely rugulose and with irregular elevated glossy spots and short lines; legs and under surface dull cupreous, rugosely punctured, the pectus [metasternum?] slightly canaliculate. Length 14.0 mm.; width 5.5 mm. Virginia. [=*Dicerca ferrea* Mels.]..... **ferrea** Mels.

Elytral apices entire, not sinuate or bidenticulate 3

3—Body elongate, parallel, but feebly inflated posteriorly, not very convex, obscure bronze, the apex but feebly cuprascent-red; under surface brighter bronzy-cupreous, the legs bronze, with the tarsi green-blue; head coarsely, confusedly punctato-rugose, broadly concave anteriorly, the median line basally elevated and with a fine median stria; antennæ deep greenish-blue; prothorax nearly twice as wide as long, widest behind the middle, the sides evenly rounded, becoming gradually very convergent and straighter anteriorly, the apex broadly, subevenly sinuate; surface coarsely, closely punctate, with very large irregular callous spots scattered throughout, the median smooth line slightly elevated and entire; elytra evidently wider than the prothorax and five times as long, more than twice as long as wide, the sides very gradually rounding and then rather rapidly converging in posterior two-fifths, becoming sinuate before the slightly prolonged and divaricate apices, the tips very much and rapidly narrowed from within by the separating notch and narrowly truncate; surface punctato-striate, the striæ obsolete laterally, the intervals punctate and with small irregular smooth black and very feebly elevated spots; under surface (♀) densely, rugosely punctate laterally, smooth and sparsely but strongly punctate medially, the prosternum convex between the lateral sulci, the fifth ventral with a small, evenly rounded sinus which is twice as wide as deep. Length 14.5 mm.; width 5.0 mm. Colorado; Missouri Valley,—Say. [=*Buprestis cyanipes* Say].....**cyanipes** Say

Body much less elongate, moderately convex, more blackish, with the smaller depressed areas gray-bronze above, the posterior extremity but faintly cuprascent and very near the tips only; under surface more shining, cupreous, the legs and tarsi bright bronze, the latter with a very faint greenish lustre except basally; head densely, rugosely punctate, with a large and deep rounded anterior depression, the median parts thence to the base strongly, broadly elevated, smooth and with a very coarse impressed median stria; antennæ obscure bronze; prothorax parallel, widest at the middle, the sides evenly and rather strongly arcuate, equally converging apically and basally, the apex feebly, subevenly sinuate; surface rather uneven, more or less impressed posteriorly near the sides, very coarsely, densely punctate and rugose, the median polished line sharply defined and entire; scutellum shorter, more transverse and less narrowed basally than usual, dull blackish; elytra obviously wider than the prothorax, but feebly inflated posteriorly, twice as long as wide, the sides gradually rounding and converging posteriorly, becoming only feebly sinuate near the apices, which are scarcely at all prolonged and but little narrowed by the very small separating notch, the tips rather broad and truncate; surface much more rugose than usual, the strial intervals more convex and prominent, the black polished elevated spots much more extensive than the small and depressed bronze spots, which are rather coarsely punctate; under surface (♂) rugulose laterally, the median parts pubescent, the prosternum broad, rather closely punctate throughout and flat, the metasternum impressed along the middle, the fifth ventral with a large abrupt sinus

between the acute apices twice as wide as deep. Length 12.6–14.0 mm.; width 4.7–5.2 mm. Wisconsin (Bayfield),—H. F. Wickham.
eupripes n. sp.

Body larger and stouter, moderately convex, much inflated posteriorly, dull cupreous and black above, with the apices a little more cupreous, the under surface obscure purplish-bronze, the legs cupreous, the tarsi subcupreous with strong blue-green metallic lustre which is fainter basally; head very small, densely, rugosely punctate, with a moderate and rather indefinite anterior concavity, the callous basal median parts low and only extremely finely striate along the middle; antennæ bluish-bronze; prothorax much more than twice as wide as the head, fully twice as wide as long, widest scarcely behind the middle, the sides rounded, gradually strongly converging anteriorly, the apex bisinuate, the angles anteriorly prominent; surface coarsely and unevenly punctato-rugose, strongly impressed just behind the middle near each side, the polished median line entire; scutellum cupreous, strongly trapezoidal as usual, impressed medially; elytra wider than the prothorax, the sides posteriorly rapidly converging from the rounded post-median inflation, becoming only very feebly sinuate for a short distance before the apices, which are barely at all prolonged, the tips narrowly truncate and with rounded external angles; surface strongly, very irregularly punctate, with rather fine striæ, the intervals feebly convex, with oblong polished black spots which are much confused as a rule; under surface (♀) rugose laterally and smooth and sparsely punctured medially as usual, the prosternum convex and almost impunctate between the sulci, the fifth ventral with a small deep rounded notch. Length 16.0 mm.; width 5.9–6.2 mm. New Mexico..... **parvieeps** n. sp.

4—Form oblong, stouter than in the preceding species, dark bronzy-cupreous above, the posterior extremity without the faintest tendency to become cupreous, the under surface and legs brighter bronze, the tarsi very dark metallic green-blue to indigo-black; head less coarsely and more evenly, densely punctato-rugulose, broadly concave anteriorly, the median callous part at base with a strong though fine stria; antennæ blue-blackish; prothorax two-thirds wider than long, the sides obtusely subangulate at or just behind the middle, parallel thence to the base and strongly converging and straighter to the apex, which is broadly sinuate; surface coarsely, densely and more evenly punctate, with a broad and uneven sublateral callous vitta and a very irregular callous area medially near each side, the median smooth line distinct, entire; scutellum trapezoidal, metallic, impressed medially; elytra scarcely twice as long as wide, slightly inflated post-medially, the sides there rounding, becoming oblique, then feebly sinuate to the apices, which are not evidently prolonged, the tips rather broad, sinuato-truncate, with rather acute angles; surface with the striæ fine and closely, finely punctate, scarcely impressed, the intervals flat, closely punctate, coarsely and transversely, subconfluently so laterally, the black callous spots numerous but small and very irregular; under surface (♀) rugose laterally, broadly smooth medially, the prosternum very broad,

gently, evenly convex, with sparse though distinct punctures, the fifth ventral with the somewhat narrow tip very feebly sinuato-truncate. Length 14.5–18.0 mm.; width 5.6–6.9 mm. Kansas. [=*Buprestis costicollis* Lap.-Gory] ..... **thureura** Say

5—Form nearly similar to the preceding, the size very much smaller, cupreo-æneous; prothorax subtransverse, narrowed from the base anteriorly, the sides broadly rounded, the surface roughly punctate, the median vitta rather wide, smooth, with another not very distinct at each side; elytra striate, in general densely punctured, variegated with obscure smooth spots, the apices truncate and slightly bidenticulate; abdomen (♀) with the fifth ventral entire and rounded at apex, the prosternum subglabrous. Length 12.0 mm. Maryland (Baltimore) .. **debilis** Lec.

There has been a tendency among various recent authors to suppress both *erecta* and *debilis*, but I do not hold this to be justifiable; the former is the widely diffused eastern form, with brilliantly cupreous apex of the elytra and blue tarsi, usually identified in cabinets as *cyanipes*, which however is a very different and far western species, probably rather rare in collections.

Anataxis n. gen.

Although the prosternum in this genus is almost exactly as in *Pœcilonota*,—broadly convex between the narrow lateral sulci,—both the metasternum and first ventral are broadly and evenly convex, and, that we have here a remarkably isolated type, not at all closely related to anything that precedes, is amply shown in addition by the transversely parallel hind coxæ, parallel inner margins of the eyes and by the antennal structure. The body is cuneiform, convex and not unlike *Acmæodera* in general outline, the evenly convex front feebly impressed medially, the epistoma depressed and sinuato-truncate, the labrum short, sinuate and closely, stiffly pubescent, the mentum transverse, corneous, metallic and medially produced in a narrowly rounded prominence at apex and the maxillary palpi slender and moderate in length. The antennæ are short, compact, somewhat as in *Dicerca* but with the third joint longer than the second or fourth, the outer joints transversely and obtusely serriform, their outer sides smooth but having each a very large oval sensory intero-apical fossa, and another, smaller and transversely oval, near the base of the joint, with a number of coarse sensitive punctures between; they are inserted in small and widely separated foveæ, which have their upper margins slightly prominent. The prothorax is evenly convex, excepting a feeble

impression along the middle near the base, the scutellum small, slightly transverse, flat and rounded behind, the elytra cribrate and with some fine and only slightly apparent, somewhat more convex punctureless lines, the sides posteriorly serrulate, the tips not at all prolonged, rather narrowly rounding to the suture and serrulate. The legs are short and slender, the hind tarsi short, slender, with the basal joint but slightly elongate and the first ventral suture is straight and very fine, almost obliterated in the middle.

It is of course within the most evident possibility, that in placing *Anataxis* here, the genus may be unwarrantably removed from some of the preceding genera, with which it may in reality and despite its very different appearance be more closely related. This surmise occurs on considering the actual outline of the compact outer antennal joints, the latter having a feebly defined truncature of the lower edge, which posteriorly thereto converges much more rapidly to the base, in conjunction with the complex system of sensory fossæ, which might suggest that it be placed in closer proximity to *Psiloptera*. In considering the figure of *Anthaxia gigas*, the type of *Agœocera* Wat., as given by Laporte and Gory, it is observed to differ in several external characters, such as the four pronounced costæ of each elytron, the triple longitudinal impression of the pronotum and the apparent absence of serrulation of the postero-lateral margins of the elytra. Making due allowance for inaccuracy of drawing, it seems to me probable that these marked external incongruities betoken other differences in the organs of the head and structure of the under surface, which I am unable to express at present, but which may be even more significant. The single species of *Anataxis* may be described as follows:—

Body moderately slender, convex, rather shining, bright green in color throughout, the under surface more polished and partially cuprascent, glabrous; head rather finely, closely and evenly punctate, the eyes well developed but not prominent, the antennæ but little longer than the head, black with feeble greenish lustre; prothorax two-thirds wider than long, the sides broadly, evenly rounding and converging anteriorly, becoming very gradually parallel basally, the base broadly bisinuate, the apex very obsoletely bisinuately truncate; surface rather finely but strongly, loosely punctate, gradually more coarsely, densely so laterally, even, the feeble impression behind the centre ending, at some distance before the middle of the base, in a small punctiform fovea, the bottom of the impression finely striiform near the puncture;

elytra at base as wide as the thoracic base to somewhat narrower, between three and four times as long as the prothorax, the sides straight and scarcely visibly converging to apical two-fifths, there very gradually rounding and arcuately converging to the very narrow stronger arcuation extending to the sutural angles; surface irregularly but subequally cribrate, with rather small and deep punctures, nearly wanting in two broader, feebly convex lines on each near the suture, dense laterally, the submarginal prominent ridge rather evident; under surface finely, more feebly punctate, rather closely so laterally, the surface smooth and convex, the fifth ventral transversely truncate at the rather narrow apex, with the ends of the truncature minutely dentiform, the edge impunctate to a fine transverse striiform parallel line a short distance therefrom, apparently not differing noticeably in the two sexes. Length 9.0–12.2 mm.; width 3.0–4.3 mm. Texas (El Paso). [=*Halecia gentilis* Horn and *Agœocera gentilis* Waterh.]..... **gentilis** Horn

The male is smaller and narrower than the female, if I have properly identified the sexes, but does not differ otherwise, except in having the prothorax more parallel and less narrowed anteriorly. The single male before me has a small irregular depression at each side of the median line near anterior fourth, but these impressions are probably adventitious.

Nanularia n. gen.

This genus and the two following form a group, altogether distinct from any of those that precede in having the mesosternum separated from the metasternum by a deep cleft; there is, however, little or no harmony between these three genera in other structural characters, and I am unable at present to assign a definite value to the character as a means of dividing the entire family into lesser subdivisions. The body in *Nanularia* is small, convex and deep, not unlike *Anataxis* in this respect, as well as in sculpture, except that the outline is parallel and not cuneate. The head is relatively large and but little narrower than the prothorax, the front even, but with a narrowly impressed and subentire median line, the eyes moderate, with their inner margins converging upward though very feebly, the epistoma not depressed, broadly, feebly sinuate, the labrum short, subcoriaceous, feebly sinuate, sparsely punctate and with short stiff sparse hairs, the mentum short, very transverse and very broadly, parabolically rounded, the palpi rather slender. The antennæ are inserted in small and widely separated foveæ, each margined above by a small inconspicuous oblique ridge, the ridges tending however to join each

other transversely, especially in the male; in the female there is only a small median part of the transverse ridge visible; they are short and compact but not very stout, the third joint elongate, the outer joints including the fourth, serriform but unusually convex and not much compressed, with their lower margins obliquely though somewhat vaguely and narrowly truncate, then very rapidly converging to the base, their inferior surface entirely opaque from very dense punctuation and each with a distinct circular sensory fossa on the oblique apical surface, though more visible from within; the last joint in both sexes is strongly and narrowly prolonged on the inner side, forming a narrow process nearly as in *Gyascutus*. The pronotum is almost even, the scutellum small but distinct, rounded and medially foveate, the elytra cribrate, imperfectly and very finely striate, not distinctly serrate at the sides and with the apices not at all prolonged and narrowly truncate. The under surface is strongly convex, the prosternum narrow, feebly convex, not sulcate at each side and densely sculptured throughout, the first ventral suture perfectly rectilinear, fine but rather distinct, the first segment not free, the last narrowly and evenly rounded at tip, more broadly in the male. The legs are short and slender, the hind tarsi three-fourths as long as the tibiæ, slender, with the basal joint but slightly elongate, although nearly as long as the next two combined. The single type known to me may be described as follows:—

Body parallel, subcylindric, scarcely shining, obscure cupreous to blackish-brown, the female subglabrous, the male with short though rather numerous hairs beneath and on the head, the latter evenly and deeply, rather densely cribrate, more rugose in the male, the antennæ about a third longer than the head; prothorax a third wider than long, subparallel, the sides feebly rounded anteriorly, becoming very broadly, feebly sinuate posteriorly, the apex but little narrower than the base, broadly and evenly arcuato-truncate, the base broadly, transversely lobed medially, sinuate laterally, the surface gradually very deeply declivious laterally, somewhat coarsely, deeply and closely cribrate throughout, very feebly impressed subapically along the median line, the entire posterior dorsal part of the surface very feebly impressed, so that the margin at the median lobe is turned slightly upward and is less punctate, sometimes also having a small sinus at the scutellum; elytra but barely wider than the prothorax and about three times as long, the sides parallel to apical third, there broadly rounding and gradually arcuately converging to the apical truncature, which is wider in the female; surface subevenly and closely cribrate, the punctures not as large as those of the pronotum, also having fine and unimpressed

striæ arranged in pairs and more or less evident throughout the width; under surface rather finely but deeply, closely cribrate, the abdomen very finely punctate, sloping upward posteriorly. Length 7.9–9.8 mm.; width 2.5–3.1 mm. California (San Diego Co.,—Poway).
cupreofusca n. sp.

The following species is provisionally included:—

Form oblong, subcylindric, gradually narrowed posteriorly, color bronze with slight æneo-cupreous lustre; front slightly convex, densely and coarsely punctured; epistoma broadly emarginate, the antennal ridges short; antennæ shorter than the head and prothorax, serrate, the terminal joint obtuse at tip; prothorax slightly broader than long, cylindric, the sides slightly arcuate in front, feebly sinuate at basal half, which is subacutely margined, the hind angles subacute posteriorly; apex truncate, the base bisinuate and at middle subtruncate; surface moderately convex, coarsely and deeply but not densely punctate; scutellum semicircular, nearly smooth; elytra subcylindric, parallel, gradually narrowed at apical third, the margin near the apex finely serrate, the apex obtuse; surface densely punctate and with traces of striæ at the sides and apex; under surface coarsely but not densely punctured and with a few short cinereous hairs; posterior tarsi with the first joint feebly compressed and not greatly longer than the second. Length 9.0–12.0 mm. California (San Joaquin Valley). [=*Gyascutus californicus* Horn]..... **californica** Horn

Among the remarks following the description of *californica*, Dr. Horn states, in referring to the species of *Gyascutus*, that "traces of a false joint at the end of the eleventh occur in the antennæ, excepting in *californicus* and *sphenicus*, in which the eleventh joint is simply obtuse as in *Psiloptera*." The form of the eleventh joint in *californica* must therefore depart very radically from that characterizing *cupreofusca*, and the allusion to an obtuse eleventh joint in *sphenicus* (*Hippomelas*) refers, as I have stated under that genus, to the male alone.

Cinyra Lap.-Gory.

The type of this genus is stated, in the preceding table of genera, to be the Brazilian *Buprestis elongata*, of Laporte and Gory, but the diagnosis there given is drawn from our small aberrant *Dicerca gracilipes*, of Melsheimer, or more accurately from a very similar species described below under the name *macilenta*, and the corresponding characters of *elongata* are unknown to me. So there is a possibility, which amounts almost to a certainty, when we consider the very different style of sculpture of *gracilipes*, that the latter may constitute a different genus from the true *Cinyra*, where it was first placed by LeConte;

in the Kerremans Catalogue it appears under the genus *Halecia*. I will therefore assign our species to the following subgenus of *Cinyra*:—

Body slender, the elytra roughly and unevenly sculptured, having large, indefinitely limited and feebly depressed areolæ of finer closer punctuation, the sides posteriorly without trace of serrulation and perfectly even; posterior tarsi with the pads of the first three joints small and depending vertically from the under part of the extreme apices of the joints, the fourth gradually oblique and lamellate under the fifth, impressed along the median part of the surface and evenly sinuato-truncate at tip. [Type *Dicerca gracilipes* Mels.]. **Spectralia** n. subgen.

The type is rather rare and I have in my collection but a single example of the subgenus, which however comes so far from satisfying the original diagnosis of Melsheimer, that it seems necessary to regard it as a different though closely allied species, of which the description appended below is made unusually complete, in order to bring out possible generic as well as specific characters. The head is as wide as the thoracic apex, vertical, the front flat, the epistoma not depressed, deeply and parabolically sinuate at apex, the labrum corneous, sinuate and with an abrupt pale coriaceous margin at apex, the mentum short, wholly corneous and roughly sculptured, truncate and trapezoidal, the palpi slender, the eyes with their inner margins evidently converging upward. The antennæ are somewhat as in *Buprestis* though still more slender and elongate, inserted in small and widely separated foramina, which are concealed from above by the sharply defined and somewhat prominent though porrect frontal margins above them. The prosternum is moderately wide, flat or very feebly convex, having throughout a very fine marginal bead; it is abruptly and obliquely narrowed posteriorly to a rather narrow apex, which does not quite attain the rounded apex of the metasternum in the wide cleft between the lobes of the mesosternum. The first ventral segment is fully as long as the next two combined, with the suture fine but distinct and rectilinear. The descriptions follow:—

Form slender, subcylindric, dark brassy-brown above; head bright cupreous, roughly chagrined, with a transverse arcuate glossy line between the eyes, which are black-brown; prothorax transverse, with the sides rectilinear, the apex truncate and the base bisinuate; surface with an obvious entire furrow, rugosely punctate; scutellum obtuse, triangular; elytra faintly striate, with about four or five longitudinal raised lines, the interstices rugose, punctulate; surface with a distinct cupreous impressed spot a little before the middle and an obsolete double one

behind the middle; sides parallel from the base to the apical curve, the sides posteriorly not serrate, the tips much narrowed, feebly bidentate; feet and under surface bright cupreous, rugosely punctate; tibiæ long, slender; venter almost rounded at tip; pectus feebly canaliculate. Length 10.0 mm.; width 3.5 mm. Pennsylvania. [=*Dicerca gracilipes* Mels.] ..... **gracilipes** Mels.

Form slender, moderately convex, fusoid, above slightly shining, blackish with feeble cupreous reflections, except the elytral foveolæ which are greenish, beneath more cupreous and less glabrous, each puncture having a small decumbent hair; head nearly as wide as the thoracic apex, obscure in color, the front flat, rather finely, densely, almost uniformly punctato-rugulose and evidently pubescent, without trace of transverse callus but with the median line slightly elevated and smooth near the centre; antennæ piceous, with slight cupreous lustre except apically, very slender, extending somewhat beyond the thoracic base; eyes well developed, rather convex and prominent; epistoma cupreous, the sinus small, deep, parabolic; prothorax widest at base, nearly one-half wider than long, feebly trapezoidal, the sides very feebly arcuate, becoming straight basally, the angles not at all everted; apex broadly sinuate, the base arcuate, becoming feebly sinuate near the sides; surface strongly, rather sparsely and subevenly punctate medially, with a deep entire median sulcus which is broadly impressed posteriorly, becoming more acute anteriorly, and another, near each side, very feeble anteriorly but becoming deep at base, concave and densely punctate and bounded externally by a tumid and less punctured ridge, which is obsolescent anteriorly; scutellum small, flat, opaque, blackish; elytra but little wider than the prothorax and about four times as long, separated along the inner sides in the type from basal fifth to the apex; sides parallel and nearly straight for three-fifths, then very gradually rounded and convergent, even and without trace of serrulation to the narrowly transverse sinuato-truncate apices, which are feebly bispiculose; surface with rather coarse, uneven interrupted striæ, except laterally, with the narrow intervals alternately a little more prominent, strongly so apically, very unevenly but closely, rather coarsely punctate and rugulose, more sparsely and coarsely on the general surface but more densely and finely in the shallow and very uneven vague depressions, of which there is one very large and obliquely transverse before the middle and some smaller from the middle to the apex, the small punctate patches well separated along the smoother sutural intervals much as in *Dicerca;* prosternum perfectly flat, transversely truncate anteriorly, rather coarsely, closely and evenly punctured throughout; entire metasternum equally densely and uniformly but less coarsely punctate, the abdomen much more sparsely, especially toward the middle, and more polished and rather narrowly sinuato-truncate apically in the type; legs long, very slender, the basal joint of the hind tarsi as long as the last three combined. Length 10.5 mm.; width 3.2 mm. Texas. **macllenta** n. sp.

The description of *gracilipes* is drawn directly from the originally

published characters. It is stated by LeConte that the anterior tibiæ of the male are serrate within; in the type of *macilenta* the anterior tibiæ are almost straight, with the inner margin very finely spiculoserrate throughout the length; the middle tibiæ are longer, feebly arcuate and also finely and closely but less evidently spiculose throughout the length. The hind coxæ are rapidly dilated inwardly as usual.

Mr. Chas. Schaeffer has lately (Journ. N. Y. Ent. Soc., 1904, p. 205) described a *Cinyra prosternalis* from Texas, and, still more recently, *Cinyra purpurascens*, from Lower California (Bull. Br. Inst., I, p. 127, 1905). Without being able to decide upon the proper systematic position of these species, it may be safely stated that neither of them can be assigned to *Spectralia*, the first differing in its feebly and apparently more broadly sinuate epistoma, obsolescent thoracic sulcus and very different elytral sculpture, and the latter because of its very short elytra, absence of thoracic sulcus, shorter hind tarsi, differently sculptured abdomen and many other important characters. The antennæ in neither of these species is so described as to afford a clue as to whether they belong in this vicinity, or are more closely allied to *Anataxis* or *Nanularia*. It is probable that they are not properly assignable to *Cinyra*, even in its broadest sense.

Trachykele Mars.

The species of this genus recently formed the subject of a review by Mr. H. C. Fall (Ent. News, 1906, p. 160), in which the characters of the four known species were given in considerable detail, but no mention was made of the generic characters, nor was any opinion advanced as to the relationships of the genus or its proper position in the family. The separation of the meso- and metasterna by a cleft-like suture, is apparently quite unusual in this family and present only in *Nanularia*, *Cinyra* and *Trachykele*, of those genera discussed in the present paper, but, because of my insufficient knowledge of exotic types, I am unable to put forward any useful suggestions as to the relative significance of this character in a general analysis of the family. In any event, however, it clearly isolates these three genera from those above them in the table given at the beginning of this paper, and there seems to be, besides, a pronounced tendency in them toward a more mobile connection between the first and second abdominal segments, this feature being especially pronounced in *Trachykele*,

where the first segment appears to be virtually free, the first suture not differing to external view from the others.

The species are extremely rare in collections but, in greater likelihood than actual rarity, perhaps, they may be abundant only at certain very short periods of the year or in relatively few limited localities, like *Buprestis confluenta* and some others of this family, and as also frequently noted in the Cerambycidæ. The genus was consequently wholly unknown to me in nature, until Prof. Wickham very kindly lent me the only example that he had secured during many years of skillful collecting. This specimen has served as the type of the diagnosis given in the table of genera on p. 53; it appears to satisfy the general characters of *opulenta* Fall, which is closely allied to *blondeli* Mars., the true type of *Trachykele*, and was taken at Nanaimo, Vancouver Island. It is glabrous, very densely and rather finely cribrate and bright green throughout, the elytra with a few small and irregular black spots. These spots are observed under higher power of amplification to be due, not to pubescence, but to actual blackness of the integument, accompanied by a strong granulato-reticulation of the surface, which gives them their velvety appearance.

PROCEEDINGS

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. XI, No. 3, PP. 179–238 August 14, 1909*

THE STRATIGRAPHIC RELATIONS AND PALEONTOLOGY OF THE "HELL CREEK BEDS," "CERATOPS BEDS" AND EQUIVALENTS, AND THEIR REFERENCE TO THE FORT UNION FORMATION.[1]

BY F. H. KNOWLTON.

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*Author's separates of this paper were distributed June 25, 1909.

[1] Published with the permission of the Director of the U. S. Geological Survey.

This paper was read before the National Academy of Sciences on April 22, 1909, under the title: "Stratigraphic relations and Paleontology of the lower member of the Fort Union Formation," the title finally selected having been decided upon too late for printing in the Programme of the Academy meetings.

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Introduction.

Problem and conclusion.

The present paper deals with the extensive series of fresh-water deposits of the northwest (*i. e.*, broadly, the region east of the Rocky Mountains and between Wyoming and the valley of the Mackenzie River) comprising what is here considered as the Fort Union formation. It is shown that the Fort Union embraces more than has been commonly assigned to it. Conformably below the beds by some geologists considered as the true Fort Union occur dark-colored sandstones, clays and shales, which have often been incorrectly referred to the Laramie, or its equivalent, but which are stratigraphically and paleontologically distinct from the Laramie, and the contention is here made that these beds, which include the "Hell Creek

beds"[2] and so-called "somber beds" of Montana, the "Ceratops beds" or "Lance Creek beds" of Wyoming, and their stratigraphic and paleontologic equivalents elsewhere, are to be regarded as constituting the lower member of the Fort Union formation, and are Eocene in age.

Historical Summary.

To all students of the late Cretaceous and early Tertiary formations of the northwest, the Fort Union formation is a familiar term. The name was originally given by Dr. F. V. Hayden[3] in 1861 to his great lignite group which: "Occupies the whole country around Fort Union, extending north into the British possessions, to unknown distances; also southward to Fort Clark." At the same time it was stated that the formation had also been observed under the White River group on the North Platte River above Fort Laramie, and on the west side of the Wind River Mountains. The beds were described as consisting of clays and sands, with round ferruginous concretions, and numerous beds, seams and local deposits of lignite. The fossil contents were very abundant, consisting of great numbers of dicotyledonous leaves, fresh-water shells of several genera, scales of *Lepisosteus*, together with bones of *Trionyx*, *Emys*, *Compsemys*, crocodiles, etc. The abundant fossil plants obtained by Doctor Hayden were submitted to Dr. J. S. Newberry for study, and his report on them was published in 1868.[4] The plants were collected at various points on the Missouri River, at Fort Clarke, at Red Spring thirteen miles above, at Fort Berthold, at Crow Hills, one hundred miles below Fort Union, at the mouth of the Yellowstone, on O'Fallon's Creek one hundred miles above the mouth of the Yellowstone, and in the valley of that stream. On account of their association with invertebrates reported by Professor Meek to be of Miocene age, as well as from their agreement with plants stated by

[2] In this paper the terms "Hell Creek beds," "Ceratops beds," "Lance Creek beds," "Somber beds," "Upper Laramie" and "Black Buttes beds" are placed within double quotation marks because these terms have not been formally adopted by the U. S. Geological Survey. In other cases, *e. g.*, 'Fox Hills,' 'Laramie' etc., single quotation marks are used only when the beds are not regarded by the writer as properly identified.

[3] Proc. Acad. Sci. Phila., 1861, p. 433.

[4] Ann. N. Y. Lyc., vol. 9, April, 1868, pp. 27–76.

Heer to be of this age from the mouth of the Mackenzie River, in Greenland, Spitzbergen, and various European localities, Doctor Newberry was led to refer them to the Miocene. Subsequent events have shown, however, that the position assigned the above mentioned beds by Heer was too high, and as a consequence it has come to be recognized that the Fort Union beds are beyond question of Eocene age. This result, however, was not reached without much diversity of opinion and conflict of authority.

It is largely to the efforts of Dr. J. S. Newberry that we are indebted for keeping alive the question of the distinctness of the Fort Union from the typical Laramie. From the beginning of his studies of the Fort Union flora, until his latest utterance on the subject, he insisted upon their separation. His last words concerning it are as follows:[5]

> Whether the Laramie is Cretaceous and the Fort Union Tertiary are other questions, but they are certainly distinct from each other, distinct in the general botanical facies of their floras as well as in the absence of common species. That the Fort Union flora is Tertiary there can be no reasonable doubt; it has many species in common with the recognized Tertiary in the Canadian provinces of North America, in Greenland, and in the British Islands, and it contains some plants which are living at the present day. . . . Moreover, the grouping of the plants comprising it gives it a facies which enables one to recognize it at a glance. The abundance of species of *Populus*, *Viburnum*, and *Corylus*, imparts to it an aspect as different from that of the flora of the Laramie as are the recent floras of Europe and America from each other.

That it is of Tertiary age is no longer seriously questioned.

Areal Distribution and Lithologic Character of Fort Union Formation.

The Fort Union formation, as now known, covers a vast area in the central Canadian provinces and, as predicted by Doctor Hayden, touches the Arctic Ocean in the valley of the Mackenzie River, while to the southward it is the surface formation over much of the western

[5] Trans. N. Y. Acad. Sci., vol. 9, 1889, pp. 30, 31.

half of North Dakota, eastern Montana as far west as the Bridger Range, western South Dakota, eastern and central Wyoming, and northwestern Colorado. It is a fresh-water formation, consisting of comparatively fine material, mainly clay shale, sands and soft sandstones, with numerous beds of lignite and occasional thin beds of impure limestone. Owing to the many alternations of soft rocks with thin hard layers extensive erosion has given rise to the well-known bad-land topography so characteristic of much of the area covered by the formation in Montana, North Dakota and Wyoming. The maximum thickness of the Fort Union exceeds 8000 feet. It rests, sometimes in apparent conformity and in other cases with unconformity, on various underlying formations. The relationship with lower beds will be discussed later.

Division of Fort Union Formation into Two Members.

In many cases—notably in the vicinity of Hell Creek, along the Yellowstone River at Miles City and Glendive, Montana, adjacent southwestern North Dakota, and east of the Bighorn Mountains in Wyoming—it is possible to separate the Fort Union into two members on the ground of a marked difference in lithologic character. The upper member is composed in the main of light-colored, yellowish sandstones and clays, while the lower member is made up of many alternating beds of clay shale and sandstone of a dark gray or somber hue, whence, as a convenient field term, they have often been designated the "somber beds." The contact of the lower and upper members is so sharp, and the contrast in coloration so marked, that they may usually be recognized at a distance and traced with little difficulty. In certain parts of the area a thick bed of coal, or a bed of red baked clay due to the burning out of the coal, marks the point of contact. The present paper deals only with the stratigraphic relations and paleontology of the lower member.

The dark gray so-called "somber beds" of eastern Montana naturally attracted the attention of those who visited this region. From their stratigraphic position and the sharp lithologic contrast between them and the overlying beds, they were presumed to belong to the Laramie, but recently secured paleobotanical and stratigraphic data shows that they have little or no relation to the Laramie,

and must be considered as the lower member of the Fort Union. So far as known to the writer the Laramie is not present in this general region.

Areal Distribution and Paleontologic Contents of Lower Member of Fort Union Formation.

1. Hell Creek, Montana.

In 1907 Mr. Barnum Brown[6] published a valuable contribution on the geology of the Hell Creek region of northeastern Montana. To the beds in this area which contain a rich dinosaur fauna he gave the name Hell Creek beds, and also stated that:

> These beds are exposed on the Yellowstone River at Sentinel [Castle?] Butte near Forsyth; at Glendive; near Eklaka; and at Hockett P. O., south of the Yellowstone. They are probably continuous with the dinosaur-bearing beds of the Little Missouri, and of the Grand and Moreau Rivers.

The "Hell Creek beds," which are between 300 and 400 feet in thickness, are stated by Brown to rest unconformably on the Fox Hills, and are composed of two members, a basal massive sandstone, and an upper member of alternating dark arenaceous clays, carbonaceous shales and sandstones. Overlying the dinosaur clays, and forming an "uninterrupted continuation" of them, are the so-called lignite beds 100 feet in thickness which are characterized by the presence of numerous beds of coal; they are referred by Brown with question to the Fort Union. Above the lignite beds without apparent break are the light-yellow sandstones and clays of the "identified Fort Union." At several points in the "Hell Creek beds," but particularly in the massive basal sandstone, Brown records the presence of numerous concretions which are sometimes of very irregular shape, but often resemble huge tree-trunks. It is perhaps noteworthy that similar concretions occur in approximately the same stratigraphic position at widely scattered localities within this lower member of the Fort Union, as at Forsyth, Miles City, near Glendive, Montana,

[6] Bull. Am. Mus. Nat. Hist., vol. 23, 1907, pp. 823–845.

between the Grand and Moreau Rivers, South Dakota[7] and Converse County, Wyoming.

The fauna of the "Hell Creek beds" is a comparatively rich one, comprising a few mammals, numerous dinosaurs belonging to the families Ceratopsidæ, Trachodontidæ, etc., together with crocodileans, turtles, scales and vertebræ of fishes, and some thirty species of invertebrates, mainly Unios. On the basis of the identity of many genera and species of both vertebrates and invertebrates, as well as on the striking lithologic similarity, the "Hell Creek beds" of Montana are correlated by Brown with the "Ceratops beds" of Converse County, Wyoming, a correlation confirmed by Hatcher and Lull in the recently published monograph of the Ceratopsia.[8]

Up to the time of the publication of Brown's paper (1907), but few fossil plants had been found in the "Hell Creek beds," and these in only the upper member. Dr. Arthur Hollick, to whom they were submitted, identified *Equisetum lævigatum* Lesq., *Rhamnus salicifolius* Lesq., *Ficus spectabilis* Lesq., *Pterospermites* sp., *Sequoia heerii* Lesq., and a mass of seeds resembling *Sabalites fructifer* Lesq. To these I was able to add a peculiar undescribed *Ficus* fruit, which has also been found in Converse County and at Forsyth. In the past season, however, Mr. Brown was fortunate in securing a fine collection of leaves in direct association with the skeleton of a dinosaur. This collection, which he has kindly permitted me to study, embraces the following species:

Big Dry Creek, 60 miles south of Glasgow, Montana. Clays between middle and basal sandstones and in association with skeleton of a dinosaur.

Sequoia nordenskiöldi Heer.
Taxodium occidentale Newb.
Ginkgo adiantoides (Ung.) Heer.
Populus cuneata Newb.
Populus amblyrhyncha Ward.
Quercus sp. (Same as at Glendive.)
Ficus artocarpoides Lesq.
Sapindus affinis Newb.

East side of Big Muddy Creek, 28 miles south of Lisner, Montana. 250 feet above Fox Hills.

Sequoia heerii Lesq.

[7] Todd, Am. Geol., vol. 17, 1896, pp. 347–349.
[8] Mon. U. S. Geol. Surv., No. 49, 1907, p. 184.

Ficus sp. (Same as found at Forsyth, Montana, and Ceratops beds of Converse County.)
Viburnum antiquum (Newb.) Hollick.

2. MILES CITY, MONTANA AND VICINITY.

In 1907 Messrs. A. J. Collier and C. D. Smith, while engaged in coal classification work, surveyed about 1000 square miles of country comprising the so-called Miles City, Montana, coal field. With the exception of some unimportant alluvial deposits in the valleys, all the rocks of the region were found to belong to the Fort Union formation, which they show is comprised of two members. The lower member, which corresponds to the "Hell Creek beds" just described, is about 500 feet in thickness, but the base is not exposed; however, from the comparison of the Miles City section with that at Glendive, about 70 miles to the northeast, it is inferred that the base is not very deeply buried. Collier and Smith[9] give the following detailed section of the lower member of the Fort Union formation at Miles City, which is here presented entire to show not only the varied character and coloration of the beds but the relative positions of the paleontological material obtained.

Section of the lower member of the Fort Union formation near Miles City, Montana.

	ft.	in.
Limestone at base of upper member	3	
Shale, white	7	
Coal and shale, dark		6
Shale, gray	20	
Limestone, weathering brown	1	
Shale, light gray	10	
Shale, dark gray	8	
Limestone, weathering reddish brown		6
Shale, dark yellow	6	
Coal	6	
Shale, gray	21	
Limestone, weathering light red	1	
Shale, gray	25	
Sandstone, white, with limestone concretions	8	
Shale	2	
Sandstone	8	
Shale, white	2	

[9] Bull. U. S. Geol. Surv., 341A, 1908, pp. 39, 40.

	ft.	in.
Shale, gray	5	6
Sandstone, gray	20	
Limestone, weathering red		3
Sandstone, gray	4	
Limestone, weathering red		6
Sandstone, gray	4	
Coal and shale	1	10
Sandstone, gray	3	6
Limestone, weathering light red	1	6
Shale, dark	3	
Limestone, weathering red		3
Sandstone, gray	2	
Coal		8
Shale, yellow	5	
Limestone, weathering light red		8
Shale, gray	13	
Limestone, weathering red		6
Sandstone, fine gray	3	
Limestone, weathering red		2
Sandstone, gray	2	
Limestone, weathering red		2
Sandstone	5	
Coal (Weaver bed) (D)	2	4
Shale		5
Coal	1	3
Shale		10
Coal		6
Shale		6
Coal		3
Shale, sandy, dark yellow	6	
Limestone, brittle		6
Shale, dark gray	5	
Shale, fissile, dark brown	4	6
Coal		6
Shale, gray, with numerous limestone concretions	17	
Limestone, weathering red		6
Shale, dark, with thin layers of red limestone	10	
Sandstone, brown, containing fragments of carbonaceous material	7	
Coal	1	6
Shale, light gray	9	
Limestone, red		2
Shale		3
Coal		3
Shale, blue	8	
Coal, with three small streaks of bone	3	4
Sandstone	6	
Shale	4	

	ft.	in.
Sandstone	2	6
Shale	3	
Coal		7
Shale		6
Coal, dirty, with several white partings, one-half inch to 1 inch thick (Laneybed) (C)		5
Shale	1	
Sandstone	2	
Shale	4	
Limestone, weathering red		6
Sandstone, gray with some thin layers of shale	25	
Limestone, weathering red		6
Shale, sandy, yellowish gray	8	
Coal		8
Shale	3	
Sandstone, friable, gray	20	
Shale, sandy, many concretions	5	
Limestone, weathering red	3	
Sandstone, coarse, gray	17	
Limestone, weathering light red		6
Sandstone	3	
Shale, brown with blue bands	10	
Sandstone	6	
Coal and shale	2	
Shale, sandy, gray, usually cross-bedded	50	
Coal		6
Shale, sandy	5	
Coal (Kircher bed) (A)	5	
	465	3

The lower member is "conformably overlain by more homogeneous rocks, mainly sandy shale, which as exposed by erosion are generally of a light-yellow color," thus making the typical upper member.

Plants have been obtained from the lower member in this area as follows:

Six miles east of Miles City and 15 feet above the Kircher coal (A of section, yielded:

Glyptostrobus europæus (Brongn.) Heer.
Populus cuneata Newb.
Populus amblyrhyncha Ward.
Viburnum sp.

Bluffs of Yellowstone opposite Miles City, 115–125 feet above river (C of section):

Marchantia pealei Knowlton.
Onoclea sensibilis ossilis Newb.

Corylus americana Newb.
Populus amblyrhyncha Ward.
Populus cuneata Newb.
Populus nebrascensis Newb.
Populus nervosa elongata Newb.
Populus rotundifolia Newb.
Cornus newberryi Hollick.
Nelumbo sp.
Trapa microphylla Lesq., as determined by Ward.
Cocculus haydenianus Wa d.

Nine miles west of Miles City, Mont. Near N. E. cor., T 7, R. 45. "C" coal.
Onoclea sensibilis fossilis Newb.
Sequoia nordenskiöldi Heer.
Populus cuneata Newb.
Populus daphnogenoides Ward.
Populus speciosa Ward.
Populus arctica Heer of Lesq.
Betula new (nearest *B. coryloides* Ward).
Viburnum antiquum (Newb.) Hol.

Miles City field, S. W. ¼ sec. 22, T. 8, R. 47, about 50 feet below the Big Dirty coal bed.
Celastrus pterospermoides Ward.
Celastrus alnifolius Ward.
Celastrus curvinervis Ward.
Elæodendron polymorphum Ward.
Sapindus randifoliolus Ward.
Grewiopsis populifolia Ward.
Grewiopsis platanifolia Ward.
Diospyros haguei Kn. (small leaf).
Viburnum antiquum (Newb.) Hol.
Populus amblyrhyncha Ward.
Populus sp.?

Klonders ranch, 18 miles east of Miles City; 100 feet below top of "somber beds."
Onoclea sensibilis fossilis Newb.
Glyptostrobus europæus (Brongn.) Heer.
Taxodium occidentale Newb.
Sequoia (cone).
Populus cuneata Newb.
Populus amblyrhyncha Ward.
Sapindus affinis Newb.
Hicoria antiquorum (Newb.) Knowlton.

Signal Butte, 5 miles east of Miles City, 225 feet above base of section:
Taxodium occidentale Newb.
Platanus raynoldsii Newb.

Same locality as last but in upper member of "somber beds:"
Glyptostrobus europæus (Brongn.) Heer.
Taxodium occidentale Newb.

Sequoia nordenskiöldi Heer.
Corylus americana Walt.
Corylus rostrata Ait.
Betula sp.
Populus acerifolia? Newb.
Populus genetrix? Newb.
Hicoria antiquorum (Newb.) Knowlton.
Hicoria sp.
Sapindus grandifoliolus Ward.
Planera sp.
Celastrus ovatus Ward.

At a point on Sheep Creek about 40 miles east of Miles City (Sec. 16, T. 6 N., R. 52 E.) Collier obtained from just above the "D" coal the following vertebrate remains which were determined by Mr. C. W. Gilmore of the United States National Museum:

Champsosaurus sp.
Crocodylus sp.
Dinosaur fragments.
Turtles.
Ganoid fish.
Also a mammal tooth which Mr. J. W. Gidley has identified as *Chriacus?* sp.

On Powder River, about 12 miles above Hockett, Montana, and a few miles south of the above mentioned locality, Brown[10] reports finding parts of a Triceratops skeleton in the dark shale near the level of the stream and states that other fragmentary dinosaur bones were observed. In the vicinity of the Chalk Buttes, 20 miles west of Eklaka, Montana, dinosaur and other vertebrate remains were obtained by an expedition from the Field Museum of Natural History of Chicago. I am informed by Mr. E. S. Riggs, who conducted the party, that the following forms were secured:

A fine skull of *Triceratops calicornis*, two skulls of other species, and a number of other specimens, of *Ceratopsia*, also a carapace and plastron of *Basilemys sinuosa*, and individual bones of *Trachydon* and *Champsosaurus*.

3. FORSYTH, MONTANA.

The characteristic dark sandstones and clays of the lower Fort Union are known to extend as the surface formation for a distance

[10] Bull. Am. Mus. Nat. Hist., vol. 22, 1907, p. 823.

of nearly 20 miles along both sides of the Yellowstone River west of Miles City, and apparently continue uninterruptedly to Forsyth, a distance of about 40 miles. Just south of the town the rocks rise in a steep bluff about 250 feet in height, and consisting mainly of sandy shales with three layers of indurated sandstones. The beds dip greatly to the northeast. In a sandy clay about 75 feet below the top the following rather fragmentary plants were collected:

Fern, probably a *Dryopteris*.
Quercus sp.
Quercus viburnifolia? Lesq.
Lauraceous leaf (same form found in white basal beds at Glendive, Montana).
Aralia sp.
Sapindus affinis Newb.

In the valley of Porcupine Creek, about 6 miles west of Forsyth, the characteristic dark shales of the marine Cretaceous are exposed, and in the usual concretions and lenses of limestone a considerable number of typical Pierre invertebrates were obtained. About one-half mile to the eastward of the fossiliferous marine Cretaceous are the lowest members of the "somber beds," there forming low bluffs and resting on the dark clay shales. The lowest bed is a soft yellowish-white sandstone, above which it becomes massive and brownish in color and often weathers into towers and irregular pinnacles. The beds at this point add probably 100 feet or more to the base of the section as exposed just south of Forsyth, while Chimney Butte on the west side of the Yellowstone, about 6 miles east of Forsyth, exposes beds apparently higher than those above mentioned, making a total thickness of the "somber beds" in this vicinity between 400 and 500 feet.

No plants were found in either the lower or higher beds north of the river, though at a point about 5 miles northwest of Forsyth, in the lower beds, vertebrate remains have been found, and it was probably at this locality that the bones of a large dinosaur were collected some fifteen years ago by Prof. I. C. Russell. In association with the bones were numerous specimens of the undescribed Ficus fruit already mentioned as occurring in the "Hell Creek" and "Ceratops beds."

4. CUSTER, MONTANA, AND VICINITY.

Beyond the point indicated above the conditions to the west and southwest of Forsyth are not definitely known, though the marine Cretaceous extends westward nearly to Myers; but from observations made from a train, it seems not improbable that the "somber beds" may be traced as far as Bighorn or Custer. In any event, beds known to be of this age were observed near the latter place by Mr. L. J. Pepperberg, of the United States Geological Survey, during the past season. The section, there several hundred feet in thickness and resting on one of the upper members of the Pierre, is made up of light colored sandstones and shales. At a point near the top of the exposed section the following small collection of plants was secured:

Four and one-half miles southeast of Bighorn, Montana.
Platanus nobilis Newb.
Populus cuneata Newb.
Sapindus sp.

5. BULL MOUNTAIN, MONTANA, AREA.

The so-called Bull Mountain coal field[11] of Montana covers an area of about 750 square miles, lying mainly to the south of the Musselshell River and some 20 miles north of the Yellowstone River. On the southeast the lower member of the Fort Union presumably connects more or less closely with the area just mentioned near Custer, while to the northeast it will probably be found to extend directly into the Hell Creek area. The beds in question, which are composed of usually light colored sandstones, clays and carbonaceous shales, are about 2000 feet in thickness and rest upon Pierre shale. They have usually been referred on stratigraphic grounds to the Laramie, but there is little question of their belonging to the lower Fort Union, though plants have not thus far been reported from them.

6. MELVILLE, MONTANA, AREA.

The area now to be considered lies east of the Crazy Mountains and about 25 miles north of Big Timber. The geological structure

[11] See Woolsey, Bull. U. S. Geol. Surv., 341A, 1908, p. 60.

in this general region is somewhat obscure—to judge by the different results obtained by the several geologists who have visited it—and owing to the lack of sufficient paleontological data at critical points in the section, it appears that the problem is still short of a complete and wholly satisfactory solution. Thus in 1896 Mr. W. H. Weed[12] published the record of a section taken along Lebo Creek in which he recorded the presence of over 7000 feet of Livingston beds, above which was a thickness of 4000 feet of Fort Union. A few years later Mr. Earl Douglass[13] visited this region, and although within a few miles of the Lebo Creek section of Weed, he failed to note the presence of Livingston rocks, referring this part of the section apparently to the 'Fox Hills' and 'Laramie.' The same area was surveyed by Mr. R. W. Stone[13a] and party in 1907, and while he recognized tentatively the presence of the Livingston it was presumed to be only a few hundred feet in thickness and is located in another part of the section. The succession as worked out by Stone is as follows: Above the highest marine Cretaceous (Bearpaw of the Montana) in the region is a series of red and greenish sandstones 200 to 460 feet in thickness which form a conspicuous ridge, and which was provisionally regarded as a part of the 'Laramie.' The succeeding beds, 1000 to 2400 feet thick, of soft shales and sandstones of a light-gray color, are regarded as the upper part of the 'Laramie.' At this point Stone says:

> The gray beds of the Laramie formation are overlain, possibly with unconformity, by somber-colored sandstone and shale which may represent the Livingston formation. Sufficient paleontologic evidence has not been obtained, however, to determine the limits of these stratigraphic units.

The thickness of the 'Laramie' is approximately 5500 feet, above which comes nearly as great a thickness of Fort Union.

This section as interpreted by the writer is as follows: Above the Bearpaw is a series of shaley sandstones, at least several hundred feet in thickness, that unmistakably belongs to the Livingston, as plants identical with those found near the base of this formation

[12] Am. Geol., vol 18, 1896, pp. 201–211.
[13] Proc. Am. Phil. Soc., vol. 41, 1902, p. 217.
[13a] Bull. U. S. Geol. Surv., 341A, 1908, pp. 76–89.

southeast of Bozeman, Montana, have now been located,[11] and moreover the matrix is characteristically that of the Livingston. Between this point and the base of the upper member of the Fort Union according to Stanton is a thickness of 3000 to 5000 feet of beds, a portion of the lower part of which belongs with little doubt to the Livingston, but the top of the Livingston has not been definitely placed, though its maximum thickness apparently exceeds 2000 feet. The dinosaurs occur in this thick series of beds above the Livingston, and the beds are probably referable to the lower member of the Fort Union, though no plants have been found until within approximately 1000 feet of the top, where the following species have been obtained:

Widdecomb Bros. ranch, northeast of Melville, Montana [sec. 29, T. 6 N., R. 16 E.]

Salix sp.
Populus amblyrhyncha Ward.
Populus cuneata Newb.
Populus genetrix Newb.
Populus daphnogenoides Ward.
Populus sp.
Aralia notata Newb.
Leguminosites arachioides Lesq.
Vitis xantholithensis Ward.
Credneria daturæfolia Ward.
Phyllites cupanoides Newb.
Carpites sp.

These plants occur about 1200 feet below the small mammals now being studied by Mr. Gidley and regarded by him as of Torrejon affinities, though scattering remains of mammals have been found down nearly to the horizon of the plants. The nearest point at which dinosaurs occur is stratigraphically about 600 feet below the mammal horizon, according to the collector, while according to Stanton the main Triceratops horizon may be 2000 to 3000 feet below this point.

[11] When this collection was first studied it proved very puzzling, and although no species were positively identified, it was tentatively regarded possibly Laramie or older. Subsequently, however, large collections were made and studied from the Livingston with the result of showing that it clearly belongs to the latter.

7. RED LODGE, MONTANA.

The Red Lodge coal field lies along the foot-hills of the Beartooth Mountains, on the extreme south-central border of Montana. The Fort Union beds in this area show the immense thickness of 8500 feet, the productive coals being confined to a middle portion only about 825 feet in thickness, below which are barren beds 5700 feet thick. According to Mr. E. G. Woodruff[15] who reported on the coals of this region in 1908, the

lowest member is composed mostly of yellowish sandstone and shale. Beginning 1650 feet above the bottom of the formation is a group of beds 1000 feet thick composed of vari-colored sandy shale, with a few beds of soft yellowish sandstone, numerous beds of carbonaceous shale, and in the upper part a few coal beds. Above this group carbonaceous shale and coal beds occur at diminishing intervals as the productive measure is approached.

The lowest point at which Fort Union plants have been found in the section above described is about 700 feet above its base, and on this account this basal 700 feet has sometimes been referred tentatively to the 'Laramie.' In the opinion of the writer it is an inseparable portion of the lower Fort Union.

The exact area covered by the lower Fort Union in this vicinity has not been definitely determined, though it is known to extend to the west of Red Lodge for at least 25 miles, where it was found by Mr. W. R. Calvert resting conformably on the Livingston formation, while to the east it extends nearly to Bridger. To the southeast this area undoubtedly connects with the beds of this age exposed as a ring about the margin of the Bighorn Basin, Wyoming. Plants have been obtained in the Red Lodge area at the following localities:

About 8 miles west of Bridger, Montana.

Taxodium occidentale Newb.
Platanus nobilis Newb.
Platanus haydenii Newb.
Populus amblyrhyncha Ward.
Sapindus grandifoliolus Ward.
Laurus sp.?
Ficus sp.

[15] Bull. U. S. Geol. Surv., 341A, 1908, p. 92.

About 8 or 9 miles west of Bridger, Montana.
Platanus nobilis Newb.
Populus inæqualis? Ward.
About 25 feet below the last collection.
Taxodium occidentale Newb.
Populus cuneata? Newb.
Platanus sp.
About 25 miles northwest of Red Lodge, near center sec. 33, T. 6 N., R. 18 E. 300+ above base.
Platanus raynoldsii Newb.
Same area as last, sec. 36, T. 5 N., R. 18 E. Within 300 feet of contact with Livingston beds.
Aralia notata Newb.
Populus sp.

8. GLENDIVE, MONTANA, AND VICINITY.

Returning to the Miles City field, as already set forth, the conditions are known for 40 miles to the east. Down the valley of the Yellowstone identical conditions prevail to near the vicinity of Iron Bluff where, at the mouth of Sand Creek, some 12 miles southwest of Glendive, an anticlinal fold brings the marine Cretaceous to the surface. The exposure is about 100 feet in thickness above the level of the river, on both sides of which it may be observed. It is upper Pierre (Bearpaw) in age and contains a rich fauna which has been listed by Dr. T. W. Stanton.[16] This exposure, which is known to continue for some distance to the southeast, is thought by Prof. A. G. Leonard[17] to be connected with a similar area along the extreme eastern edge of Custer County, Montana, and adjacent counties in North Dakota.

Immediately above the Pierre, and in apparent conformity, are 150 feet of beds the lower half of which is made up of sandstones and shales, and the upper half of a brownish sandstone. While these beds are in the position of the Fox Hills, their age is in doubt. No invertebrates have been found, the only fossils being two or three small collections of dicotyledonous plants which are so fragmentary as to be undeterminable. According to Leonard[18] they do not

[16] Bull. U. S. Geol. Surv., 316, 1907, p. 196.
[17] L. c., p. 197.
[18] Loc. cit., p. 197.

agree with the Fox Hills beds of the Hell Creek section, and should probably be referred to the lower member of the Fort Union as exposed in this region. The absence of invertebrates and presence of plants in a measure supports this view. On this point Leonard says:

The line of contact between the Pierre and the overlying dinosaur-bearing beds, while not discordant so far as structure is concerned, may possibly represent a time break in which most of the upper fresh- and brackish-water beds of the Cretaceous are wanting.

Overlying the last mentioned beds is a very conspicuous white, massive sandstone 35 to 50 feet in thickness, which first appears at the north end of Eagle Bluff, 2 miles west of Glendive, and persists for many miles up Sand Creek. The upper surface is somewhat uneven, suggesting the possibility of an unconformity, though this may be only local and of little importance. In the middle of this white sandstone, at a point about 5 miles up Cedar Creek, Dr. A. C. Peale collected fragmentary plants, among them *Populus cuneata* Newb., while in the upper portion at Eagle Bluff the following forms were obtained:

Ginkgo adiantoides (Unger) Heer.
Quercus sp.
Lauraceous leaf.
Ficus trinervis Kn.
Ficus or *Sapindus* sp.
Viburnum whymperi Heer.
Viburnum n. sp.

Other localities for plants in the Glendive area are as follows:

Bluff east of Sand Creek, 6 miles above Glendive, Montana, 420 feet above the Pierre.

Taxodium sp.
Ginkgo adiantoides (Unger) Heer.
Salix angusta Al. Br.
Quercus breweri Lesq.
Populus cuneata Newb.

Mouth of Cedar Creek, $11\frac{3}{4}$ miles above Glendive, Montana, 400 feet above Pierre.

Glyptostrobus europæus (Brongn.) Heer.
Sequoia sp.

Populus genetrix Newb.
Corylus rostrata Ait.
Pterospermites minor Ward.
Pterospermites whitei Ward.
Cocculus haydenianus Ward.
Elæodendron polymorphum Ward.

Eight or nine miles above Glendive, Montana, 100 feet above Pierre.

Taxodium sp.
Platanus raynoldsii Newb.
Platanus sp.
Populus amblyrhyncha Newb.
Corylus americana Walt.
Carpolithes lineatus Newb.

Bluffs of Yellowstone River 1½ miles from Glendive, Montana, 400 feet above Pierre.

Onoclea sensibilis fossilis Newb.
Sequoia nordenskiöldi Heer.
Ginkgo adiantoides (Unger) Heer.

Bluffs ¼ mile east of town of Glendive, Montana. Base of bluff or 350 feet from top.

Sequoia sp.
Aralia notata Lesq.

Same locality as last, 195 feet below top.

Carpites sp.
Populus sp.

Same locality, 125 feet below top of bluff.

Equisetum sp.
Thuya interrupta Newb.
Sequoia nordenskiöldi Heer.
Ficus sp.
Carpites sp.

Bluff on west side of Yellowstone River opposite Glendive, Montana, about the same horizon as the last.

Thuya interrupta Newb.
Sapindus grandifoliolus Ward.

Bluffs along Yellowstone River at Harpster's ranch, 10 miles northeast of Glendive, Montana. In upper portion of lower Fort Union.

Equisetum sp.?
Glyptostrobus europæus (Brongn.) Heer.
Populus cuneata Newb.
Populus sp.
Populus sp.
Platanus raynoldsii Newb.
Platanus guillelmæ Göpp.
Sapindus grandifoliolus Ward.
Polygonum n. sp.

A few fragmentary remains of vertebrates have been found in the Glendive area. Thus, Barnum Brown[19] records having found the weathered fore limb of a Triceratops "in the badlands near Glendive at an elevation of about 50 feet above the railroad track," which would bring its position at about 275 to 300 feet above the top of the Pierre. He also adds that "several other fragments of *Triceratops* and Trachodont dinosaurs were seen in this locality but not sufficiently preserved for specific determination."

In the bluffs just east of Glendive Dr. A. C. Peale and the writer secured, in 1907, fragmentary remains of turtles and a single mammal jaw near the base of the bluff, and remains of turtles and fragments of a large dinosaur at a point about 100 feet above the base. It is probable that more careful search in this vicinity would disclose the presence of other localities for vertebrate remains, of which we heard vague rumors from the residents.

9. GLENDIVE, MONTANA, TO MEDORA, NORTH DAKOTA.

The lower member only of the Fort Union is exposed in the immediate vicinity of Glendive, the beds dipping at a very slight angle to the northeast, and it is 12 or 15 miles down the Yellowstone and some miles back from the river, before the yellow beds of the upper member appear. Thus in the valley of lower Seven Mile Creek, which enters the Yellowstone from the north about 10 miles below Glendive, one first passes from near the level of the stream over the dark sandy shales and clays of the lower member for a distance of 6 or 8 miles before the yellow sands and sandy clays of the upper member appear in the bluffs on either side. Probably about 15 miles to the east (the exact point was not noted) of Glendive the lower member has disappeared and the upper member is the surface formation, a condition continuing probably to the valley of the Little Missouri River. Sentinel Butte, North Dakota, which rises 650 feet above the level of the plain in which it stands is entirely in the upper beds (except for a very thin capping of supposed Oligocene containing fish remains), as are at least the upper portions of the bluffs bordering the

[19] Bull. Am. Mus. Nat. Hist., vol. 23, 1907, p. 823.

Little Missouri River. The valley of this stream, according to Leonard and Smith,[20] has a depth of 420 to 440 feet below the surface of the plain in which it has been eroded, and may have cut into the beds of the lower member, though the deep well sunk at Medora carries the section down for a distance of 940 feet below the lowest beds exposed in the region, and this, on the basis of the thickness at Glendive, must be near to the base of the section. The entire thickness of the section in this area, including the beds passed through by the Medora well, is 1720 feet, and it is possible that the upper portion of the lower member of the Fort Union may be exposed, but as this is not definitely known it is omitted from present consideration. In any event all of the numerous finely preserved plants obtained in this region are distinctly of Fort Union age.

10. BISMARCK, NORTH DAKOTA, AND VICINITY.

To the eastward of Medora along the line of the Northern Pacific Railroad Fort Union plants have been collected at a number of points, as at Lehigh, Dickinson, Sims, etc., but as the stratigraphic relations are not definitely known through this region, we may pass on to Bismarck, North Dakota, where the lower member is undoubtedly present. Near the mouth of Apple Creek, about 10 miles southeast of Bismarck, are exposures of soft sandstones and clays of dark-gray color which form a bluff 75 to 100 feet high. Near the base of this bluff at a point 1½ miles above the mouth of Apple Creek the following very fragmentary plants were obtained:

Adiantum? sp.
Salix sp.
Quercus sp.
Ficus sp.
Laurus? sp.
Carpites sp.

The beds mentioned above are not the base of the lower member of the Fort Union, but at a point on the west side of the Missouri River about 20 miles below Mandan, Dr. T. W. Stanton obtained the fol-

[20] Bull. U. S. Geol. Surv., 341A, 1908, p. 15.

lowing plants in shaley sandstone about 100 feet above the top of the Fox Hills:

Taxodium sp.
Populus amblyrhyncha Ward.
Sapindus affinis Newb.
Quercus sp.
Sassafras sp. (Same found in Ceratops beds of Converse County, Wyoming).
Ficus sp. new?
Ficus sp. new.

About 25 miles to the northward of Bismarck, near the town of Washburn, the yellow sands and sandstones of the upper Fort Union appear and become the surface formation as far at least as Coal Harbor. At old Coal Harbor in the bluffs overlooking the Missouri typical Fort Union plants and invertebrates were collected.

II. YULE, BILLINGS COUNTY, NORTH DAKOTA, AND VICINITY.

I am informed by Prof. A. G. Leonard that near Yule, in western Bowman County, North Dakota, the lower member of the Fort Union (dinosaur-bearing beds) again makes its appearance, and is there about 600 feet in thickness. He has kindly prepared the following section:

Section of lower member of Fort Union (dinosaur beds) in the vicinity of Yule, North Dakota.

Typical buff and light-gray shales and sandstones of the Fort Union outcropping on the Little Missouri in the vicinity of Yule, where they are seen resting on the "somber beds."

Somber beds	75 to 100
Shales and sandstones carrying leaves	25 to 50
Somber shales and sandstones	200 to 250
Somber beds containing dinosaur bones. These lie as near as could be estimated, about 200 feet above the unconformity. The vertical range of the dinosaurs was not determined.	
Somber shale and sandstones to unconformity	200
Unconformity	
Sandstone and andy shale; no fossils found in these beds, but they are perhaps Fox Hills	80
Pierre shale yielding abundant typical Pierre shells, exposed	60

This section, it will be observed, is strikingly similar to that at Glendive, Montana, and it is extremely probable, as already pointed out, that it is the same anticlinal fold which brings up the marine Cretaceous in both areas. From the shales and sandstones indicated as carrying leaves in the above section, the following species were obtained:

Taxodium occidentale Newb.
Populus amblyrhyncha Ward.
Pla anus haydenii Newb.
Juglans rugosa? Lesq.
Hicoria antiquorum (Newb.) Kn.
Sapindus affinis Newb.
Viburnum whymperi Heer.
Trapa microphylla Lesq. of Ward.
Cocculus haydenianus Ward.

Professor Leonard has sent specimens of the dinosaur obtained from near Yule to the United States National Museum, and it has been identified by Mr. Gilmore as *Triceratops horridus* (Marsh), this species being the type of the genus.

12. PROBABLE AREA OF LOWER FORT UNION IN NORTHWESTERN SOUTH DAKOTA.

The exact outline of the area covered by the lower member of the Fort Union in southwestern North Dakota is not at present definitely known, nor has its extension to the southward been thoroughly traced, though I am informed by Mr. J. W. Gidley that he has observed dinosaur-bearing beds that are stratigraphically and lithologically similar to the "Ceratops beds" of Converse County, Wyoming, in the country between the Grand and Moreau rivers in South Dakota, on both the east and west sides of Long Pine Hills. From these beds near the eastern base of Long Pine Hills remains of gigantic Trachodont dinosaurs have been exhumed.

Since the above was written Mr. W. R. Calvert has sent in (under date of May 2, 1909) the following collection from McCord coal bank in N. W. ¼, Sec. 5, T. 129 N., R. 88 W., on the north side of the Cannonball River in the Standing Rock Indian Reservation. The

horizon is about 250 feet above the Fox Hills and embraces the following list of species:

Thuya interrupta Newb.
Sequoia nordenskiöldi Heer.
Populus amblyrhyncha Ward.
Populus daphnogenoides Ward.
Sapindus grandifoliolus Ward.
Aristolochia cordifolia Newb.
Celastrus curvinervis Ward.
Pali rus pealei? Ward.
Viburnum sp., cf. *V. antiquum* (Newb.) Hol.

13. AREA IN WESTON COUNTY, WYOMING.

It is quite probable, however, that the beds under consideration can be traced from the area last considered in more or less continuous exposures into Weston and Converse counties, Wyoming. In the southwestern portion of the Newcastle quadrangle which lies mainly in the extreme southwestern corner of Weston County, Mr. N. H. Darton[21] has described as 'Laramie' the beds in question which overlie the Fox Hills.

Although Darton does not mention an unconformity between the Fox Hills and the 'Laramie,' he speaks of the difficulty of drawing the line between them. However, Mr. Barnum Brown found unconformable relations between them. He says:[22]

On Alkali Creek, about 35 miles northwest of Edgemont, S. D., and 6 miles north of the Cheyenne River the dinosaur-bearing beds do rest on the marine Fox Hills. In 1901 I obtained characteristic fossils from both formations near their contact at that locality. At that place the conditions are similar to those in the Hell Creek region.

From the base of the "series of lignite beds overlying the Converse County beds similar to those overlying the Hell Creek beds" on Seven Mile Creek, 40 miles northwest of Edgemont, Brown obtained the following plants:

Taxodium occidentale Newb.
Sequoia nordenskiöldi Heer.

[21] U. S. Geol. Surv., Folio 120, 1904.
[22] Bull. Am. Mus. Nat. Hist., vol. 23, 1907, p. 844.

Dammara? sp.
Platanus raynoldsii Newb.
Platanus sp.
Quercus sp.
Carpites sp.

From the same locality on Seven Mile Creek, "but lower and associated with a dinosaur skeleton (*Claosaurus annectens* Marsh)," the following plants were collected by Brown:

Sequoia heerii Lesq.
Taxodium distichum miocenum (Brongn.) Heer.
Ginkgo adiantoides (Ung.) Heer.
Musophyllum sp. (probably new).
Flabellaria eocenica Lesq.
Sabalites grayanus Lesq.
Palmocarpon palmarum (Lesq.) Kn.
Platanus rhomboidea Lesq.
Platanus sp.
Ficus spectabilis Lesq.
Viburnum sp.

14. NORTHWARD EXTENSION OF WESTON COUNTY AREA CONNECTING WITH THE MILES CITY AREA.

It is now possible, through the work of Mr. E. S. Riggs of the Field Museum of Natural History, to extend the known distribution of the dinosaur-bearing beds to the northward of the Weston County area, and make practical connection with the beds of similar age in the Miles City, Montana, field. Mr. Riggs informs me that on passing northward from New Castle, Wyoming, these beds were first encountered on the head waters of the Little Missouri River 20 miles west of Devil's Tower. Again, on the east fork of Little Powder River, in Montana, he found a weathered skeleton of *Trachydon*, partial skulls of *Ceratopsia* and fragments of a large carnivorous dinosaur, probably a *Tyrannosaurus*. The formation was thence traced along the east bank of Powder River from Powderville, Montana, to a point on Sheep Creek some miles northeast of Mizpah, which brings it well within the area studied by Collier and Smith. During the past season (1908) Mr. R. W. Stone of the U. S. Geological Survey, found remains of *Ceratopsia* in the vicinity of Moorecroft, Wyoming, which makes an additional point connecting the areas.

15. CONVERSE COUNTY, WYOMING, AREA.

We may now take up the consideration of the celebrated "Ceratops beds," a direct northern extension of which are those just mentioned in Weston County.

In 1889 Marsh[23] gave the name of "Ceratops beds" to a series of beds characterized by the presence of an extensive fauna of the then little known group of quadrupedal, horned, herbivorous dinosaurs. He did not then, nor indeed subsequently, give any very definite account of either the geographic location or stratigraphic position of the beds, beyond stating that they were in the 'Laramie of Woyming,' and that the horizon "has now been traced for nearly 800 miles along the eastern flank of the Rocky Mountains." Of the position he says:

> They are fresh-water or brackish deposits, which form a part of the so-called Laramie, but are below the uppermost beds referred to that group. In some places, at least, they rest upon marine beds which contain invertebrate fossils characteristic of the Fox Hills deposits.

It was reserved for Professor Marsh's assistant, Mr. J. B. Hatcher, to give the first definite and precise information on these points. The principal, and what may be called the typical, "Ceratops beds" are really of very limited extent, occupying a strip about 15 miles in width from east to west, by 30 miles in length from north to south, in the northeastern part of Converse County, Wyoming, along Lance Creek and the area drained by the lower portions of Doegie, Cow, Buck, and Lightning creeks. This area furnished not only all of the Ceratopsidæ described by Marsh from Wyoming, but fully 95 per cent of the entire group known at that time. The "Ceratops beds" are best exposed along the eastern and southern borders of a synclinal basin, and according to Hatcher are 3000 feet in thickness, though Dr. T. W. Stanton and myself, when we visited the area in 1896[24] concluded that they could hardly exceed 2000 feet, but as a large portion of the beds are exposed at a low angle in a broad, flat, grassy plain, it is impossible to measure the beds with a great degree

[23] Am. Jour. Sci. (3), vol. 38, 1889, p. 501.
[24] Bull. Geol. Soc. Am., vol. 8, 1896, pp. 128–137.

of accuracy. The entire section of the region, which begins with several hundred feet of soft, bluish shales of the Pierre, up to and including the acknowledged Fort Union, was supposed by Marsh and Hatcher to be one of continuous deposition; that is to say, no actual unconformity had been detected. The Fox Hills, with an estimated thickness of 500 feet, consists of an alternating series of sandstones and shales. The massive sandstones at the top contain numerous large concretions and a rich marine fauna of characteristic Fox Hills species. The line between the Fox Hills and the overlying beds is a difficult one to draw, Hatcher, at first, placing it arbitrarily at a six-inch band of hard sandstones which separates the fossil-bearing Fox Hills sandstone below from the very similar but non-fossiliferous sandstones above.

Later, however, Hatcher appears to have changed his mind regarding the lower limits of the "Ceratops beds," for he says:[25]

> At no place in the Converse County region do the true Ceratops beds, with the remains of horned dinosaurs, rest upon true marine Fox Hills sediments; nor are the Ceratops beds in this region overlain by strata which could be referred without doubt to the Laramie.

This point was apparently well taken, for Stanton and I found four species of brackish-water invertebrates in clays above a forty-foot bed of massive sandstone over 400 feet above the highest fossiliferous Fox Hills horizon in that particular section. The fact remains, however, that the fossiliferous portion of the "Ceratops beds" is mainly the upper portion, the highest point at which dinosaurs were found, being only 100 to 150 feet below the Fort Union.

The fossil-bearing members of the "Ceratops beds" consist, as described by Hatcher,[26]

> of alternating sandstones, shales, and lignites, with occasional local deposits of limestones and marls. The different strata of the series are not always continuous, a stratum of sandstone giving place to one of shales, and *vice versa*. This is especially true of the upper two-thirds of the beds. This lack of continuity in the different strata has rendered it well nigh impossible to establish any definite horizons in the upper members of the series.

[25] Am. Nat., vol. 30, 1896, p. 117.
[26] Am. Jour. Sci. (3), vol. 45, 1893, p. 137.

Following is the list of plants thus far obtained from the "Ceratops beds" of Converse County:

Alga (Gen. et sp. nov.)
Aralia sp. (Like species from Forsyth).
Carpites 2 sp.
Cyperacites sp.
Equisetum sp.?
Ficus 5 sp.
Flabellaria eocenica Lesq.
Grewiopsis eocenica (Lesq.) Kn.
Fern (Gen. et sp. nov.).
Hicoria sp.
Juglans 2 sp.
Lysimachia sp. (new).
Myrica torreyi Lesq.
Ottelia? sp. (new).
Palmocarpon palmarum (Lesq.) Kn.
Phyllites 3 sp.
Platanus raynoldsii Newb.
Platanus raynoldsii integrifolia Lesq.
Populus subrotundata Lesq.
Populus amblyrhyncha Ward.
Quercus cinereoides Lesq.
Quercus viburnifolia Lesq.
Quercus 3 sp. (new?).
Sabal rigida Hatcher.
Salix angusta Al. Br.
Salix 3 sp. (new?).
Salvinia sp.
Sassafras sp. (New; same found below Mandan, N. D.)
Sequoia nordenskiöldi Heer.
Taxodium distichum miocenum Heer.
Trapa microphylla Lesq.
Ulmus sp.
Viburnum sp. (new).
Viburnum whymperi Heer. (Also found at Glendive, Hell Creek, and below Mandan.

In 1896 Dr. T. W. Stanton and the writer spent about three weeks in the study of the "Ceratops beds" of Converse County, our results being set forth in a joint paper under the title: "Stratigraphy and Paleontology of the Laramie and related formations in Wyoming."[27] After reviewing the stratigraphy and local development in this region, so far as our observations permitted, the "Ceratops beds" were

[27] Bull. Geol. Soc. Am., vol. 8, 1897, pp. 127–156.

correlated with the dinosaur-bearing beds at Black Buttes, Wyoming, and both were then concluded to be of Laramie age. For several years past, however, data having a distinct bearing on the problem have been accumulating in adjacent and more remote areas, which have induced the present writer to completely change his opinion concerning the relations and age of the beds in question. When the invertebrate fauna and the flora of the "Ceratops beds" are compared with those of Black Buttes alone, it is true that a certain degree of relationship can be established. Among the invertebrates, for instance, it was shown that 9 species—7 of which belong to *Unio*—of the 28 species found in the "Ceratops beds," occur also at Black Buttes, while of the 24 forms of plants then recognized it was possible to identify only 8 specifically, one of which was from an unknown locality, thus leaving less than one-third of the total number on which to ascertain the bearing on the question of age. Of the remaining 7 species, 3 were found at Black Buttes, one in the Montana at Point of Rocks, 2 in the Laramie at Golden, Colorado, and one in the Raton Mountains of New Mexico, then supposed to be of Laramie age but now thought to be higher.

Of the undescribed forms I wrote at that time as follows:

> The affinity of the undescribed forms is also quite clearly with the true Laramie flora, and thus as nearly as can be made out, the plants confirm the Laramie age of the Ceratops beds.

This statement was based on tenative comparisons with beds then supposed to be Laramie in age, but which subsequent investigation has shown belong to higher horizons. Since the publication of the above-mentioned paper the plants have been more thoroughly studied, with the result of increasing the number to 48 forms, as already listed, though still showing a large proportion of new forms, with more modern affinities. Of the 14 species having an outside distribution, 9 are found in the Fort Union, 5 in the Shoshone, and 4 each in the Laramie and Montana, thus slightly modifying the distribution as given in Brown's paper.[28] On these grounds the correlation of the "Ceratops beds" with the beds at Black Buttes is no longer admitted by the writer, and the Laramie age of the "Black Buttes beds" is held in abeyance.

[28] Bull. Am. Mus. Nat. Hist., vol. 23, 1907, p. 844.

The vertebrates and invertebrates found in the typical "Ceratops beds" will be considered later.

16. AREA TO THE EASTWARD OF THE BIGHORN MOUNTAINS, WYOMING.

To the northwest of Converse and Weston counties, Wyoming, the beds under consideration occupy a vast area in the central Great Plains region between the Black Hills and the Bighorn Mountains, extending into Montana for an unknown distance, and completely encircling the Bighorn Basin. The complete areal distribution in this region is not yet a matter of published record, though the presence of the beds at numerous points is attested. Mr. N. H. Darton[29] to whom we are indebted for most of the published knowledge concerning this area, made the following disposition of the Upper Cretaceous and Tertiary rocks of the region. The name of Parkman sandstone was given to the several hundred (about 350) feet of soft sandstone overlying the more typical Pierre shale, which, from its position, was supposed to represent the Fox Hills, but according to Dr. T. W. Stanton it may be as old as the Claggett—one of the lower members of the Pierre. Immediately above the Parkman but separated from it with difficulty, is the Piney formation, a name proposed

> for the lowest formation of the thick series of fresh-water sandstones and shales of later Cretaceous age, formerly designated 'Laramie,' lying in the great Basin adjoining the Bighorn uplift.

The maximum thickness of the Piney, according to Darton, is about 3000 feet, but according to Mr. C. A. Fisher this does not constitute a lithologic unit, only the lower 600 to 800 feet of sandstones being properly referable to this formation, while the remainder, composed of gray sandstones, dark shales and coal streaks, belongs to the lower Fort Union (somber beds). Whatever its proper limits, so far as present facts indicate, the whole section above the marine Cretaceous is to be regarded as belonging to the Fort Union.

Unconformably overlying the Piney as defined by Darton, but probably without the intervention of any considerable erosional interval, is a great thickness of conglomerate to which the name

[29] Geol. Bighorn Mts., U. S. Geol. Prof. Paper, No. 51, 1906.

Kingsbury conglomerate has been given. It occupies a narrow band only 6 or 8 miles in width and 25 to 30 miles in length, adjacent to the mountains, and strikes approximately north and south. Its north and south extent coincides very nearly with faults which, according to Darton, attended an uplift of some 9000 feet of this portion of the Bighorn Mountains. This uplift, which involved also the Piney formation, resulted in a sharp fold, or in some cases probably a break, of the underlying beds resting against the granite mass, while the increased elevation of the mountain mass accelerated erosion and precipitated the debris which forms this conglomerate, embracing as it does rocks of all ages from the granites to and including the Piney. That the unconformity at the base of the Kingsbury is not of wide significance is shown by the fact that it was not detected in a section made at Parkman, only about 25 miles north of the northernmost extension of the Kingsbury, nor has it been found a few miles to the southward of the southern limits of the formation. Along the eastern margin of the Kingsbury it may be observed fingering into the soft shales and sandstones of the De Smet formation, the name given by Darton to the 5000 feet or more of beds overlying the Piney, and with which sedimentation was apparently continuous; in fact the Kingsbury was regarded by Mr. J. A. Taff, who surveyed this area for coal in 1907, as merely the near-shore phase of the upper member of the Fort Union. At a number of horizons in the Kingsbury Fort Union plants have been collected, and at a point about 650 feet above its base Mr. H. S. Gale obtained a mammal jaw which Mr. Gidley identifies as identical with a Fort Union species found at Fish Creek, Montana.

The first two of the following lists of plants are from the Kingsbury conglomerate, and are given to show how similar is the flora of the upper and lower members of the Fort Union; the others are from the lower member:

Sequoia sp.?
Cyperacites sp.
Populus sp.?
Platanus haydenii Newb.
Ficus plani ostata? Lesq.
Cinnamomum affine Lesq.
Sapindus grandifoliolus Ward.
Diospyros ficoidea Lesq.

Cissites parrotiæfolia Lesq.
Berchemia multinervis Al. Br.
Aristolochia cordifolia Newb.
Cornus newberryi Hollick.
Viburnum sp.
Viburnum whymperi Heer.
Carpites sp.

Seven miles southwest of Buffalo, Wyoming.

Dryophyllum subfalcatum Lesq.
Ficus planicostata Lesq.
Diospyros ficoidea Lesq.
Carpites sp.

On road from Buffalo to Klondike, Wyoming. [Sec. 6, T. 49 N., R. 82 W.] Piney formation.

Sequoia nordenskiöldi Heer.
Populus arctica Heer of Lesq.
Populus amblyrhyncha Ward.
Populus nobilis Newb.
Sapindus grandifoliolus Ward.

About 1½ mile northeast of Dayton, Wyoming.

Glyptostrobus europæus.
Populus arctica Heer.
Platanus guillelmæ Göpp.
Platanus sp.
Fruit, gen. et sp.?

Two and one-quarter miles northeast of Ranchester, Wyoming. Lower De Smet or Piney.

Taxodium occidentale Newb.
Sequoia sp.?
Sparganium stygium Heer.
Populus acerifolia Newb.
Platanus nobilis Newb.
Sapindus affinis Newb.
Acacia sp. [new].
Bauhinia sp. [new].
Nelumbo sp.?

Two and one-half miles southeast of Ranchester, Wyoming; 75 feet below top of lower member.

Platanus sp.
Hicoria antiquorum (Newb.) Kn.
Sapindus grandifoliolus? Ward.

Slater Creek, 6 miles northeast of Monarch, Wyoming; 40 feet below top of lower member.

Populus amblyrhyncha Ward.
Populus genetrix Newb.
Populus sp.?

Platanus nobilis Newb.
Leguminosites arachioides Lesq.
Sapindus sp.
Viburnum whymperi Heer.

17. BIGHORN BASIN, WYOMING.

The following discussion of the lower Fort Union in this area is based on the published work of Mr. C. A. Fisher's,[30] personal observations made during the seasons of 1907 and 1908, and the work of United States Geological Survey field parties under the charge of Mr. E. S. Woodruff, made during the same years. In the extreme northwestern part of the Basin the lower Fort Union undoubtedly connects with the area about Red Lodge, Montana. At the time Mr. Fisher's paper was prepared sufficient paleontologic data had not been obtained to fix definitely the limits of this, as well as underlying and overlying beds, and the whole series, aggregating more than 5000 feet in thickness, was described and mapped as 'Laramie and associated formations.' As shown on Fisher's map, these beds are exposed continuously about the outer edge of the Basin, having their maximum areal extent in the northeastern portion and their minimum exposure along the northwestern border just below the Montana state line.

The lowest member of the aggregated 'Laramie and related formations,' resting upon the Pierre, is composed of about 300 feet of a "massive gray to buff sandstone," which lithologically resembles the supposed 'Fox Hills' on the eastern side of the Bighorn Mountains, and for this reason was tentatively referred to the 'Fox Hills.' The few invertebrates do not serve to fix definitely the age, according to Stanton,[31] since they may occur below the Judith River as well as in Fox Hills. Above these beds, whether with or without an erosional interval is not definitely known, comes the great thickness of Fort Union which Fisher has shown may be divided into two parts. The lower member, which corresponds to the beds already so extensively traced, is composed of dark sandstones, shales and clays with occasional seams of coal and coaly shales. Throughout the lower por-

[30] Geol. and Min. Res. Bighorn Basin, Wyoming: U. S. Geol. Surv., Prof. Paper 53, 1906, p. 31 et seq.
[31] In Fisher, Bull. U. S. Geol. Surv., Prof. Paper, 53, p. 32.

tion the sandstones are usually fine-grained and massive, and sandstone concretions are of frequent occurrence. The line between the lower and upper members is a lithologic one, the sedimentation being continuous.

At various localities in the Basin vertebrate remains have been obtained in this lower member, but they are usually so fragmentary that little can be said concerning them beyond the fact that they belong to dinosaurs. Plants are abundant in many places, as the following lists attest.

The following localities for plants are known within the Bighorn Basin:

Near I o P. O., Bighorn County, Wyoming; above 500 feet above base of beds.

Onoclea sensibilis fossilis Newb.
Sequoia nordenskiöldi Heer.
Sequoia sp.
Protophyllocladus? sp. new.
Populus cuneata Newb.
Populus daphnogenoides Ward.
Populus arctica Heer of Lesq.
Populus n. sp.
Populus amblyrhyncha Ward.
Juglans sp.
Corylus americana Wa'ter.
Platanus haydenii Newb.
Sapindus grandifoliolus Ward.
Celastrus taurinensis Ward.
Celastrus sp.
Paliurus pulcherrimus Ward.
Pal urus sp.
Diospyros sp.

Two miles north of Ilo P. O., Bighorn County.

Ginkgo adiantoides (Ung.) Heer.
Populus amblyrhyncha Ward.
Quercus sp.
Platanus nobilis Newb.
Magnolia tenuinervis? Lesq.
Ficus sp. (type of F. *planicostata*).
Celas rus sp.
Berchemia multinervis Al. Br.
Viburnum newberryanum Ward.
Viburnum antiquum (Newb.) Hollick.

Twelve miles west of Ilo P. O., Bighorn County.

Cocculus haydenianus Ward.

West of Winchester Hills, Bighorn Basin (Sec. 34, T. 45 N., R. 95 W.).

Platanus nobilis Newb.
Platanus haydenii Newb.
Sapindus affinis Newb.
Sapindus grandifoliolus Ward.

Three miles northwest of Meeteetse, Wyoming. Black Diamond Mine. About 50 feet above base of section.

Dryopteris sp. new.
Sequoia langsdorfii or near it.
Sapindus grandifoliolus Ward.
Lauraceous leaf, probably new.

Shoshone River, near Cody, Wyoming. [This and the following collection may be from the upper member.]

Sequoia langsdorfii (Brongn.) Heer.
Populus glandulifera? Heer.
Platanus nobilis Newb.
Sapindus grandifoliolus Ward.
Juglans sp.

Near Cody, Wyoming [Sec. 3, T. 53 N, R. 101 W.]

Platanus haydenii? Newb.
Populus speciosa Ward.
Hicoria antiquorum (Newb.) Kn.

Shoshone River at mouth of Sage Creek, 3 miles below Cody, Wyoming.

Platanus raynoldsii Newb.
Platanus haydenii Newb.
Platanus nobilis Newb.

Southeast of Rairden, Bighorn Basin [Sec. 5, T. 48 N., R. 91 W.]

Glyptostrobus europæus (Brongn.) Heer.
Sapindus grandifoliolus? Ward.
Sapindus affinis Newb.
Populus sp.

Bud Kimball mine, Bighorn County, Wyoming [T. 45, R. 89 W.]

Glyptostrobus europæus Heer.
Taxodium occidentale Newb.
Viburnum whymperi Heer.

Three-fourths mile west of Nowater mine [T. 44 N., R. 90 W.], Bighorn County, Wyoming.

Populus cuneata Newb.
Platanus raynoldsii Newb.
Hicoria antiquorum (Newb.)Kn.
Carpites sp.

Bluff on east side of Bighorn River, opposite Kirby, Wyoming; 200 feet above base of lower Fort Union.

Glyptostrobus europæus Heer.
Sequoia nordenskiöldi Heer.

Taxodium occidentale Newb.
Platanus guillelmæ Göpp.
Cocculus haydenianus Ward.

Same locality as last but about 300 feet above base of lower Fort Union.

Taxodium occidentale Newb.
Populus amblyrhyncha Ward.
Populus cuneata? Newb.
Populus genetrix Newb.
Viburnum perplexum Ward.

Same locality as last two, but near top of lower Fort Union.

Taxodium distichum miocenum Heer.
Berchemia multinervis Al. Br.
Celastrus ferrugineus Ward.

18. POSSIBLE DISTRIBUTION OF LOWER FORT UNION IN OTHER AREAS.

Having passed in review the areas where the lower member of the Fort Union is known to occur, a brief mention may be made of certain extra-limital areas where the evidence is incomplete or conflicting, and further data are to be looked for.

In the central Canadian provinces the Fort Union is known to be present over a wide area, and it is more than probable that it will ultimately be found possible to differentiate the lower and upper members; in fact it is thought that the Edmonton beds of the Canadian geologists may correspond to the lower member and their Paskapoo beds to the upper member. But the writer has seen no material from Canadian sources, and the above reference is tentative.

From scanty information at hand it seems likely that the lower Fort Union will be found spreading over a considerable area in northern Montana near Big Sandy, along the Missouri River in the Fort Peck Indian Reservation and in southern North Dakota and northern and northwestern South Dakota.

At Black Buttes, Wyoming, beds containing a Fort Union flora have been found resting with marked unconformity on the so-called "Black Buttes beds" (the beds containing *Agathaumas sylvestris*), while 20 miles to the southward they rest on the Lewis shale, this condition continuing to the outliers of the Uintas near the Wyoming-Colorado line. That these beds with a Fort Union flora are the beds described and mapped by King as Vermilion Creek or Wasatch,

is perhaps a sufficient excuse for omitting their further consideration until additional information, both paleobotanical and stratigraphic, is at hand.

To the eastward of Black Buttes, in the vicinity of Creston, Riner and Rawlins, and as far at least as the vicinity of Carbon, Fort Union plants and occasional dinosaurs have been found. The beds containing them belong to the so-called "upper Laramie" of Veatch and others, that is above the unconformity at the top of the Laramie, but whether or not this series of beds is a unit is an open question at present. It seems probable to the writer that the lower portion may belong to the recently established Shoshone group of Cross, and the upper portion only to the Fort Union. To the west in the vicinity of Evanston a few Fort Union species have been noted, but in all these cases further data are demanded.

Relations Between the Lower Member of the Fort Union and Underlying Formations.

Having traced the areal distribution of what is here called the lower member of the Fort Union formation, as completely as present facts seem to warrant a brief recapitulation of the relations that have been demonstrated of these to the underlying beds may be made. In the Hell Creek region of Montana, the vicinity of Yule, North Dakota, and on Alkali Creek, Weston County, Wyoming, the beds rest *unconformably* on the Fox Hills. At Forsyth, near Custer, the areas south and east of the Bull Mountains, and probably at Glendive, all in Montana, and at Buffalo, Wyoming, the beds rest directly on the Pierre, and not always its uppermost member. In Converse County, Wyoming, the basal conditions are not definitely known, though presumably the relations may be similar to those obtaining in adjacent Weston County. Throughout the Great Plains area the Fox Hills is usually, but not always present, and even when present has not always been satisfactorily separated from the overlying beds.

The evidence is conclusive where actual unconformity has been shown, as well as where the beds are found resting on a lower member (Pierre) of the Upper Cretaceous, and hence, in intermediate areas where discordance has not been observed, it is reasonably cer-

tain that a time interval is represented during which certain of the Upper Cretaceous sediments and, if my view be correct, also certain lower Tertiary beds, including the Arapahoe and Denver or their equivalents, were removed. It is therefore demonstrated beyond reasonable doubt that the beds under consideration are the same throughout the wide area over which they have now been traced. As they are above an unconformity they can, on the basis of stratigraphy, no longer be considered as a part of the 'conformable Cretaceous series.'

Relations Between Lower and Upper Members of the Fort Union.

With the exception of the limited area covered by the Kingsbury conglomerate east of the Bighorn Mountains, which as already shown was a comparatively local affair consequent upon the Bighorn uplift, the lower member of the Fort Union is conformably overlain by the upper member throughout the entire region. Of the many workers who have observed the field relations at hundreds of points, not one, so far as known to the writer, has recorded the presence of unconformity between them. The strong lithologic difference, as already described, makes it possible to separate them usually with little difficulty, but the sedimentation appears to have been continuous. The possibility of unconformity by overlap, always a difficult condition to demonstrate, has not been overlooked, but if present it should have been detected on the borders of the areas along the mountains, which does not seem to have been done. Therefore, it appears that the lower and upper members cannot be separated on structural grounds.

Stratigraphic Relations of the Lower Member of the Fort Union to the Laramie.

The beds that are here regarded as constituting the lower member of the Fort Union have usually been—and by many are still—called 'Laramie,' but when it is recalled that, by original definition, the Laramie is the uppermost member of the conformable Cretaceous series above the Fox Hills, it is seen at once that they cannot be so considered since they are separated from the Cretaceous by an uncon-

formity. Mr. Barnum Brown[32] has clearly recognized the validity of this position, concerning which he writes as follows:

> Strictly following King's definition of Laramie, neither of these deposits ["Hell Creek beds," "Ceratops beds," etc.] can be considered as such, for neither one represents a continuous sedimentation from the marine Fox Hills. They should therefore be grouped with the Livingston, Denver, and Arapahoe beds and may be considered Post-Laramie.

This interpretation by Brown makes the unconformity at the base of the lower member of the Fort Union the same as that demonstrated by Mr. Whitman Cross as occurring at the top of the Laramie in the Denver Basin of Colorado. In the latter area, while an unknown thickness (estimated by Cross at 12,000 to 15,000 feet) has been removed, a considerable thickness of Laramie beds still remain, whereas in the areas covered by the lower Fort Union, the Laramie, as well as the Arapahoe and Denver, or their equivalents, if ever present, has been entirely removed so far as known, and the beds rest on other members of the Upper Cretaceous series. A comparison of the conditions of sedimentation in the two sets of beds, as indicated by their invertebrate fauna, confirms their distinctness. Thus, the Laramie is described as a series of brackish- and fresh-water beds, indicating transition from estuarine or marine conditions, while the Fort Union was laid down in fresh water, and affords little or no convincing evidence of even temporary or occasional incursions of the sea.[33]

Paleontological Characters of the Lower Fort Union.

1. PLANTS.

We may now proceed to the consideration of the various lines of paleontological data, beginning with that of the plants. On reviewing the foregoing account it appears that plants have been obtained

[32] Bull. Am. Mus. Nat. Hist., vol. 33, 1907, p. 845.

[33] The possible exceptions are a single species of *Corbicula* reported by Whitfield from the upper portion of the "Hell Creek beds," this genus being found in both brackish and fresh waters, and *Ostrea glabra* reported from the section near Yule, North Dakota.

at over fifty localities, and when these are brought together in a single list we have no less than 193 forms that have thus far been found in the lower member of the Fort Union. After eliminating the new forms, and those not specifically named, we have the following 84 species that are positively identified:[34]

a List of plants identified in lower Fort Union.

**Aralia notata* Lesq.
**Berchemia multinervis* (Al. Br.) Heer.
**Carpolithes lineatus* Newb.
**Celastrus alnifolius* Ward.
**Celastrus curvinervis* Ward.
**Celastrus ferrugineus* Ward.
**Celastrus ovatus* Ward.
**Celastrus pterospermoides* Ward.
**Celastrus taurinensis* Ward.
**Cinnamomum affine* Lesq.
**Cocculus haydenianus* Ward.
**Cornus newberryi* Hollick.
**Corylus americana* Walt.
**Corylus rostrata* Ait.
**Credneria daturæfolia* Ward.
**Diospyros haguei* Kn.
**Elæodendron polymorphum* Ward.
**Equisetum prelævigatum* Cockerell.
**Ficus artocarpoides* Lesq.
**Ficus spectabilis* Lesq.
Ficus trinervis Kn.
Flabellaria eocenica Lesq.
**Ginkgo adiantoides* (Ung.) Heer.
**Glyptostrobus europæus* (Ung.) Heer.
**Glyptostrobus europæus Ungeri* Heer.
Grewiopsis eocenica (Lesq.) Kn.
**Grewiopsis platanifolia* Ward.

[34] It should not be supposed that when the several undoubtedly new species, together with such of the unnamed forms as may be subsequently allocated, shall have been worked up in detail, the relation to the upper member of the Fort Union will be less marked. On the contrary it is likely to increase the number of species common to the two members, especially as there are large unworked collections, belonging certainly to the upper member, with which they may be compared. It will be observed that the unnamed forms in the lists belong largely to such genera as Populus, Platanus, Viburnum, Hicoria, Planera, Quercus, Sequoia, Taxodium, Carpites, etc., which are strongly represented in the Fort Union; indeed, certain of these genera (*e. g.*, Taxodium, Planera, Glyptostrobus) are not known to be present in the Laramie.

**Grewiopsis populifolia* Ward.
**Hicoria antiquorum* (Newb.) Hollick.
**Juglans rugosa* Lesq.
**Leguminosites arachioides* Lesq.
Marchantia pealei Kn.
Myrica torreyi? Lesq.
Magnolia tenuinervis Lesq.
**Onoclea sensibilis fossilis* Newb.
Paliurus pulcherrimus Ward.
Palmocarpon palmarum (Lesq.) Kn.
**Phyllites cupanoides* Newb.
**Populus acerifolia* Newb.
**Populus amblyrhyncha* Ward.
**Populus arctica* Heer. of Lesq.
**Populus cuneata* Newb.
**Populus daphnogenoides* Ward.
**Populus genetrix* Newb.
**Populus glandulifera* Heer.
**Populus inæqualis* Ward.
**Populus nebrascensis* Newb.
**Populus nervosa elongata* Newb.
**Populus rotundifolia* Newb.
**Populus subrotunda* Lesq.
**Populus speciosa* Ward.
**Platanus guillelmæ* Göpp.
**Platanus haydenii* Newb.
**Platanus marginata* (Lesq.) Heer.
**Platanus nobilis* Newb.
**Platanus raynoldsii* Newb.
**Platanus raynoldsii integrifolia* Lesq.
**Platanus platanoides* (Lesq.) Kn.
**Platanus rhomboidea* Lesq.
**Pterospermites minor* Ward.
**Pterospermites whitei* Ward.
Quercus breweri Lesq.
Quercus cineroides Lesq.
Quercus viburnifolia Lesq.
Rhamnus salicifolius Lesq.
Sabal rigida Hatcher.
Sabalites fructifer Lesq.
Sabalites grayanus Lesq.
Salix angusta Al. Br.
**Sapindus affinis* Newb.
**Sapindus grandifoliolus* Ward.
**Sequoia langsdorfii* (Brongn.) Hr.
**Sequoia heerii* Lesq.
**Sequoia nordenskiöldi* Heer.
**Sparganium stygium* Heer.
**Taxodium dictichum miocenum* Heer.

**Taxodium occidentale* Newb.
**Thuya interrupta* Newb.
**Trapa microphylla* Lesq.
**Viburnum antiquum* (Newb). Hol.
**Viburnum newberryianum* Ward.
**Viburnum perplexum* Ward.
**Viburnum whymperi* Heer.
**Vitis xantholithensis* Ward.

[In the above list the species marked with an asterisk (*) are found also in the upper member of the Fort Union.]

To any one familiar with the flora of the Fort Union, it needs but a glance at the species here listed to show how overwhelming is the preponderance of the elements of this flora. As Doctor Newberry long ago stated, it has a botanical facies which is unique and unmistakable. Attention is especially directed to the great development of the genus Populus with 13 species, and the presence of such distinctive genera as Celastrus, Pterospermites, Elaeodendron, Grewiopsis, Cocculus, Marchantia, etc., while of the species it may be stated that nearly half (37) have never been found outside this formation, at least in this country. The following table presents graphically the relations that exist between the flora of the lower member of the Fort Union and that of other formations:[35]

Total known Fort Union flora (including lower and upper members) about	500
Total forms known from lower member	193
Forms specifically identified in flora of lower member	84
Of these 84 species there are common to upper member	61
Common to lower member and Laramie	11
Common to lower member and Montana	11

[35] To the possible criticism that too much dependence has been placed in a statistical comparison, rather than one based on relative abundance, the following facts may be pointed out. The presence of a species in the list does not, of course, indicate its abundance as an element of this flora, but on turning back to the lists of species recorded under each locality, it will be noted that the frequent repetition of names shows the extent to which many of the commonest and best known species are distributed. Thus *Populus amblyrhyncha* occurs at 15 localities; *P. cuneata* at 11 localities; *Sapindus grandifoliolus* and *Tazodium occidentale* at 12 localities each, etc.; indeed, very few are present at a single locality only. In most cases the plants are neither so well preserved nor so abundant in the lower member as they are in the upper, and large collections are secured with more difficulty.

Common to lower member and Arapahoe and Denver	22
Common to lower member and Shoshone	35
Common to lower member and other Eocene	15
Common to lower member and Cretaceous [including Laramie and Montana.]	16
Common to lower member and Tertiary [Eocene to Miocene]	68

From the above table it appears that of the entire number of forms now known in the lower member of the Fort Union only 16 species are common to it and the Cretaceous, this including both Laramie (11) and Montana (11), and of these there are 7 species which run from the Cretaceous through the lower Fort Union into or above the upper member of the Fort Union, thus leaving really only 9 species confined exclusively to the beds under consideration and the Cretaceous below. Following is the list of the 16 species, the asterisk indicating Montana species and the dagger Laramie species:

*†*Ficus trinervis.*
†*Flabellaria eocenica.*
*†*Juglans rugosa.*
*†*Myrica torreyi.*
* *Magnolia tenuinervis.*
†*Palmocarpon palmarum.*
†*Platanus haydenii.*
*†*Platanus marginata.*
* *Platanus platanoides.*
†*Platanus raynoldsii.*
†*Quercus viburnifolia.*
*†*Rhamnus salicifolius.*
*†*Sabalites grayanus.*
* *Salix angusta.*
* *Trapa? microphylla.*
* *Viburnum whymperi.*

A close analysis of the distribution of these species shows that, for one reason or another, comparatively little weight is to be attached to certain of them. Thus, *Ficus trinervis*, which occurs only in the lower beds at Glendive, Montana, is a species of wide distribution in the Montana and Laramie, and has been found in the Shoshone. *Flabellaria eocenica*, reported from Converse and Weston counties, finds its main distribution in the Laramie and occurs also at Black Buttes. *Juglans rugosa*, of which there is but a single specimen in the dinosaur beds at Yule, is of very wide distribution,

occurring at Point of Rocks, Rock Springs, Black Buttes, Evanston, and Carbon, Wyoming, Marshall, Colorado, and the Livingston of Montana. *Myrica torreyi* is present in the lower Fort Union of Converse County, where a single specimen was doubtfully so determined; its principal distribution is in the Montana and Laramie, and also at Black Buttes. *Magnolia tenuinervis* was originally described from the Denver, has been found at Black Buttes and Hodge's Pass, Wyoming, and doubtfully in the Montana at Coalville, Utah. *Palmocarpon palmarum* is a fruit of uncertain status. Of the four species of *Platanus*, two (*P. haydenii* and *P. raynoldsii*) are very abundant and widely distributed in both lower and upper members of the Fort Union, and of rare or exceptional occurrence in the Laramie. Of the others, *Platanus marginata* is found at Point of Rocks and Black Buttes, and in the Laramie at Crow Creek, Colorado, and *P. platanoides* at Black Buttes and the supposed Montana of the Grand Mesa region of Colorado. *Quercus viburnifolia* is found in Arapahoe and Denver and the Laramie of Crow Creek. *Rhamnus salicifolius*, reported only from the "Hell Creek beds," is mainly a Laramie species but has been found in the Montana at Rock Springs, Wyoming. *Saballites grayanus* is of wide distribution in the Montana, Laramie, Denver, and Livingston; it is usually obscurely preserved and difficult of certain identification. *Trapa microphylla* has now been found at so many points from Montana to upper Fort Union that it is of little value in fixing the age of beds. *Viburnum whymperi* has been found at Point of Rocks, Black Buttes, and in the upper Fort Union.

It is significant that of the 84 species found in the lower Fort Union only 16 are distributed into the Cretaceous, while no less than 68 are confined to the Tertiary.

As might be expected, the relationship between the flora of the Arapahoe and Denver and that of the lower Fort Union is much stronger, there being some 22 of the 84 species that are common. As the flora of the Arapahoe and Denver now numbers about 200 species, it is seen that the species common to the lower Fort Union is not strong enough to bring them together, though, as most of the common species come from the areas nearest to the Denver Basin, it may be shown that the relationship is closer when larger collections from intermediate points are available for comparison, but for the

present they are regarded as being slightly older than the beds under discussion, though of Eocene age.

It is not deemed necessary in the present connection to attempt a further analysis of the relations between this flora and that of other Eocene and the Miocene. The number of common species show the direction in which the affinities lie.

b Paleobotanical Proof of the Eocene Age of the Fort Union Flora.

As stated in the opening pages of this paper little doubt is now entertained as to the Eocene age of the Fort Union. So long, however, as it was confused with the Laramie and other formations, attempts at interpreting its floral affinities could but lead to conflicting or indecisive results. Thus, in 1886 Professor Ward[36] instituted an elaborate investigation to ascertain the Cretaceous or Tertiary age of the 'Laramie,' which was destined to failure, as it included plants from beds now known to belong to the Montana, Laramie, Arapahoe, Denver, Livingston and Fort Union. It should not be supposed, however, that he failed to note the well-marked differences between the flora of the Fort Union and that of the other formations considered with it. He saw these clearly enough, and pointed them out, but was misled by the prevailing opinion of the time, mainly that of the invertebrate paleontologists, that it could not be separated from the 'Laramie,' just as Newberry had been earlier misled into referring the Fort Union to the Miocene, on the basis of the then current correlation of certain plant-bearing horizons in Greenland, England and elsewhere. But as early as 1875, Sir William Dawson and Dr. Geo. M. Dawson[37] maintained the Eocene age of the Fort Union (the "Upper Laramie" of Canadian geologists), and neither one, so far as known to the writer, ever changed this opinion as to its position.

The flora of the Fort Union, as Newberry stated, has a botanical facies that permits at a glance its separation from that of the Laramie. It clearly inaugurates a new order of events and witnessed

[36] Synopsis of the Flora of the Laramie Group; Sixth Ann. Rept. U. S. Geol. Surv., 1884, 1885 (1886), pp. 399–557, pls. 31–65.

[37] Brit. N. A. Bound. Com., Geol. & Resources Vic. 49th Parallel, 1875, pp. 183–202.

the introduction of the earlier representatives of certain important genera and species. For example, the Fort Union contains several species (*Onoclea sensibilis*, *Corylus americana*, *Corylus rostrata*, etc.) now living, a condition not known to obtain in any earlier American horizon, while others are so obviously close to living species as to be separated with difficulty.

Of the various Old World plant deposits containing identical or closely related species, mention may first be made of the English Eocene. Thus, from Ardtun in Mull, which is regarded by Gardner as referable to the lower Eocene and approximately of the same age as Gelinden, we have the following conifers common to the Fort Union: *Sequoia langsdorfii*, *Glyptostrobus europæus*, *Sequoia couttsiæ*, and *Ginkgo adiantoides*. Of the ferns from the same locality, *Filicites hebridicus* Forbes [*Onoclea hebridica* Gard. and Ett.] is identical with our *Onoclea sensibilis fossilis*, to which also is referred *Woodwardites arcticus* Heer, from Atanekerdluk, North Greenland. *Osmunda lignitum* (Giebel) from Bornemouth is apparently the same as *Asplenium magnum* Kn. Among the dicotyledons of the British Eocene, mention may be made of their *Platanites hebridica*, which is apparently the same as our great *Platanus nobilis*, while among identical species are *Corylus macquarrii*, *Populus arctica*, *Populus richardsoni*, etc., while many genera (*e. g.*, *Cinchonidium*, *Diospyros*, *Sapindus*, *Bauhenia*, *Ulmus*, *Ficus*, *Juglans*, *Laurus*, *Celastrus*, *Elæodendron*, *Zizyphus*, *Leguminosites*, etc.) show related and in some cases identical species.

From the well-known lower Eocene deposits of Sezanne in the Paris Basin, the following species have been identified in our Fort Union: *Monimiopsis fraterna* Sap., *M. ambrosiæfolia* Sap., and *Hamamelites fothergilloides* Sap., while *Marchantia sézannensis* Brongn., is very close to *M. pealei* Kn.; *Viburnum giganteum* Sap., to *V. antiquum* (Newb.) Hollick; *Grewiopsis credneriæfolia* Sap., to *G. populifolia* Ward; *Celastrinites hartogianus* Sap., to *Elæodendron polymorphum* Ward, etc. Among common genera with related species we have: *Pterospermites*, *Aralia*, *Celastrinites*, *Zizyphus*, *Cornus*, *Hedera*, *Laurus*, *Sassafras*, *Daphnogene*, *Populus*, *Ulmus*, etc.

The lower Eocene deposits at Gelinden in Belgium, regarded as about the same age as Sezanne, have *Aralia looziana* Sap. and Mar.,

common to the Fort Union, while their *Viburnum vitifolium* is not greatly different from our *V. antiquum*. Of common genera mention may be made of the following: *Celastrophyllum, Aralia, Hedera, Litsæa, Hamamelites, Laurus, Cinnamomum*, etc.

Other affinities could be pointed out, but space will be taken only for a brief conparison with the extensive plant deposits in North Greenland. The age of these beds was at first considered by Heer to be Miocene, but later students, among them Saporta, Gardner, Ettingshausen and many others, have quite generally referred them to the Eocene. There are many species in common with the Fort Union, such as *Sequoia langsdorfii, S. couttsiæ, Ginkgo adiantoides, Taxodium distichum miocenum, Glyptostrobus europæus, Populus arctica, P. glandulifera, Sparganium stygium, Corylus macquarrii, Juglans nigella, Paliurus colombi, Grewia crenata, Platanus aceroides, Diospyros brachysepala*, etc., etc.

It is perhaps hardly necessary to add that there can be no doubt as to reference of the European localities mentioned to the Eocene, their position being fixed by various lines of evidence.

2. INVERTEBRATE EVIDENCE.

The invertebrates of the lower member of the Fort Union are relatively much less numerous both in species and individuals than are the plants, yet, fortunately, considerable collections have been secured in the critical areas. By combining the list of species given by Dr. T. W. Stanton[38] for the "Ceratops beds," of Converse County, Wyoming, with that given by Dr. R. P. Whitfield[39] for the "Hell Creek beds" of Montana, we have an aggregate of 49 forms. It should be stated, however, that this total includes 8 unnamed but supposed new species of Unio mentioned by Stanton as occurring in the "Ceratops beds." The distribution of these invertebrates is shown in the accompanying table:

List of invertebrates from "Hell Creek" and "Ceratops beds."

[In the list the species marked with an asterisk are found in the "Hell Creek beds"; those marked with a dagger, in the "Ceratops beds." The

[38] Bull. Geol. Soc. Am., vol. 8, 1897, p. 135.

[39] Bull. Am. Mus. Nat. Hist., vol. 23, 1907, table facing p. 829.

species preceded by a cross (x) are common to these beds and the Colorado Laramie.]

**Unio æsopiformis* Whitf.
**Unio corbiculoides* Whitif.
**Unio pyramidellus* Whitf.
**Unio verrucosiformis* Whitf.
**Unio retusoides* Whitf.
**Unio brownii* Whitf.
**Unio percorrugata* Whitf.
**Unio postbiplicata* Whitf.
**Unio aldrichi* White.
*†*Unio danæ* M. and H.
*†*Unio holmsiana* White.
**Unio vetusta* Meek.
*†*Unio cryptorhynchus* White.
**Unio biasopoides* Whitf.
**Unio cylindricoides* Whitf.
**Unio letsoni* Whitf.
**Unio gibbosoides* Whitf.
**Unio pyramidatoides* Whitf.
**Unio subtrigonalis* Whitf.
†*Unio brachyopisthus* White.
†*Unio cou si* White.
†*Unio proavitus* White.
†*Unio endlichi* White.
[About 8 undescribed species, Stanton.]
†x*Anodonta parallela* White.
†*Anodonta propatoris* White?
*†*Sphærium planum* M. & H.
†*Sphærium* sp.
†*Viviparus trochiformis* M. & H.
*x*Viviparus plicapressus* White.
†x*Tulotoma thompsoni* White.
*†*Campeloma producta* White.
**Campeloma vetula* M. & H.
*†*Campeloma ultilineata* M. & H.
†*Goniobasis tenuicarinata* M. & H.
*†*Thaumastus limneiformis* White.
†*Physa copei canadensis* Whiteaves.
†*Helix vetusta* M. & H.
†*Limnæa* sp.
*x*Corbicula subelliptica* M. & H.
**Cassiopella turricula.*
**Bulinus rhomboideus* M. & H.

This table presents some interesting features. In the first place it is to be noted both the "Hell Creek" and the "Ceratops beds" afford 28 forms each, of which 7 are common to the two areas, mak-

ing the aggregate number 49, as stated above. It is very probable, however, that at least some of the undescribed Unios from Converse County may prove to be identical with those from Hell Creek. It is significant that of the 49 species only 4 species (8.3 per cent) are common to the Laramie of the Denver (Colorado) region. These are *Anodonta parallela*, *Tulotoma thompsoni*, *Corbicula subelliptica* and *Viviparus plicapressus*, the second species mentioned being found also in the Montana, and two of the others at Black Buttes,[40] Wyoming, which reduces their value as diagnostic markers for the Laramie. There are 8 species common to the "Hell Creek" and "Ceratops beds," and the acknowledged Fort Union, of which 7 fall within the 18 species other than Unios. The most remarkable feature of this fauna is the abundance of Unios, there being 31 of the 49 species that are referred to this genus, whereas in the Colorado Laramie there is but a single fragmentary Unio, which cannot be specifically identified. And, it may be added, these Unios are found in the Hell Creek and Converse County areas in direct association with both dinosaurs and plants, so there can be no question as to their having come from within the dinosaur-bearing beds.

Whitfield,[41] who described the Unios from the Hell Creek region, was so impressed with their evident affinity to species living in the Mississippi and Ohio watersheds, that he gave to many of them names designed to indicate this relationship (*Unio gibbosoides* Whitf., cf. *Unio gibbosus* Barnes; *U. retusoides* Whitf., cf. *U. retusus* Lam., etc.), and adds:

> Some of them are so nearly like the living species that it would do but little violence to specific features, to state that they were the same.

This indicates either that the "Hell Creek beds" are comparatively recent, or that Unios are not of great value as time markers. As Brown well says[42] "The invertebrates plainly forshadow Tertiary and living species."

[40] The fossiliferous, dinosaur-bearing bed at Black Buttes, Wyoming, is not here admitted as being certainly referable to the Laramie, but rather to post-Laramie, or Shoshone.

[41] Bull. Am. Mus. Nat. Hist., vol. 19, 1903, pp. 483–487; idem, vol. 23, 1907, pp. 623–628.

[42] Idem, vol. 23, 1907, p. 845.

3. VERTEBRATE EVIDENCE.

a Dinosaurs.

Basing their conclusions upon identity of forms as well as on general similarity, there seems to be substantial agreement among vertebrate paleontologists in regarding the dinosaur-bearing "Hell Creek beds" and "Ceratops beds" as being of the same age. Throughout the other areas described in this paper wherever the dinosaurs have been found sufficiently preserved to admit of identification, they have been shown to be identical with those from the principal deposits above mentioned. It may, therefore, be taken as also established by vertebrate paleontology that the beds under discussion are of identical age throughout the field over which they have been traced. It is very much to be regretted that the series of monographs planned by the late Professor Marsh on the several groups of dinosaurs are, with the exception of that on the Ceratopsia, still unpublished. A summary of present knowledge concerning their distribution would be very helpful at this time, but, so far as known to the writer, there is no place in the United States where they are known to occur in undoubted Laramie.

Vertebrate paleontologists have been so long accustomed to regard the presence of dinosaurs as *prima facie* evidence of Cretaceous age, that doubtless a storm of protest will be raised at the position here assigned them; yet it should need but a moment's reflection to show that there is apparently no inherent structural or physiological peculiarity which barred them from crossing the line—if there be such—between Cretaceous and Tertiary time. To the naïve statement that the dinosaurs possess "decided Mesozoic affinities" there cannot be the slightest objection, since, being without known descendants, it is possible to compare them only with their ancestors, which were of course Mesozoic. It has also been urged recently, in all seriousness, that the time-honored custom of denominating the Cretaceous as the "Age of Reptiles" will be broken down if the dinosaurs are permitted to pass into the Tertiary, yet even this objection does not seem serious, especially as there are other undoubted Tertiary as well as living reptiles. The Nestors of American vertebrate paleontology have all, at one time or another, admitted the possibility

of the dinosaurs passing up into the Tertiary, and it would seem that the time had come to demand something more tangible than mere assumption for the Cretaceous age of the dinosaurs.

Hatcher,[43] in speaking of the Ceratops fauna, frankly stated that

> owing to the fact that very few vertebrates had previously been described from the typical Laramie, as first defined by Mr. Clarence King, and the consequent lack of vertebrate forms known to have come from the Laramie for comparison with those found in the Ceratops beds, it must be admitted that the vertebrate fauna of the latter is, in itself, at present not sufficient proof to establish the Laramie age of the Ceratops beds.

In the Denver Basin, where, as already set forth, the relation of the Laramie to underlying and overlying formations has been thoroughly and satisfactorily elucidated, the dinosaurs have not been found in the Laramie, though they are found in both Arapahoe and Denver formations. During pre-Arapahoe time, as Cross has shown, there was inaugurated the profound orogenic movement which originated the Rocky Mountains and a period of erosion which cut through many thousands of feet of strata before the beginning of deposition in the Arapahoe Lake. The vertebrate paleontologists do not appear to appreciate the significance of this great erosional interval and its attendant phenomena. Mr. Cross[44] has so admirably stated these conditions and the inference to be drawn from them, that I cannot refrain from quoting his words:

> The dinosaurs of the Ceratops beds are highly modified and specialized forms unknown as yet in other parts of the world except, perhaps, in the Gosau[45] formation of Austria, and the conclusion that they necessarily indicate a Mesozoic age implies some reason why they may not have survived into the early Tertiary.

In the light of the facts which have been presented concerning the

[43] Am. Jour. Sci. (3), vol. 45, 1893, p. 140.

[44] Mon. U. S. Geol. Surv., 27, 1896, p. 251.

[45] The Gosau beds near Vienna, Austria, are usually referred to the upper Turonian or lower Senonian. They are overlain by several hundred feet of fossiliferous marine Cretaceous, and the dinosaur fauna, together with the associated fossil plants, indicate an age that is approximately that of the Judith River.

Prof. R. S. Lull (*in litt.*, January 19, 1909) coincides with this conclusion as to the stratigraphic position of the beds.

several epochs succeeding the Laramie it is not clear to the writer why this belief that the dinosaurs, or, indeed, the whole vertebrate fauna, surely indicate a Mesozoic age should be so positively maintained as is done by the vertebrate paleontologists.

If the dinosaurs of the Ceratops fauna did actually live in the Laramie epoch of Colorado they survived a great orographic movement and its accompanying climatic changes, and continued through the Arapahoe and Denver epochs so little modified that Professor Marsh has not detected any changes corresponding to the stratigraphic time divisions. This is all the more remarkable since the fossil plants show a great modification during this time, and it has been commonly claimed that enormous and highly specialized vertebrate animals are particularly sensitive to conditions of environments. If the Laramie vertebrates were unaffected by the known dynamic phenomena of the Colorado region in post-Laramie times, it may well be asked what caused their extermination in the post Denver interval, where as yet no evidence of orographic movements comparable with that of the pre-Arapahoe have been found. And if their extinction was due in large measure to other causes than those associated with dynamic phenomena, may that extinction not have been deferred until the Eocene?

These considerations seem to the writer ample ground for the demand that the causes leading to the extinction of the Ceratops fauna should be definitely connected with some orographic disturbance at the close of the Denver epoch before their presence in the Arapahoe and Denver beds can be admitted as full proof of the Mesozoic age of these formations.

That the ground above taken is logical and irrefutable is shown by the occasional testimony of vertebrate paleontologists themselves. Thus, Mr. Earl Douglass[46] in a paper dealing with the dinosaur- and mammal-bearing beds near Melville, Montana, says:

> If we could point to any time when dinosaurs ceased to be and the higher orders of mammals took their places, then the matter would be easy; but heretofore most of the Cretaceous dinosaurs—in fact nearly all of them—have been supposed to come from the uppermost Cretaceous—the Laramie—but the other fossils found in these beds have not been of a character to settle the doubt concerning the horizon. There is no direct proof that the dinosaurs died out before the higher forms of mammals became numerous. Though they have not yet, so far as I know, been found in the same beds,

[46] Proc. Am. Phil. Soc., vol. 41, 1902, pp. 218, 219.

yet there seems good reason for believing that dinosaurs were contemporaneous with Puerco mammals.[47] . . . It is extremely unsafe to say when and where these strange reptiles breathed their last, for the presence of fossils is certain evidence of the existence of life, but the lack of them is no evidence of its absence. Dinosaurs may have continued long in the Eocene, but conditions in the places where so many mammalian remains have been found may not have been favorable for them.

The causes which led to the extinction of the dinosaurs are of course unknown and may always remain so. Being highly specialized and supposedly sensitive to environmental changes, it is difficult to imagine what could have caused their sudden and absolute decimation. An orogenic movement with the effect it would have had on climate and vegetation; the draining of the waters in which, or beside which, they lived; the sudden incursion of mammal enemies able to cope with them; the outpouring of volcanic material; these, or any one of them, might account for their disappearance, but we have no evidence of the occurrence of either of these phenomena. If there was a change in climate, it was not reflected in the flora; if there were enemies, their remains have not been found; if there were volcanic disturbances, the ejectamenta are not present in the sediments, and finally, the waters were not drained; for sedimentation

[47] A striking confirmation of this prediction has just been brought to the writer's attention, this being an important discovery made by Mr. Jas. H. Gardner, of the U. S. Geological Survey, during the field season of 1908. At a point near the head of Coal Creek, 1 mile southeast of Ojo Alamo, New Mexico (about 12 miles south of Farmington), in variegated sands, shales and conglomerates, indisputable above the unconformity at the top of the Laramie, and thus apparently of Puerco age, he found "near the top of the section" vertebrate remains which have been studied by Mr. C. W. Gilmore who reports the presence of *Triceratops*, *Trachodon*, *Tyrranosaurus*, *Aspidiretes*, and crocodiles. Of this fauna Mr. Gilmore says: "Appears to represent a typical fauna of the so-called Laramie, or better, Ceratops beds." The significance of finding a typical "Ceratops beds" dinosaur fauna in beds that are more than probably of Puerco age, is apparent. It is also of interest to note that this locality (Head of Coal Creek) is exactly the same as that given by Wortman (Bull. Am. Mus. Nat. Hist., vol. vii, 1895, p. 2) as one of the localities at which he obtained Puerco mammals. And in this connection it may be added that the writer has just been informed that dinosaurs have been found associated with mammals in the so-called Pyrotherium beds of South America, which, it is said, are of acknowledged Eocene age, and correspond approximately to our Puerco.

was continuous. No more plausible theory occurs to the writer than that they were suddenly removed by epidemic disease, so many examples of which among recent animals have been given by Professor Osborn.[48]

b Mammals.

There is, in the present connection, neither opportunity, nor particular occasion, for going exhaustively into the bearing of the mammals on the questions here involved, other than a general statement as to their apparently complete distinctness from the mammals of the Cretaceous, and argeement with those of undoubted Tertiary age. When the mammals of the "Ceratops beds" were first mentioned by Marsh he made the following statement[49] concerning them:

All the mammals are of small size. They are mainly Mesozoic in type, and more nearly related to the Jurassic forms below than to those in the Tertiary above. . . . These remains are not transitional between Mesozoic and Tertiary forms, but their affinities are with the former beyond a doubt; thus indicating a great faunal break between the time in the Cretaceous when they lived and the earliest known Tertiary, or between the Ceratops horizon and the *Coryphodon* beds of the Eocene Wasatch. The lower division of the *Coryphodon* beds, or lower Wasatch (Puerco) is clearly Tertiary, and the great break is between this horizon and the Ceratops beds of the Laramie.

In this connection he also makes the following vigorous statement:

Bearing in mind all that is known today of the development and succession of vertebrate life in America, from early Silurian on to the present time, it is safe to say that the faunal break as now known between the Laramie and the lower Wasatch, is far more profound than would be the case if the earlier Jurassic and Cretaceous below the Laramie were wanting.

On the other hand Prof. H. F. Osborn[50] in his "Rise of the Mammalia," published the same year as the above quotation from Marsh, and based on similar material, makes the evolutionary break much

[48] Am. Nat., vol. 40, 1906, pp. 829–837.
[49] Am. Jour. Sci. (3), vol. 43, 1893, pp. 249–251.
[50] Studies from Biol. Lab. Col. Coll., Zoöl., vol. i, 1893.

less marked between the mammals of the "Ceratops beds" and those of the Puerco. His statement is as follows:

Estimating the geological intervals by dental evolution and faunal succession, there is first the great gap between the Trias of Microlestes and Dromotherium and the Jurassic of the Stonesfield state; there is a relatively shorter interval, but still a considerable one, between this and the Purbeck or Atlantosaurus beds. Then follows another long and very important interval between the Atlantosaurus beds and the Laramie (Upper Cretaceous). The gap between the Laramie and Puerco was relatively short as indicated by the comparatively limited evolution both of the Plagiaulacidæ and Tritubercula tes.

Mr. J. W. Gidley, of the United National States Museum, who has had opportunity of studying much of the material seen by Marsh, together with that upon which Osborn based his conclusions as well as some new material, takes even stronger ground than Osborn as to the affinities between the Ceratops and Puerco and Torrejon mammals. He says:

I do not hesitate to say, judging from the known forms, that the differences between the mammals of the Jurassic and those of the Ceratops beds are at least ten times as great as they are between the mammals of the Ceratops beds and those of the Puerco. This conclusion is based on morphological ground rather than actual relationships. Leaving the multituberculates out of consideration at present the pattern of the tooth-crowns, especially of the upper molars, in the Jurassic mammals is fundamentally different from that of the known mammals of any later horizons, while most of the forms of the Ceratops beds have attained the typical tritubercu ate pattern, which, with very slight variations, has been repeated over and over again in every higher horizon where mammals are found, and is the dominant form in most of living orders. The natural inference follows, therefore, that the time interval between the Ceratops beds and the lowest acknowledged Tertiary above is very slight as compared with that between the Ceratops beds and the Morrison beds below.

The multituberculates show almost as wide a difference in time between the Morrison and Purbeck, and Ceratops beds, while the Ceratops beds and Torrejon probably contain at least three genera of mammals (*Ptilodus*, *Cimolomys* and *Meniscoessus*) in common, and there are no genera in common with the Puerco. It is thus

made plain, that, so far as present knowledge goes, the relationships of the mammals of the Ceratops beds are, with the exception of the two doubtfully placed Judith River forms, exclusively Tertiary and not Cretaceous. That they had an anterior period of development is, of course, probable, but we do not know at present what that was, or how far back we must go for their starting point.

From what Mr. Gidley has stated it appears that the mammals of the "Ceratops beds" cannot be considered as affording evidence against the reference of these beds to the Tertiary. The Ceratops mammals cannot be regarded as the direct ancestors of those in the Puerco—for this would imply a considerable time interval—but rather as a different, possibly slightly older, phase of the same evolutionary stage. Recently Mr. Gidley has been studying a very interesting mammalian fauna secured in the vicinity of Melville, Montana, in beds of the Fort Union, which are of undoubted Torrejon affinity, while in beds of the upper member about 1200 feet above its base is another fauna which is even more typical of the Torrejon. Mr. Gidley permits me to say that the mammals of the "Ceratops beds" are apparently more closely related to those of the Fort Union (Torrejon) than they are to those of the Puerco, there being among the multituberculates as already stated three genera in common with the former and none with the latter. The evidence afforded by the trituberculates in general is similar, that is, they show more affinities with those of the Torrejon than with the Puerco.

c Chelonians.

Remains of turtles appear to be of rather common and widespread occurrence in the lower Fort Union, but they are usually so fragmentary as to be difficult or impossible of satisfactory identification; in any event, among the numerous specimens brought in in recent years by the writer and others, it has not been found possible to make even generic determinations by the paleontologists to whom they have been submitted.

It has recently been confidently asserted on eminent authority that the turtles of the "Ceratops beds" are very closely related to those of the Judith River formation; in fact that several species are identical, and others so close as to be separated with difficulty.

Fortunately the work of Hatcher,[51] published as late as 1905, has left us with a very complete annotated list of the Judith River forms, which makes a valuable basis for comparison of the two faunas. It needs, however, but a cursory examination to show that at least half of the species listed as belonging to the Judith River do not belong to this fauna at all, but come from the Fort Union, Arapahoe, etc., or are so fragmentary as to be unidentifiable. When there is added to this the possibility of the truth of Professor Osborn's[52] conjecture that there has probably been a mixture of horizons in the so-called Judith River fauna, any comparison of the turtles of the Judith River formation with those of the "Ceratops beds" as tending to support the Cretaceous age of the latter, does not make a very impressive case.

d Fishes.

The few and fragmentary fish remains from the "Hell Creek beds" were studied by Dr. C. R. Eastman and Dr. L. Husakof. Concerning them Eastman says: "As a whole the collection does not have a decided Cretaceous aspect," and adds that "it would be useless to argue from this that the beds in question are of Eocene age, for there are numerous fishes of preponderating Eocene type in the Fort Benton Cretaceous of Wyoming." From this it appears that the fish remains are not likely to be much of a factor in fixing the age of these beds, though if anything they favor the Eocene age.

Line Between Cretaceous and Tertiary.

All things considered it seems that the logical point at which to draw the line between the Cretaceous and Tertiary is at the top of the true Laramie. If a locality could be found at which sedimentation was continuous, it would probably be necessary to draw an arbitrary line, but we do not yet know any section of such completeness in this country. In favor of placing it at the point indicated, we have the evidence of diastrophism as signalized by the upbuilding

[51] Bull. U. S. Geol. Surv., 257, 1905, pp. 72–80.
[52] Geol. Surv. Canada: Contr. Can. Pal., vol. 3, pt. 2, 1902, pp. 8, 9.

of the Rocky Mountains, the general elevation of the country, and the permanent banishment of the sea, as well as the change in the character of the sediments. Plants show distinctly the inauguration of a new order of things, extremely few of the forms passing over from the Laramie, while many new types are introduced, among them a number of species which are living today, a condition not known for the flora of any earlier American horizon. If, as has been suggested, the line between the Cretaceous and Tertiary be drawn at the point where the dinosaurs happened to disappear, we are left without the support of contributory data. Diastrophism, orogenesis, continuity of sedimentation, floral similarity, as well as the evidence of invertebrates and mammals, are nullified.

Summary and Conclusions.

1. The Fort Union formation is a fresh-water Tertiary formation of wide areal extent mainly east of the Rocky Mountains, ranging from Wyoming and western South Dakota over western North Dakota, eastern and central Montana, the central Canadian provinces and reaching the valley of the Mackenzie River.

2. It is shown that the Fort Union formation may be separated into two members on lithologic grounds. The present paper deals only, or largely, with the stratigraphy and paleontology of the lower member, which includes the "Hell Creek beds" and so-called "somber beds" of Montana, and the "Ceratops beds" of Wyoming.

3. The areal distribution of the lower member is traced in Montana, North and South Dakota and Wyoming, and its probable extension in other areas is indicated. Complete lists of the fossil plants are given by localities for each of the areas.

4. It is shown that the lower member rests, in some cases unconformably, in others in apparent conformity, on the Fox Hills or Pierre, and the conclusion is reached that an erosional interval is indicated during which the Laramie—if ever present—and other Cretaceous and early Tertiary sediments were removed.

5. It is shown that the beds under consideration, being above an unconformity, can no longer be considered as a part of the "conformable Cretaceous series" and hence are not Laramie.

6. It is shown that the two members of the Fort Union, although

usually distinct lithologically, cannot be separated structurally, sedimentation having been uninterrupted, except locally.

7. The paleontological elements of the lower members are considered at length, beginning with the plants. It is shown that of the 84 known species, 61 are common to the upper member, and only 11 species to the Laramie of Colorado, while 15 species are common to other American Eocene and 9 species to the Miocene. The Eocene age of the Fort Union is fixed by tying its flora to that of various Old World beds of known Eocene position.

8. The invertebrate evidence is shown to be in substantial accord with that of the plants, there being only 4 of the 49 species common to the Colorado Laramie. All, with a single possible exception, are fresh-water forms.

9. It is shown that the vertebrates afford no positive evidence of Cretaceous age. That the dinosaurs exhibit Cretaceous affinities is not denied, since, being without known descendants, it is possible to compare them only with their progenitors. It has been proved beyond question that they survived the profound orogenic movement and attendant physical break at the top of the Laramie in the Denver Basin of Colorado, and lived on in Arapahoe and Denver time, and it is shown that in the areas considered in this paper they passed over a similar erosional interval and are found in association with the Fort Union flora, which is of Eocene age.

10. The mammals of the lower Fort Union show very little relationship with Jurassic or Cretaceous forms, but find their closest affinities with those of the Puerco and Torrejon, which are of acknowledged Eocene age.

11. The chelonians are shown to be of little value in their bearing on the age of the lower Fort Union, especially when compared with the Judith River forms, which are evidently in confusion.

12. It is held that the line between Cretaceous and Tertiary should be drawn at the top of the true Laramie.

13. The final conclusion is reached that the beds here considered ("Hell Creek beds," "somber beds," "Ceratops beds," "Laramie" of many writers) are stratigraphically, structurally, and paleontologically inseparable from the Fort Union, and are Eocene in age.

Note.—For assistance in the preparation of this paper, both in the field and in the office, I wish to acknowledge my great indebtedness to Dr. A. C. Peale of the U. S. National Museum.

PROCEEDINGS

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. XI, No. 3, PP. 239–293 August 14, 1909*

THE AGE AND STRATIGRAPHIC RELATIONS OF THE "CERATOPS BEDS" OF WYOMING AND MONTANA.

BY TIMOTHY W. STANTON.

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Throughout a large area in Wyoming and Montana the latest marine Cretaceous strata of the region are overlain by a non-marine formation of light-colored sandstones and darker sandy shales in which an interesting vertebrate fauna consisting mainly of large

*Author's separates of this paper were distributed July 20, 1909.

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dinosaurs and small primitive mammals has been found. This formation has been called by various names, such as "Ceratops beds of Converse County," "Lance Creek beds," and "Hell Creek beds," and it has furnished almost all of the "Laramie" vertebrates that have been described except those from the Judith River formation which was once considered part of the Laramie but is now known to be older. It has also yielded a considerable invertebrate fauna and a flora of more than 100 species.

The "Ceratops beds" have always been referred to the Cretaceous by those who have studied their faunas, while the paleobotanists have often contended for the Tertiary age of floras from beds considerably older than these. Recent papers by Whitman Cross[1] and F. H. Knowlton[2] have again raised the question concerning the boundary between Cretaceous and Tertiary by arguing that these "Ceratops beds" and other formations grouped together by Doctor Cross under the term Shoshone are Eocene. Doctor Knowlton goes farther and places the "Ceratops beds" in a lower member of the Fort Union formation, entirely above the Shoshone group. His argument for the Eocene age of these beds is based chiefly on (1) unconformable relations with the underlying marine Cretaceous and an inferred long period of erosion before they were deposited; (2) stratigraphic continuity and close floral connection with the overlying Fort Union which is generally admitted to be Eocene. He also holds that the invertebrate fauna has Tertiary rather than Cretaceous affinities and that the vertebrates afford no positive evidence of Cretaceous age.

The purpose of the present paper is to show that some of the data already used in the discussion are capable of a different interpretation and to call attention to some additional facts which ought to be fully considered before a final verdict is reached. All are agreed that the strata in question are near the boundary between Cretaceous and Tertiary. My opinion is that the greater weight of evidence places them on the Cretaceous side. The general question is still under

[1] Cross, Whitman: The Laramie formation and the Shoshone group. Proc. Wash. Acad. Sci., Vol. XI, No. 1, 1909, pp. 27–45.

[2] Knowlton, F. H.: The stratigraphic relations and paleontology of the "Hell Creek beds," "Ceratops beds," and equivalents, and their reference to the Fort Union formation. Proc. Wash. Acad. Sci., Vol. XI, No. 3, 1909, pp. 179–238.

investigation in the field and during the present season several important areas will be critically studied with special reference to evidence of unconformities and the stratigraphic relations of faunas and floras. In order to present somewhat in detail the data now in hand it will be necessary to give a brief review of the stratigraphy and paleontology of some of the more important areas preparatory to the general discussion of the evidence.

Local Stratigraphy and Paleontology.

Converse County, Wyoming.—This area in Eastern Wyoming was made famous 20 years ago by Hatcher's collections of the Triceratops fauna, including the dinosaur genera *Triceratops*, *Diceratops*, *Torosaurus*, and *Trachodon*, together with turtles and other reptiles, fishes and many small mammals. Hatcher's excellent descriptions[3] of the stratigraphy and general features of the region have been supplemented by Stanton and Knowlton's stratigraphic and paleontologic notes[4] and much of this material has been republished in Hatcher and Lull's Ceratopsia monograph.[5] The lowest member of the section exposed is formed by the upper part of the Pierre shale with abundant characteristic invertebrate fossils. This grades upward into sandstones that have been referred to the Fox Hills including at the top a massive bed of yellowish gray friable sandstone 100 feet thick with concretions containing *Veniella humilis*, *Sphæriola*, *Gervillia subtortuosa* and other Fox Hills fossils. No marine fossils have been found above this horizon.

Sandstones mostly of light colors with very few and thin intercalations of shale continue upward for 400 feet. This member has yielded no fossils and may belong either to the Fox Hills or to the overlying "Ceratops beds" in which Hatcher originally included it.

In the fossiliferous "Ceratops beds" there is no striking lithologic change but there is a larger proportion of shale, a more rapid alterna-

[3] Hatcher, J. B.: The Ceratops beds of Converse County, Wyoming. Am. Jour. Sci., 3d ser., Vol. XLV, 1893, pp. 135–144. Some localities for Laramie mammals and horned dinosaurs. Am. Naturalist, Vol. XXX, 1896, pp. 112–120.

[4] Stanton, T. W. and Knowlton, F. H.: Stratigraphy and paleontology of the Laramie and related formations in Wyoming. Bull. Geol. Soc. America, Vol. VIII, 1897, pp. 128–137.

[5] Mon. U. S. Geol. Survey, Vol. XLIX, 1907.

tion of shales and sandstones, and especially in the upper part the individual beds are apparently not continuous for such long distances but change their character laterally. Some of the sandstones contain very large and peculiar concretions and occasionally in the shales there are thin lignitic beds but no workable coal. Associated with one of the lowest lignite beds near the base of the formation is the only bed of brackish-water fossils found in the section. These include *Ostrea glabra* M. & H., *Corbula subtrigonalis* M. & H., *Anomia*, and *Corbicula cytheriformis* M. & H., all of which are well-known Cretaceous species that range from the Judith River formation, or lower, up to the Laramie. The dinosaurs of the Triceratops fauna have not been found directly associated with the brackish-water shells in this area but judging from Hatcher's map and descriptions they must range down to about the same horizon.[6]

In the area drained by Lance Creek, where most of Hatcher's collections were obtained, the lower part of the "Ceratops beds" is well exposed and has the same dips of 15° to 20° as the underlying marine Cretaceous, but in the higher beds the dip decreases to 5° or less and the exposures are not continuous so that it has not been practicable to make an accurate measurement of the thickness of the entire formation. Hatcher's estimate was about 3000 feet while mine was about 2000 feet. Although there is uncertainty about the exact thickness and other minor details the general stratigraphic relations and succession of the whole section are perfectly simple. I cannot do better than endorse the following statement quoted from Hatcher:[7]

All the beds of the entire section are conformable, and bear evidence of a continuous deposition, from the Fort Pierre shales up through the Fox Hills sandstones and the overlying fresh-water Ceratops beds. The Fort Pierre shales are not suddenly replaced by the Fox Hills sandstones, but the transition is a gradual one, and it is impossible

[6] The range here assigned to the dinosaurs in this section is clearly implied in his statement in the 1896 paper that "it would doubtless be better to restrict the limits of the Ceratops beds to those strata in which horned dinosaurs occur, and to consider the underlying 400 feet of barren sandstones as the equivalent of the Judith River beds." In the Ceratopsia monograph the statements concerning the stratigraphic position of the various species refer only to *type specimens*, chiefly skulls, and these were not found in collectible condition in the lower, steeply dipping beds.

[7] Am. Jour. Sci., 3d ser., Vol. XLV, 1893, pp. 139–140.

to say just where the one ends and the other commences. The same is true of the beds overlying the Fox Hills . . . . . The sandstones of the entire series are very similar, and since there is entire conformity throughout, it is absolutely impossible to determine just where the marine beds end and the fresh-water beds commence. The Ceratops beds of this region are a natural sequence of the Fox Hills. The materials composing both were evidently derived from a common source. The only safe criteria for distinguishing one from the other are their fossils.

Above the dinosaur-bearing "Ceratops beds" are similar rocks in which sandstones are a more prominent feature and there are coal beds of workable thickness. The lithologic change is not striking and there is no recognized stratigraphic break but the fossil plants have long been recognized by Doctor Knowlton as belonging to the typical Fort Union flora, i. e., the flora of the "upper Fort Union" as he now interprets it.

The fresh-water invertebrate fauna and the flora as well as the vertebrate fauna of the Converse County "Ceratops beds" have been collected mainly from the upper half of the formation. Doctor Knowlton's latest revised list[8] of the plants, which differs considerably from the one previously published,[9] need not be repeated here. Attention is called, however, to the fact that of 48 species and varieties enumerated 5 species are figs and 2 are palms, and that of the 16 identified species whose names are given 7 are reported to occur at Black Buttes. It seems, therefore, that the flora is still subtropical in character and somewhat closely related to that of Black Buttes.

A re-examination of the invertebrates has resulted in discrediting or questioning a few of the previous identifications and in recognizing some of the species of Unio described by Whitfield from the "Hell Creek beds." The revised list is as follows:

†*Unio brachyopisthus* White
†*Unio couesi* White
*†*Unio cryptorhynchus* White
†*Unio endlichi* White
*†*Unio holmesianus* White
†*Unio proavitus* White
*†*Unio stantoni* White[10]

[8] Proc. Washington Acad. Sci., Vol. XI, p. 207.

[9] Bull. Geol. Soc., America, Vol. VIII, p. 136.

[10] This is the form sometimes referred to *U. danæ* M. & H., and later named *U. gibbosoides* by Whitfield.

**Unio biesopoides* Whitfield
**Unio browni* Whitfield
**Unio letsoni* Whitfield
**Unio pyramidatoides* Whitfield
**Unio verrucosiformis* Whitfield
Unio (several undescribed species)
Anodonta parallela White
Anodonta? sp.
†*Sphærium planum* M. & H.
Sphærium sp.
Viviparus sp.
†*Tulotoma thompsoni* White
Campeloma? sp.
‡*†*Campeloma multilineata* M. & H.
‡*Goniobasis tenuicarinata* M. & H.
‡**Thaumastus limnæiformis* M. & H.?
Physa copei var. *canadensis* Whiteaves?
Helix vetusta M. & H?
Limnæa sp.

* Species so marked occur in the "Hell Creek beds."
† Species so marked occur at Black Buttes.
‡ Species so marked and possibly the two species of Sphærium, the Campeloma (?) and the Viviparus occur in the overlying Fort Union strata.

The invertebrate fauna as a whole is remarkably distinct from all those that succeed it in the American Eocene, although there are a few species that seem to survive in the typical Fort Union without change. If the resemblances seen in some of the species of Unio now living in the Mississippi Valley really mean direct descent from these species in the "Ceratops beds" (which may well be doubted) the connecting forms have not been preserved in the rocks of the region, although fresh-water shells are abundant in the Fort Union, Wasatch, and later Eocene formations. The various links that connect the fauna and the strata containing it with the Cretaceous will appear in the descriptions of other areas and in the general discussion.

Weston County, Wyoming.—Directly north of the Converse County exposures and forming part of the same continuous area Barnum Brown collected dinosaurs and fossil plants from outcrops on Seven Mile Creek and Alkali Creek, north of Cheyenne River, and has published short lists of plants (repeated in Knowlton's paper) from two horizons on Seven Mile Creek. Those from the lower bed associated with *Claosaurus* (=*Trachodon*) include a fig and three species of

palms, two of which are different from those recorded from the same formation in Converse County. Brown describes the dinosaur-bearing beds as resting on the marine Fox Hills. He says:

In 1901 I obtained characteristic fossils from both formations near their contact at that locality (Alkali Creek). At that place the conditions are similar to those in the Hell Creek region.[11]

This statement has been interpreted to mean that the "Ceratops beds" there rest unconformably on the Fox Hills sandstone and that the 400 feet of barren sandstones intervening between them in Converse County have been removed by erosion. While this may be true it is obviously unsafe to assume that it is the correct explanation until it is definitely known that both the dinosaurs and the marine Fox Hills invertebrates have the same vertical range, respectively, in both sections. It is possible that the Fox Hills invertebrates found on Alkali Creek were in sandstones represented by the 400 feet of barren sandstones farther south and it is likewise possible that some dinosaurs were found in the same member. These localities are near the southern boundary of the Newcastle quadrangle which has been mapped and described by N. H. Darton.[12] His statements concerning the formations in question are of interest in this connection:

West of the wide valley in which the Pierre formation occurs there rises a low escarpment due to a series of thin beds of hard sandstone which belongs to the Fox Hills formation. There are two or three thin layers of this sandstone, with shaly beds intercalated, and an underlying series of soft, clayey sandstone having a thickness of only 50 feet. The basal members contain abundant distinctive fossils, including at some places large numbers of *Veniella*. There is a conformable transition through 20 or 30 feet of sandy shales lying near the base of the slope. Farther south, lower sandy beds of the formation often contain large, fairly well-defined concretions due mainly to local increase of lithification. . . . .

The breadth of the outcrop of the Fox Hills formation is not more than a mile in most places and is often considerably less. South of Robbers Roost Creek it widens to 5 miles. The thickness of the formation is from 150 to perhaps 200 feet, increasing southward, but gradually diminishing to the north to 75 feet, the decrease being largely in the lower beds. There is some doubt as to the upper limit of the

[11] Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, p. 845.

[12] Newcastle folio (No. 107), Geol. Atlas U. S., U. S. Geol. Survey, 1904.

formation and there are indications that the line of lithologic change is not a constant horizon throughout; thus it may be that some of the lower members represented as Laramie formation in this region belong to the Fox Hills in other districts.

According to Darton the "Laramie formation" (i.e., "Ceratops beds") of the Newcastle quadrangle

consists of soft, massive sandstones intercalated with carbonaceous sandy clays. The thickness is 700 to 800 feet, as nearly as can be ascertained. . . . . Next above the Fox Hills beds are 80 feet of gray clays overlain by sandstones. The sandstones . . . consist mainly of fine-grained, loosely cemented sand of light-buff color, often having a thickness of 40 feet. They contain very characteristic concretions of gray color and great variety of shape. . . .

The beds of shale which occur interbedded among the sandstones of the Laramie formation are usually of dark gray color and in places lignitic, but no coal deposits have been found in them in this region.

If Darton's observations are correct the rapid northward thinning of the sandstones beneath the "Ceratops beds" is due not to erosion of the upper members but to lateral replacement of the lower members by shale.

Northward from Weston County, Wyoming, to Hell Creek on the Missouri River in eastern Montana the presence of the "Ceratops beds" is indicated by the occurrence of the characteristic dinosaurs at many localities, though it may not be possible to trace the formation continuously all the way. At these localities the sandstones representing the Fox Hills are either thin or entirely lacking, the "Ceratops beds" often resting, as at Forsyth and Myers, Montana, directly on a shale that is usually called Pierre, though Meek and Hayden early recognized the fact that its fauna contains a mixture of Pierre and Fox Hills species.

Hell Creek, Montana.—This locality, just south of the Missouri River in eastern Montana, has been made prominent by the collections and descriptions of Mr. Barnum Brown[13] of the American Museum of Natural History. The base of the section is "Pierre shale," with a total exposed thickness of nearly 200 feet, which has yielded a

[13] The Hell Creek beds of the Upper Cretaceous of Montana. Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, pp. 823–845.

marine invertebrate fauna showing a blending of Pierre and Fox Hills elements. Above that are "soft, arenaceous shales and interstratified beds of clay usually with a capping of sandstone" varying in thickness from 40 to 80 feet. These shales and sandstones have also yielded a marine fauna and are referred by Brown to the Fox Hills.

The "Ceratops beds" to which the local name of "Hell Creek beds" has been given are about 300 feet thick, and according to Brown

> may be divided into an upper and a lower member. The former is composed of arenaceous clays alternating with sandstones and carbonaceous matter. The lower member consists of massive sandstone. . . . . This is the most constant of the series. It unconformably overlies the Fox Hills, as shown near the Cook ranch on Crooked Creek; also on Hell Creek. This unconformity is erosional in character.

The unconformity has not been further described, but it may be inferred that the base of the sandstone rests on an uneven surface. Whether such an irregular base is due to an important unconformity or represents a long interval of erosion must be determined by other evidence. Similar phenomena are very common in non-marine deposits such as the typical Fort Union where almost every massive sandstone has an irregular base. A striking example of this may be seen in the Fort Union formation of the Bull Mountains, two miles south of Buckey's, Montana, where the unconformity is so striking that it was supposed to mark the base of the formation until the flora collected beneath it also proved to belong to the Fort Union.

The vertebrate fauna includes the dinosaur genera *Triceratops*, *Trachodon*, *Tyrannosaurus* and *Ornithomimus*, together with other reptiles, fishes, and a few small mammals, and is nearly identical with the fauna of the "Ceratops beds" of Converse County except that not so many species have been collected.

The invertebrate fauna is remarkable for the great development and differentiation of Unios, several of which have not yet been found elsewhere. The list as identified by R. P. Whitfield is as follows:

Unio æsopiformis Whitf.
U. corbiculoides Whitf.
U. pyramidellus Whitf.
U. verrucosiformis Whitf.
**U. browni* Whitf.

U. retusoides Whitf.
U. percorrugata Whitf.
U. postbiplicata Whitf.
†*U. aldrichi* White
†*U. holmesianus* White
U. vetustus Meek
†*U. cryptorhynchus* White
**U. biesopoides* Whitf.
U. cylindricoides Whitf.
**U. letsoni* Whitf.
**U. gibbosoides* Whitf.
**U. pyramidatoides* Whitf.
U. subtrigonalis Whitf.
Sphærium planum M. & H.
Corbicula subelliptica M. & H.
†**Campeloma multilineata* M. & H.
†*Campeloma vetula* M. & H.
Campeloma producta White
†*Viviparus plicapressus* White
†*Cassiopella turricula* White
**Thaumastus limnæiformis* M. & H.
Bulimus rhomboideus M. & H.

Species marked * occur in "Ceratops beds" of Converse County.
Species marked † occur at Black Buttes.

On the faunal and stratigraphic evidence Brown's correlation of the "Hell Creek beds" with the "Ceratops beds" of Converse County, Wyoming, is fully justified. The flora is relatively meagre and according to Knowlton shows closer relationship with the overlying Fort Union. Of 13 identified species 2 are recorded in the Laramie, 3 in the Denver, and 8 in Fort Union and later formations.

Between the "Hell Creek beds" and the typical "yellow beds" of the Fort Union there are 100 feet of lignite-bearing strata in which no dinosaurs have been found and which were tentatively assigned to the Fort Union for this reason, though the few plants obtained from them are included in the census just given.

Areas in North and South Dakota.—Along the little Missouri River in the southwest corner of North Dakota A. G. Leonard has studied a section similar to that on Hell Creek and his description of it is published by Knowlton.[14] The base of the section is a marine Cretaceous shale referred to the Pierre which is overlain by 80 feet

[14] Proc. Wash. Acad. Sci., vol. xi, No. 3, 1909, p. 201.

of unfossiliferous sandstone and sandy shale probably representing the Fox Hills. Resting unconformably on this member are about 500 to 600 feet of "somber beds" extending up to the "typical buff and light-gray Fort Union shales and sandstones which are exposed near Yule P. O." The unconformity is presumably expressed by an uneven surface as at Hell Creek. About 200 feet above this unconformity dinosaur bones were collected which have been identified by C. W. Gilmore as *Triceratops horridus* Marsh, and several species of plants referred by Doctor Knowlton to the Fort Union were obtained rom the same and higher portions of the "somber beds." Among the invertebrates submitted by Doctor Leonard for examination one lot from near Yule consists entirely of *Ostrea subtrigonalis* E. & S., which I considered sufficient evidence of Cretaceous age and stated in my manuscript report that if there is any Laramie in the region it probably includes this oyster bed. In a recent letter Doctor Leonard makes the following statements concerning the various collections from the ,somber beds:"

The plants which I sent to Doctor Knowlton and the specimens of *Ostrea subtrigonalis* were not collected from the same stratum and came from localities several miles apart. As near as I could determine the plants which came from near Yule are from a bed somewhat lower than the layer containing the shells (*Ostrea*). A few of the plants, those from near Marmarth and the mouth of Bacon Creek, are from the same beds as those containing the dinosaurs.

Before Doctor Knowlton identified the Fort Union leaves from there I was inclined to regard as Cretaceous all the somber beds below the typical light-colored Fort Union, particularly after your statement regarding the probable age of *Ostrea subtrigonalis*.

I believe with you that we are here dealing with beds near the line between Cretaceous and Tertiary and it is possible that the upper 200 feet or so of the "somber beds" containing thick coal beds, may be Fort Union, and the lower portion which is barren of coal and contains dinosaurs may be Cretaceous. But one difficulty with this view is that *Ostrea* was found in the upper portion and several leaves identified as Fort Union species were found in the lower portion carrying the bones. The fossils do not seem to tell the same story as to the age of the beds in question.

The significance of these facts and especially the occurrence of the oyster bed will be discussed later.

The same dinosaur horizon occurs on the Missouri River a few miles north of the mouth of the Cannonball River, where in 1908 I collected bones identified as *Ceratopsia* and *Trachodon* from soft sandstones and shales approximately 100 feet above the top of the Fox Hills sandstone, which is here fossiliferous and has its most northern outcrop on the west side of the Missouri near old Fort Rice, about 25 miles southeast of Mandan, North Dakota. The fossil plants listed by Knowlton from my collection were obtained from beds a few feet above the highest observed dinosaur bones.

There is doubtless a continuous area of dinosaur-bearing beds extending through northern South Dakota and southern North Dakota between the Missouri and Little Missouri rivers. Unpublished records furnished by Prof. J. E. Todd, former State Geologist of South Dakota, show localities for *Triceratops* and also for a number of brackish-water invertebrates in the region of Grand and Moreau rivers. The shells include *Anomia*, *Ostrea glabra*, *Corbicula subelliptica*, *C. cytheriformis*, and *C. occidentalis*. Dinosaurs and brackish-water shells were also obtained in this region by F. V. Hayden on one of his early expeditions.

These beds immediately overlying the Fox Hills along the Missouri in North and South Dakota might fairly be regarded as the basal part of the Fort Union formation, since it is the first named formation above the Fox Hills in the section, if it were not for the fact that Meek and Hayden limited the type section of that formation to the exposures along the Missouri from Fort Union to Fort Clark and up the Yellowstone into Montana, while these lower beds in question occur along the Missouri below Fort Clark. When the Fort Union formation was named by Meek and Hayden[15] they said it

> occupies the whole country around Fort Union [near the mouth of the Yellowstone] extending north into the British possessions, to unknown distances, also southward to Fort Clark. Seen under the White River group on North Platte River above Fort Laramie. Also on west side Wind River Mountains.

In later publications both Meek and Hayden treated these lower beds as probably distinct from the Fort Union. Thus Meek[16] says:

[15] Proc. Acad. Nat. Sci. Phila., 1861, p. 433.
[16] U. S. Geol. Surv. Terr., Vol. IX, 1876, p. XLIX.

Doctor Leidy also described among Doctor Hayden's collections from the lowest beds of the Upper Missouri Lignites near Moreau and Grand rivers, Nebraska, very probably belonging to the horizon of the Judith River group,[17] some vertebrate remains which have been considered Cretaceous types by Cope.

Hayden's last general statement on the Laramie problem in the introduction to Lesquereux's "Tertiary Flora"[18] indicates similar views, as the following quotations will show:

The physical conditions under which the sediments of the upper strata of the Fox Hills group were deposited indicated a gradual change, from deep, quiet marine seas to shallow waters, which became at length brackish and finally entirely fresh waters, during which the purely marine invertebrate fauna perished, a brackish and purely fresh-water fauna taking its place. . . . . As we proceed southward and westward from the Missouri River, the brackish beds increase in thickness until along the fortieth parallel they become three thousand feet or more, indicating, so far as can be determined, no break in the sequence from the Fox Hills group to the purely fresh-water strata of the Wasatch group. . . . . The facts as we understand them at the present time would seem to warrant this general division, viz: a marine series, Cretaceous; gradually passing up into a brackish-water series, Laramie; gradually passing up into a purely fresh-water series, Wasatch. It is also probable that the brackish-water beds on the upper Missouri must be correlated with the Laramie, and that the Wasatch group as now defined and the Fort Union group are identical as a whole, or in part at least. The plants which are recorded in this volume began their existence at the base of the Laramie group and continued through the entire series, brackish and fresh-water.

Localities on Yellowstone River in Eastern Montana.—Near Glendive the erosion of a low anticline has exposed the Pierre shale and overlying rocks in which Barnum Brown records the presence of *Triceratops* and Trachodont dinosaurs. Leonard has published[19] a detailed section and a list of invertebrates collected in the upper part of the Pierre shale which here has elements of both Pierre and Fox Hills faunas. The sandstones immediately above the Pierre have yielded no marine fossils and apparently belong to the "Ceratops

[17] The Judith River formation was then supposed to overlie the Fox Hills.
[18] U. S. Geol. Surv. Terr., Vol. VII, 1878, pp. III–VII.
[19] Bull. U. S. Geol. Survey, No, 316, pp, 195–198.

beds" rather than to the Fox Hills. No discordance has been observed here at their base. Leonard's section records 535 feet of shales and sandstones above the Pierre.

Pierre shale is exposed in a similar uplift west of Forsyth. Doctor Knowlton and I examined this section in 1908 near Castle Butte about 7 miles northwest of Forsyth, where we collected the following invertebrates:

Inoceramus sagensis Owen?
Trigonarca (*Breviarca*) *exigua* M. & H.
Leda (*Yoldia*) *evansi* M. & H.
Thetys? circularis M. & H.
Solemya? sp.
Mactra gracilis M. & H.
Corbulamella gregaria M. & H.
Amauropsis paludinæformis M. & H.
Anchura nebrascensis M. & H.
Fasciolaria (*Piestochilus*) *cretacea* M. & H.
Baculities compressus Say
Scaphites nodosus Owen
Placenticeras whitfieldi Hyatt
Placenticeras intercalare M. & H.

Above the Pierre are yellowish cliff-forming sandstones with thinner beds of shale dipping about 5° east which form the mass of Castle Butte and other conspicuous hills in the neighborhood. There is an estimated thickness of about 100 feet of these sandstones beneath the rocks that form the bluffs at Forsyth where the beds are horizontal. The contact between the Pierre shale and the overlying sandstone is very well exposed and shows beneath the massive cliff forming sandstone, a few feet of soft sandstone alternating with clay shale apparently forming a transition zone.

Mr. A. C. Silberling informs me that at and near Castle Butte he has observed remains of *Triceratops*, *Claosaurus* [*Trachodon?*], mammals, turtles, and fishes, showing that the sandstones belong to the "Ceratops beds." He also reports the occurrence of *Triceratops* four miles north of Rosebud on Horse Creek east of Forsyth and near Junction City and Custer.

The marine Cretaceous extends in a belt several miles wide from Castle Butte across country along the line of the Chicago, Milwaukee and St. Paul Railway, to Musselshell River, and up the Yellowstone to a point one mile west of Myers station, which is about 30 miles west

of Forsyth. Here also the "Ceratops beds" rest directly on marine shales and are exposed in prominent wooded bluffs to a thickness of about 300 feet. The following detailed section measured September 21, 1908, may be of interest:

Section 1 mile west of Myers, Montana.

	Feet.
1. Massive, light-gray sandstone capping one of the highest buttes southwest of Myers, with fragmentary remains of *Ceratopsia, Trachodon,* and *Ornithomimus*	40
2. Thin-bedded sandstones and sandy shales with occasional large calcareous concretions in which *Sphærium, Goniobasis, Campeloma?* and fragments of turtle shell were collected	20
3. Massive greenish gray rather soft sandstone with many brown indurated bands and masses and frequent irregular deposits of "clay ball" conglomerate especially near the base	35
4. Shale and very soft gray sandstone	30
5. Soft sandstone with band of brown concretions and indurations near middle, and fragments of dinosaur bone and crocodile scute near base	25
6. Massive gray sandstone with a brown indurated band at top	18
7. Shale, carbonaceous in upper part	10
8. Very soft, argillaceous sandstone	5
9. Carbonaceous shale with fragments of dinosaur bones	1½
10. Clay shale, more or less sandy, with several carbonaceous bands	40
11. Very soft argillaceous sandstone with an indurated band near the base	10
12. Shale, mostly carbonaceous	10
13. Massive gray sandstone with indurated bands and masses and *Ceratopsia* bones at base	40
14. Shales and soft sandstone passing laterally into massive sandstone	20
15. Soft sandstones and shales	15
16. Sandy shales with thin bands of sandstone apparently forming a transition to the beds below	12
17. Soft gray Pierre shale with a band of calcareous concretions in the upper part which yielded *Baculites ovatus, Protocardia subquadrata* to flood plain of Yellowstone River	75
Total	406½

Westward from Myers to the neighborhood of Custer and Junction City the rocks lie in a broad shallow syncline with scarcely perceptible dips, so that the "Ceratops beds" are continuously exposed along both sides of Yellowstone River, and on the left bank they extend still farther west to Pompey's Pillar and beyond. The coal bed on the high land 4½ miles southeast of Bighorn station from which

Pepperberg and Barnett collected the plants listed by Knowlton is in the highest rocks exposed in this syncline and may belong to the typical Fort Union. At any rate it is higher than any of the dinosaurs of the Triceratops fauna which are reported to be common in the sandstones immediately overlying the marine shale throughout this area. The "Ceratops beds" of this section are apparently directly connected on the northwest with the similar formation tentatively referred to the Laramie (?) which underlies the coal-bearing Fort Union of the Bull Mountains field, while on the south they follow approximately parallel with and usually east of the Chicago, Burlington, and Quincy Railroad to a connection with the lower part of the Piney formation in the Sheridan, Wyoming, area east of the Bighorn Mountains. Throughout these areas the most prominent feature of the formation consists of the exposures of light-gray, rather soft sandstones.

Bull Mountains, Montana.—A preliminary account of part of this area with a description of the coal-bearing portion of the section has been published by L. H. Woolsey.[20] He says of the Fort Union formation:

it is composed chiefly of gray to buff sandstone alternating with gray shale. The sandstone, though extremely variable, is commonly massive and evenly distributed throughout the section. The base of the formation is strongly marked by contrast with a band of olive-green clay shale, which belongs to the next lower formation. This shale is well exposed along the Billings—Roundup road, 2 or 3 miles south of Buckey post-office, and may be traced westward across various branches of Razor Creek, through Pratt's ranch, and down Dean Creek to Musselshell River.

In Woolsey's columnar section,[21] under the term "Beds on Dean Creek," it is represented as about 200 feet thick and as resting on the "Laramie" sandstones. The top of this shale is marked by the apparently eroded surface mentioned on p. 63. It has yielded a considerable number of fossil plants which Doctor Knowlton has referred to the Fort Union as follows:

Platanus basilobata Ward
Platanus guillelmæ Gopp.
Platanus raynoldsii Newb.

[20] Bull U. S. Geol. Survey, No. 341, 1908, pp 60–75
[21] Op. cit., Pl. IV.

Populus cuneata Newb.
Leguminosites arachioides Lesq.
Onoclea sensibilis fossilis Newb.
Sequoia nordenskiöldi Heer
Taxodium occidentale Newb.
Glyptostrobus europæus
Carpites sp.
Populus rotundifolia Newb.
Populus nervosa elongata Newb.
Populus amblyrhyncha Ward
Aralia notata Newb.
Corylus rostrata Aiton.
Viburnum sp.

The "Laramie" and older rocks of the section are not described in Woolsey's report, but from the exposures I visited with Mr. R. W. Richards on Dean Creek and from others I have seen north of Musselshell Post-office it is evident that the "Laramie" includes the "Ceratops beds" and that it is the same formation that is described by R. W. Stone[23] as Laramie on Fish Creek northeast of the Crazy Mountains, though there it and all the overlying formations are much thicker.

Area northeast of Crazy Mountains, Montana.—The stratigraphy of the area just mentioned, which is about 50 miles west of the Bull Mountains, had been treated by Weed,[23] Douglass,[24] and Stanton and Hatcher,[25] prior to the work of Stone, above referred to, who made a detailed geologic map (not yet published) in connection with a study of the coal resources.

After Weed's field studies were finished the work of Douglass brought out the fact that in this region a non-marine formation (now referred to the Judith River formation) is intercalated in the marine shales of the Montana group and that there is another coal-bearing

[22] Bull. U. S. Geol. Survey, No. 341, 1908, pp. 78–80.

[23] Weed, Walter Harvey: The Laramie and the overlying Livingston formation in Montana, Bull. U. S. Geol. Survey, No. 105, 1893. The Fort Union formation, Am. Geologist, Vol. XVIII, 1896, pp. 201–211. Little Belt Mountains folio (No. 56), Geol. Atlas, U. S., 1896.

[24] Douglass, Earl: A Cretaceous and lower Tertiary section in south central Montana, Proc. Am. Philos. Soc., Vol. XLI, 1903, pp. 207–224. A geological reconnaissance in North Dakota, Montana, and Idaho; with notes on Mesozoic and Cenozoic geology, Annals Carnegie Mus., Vol. V, 1909, pp. 266–278.

[25] Stanton, T. W., and Hatcher, J. B.: Geology and Paleontology of the Judith River beds, Bull. U. S. Geological Survey, No. 257, 1905, pp. 59, 60.

sandstone (now identified with the Eagle sandstone) at the base of that group. The shales and sandstones between these two have been named the Claggett formation, and the shale above the Judith River has been named Bearpaw. The latter is the equivalent of the upper part of the "Pierre" shale as developed at Glendive and elsewhere in eastern Montana and probably includes the equivalent of at least part of the Fox Hills, though the upper part of the Fox Hills is possibly represented in the base of the overlying "Laramie." The succession in the marine Cretaceous with Stone's measurements of the different formations is as follows:

Montana group:	Feet.
Bearpaw shale	700 to 1100
Judith River formation	400 to 800
Claggett formation	400 to 800
Eagle sandstone	100 to 250
Colorado shale	1300

This stratigraphic succession is developed in most of the Cretaceous areas in Montana west of a line drawn across the state through the Pryor Mountains and the mouth of Musselshell River. For detailed descriptions of these formations the reader is referred to the papers cited—especially to the one by Stone for local details—but there are some facts that deserve mention in this connection.

One of these important facts is that the Judith River formation with a vertebrate fauna of *Trachodon, Ceratopsia*, turtles, etc., occurs here in unquestionable stratigraphic sequence beneath about a thousand feet of marine Cretaceous strata which in turn are overlain by beds containing a related dinosaur fauna. Not only is this true, but Douglass[26] has recorded that the intervening Bearpaw shale [its lower part] has yielded specimens of *Trachodon* and other land dinosaurs directly associated with marine invertebrates, showing that these dinosaurs inhabited the neighboring land continuously from Judith River time until after the end of the Bearpaw. Brown records[27] a similar discovery of a dinosaur in the upper part of the Pierre shale of the Hell Creek region.

[26] Proc. Am. Philos. Soc., Vol. XLI, p. 212. Annals Carnegie Mus., Vol. V, p. 276.

[27] Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, p. 826.

Another important fact, brought out by Stone's work, is that the "Laramie" of Weed's mapping east and north of the Crazy Mountains in the Little Belt Mountain folio is really Eagle sandstone and the "Livingston" of the same area includes in its lower part the Claggett, Judith River, and Bearpaw formations. The Livingston formation was described as resting unconformably on the Laramie and older rocks and as composed largely of andesitic material, both of which features played a prominent part in correlating the Livingston with the Denver formation. It became necessary therefore to study the lithologic character of the various formations of the Montana group in this area, especially since certain beds in the Claggett and Judith River were observed to have an igneous appearance. On my request thin sections have been made of a number of specimens collected by Mr. Stone and those have been examined by Messrs. Johannsen, Calkins, and Stone. The specimens from the Eagle and a few of those from the Claggett and Judith River proved to be sandstone without admixture of igneous material, but many others from both Claggett and Judith River and some from the Bearpaw are identified as tufaceous rock and contain much andesite, as the following extracts from the report will show:

C. M. 71. Tuff. From the Claggett formation in T. 6 N., R. 15 E., sec. 14. Consists chiefly of grains of plagioclase and altered lava, and is probably a water-laid tuff.

C. M. 74. Tufaceous rock. From near the top of the Claggett formation, 650 ft. above the Eagle sandstone, in T. 6 N., R. 15 E., sec. 13. Consists of angular fragments of plagioclase and andesite, and so far as seen contains no augite and no quartz. Probably is tufaceous.

C. M. 75. Tufaceous rock. From the top of the Claggett formation, in T. 8 N., R. 12 E., sec. 29. Shows two pebbles of andesite in a matrix like No. 15. Probably is tufaceous.

C. M. 76. Tufaceous rock. From near the base of the Judith River formation, in T. 6 N., R. 15 E., sec. 13. This rock is a conglomerate with subangular to rounded pebbles, chiefly of altered porphyritic andesite and one pebble of fine sandstone with angular grains of quartz. The specimen may be an impure tuff.

C. M. 78. Tufaceous rock. From near the base of the Bearpaw, at the mouth of Lost Horse Creek, T. 7 N., R. 11 E., sec. 17. Consists of angular grains of feldspar, lava, augite, magnetite, and quartz, with considerable chlorite. It is distinctly a tufaceous rock.

C. M. 79. Tufaceous conglomerate. From near the base of the Bearpaw formation, just below No. 78, at the mouth of Lost Horse Creek, T. 7 N., R. 11 E., sec. 17. This conglomerate consists of rounded pebbles of augite-andesite, or basalt, all of which are very similar to one another. The rock is probably a water-rolled tuff.

These were selected from the report because they come from the immediate neighborhood in which plants, invertebrates, and vertebrates were obtained from the higher formations and there is no doubt as to the identity of the different horizons. Farther northwest near Summit and Dorsey and along the west side of the Crazy Mountains andesite tuffs are more common, but the marine Cretaceous formations are there not so certainly identified. Only the following will be cited:

C. M. 14. Trachyte porphyry from Claggett beds 900 feet below fossils (609) determined as Bearpaw. Sec. 4, T. 7 N., R. 9 E.

C. M. 15. Andesite tuff. From near the base of the Bearpaw; T. 7 N., R. 9 E., sec. 5. Bearpaw fossils collected above. Specimen consists of many feldspar and augite crystals, with some magnetite and rock fragments with the texture of an andesite groundmass. The rock undoubtedly is essentially a pyroxene andesite tuff.

The marine Cretaceous fossils collected above these specimens are:

Ostrea pellucida M. & H.
Avicula linguiformis E. & S.
Avicula nebrascana E. & S.
Inoceramus cripsi var. *barabini* Morton
Callista deweyi M. & H.
Baculites compressus Say

Brackish-water shells were reported by Weed[28] "as occurring northeast of the Crazy Mountains in a bed of limestone, interbedded with the Livingston sandstones and conglomerates, a few hundred feet above the base of the formation." The locality as recorded on the field label is "Muddy Creek west of Gordon Butte and Cottonwood Creek" and the species identified are:

Ostrea subtrigonalis E. & S.
Corbicula cytheriformis M. & H.
Corbula subtrigonalis M. & H.
Corbula subtrigonalis var. *perundata* M. & H.

[28] Bull. U. S. Geol. Survey, No. 105, p. 33.

These fossils were referred by me to the Laramie in 1893, but at that time the Judith River formation was not recognized as distinct from the Laramie. They actually occur at this place in the Claggett with both Judith River and Bearpaw exposed above them in the same section as was observed by R. W. Stone, C. A. Fisher, and myself in 1907. The associated conglomerate mentioned by Weed is mostly composed of igneous pebbles but there is no suggestion of an unconformity beneath it nor at any other plane within the limits of marine sedimentation.

With the facts above recited in mind the whole question of the age and relations of the Livingston formation is reopened, and incidentally the occurrence of 5 per cent of andesite in the Hell Creek beds recorded by Brown[29] loses much of the significance that has been attached to it. Whatever may be true of the Livingston in the type area near the town of that name, the rocks assigned to it by Weed east of the Crazy Mountains, notably in the Lebo Creek section, certainly belong to several distinct formations ranging in age from well down in the Cretaceous to the lower Eocene.

The rocks immediately overlying the Bearpaw shale in the Fish Creek section are thus described by Stone:[30]

> The red and greenish sandstones overlying the Bearpaw shale constitute a distinct lithologic unit, ranging in thickness from 200 to 460 feet, and although containing some shale members, are sufficiently sandy and hard to form a conspicuous ridge. This formation is particularly well exposed as a ridge along the western side of T. 5 N., R. 17 E., and crosses Fish Creek at the George Moore ranch. A mile farther north it swings to the west and can be traced readily all the way to Lennep. A peculiarity of this formation is its general reddish color and the occurrence of a layer of red, sandy, cannonball nodules near the middle. Its age has not been definitely determined, but lithologically it belongs to the overlying formation and hence it will be provisionally regarded as a part of the Laramie.

The red color of this member has not impressed other observers. To my eye the prevailing tints are grays and browns, but the topographic importance of the horizon has been recognized by all. The

[29] Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, p. 832.
[30] Op. cit., pp. 79, 80.

rocks are designated as "Fox Hills(?)" in Douglass' latest paper, but in his first description of this section that term was made to include the lower members which he now refers to the Laramie and which "contain in almost every good exposure bones of dinosaurs, such as *Triceratops* and probably *Trachodon.*" Some additional paleontologic evidence has been obtained from beds beneath the horizon of these dinosaurs. About 2½ miles northwest of George Moore's (formerly McClatchey's) ranch in sec. 23, T. 6 N., R. 16 E., the following succession was observed in ascending order:

	Feet.
1. Valley underlain by Bearpaw shale not well exposed.	
2. Light colored, friable, rather heavy bedded sandstone with a fossiliferous band at the top yielding *Ostrea glabra, Anomia, Corbicula, Melania wyomingensis?* etc	30 to 40
3. Dark shales and sandstones with nodules containing *Nucula planimarginata, Leda* (*Yoldia?*) *evansi, Mactra warrenana, Thracia* (*?*), *Lunatia,* and other marine Cretaceous fossils	100
4. Light-colored sandstone	30
5. Soft sandstones and shales with bands of hard brown sandstone. One of these at the top contains many fossil plants	50

The plants were examined by F. H. Knowlton in 1903 and were then considered possibly older than Montana, though the evidence was unsatisfactory. Doctor Knowlton has recently again examined these plants and has pronounced them Livingston.[31]

This plant horizon is on the top of the ridge formed by the rocks of Douglass' "Fox Hills (?)" which here dips 23° southerly. Somewhat more than a mile along the strike in section 16 of the same township bones and teeth of *Triceratops* and other dinosaurs were collected at the southern base of the ridge not more than 150 or 200 feet above the plant bed.

A few fresh-water invertebrates have been collected from beds near the dinosaur horizon. These include

Unio brachyopisthus White
Unio retusoides Whitfield?
Unio sp.
Campeloma? sp.
Limnæa? sp.

[31] Proc. Wash. Acad. Sci., Vol. XI, No. 3, 1909, p. 194.

The Unios indicate close relationship with the fauna of the "Ceratops beds" of Hell Creek and Converse County.

Stone describes the upward stratigraphic succession as follows:

Taken as a whole, the upper part of the Laramie formation is distinguished from the formations above and below by its light-gray color in comparison with their somber hues. It is composed largely of soft gray sandstone and variegated shale. The gray beds, from 1000 to 2400 feet thick, make a conspicuous valley across the middle of T. 6 N., Rs. 13 to 16 E. As a whole the formation weathers so readily that it normally forms low country, and for some miles in this area it coincides with the valley of Fish Creek. The gray beds of the Laramie formation are overlain, possibly with unconformity, by somber-colored sandstone and shale which may represent the Livingston formation. Sufficient paleontologic evidence has not been obtained, however,to determine the limits of these stratigraphic units. A section measured by C. A. Fisher and T. W. Stanton on a fork of Big Elk Creek gives a thickness of 5592 feet from the base of the Laramie to the base of the sandstone and grit of probable Fort Union age, and of 10,324 feet for the beds above the Bearpaw shale. Further field work is necessary before the lithologic and paleontologic distinctions of the Laramie and Livingston formations can be determined.

The Fort Union formation, of unknown thickness, but exceeding 4,300 feet, is the youngest in this area. It is composed largely of sandstone, alternating with shale. The base of the formation is a particularly massive, coarse-grained sandstone which forms pronounced wooded ridges. Fort Union beds underlie the southern part of T. 6 N., Rs. 12 to 16 E., and compose the north and east bases, at least, of the Crazy Mountains.

It was my privilege in 1908 under the guidance of Mr. A. C. Silberling to review the upper part of the Fish Creek section, from the Triceratops horizon upward, especially in townships 5 and 6 north, ranges 15 and 16 E. The area is important because it was here that Douglass[32] found the first specimens of the primitive mammalian fauna on which the correlation of the Fort Union with the Puerco and Torrejon formations is based, and with one exception all the "Fort Union" mammals known were found within a few miles of this place. The strati-

[32] Proc. Am. Philos. Soc., Vol. XLI, 1902, pp. 217–224. Annals Carnegie Mus., Vol. V, 1908, pp. 11–26.

graphic relations of the various paleontologic zones are easily determined.

In T. 6 N., R. 16 E., the gray beds forming the "upper part of the Laramie" of Stone's classification have at least the maximum thickness he assigns to them (2400 feet) as they underlie a belt considerably more than a mile wide with a dip of 23°. Except near the base where dinosaur remains are common, as already noted, fossils are rare in this part of the section. In the upper half a few localities farther west in the general region have yielded two or three species of *Unio*, a *Viviparus*, and *Campeloma multilineata*, but nothing distinctive. Dinosaurs may range to the top of these "gray beds" but all the evidence now available on their upper limit are in the following excerpts from letters of Mr. Silberling:

Dinosaur bones in top of Fox Hills and in base of Laramie [the thickness of which be estimates to be 3000 feet]. Dinosaur bone found in 1902 by myself 1800 or 2000 feet above base of [Laramie] beds, but there is some doubt as to the bones being in position. Dinosaur bones found in December 1908 within 600 feet of the top of the formation by A. Strand. I have not as yet seen the locality.

Under date of January 28, 1909, Mr. Silberling writes:

Don't be surprised if I should drop you a line some of these days and tell you John Winsbrough had found dinosaur bones in my Fort Union No. 1. He has found a big limb bone over in T. 4 N., R. 16 E., somewhere, but cannot at present locate it.

Silberling's "Laramie" has the same limits as those given in Stone's description, and his "Fort Union" begins with the "somber-colored sandstone and shale which may represent the Livingston" according to Stone.

Mr. Silberling was employed in this area for several months last year under my direction in collecting vertebrate and other fossils for the U. S. Geological Survey and the U. S. National Museum. He obtained an excellent collection of primitive mammals now being studied by Mr. J. W. Gidley, who states that they are related to the Puerco and Torrejon faunas of New Mexico with rather closer resemblance to the Torrejon. In order to indicate the relative positions of his collections Silberling made use of prominent lithologic and topographic features to separate the rocks into three members which

he designated as "Fort Union Nos. 1, 2, and 3," respectively. The lower member, or "No. 1," and the middle member, or "No. 2," together constitute the softer, darker colored shales and sandstones with a combined thickness of about 1300 feet, while the upper member, or "No. 3," consisting of massive sandstones interbedded with shales, is more than 4000 feet thick and is identical with the whole of the Fort Union as recognized by Stone in this section and earlier by Weed in the Lebo Creek section.

The lower and middle members were measured by Mr. Silberling and myself in sec. 15, T. 6 N., R. 15 E., where the rocks are well exposed, including the contacts with the "Laramie" gray sandstones below and with the massive basal sandstone of "No. 3" above. On account of the importance of the paleontologic collections obtained in these members in adjacent townships where the succession is identical it may be well to give the details.

Section on branch of Fish Creek, Montana, in sec. 15, T. 6 N., R. 15 E.

	Feet.
"Fort Union No. 3."	
a. Massive sandstone forming base of this member.	
"Fort Union No. 2."	
b. Shale with a few thin bands of sandstone	112
c. Gray sandstone	5
d. Shale	18
e. Gray limestone, weathering brown	3
f. Greenish gray shale with much soft sandstone of same color and brown ironstone concretions in lower third; a few thin bands of sandstone in upper part and several concretionary layers near top	700
	838
"Fort Union No. 1."	
g. Brown, thinly cross-bedded sandstone forming top of a conspicuous broken ridge	32
h. Shale	200
i. Greenish gray sandstone	15
j. Greenish gray shale	249
	496
Total thickness of Nos. 1 and 2	1334
"Laramie."	
k. Rather soft, gray sandstone forming top of underlying formation.	

The lowest fossil plants listed by Knowlton as Fort Union came from a bed about 50 feet above the base of Silberling's lower member

of the Fort Union. A few fragmentary mammals remains, among which Mr. Gidley has identified *Clænodon* sp. nov., and *Mioclænus?* sp., were obtained from about the same horizon which, it should be remembered, is above the highest recorded occurrence of dinosaurs in the region, and fully 2000 feet above the highest horizon where dinosaurs are abundant and positively known to occur.

The most important collections of mammals were found in the middle member ("Fort Union No. 2"), and especially in the quarry opened in a thin sandstone 65 feet below the top of the member on the east side of Bear Butte in sec. 4, T. 5 N., R. 16 E. On preliminary examination Mr. Gidley has recognized *Ptilodus montanus* Douglass, *P. gracilis* Gidley, *P. serratus?* (Marsh), *P. formosus?* (Marsh), *Mioclænus* sp. nov., *Euprotogonia* sp. nov., *Didymictis* sp.nov., *Ectoconus?* sp. nov., *Deltatherium?* sp., *Psittacotherium* sp., *Chriacus* sp., *Pantolambda* sp., *Oxyclænus* sp., *Tricentes?* sp., *Pentacodon?* sp., *Mixodectes?* sp. The two doubtfully determined species of *Ptilodus* described by Marsh occur in the "Ceratops beds" of Converse County, Wyoming. All the others are related to species in the Torrejon fauna of New Mexico, which was originally included in the Puerco. *Clænodon ferox* (Cope) and *Pantolambda cavirictus?* Cope, belonging to the same general fauna, were obtained in Silberling's upper and thicker member of the Fort Union, the sandstones of which yield abundant remains of a typical Fort Union flora. The upper and middle members also yielded the reptiles *Champsosaurus puercensis?* Cope and *Crocodilus* sp.

In both the middle and the upper members fresh-water shells are common at several horizons. They include *Campeloma multilineata*, which in some of its varieties ranges from the Laramie of the Denver basin and the "Ceratops beds" into the Fort Union, *Viviparus*, and several species of *Unio*, most of which appear to be undescribed. The Unios are all of simple types and do not include any of the peculiarly sculptured forms like those of Hell Creek, Converse County, and Black Buttes.

As compared with the Bull Mountains section the "Laramie" of Fish Creek is much thicker, the lower and middle members of the Fort Union (1300 feet thick) correspond lithologically and stratigraphically with the 200 feet of shale on Dean Creek, and the upper member, though much thicker, resembles the coal-bearing Fort Union

of the Bull Mountains. If these resemblances could be accepted as identity in each case the smaller thicknesses in the Bull Mountains could be explained as due either to slower deposition, owing to greater distance from the source of materials, or to partial removal by erosion during one or more periods. From eastern Montana westward to the Crazy Mountains there appears to be a progressive thickening of the beds lying between the marine Cretaceous and what has hitherto been generally called the typical Fort Union, and there is a similar thickening southward from Hell Creek to Converse County, Wyoming, but in all this region the lowest bed containing the Triceratops fauna is never very far above the same general horizon of the marine Cretaceous, and the evidence for an important period of extensive erosion at its base is very slight—not greater than the evidence for such erosion at the base of the typical, or "upper," Fort Union.

Area east of the Bighorn Mountains near Sheridan, Wyoming.—The formations of this area have been named and described by N. H. Darton.[33] The coal-bearing rocks have also been studied by J. A. Taff.[34] The highest recognized marine Cretaceous is the Parkman sandstone with a fauna related on the one hand to that of the Claggett and on the other to the Fox Hills fauna. Evidence was obtained by C. A. Fisher and myself in neighboring areas on the north that there are marine shales above the Parkman sandstone, but in this area the beds are not all well exposed and the details of the stratigraphy—especially the contacts between some of the formations—have not been worked out.

Above the Parkman sandstone is the Piney formation, consisting of dark shales with coaly seams alternating with beds of massive light-colored sandstone. In the Dayton quadrangle according to Darton its thickness is 2000 to 3000 feet and it is believed to be entirely of fresh-water origin. At a locality one-half mile north of Parkman, Wyoming, a sandstone in the Piney about 1000 feet above the Parkman sandstone has yielded some fragments of dinosaur bones together with imperfectly preserved species of Unio and other fresh-water shells

[33] Bald Mountain-Dayton and Cloud Peak-Fort McKinney folios (Nos. 141 and 142), Geol. Atlas U. S., 1906. Geology of the Bighorn Mountains, Prof. Paper, U. S. Geol. Survey, No. 51, 1906.

[34] Bull. U. S. Geol. Survey, No. 341, pp. 123–150, 1909.

which, while not specifically identifiable, are apparently of types that elsewhere occur in the "Ceratops beds" and older formations. This is the only locality in the region where dinosaurs have been found.[35]

The next higher formation in Darton's classification of the Dayton quadrangle is the De Smet, which in its upper half contains the principal coal beds mined at Monarch, Carneyville, Dietz, and elsewhere in the region. The lower member beneath these coals is described by Taff as "essentially all shale or . . . . shaly in character and prevailingly dull drab, bluish and brown in color," and has an estimated thickness of 2500 to 2800 feet. The upper member, of approximately the same thickness in the area studied by Taff, is lighter-colored and contains a larger proportion of sandstone and coal. The fossil plants of both members belong to the Fort Union flora according to Knowlton, and the invertebrates which have been found only in the upper member are also Fort Union forms. Attention is called to the fact that all the plants from this district listed by Knowlton as lower Fort Union, except one small lot from near Buffalo, which will be referred to again, are from the De Smet formation and the lowest of them are from several hundred feet above its base. In other words they have nothing whatever to do with the "Ceratops beds" which are without much doubt represented in the Piney formation.

Farther south in the Fort McKinney quadrangle and in the southern part of the Dayton quadrangle the Kingsbury conglomerate has been mapped between the Piney and De Smet formations, though Darton[36] states that it probably develops out of the lower part of the De Smet. Taff's work in tracing individual coal beds and associated rocks led him to believe that the Kingsbury conglomerate is considerably higher in the section. His observations are recorded[37] as follows:

A considerable part of the coal-bearing rocks change in character in certain respects toward the south, in the general direction of the strike of the beds. Near the State line, in T. 58 N., R. 86 W., cer-

[35] Hatcher has reported horned dinosaurs east of the Bighorn Mountains about 40 miles south of Buffalo, Wyoming, but nothing is known as to their stratigraphic position.

[36] Bald Mountain, Dayton folio (No. 141) Geol., Atlas U. S., 1906, p. 8.

[37] Bull. U. S. Geol. Survey, No. 341, p. 131.

tain light-colored sandstone strata in the upper part of the lower member thin out and disappear southward along the strike. Some brownish and yellow sandy strata that lie still higher, near the top of the same member on Tongue River, seem to thin out toward the south and give place to dull-colored shale or sandy strata on Goose and Beaver creeks in T. 55 N., R. 85 W. These conditions seem to indicate that the parting between the two members rises in the rock section toward the south.

The upper member also changes in character southward along the strike of the rocks. From the central part of the field southward the differentiation between the sandstone and the shale strata becomes less distinct. The sandstone on the whole is duller in color, and near the southern boundary of the mapped area the sandstone beds contain pebbles of limestone, quartz, and chert. In the southeastern part of T. 54 N., R. 83 W., and in T. 54 N., R. 84 W., many hundred feet of strata in the central part of the upper member merge into conglomerate. The constituent parts of the conglomerate become coarser rather abruptly on the approach to the Paleozoic rocks of the Bighorn Mountains, upon which the conglomerates overlap unconformably. The exposed section of conglomerate strata is more than 1000 feet thick between Little Goose and Sandy Creek valleys, at the base of the Bighorn Mountains, on the southern border of the Sheridan field. The gradation from the conglomerate into the sandy and shaly strata takes place toward the east and north, and involves almost the whole section of this member from the Tongue River coal group upward nearly to the top of the rock section. The economic bearing of the conglomerate is a negative one, for the coal beds thin out and disappear near its outer fringe.

The Kingsbury conglomerate has a maximum thickness of at least 2500 feet west and southwest of Buffalo, Wyoming, where the basal beds and all the underlying formations are sharply upturned. Some of the beds are very coarse and the boulders and pebbles include granite and all of the harder Paleozoic rocks of the Bighorn Mountains. Fossil plants and invertebrates were collected here by Mr. T. E. Williard in 1907 and additional collections, including a mammal jaw found by Mr. Gale, were obtained by Messrs. H. S. Gale, C. A. Fisher, and myself in 1908. Mr. Gale made a plane table map (unpublished) and structure section of several land sections in the southwest part of T. 50 N., R. 82 W., and in the northwest corner of T. 49 N., R. 82 W., which enabled him to determine accurately the stratigraphic positions of the various collections and to demonstrate that there was a large

amount of erosion of the underlying beds before the conglomerate was deposited. Taking as a datum plane a fossiliferous band in the Parkman sandstone it is seen that the beds between it and the base of the conglomerate vary in thickness from about 1300 feet to more than 3000 feet in a distance of two miles along the strike.

In a small collection of fossil plants from a white, friable sandstone about 2000 feet above the Parkman and nearly the same distance below the Kingsbury in sec. 6, T. 49 N., R. 82 W., Doctor Knowlton has identified 5 Fort Union species which are listed in his paper. What relation this horizon bears to the Piney farther north where dinosaur bones were found is still an open question. The most important collections, however, are from finer strata interbedded with the Kingsbury conglomerate about 600 feet above its base. From this part of the section the collections include a considerable list of Fort Union plants, a few land and fresh-water invertebrates most of which are undescribed but seem to be related to Wind River and Wasatch rather than to earlier forms, and a part of a small mammal jaw with the teeth in place. Concerning this jaw Mr. J. W. Gidley reports that it is

> identical with a genus and species occurring in the 'Silberling quarry" in Silberling's Fort Union No. 2. Apparently the genus and species are new, so that at present about all that can be said of the Gale specimen is that it is closely allied to *Tricentetes*, a genus found in the Torrejon of New Mexico. The close correspondence of the specimen to like portions found in the bed of the Silberling quarry, leaves little doubt that the horizons are equivalent.

All the evidence both paleontologic and stratigraphic tends to prove that the unconformity at the base of the Kingsbury conglomerate is well up in the Fort Union. Since it has been proved to hold this high position the assertion has been made that the unconformity is purely local and relatively unimportant because the conglomerate extends for only 30 or 40 miles along the strike. That it is unimportant and local may be true, but such an assumption should not be made until it has been compared with other observed unconformities which also may or may not be local.

Bighorn Basin.—Except in the extreme northern part it has been difficult to recognize in Bighorn Basin the same subdivisions between

the Colorado shale and the Fort Union that have been used as formations in Montana, because both the Claggett and the Bearpaw as marine formations are either very thin or entirely represented by non-marine deposits. The geology has been described by Fisher[38] who did not attempt to classify these higher rocks and brief abstracts of the more detailed work by Woodruff[39] and Washburne[40] have been published.

In the Shoshone River section below Cody there is a conglomerate which is comparable in many respects with the Kingsbury. The basal bed exposed at the mouth of Sage Creek contains many pebbles of igneous rock, abundant rounded fragments of silicified wood and many pebbles that look like the underlying Cretaceous rocks. Fort Union plants identified by Doctor Knowlton were obtained from beds intercalated in the conglomerates, as well as above them, and they range down some distance below their base. The presence of the "Ceratops beds" is indicated at several localities in the Basin by fragmentary dinosaur bones and by a few fresh-water invertebrates which are usually associated with them, though nothing strictly distinctive has been found among the invertebrates. In every case the dinosaurs were found in beds lower than the lowest recognized Fort Union plants.

Similar stratigraphic relations are found just north of Bighorn Basin near Belfry and between Bridger and Red Lodge, Montana, except that the marine formations are recognizable and the Fort Union is much thicker and contains many workable coals. Dinosaur bones are found in the part of the section designated as "Laramie" in Woodruff's[41] sketch and associated with them are the following invertebrates:

Unio sp. Related to *U. brachyopisthus* White
U. pyramidatoides Whitfield?
U. cylindricoides Whitfield?
U. verrucosiformis Whitf.
Sphærium
Physa

[38] Fisher, C. A.: Geology and Water Resources of the Bighorn Basin, Wyoming, Professional Paper, U. S. Geol. Survey, No. 53, 1906.

[39] Woodruff, E. G.: Coalfields of the southwest side of the Bighorn Basin, Wyoming, Bull. U. S. Geol. Survey, No. 341, p. 200–219.

[40] Washburne, C. W.: Coalfields of the northeast side of the Bighorn Basin, Wyoming, Idem., pp. 165–199.

[41] Bull. U. S. Geol. Survey, No. 341, p. 96.

Columna
Viviparus trochiformis M. & H.?
Campeloma multilineata M. & H.
Goniobasis tenuicarinata M. & H.

The fauna is closely related to that of Hell Creek and Converse County. The lowest Fort Union plants recorded occur several hundred feet higher, except a fig identical with one found in Converse County and Hell Creek.

Black Buttes, Wyoming.—This locality has been the subject of much discussion ever since 1872, when the dinosaur, *Agathaumas sylvestris* Cope, now referred to the Ceratopsia, was found there. The following description by Stanton and Knowlton[42] will show the paleontologic characteristics of the dinosaur-bearing formation and the relative positions of the various species:

The most prominent feature of the section at Black Buttes is the massive bed of sandstone, somewhat over 100 feet thick at the base of the exposure, forming steep hills and cliffs northeast of the railroad opposite the station and passing beneath the surface by its dip of 9 or 10 degrees near the coal mine. The upper portion of it is also exposed on the south side of Bitter Creek valley, about a mile from the station. All of the Laramie fossils, whether plants, invertebrates, or vertebrates, that have hitherto been described or listed as coming from Black Buttes were obtained from the overlying beds within about 100 feet of the top of this massive sandstone. The original specimen of *Agathaumas sylvestris* was found about 20 feet above it, and the plants that have been described came from the same horizon and from several higher bands up to the bed overlying the principal coal, some 60 or 75 feet higher. The invertebrates from this locality have about the same range. Most of the beds vary considerably in character and thickness within short distances, but the fossiliferous and overlying portions of the sections may be described in general terms as a series of variable sandstones, clays, and coal beds exposed in low hills and ridges with a dip of 9 or 10 degrees eastward at the base, but decreasing in the upper portions to 5 or 6 degrees, which is about the same as the dip of the overlying Wasatch beds.

The character of the mollusks shows that the lower beds were mostly deposited in brackish waters, but that there were alternations of fresh waters in which the genus *Unio* thrived with an abundance of individuals and great variety of species, and several fresh-water gasteropods were common. Between the top of the massive sandstone and the

[42] Bull. Geol. Soc. America, Vol. VIII, 1897, pp. 143–145.

Dinosaur horizon there is a band filled with brackish-water fossils, including *Ostrea glabra* var. *arcuatilis* Meek; *Anomia micronema* Meek; *Corbula undifera* Meek, and *Modiola* sp. The greater number of the Black Buttes invertebrates, however, have been obtained from strata some 40 or 50 feet higher, and consequently a little above the Dinosaur bed. Here there is a band which in some places is about four feet thick, almost wholly made up of shells. By far the most abundant species is *Corbicula fracta* Meek, and immediately associated with it are *Corbicula occidentalis* M. & H.; *Neritina baptista* White; *N. volvilineata* White, and *Melania wyomingensis* Meek, all of which probably lived in slightly brackish water, for this species of *Melania* has almost invariably been found associated with brackish water or marine forms, although it is referred to a fresh-water genus. At the base of this shell bed and immediately above a coal seam *Unio* shells are abundant. These purely fresh-water forms are found on the slope mingled with the *Corbicula* shells, but all that were found *in situ* were either at the base of or a few feet above the Corbicula bed.

The Unione fauna is strikingly like that of the Ceratops beds in Converse County, as the following list of species will show:

Unio couesi White
Unio propheticus White
Unio aldrichi White
Unio proavitus White
Unio holmesianus White
Unio endlichi White
Unio cryptorhynchus White
Unio brachyopisthus White
Unio goniambonatus White
Unio danæ M. & H.

Immediately above the *Corbicula* bed a band is locally filled with *Tulotoma thompsoni* and occasional Unios, and it is overlain by shales containing *Ostrea* and *Anomia* in the lower part and the following species above:

Unio couesi White
Corbula undifera Meek
Corbula subtrigonalis M. & H.
Cassiopella turricula White
Goniobasis gracilenta M. & H. (?)
Viviparus plicapressus White
Campeloma vetula M. & H.
Campeloma multilineata M. & H.

The fossil plants of Black Buttes, ranging through the same strata as the invertebrates and extending up a few feet higher to the bed just above the principal coal, are as follows:

Apeibopsis discolor Lx.
Cissites lobato-crenata Lx.
Cissites tricuspidata Heer
Ficus planicostata Lx.
Ficus planicostata latifolia Lx.
Grewiopsis saportanea Lx.
Grewiopsis tenuifolia Lx.
Myrica torreyi Lx.
Ophegrapha antiqua Lx.
Pisonia racemosa Lx.
Podogonium americanum Lx.
Quercus viburnifolia Lx.
Rhamnus salicifolius Lx.
Sapindus caudatus Lx.
Sequoia acuminata Lx.
Smilax grandifolia Ung.
Viburnum marginatum Lx.
Viburnum platanoides Lx.
Viburnum rotundifolium Lx.
Viburnum whymperi Heer
Zizyphus fibrillosus Lx.

The fresh-water element of the invertebrate fauna shows close relationship by means of specific identity with the fauna of Hell Creek and Converse County, while the brackish-water species are similarly connected on the one hand with the Laramie fauna of Crow Creek, Colorado, which is in the Denver Basin, and on the other with the Mesaverde[43] fauna of Point of Rocks and other localities in southern Wyoming and western Colorado. Of the fresh-water forms also *Tulotoma thompsoni* ranges down into the Mesaverde and a few of the Unios are represented by related species in that formation. While this range removes such species from the list of distinctive *Laramie* species it does not impair their value as evidence of the *Cretaceous* age of the beds where they are found.

The fossil plants of Black Buttes also show some species in common with Converse County though according to Knowlton the relationship is not close. The flora is apparently more closely connected with that of Point of Rocks, which is in the upper part of the Mesa-

[43] In the current work of the Coal Division of the U. S. Geological Survey the formation names used in western Colorado have been applied in southern Wyoming. The Mesaverde corresponds in a general way with the combined Eagle, Claggett, and Judith River formations of Montana and the Lewis shale is the approximate equivalent of the Bearpaw.

verde and separated from the Black Buttes horizon by the marine Lewis shale. Lesquereux[44] recognized the close relationship of the floras of these two localities, saying that they had 9 species in common.[45] That the advance in science of the last 30 years has not changed this relationship is shown by two small collections obtained last year near Table Rock from the Black Buttes horizon in which the following species were identified by Doctor Knowlton and referred to "age probably same as at Black Buttes."

**Viburnum marginatum* Lesq.
V. contortum Lesq.
**Myrica torreyi* Lesq.
Sequoia reichenbachi (Gein.) Heer
Sequoia heeri Lesq.
**Dryophyllum subfalcatum* Lesq.
**Ficus dalmatica* Ett.
Ficus planicostata Lesq.
Ficus sp.
**Phyllites triloba* Kn.

Of the nine identified species five (marked *) are reported from Point of Rocks.

The general relations of these beds are clearly presented by A. R. Schultz[46] who calls them the Black Buttes coal group. He states that the Black Buttes coal group rests conformably on the Lewis shale, but that the overlying Black Rock coal group is separated from it by an unconformity of considerable magnitude. This unconformity was not observed by Doctor Knowlton and me in 1896, but last year, in company with Messrs. Veatch, Schultz, and Fisher, we visited a locality a few miles south of Black Buttes, where the true relations are strikingly apparent, as within a short distance the Black Rock coal group overlaps the Black Buttes coal group and rests directly on the Lewis shale. The beds above the unconformity contain a Fort Union flora.

As evidence of the great geographic distribution of the Black

[44] Tertiary Flora, U. S. Geol. Survey Terr., Vol. VII, 1878.

[45] Doctor Knowlton admits only 8 species in common and says of them (Bull. U. S. Geol. Survey, No. 163, 1900, p. 77) "Several are open to more or less question, as they depend on one or two fragments."

[46] The northern part of the Rock Springs coalfield, Sweetwater County, Wyoming, Bull. U. S. Geol. Survey, No. 341, pp. 256–268.

Buttes invertebrate fauna at about the same horizon the following lists of fossils collected by Robert Forrester in the Laramie of southwest Colorado may be given:

Beaver Creek, T. 34 N., R. 5 W., near boundary line between La Plata and Archuleta counties, Colorado. Coal measures immediately above the Lewis shale.

Anomia sp. Related to *A. micronema* Meek.
Modiola laticostata White.
Corbicula sp. Related to *C. subelliptica* M. & H.
Corbicula occidentalis M. & H.
Corbula undifera Meek
Melania wyomingensis Meek?

Yellow Jacket Creek, T. 34 N., R. 5 W., "Coal measures above Lewis shale."

Ostrea sp.
Unio holmesianus White
Unio brachyopisthus White
Unio verrucosiformis Whitfield?
Unio sp. Undescribed, possibly two species.
Tulotoma thompsoni White
Campeloma? sp.
Neritina sp.

Mr. James H. Gardner, of the U. S. Geological Survey, who has done detailed work in the region, verifies the identification of the horizon at the localities where these collections were made.

Area west of Rawlins, Wyoming.—At Black Buttes the marine Cretaceous and immediately overlying rocks dip gently eastward passing under beds of Wasatch, Green River, and Bridger age in the broad syncline of the Great Divide Basin. They again come to the surface with a westward dip a few miles west of Rawlins and 60 to 70 miles east of Black Buttes. A summary description of the section exposed here is published by E. Eggleston Smith,[47] to which the reader is referred for lithologic and areal details. The paleontologic material discussed below was collected in part by the field parties of Messrs. Smith and Ball and in part by myself. The estimates of thickness are Smith's.

The Mesaverde formation, which is coal-bearing and about 3600 feet thick, is not very fossiliferous in this area, but a few marine invertebrates have been obtained in the lower part and near the top there is

[47] The eastern part of the Great Divide Basin coalfield, Wyoming, Bull. U. S. Geol. Survey, No. 341, pp. 220–242.

a thin bed of mostly brackish-water shells, among which the following have been identified from a locality in T. 22 N., R. 89 W.:

Ostrea subtrigonalis E. & S.
Ostrea glabra M. & H.
Anomia micronema Meek
Mytilus subarcuatus M. & H.?
Corbicula occidentalis M. & H.
Melania wyomingensis Meek?
Odontobasis buccinoides White

Above the Mesaverde is the Lewis shale, about 1500 feet thick, with some layers of concretionary sandstone which are often fossiliferous. In the township above-mentioned these yielded the following marine fossils:

Ostrea sp.
Modiola galpiniana (E. & S.)?
Avicula nebrascana E. & S.
Syncyclonema rigida H. & M.
Nucula sp.
Protocardia subquadrata E. & S.
Corbula sp.
Dentalium gracile H. & M.
Anchura sp.
Baculites ovatus Say
Scaphites nodosus Owen

The same fauna, with some additional species, such as *Avicula fibrosa* M. & H. and *Lucina occidentalis* (Morton) is also found in calcareous concretions in the dark shales.

The coal-bearing formation, about 3900 feet thick, conformably overlying the Lewis, is called Laramie in Smith's report. Near the middle of the formation in T. 22 N., R. 89 W., in line across the strike from the Mesaverde and Lewis localities above recorded, *Corbula subtrigonalis* M. & H. was collected and 10 feet higher *Tulotoma thompsoni* and *Campeloma* sp. occur. Fuller collections were obtained from this formation from the adjoining township on the south. Here a brackish-water bed about 1000 feet above the base yielded

Ostrea glabra M. & H.
Ostrea subtrigonalis E. & S.?
Anomia micronema Meek
Mytilus subarcuatus M. & H.?

Corbicula cytheriformis M. & H.
Corbicula fracta Meek
Panopæa simulatrix Whiteaves?
Neritina volvilineata White

This is evidently a recurrence with slight modifications, of the brackish-water fauna found at the top of the Mesaverde and it is practically identical with the brackish-water element of the fauna at Black Buttes.

Considerably higher in the section near the middle of the "Laramie" the following fresh-water shells were obtained:

Unio goniambonatus White
Unio stantoni White
Unio verrucosiformis Whitfield
Unio brachyopisthus White?
Tulotoma thompsoni White
Goniobasis sp.

All of these species except one are found at Black Buttes and that one occurs at Hell Creek and Converse County.

The stratigraphic, areal, and structural relations and the faunal evidence all seem to justify the correlation of the "Laramie" of this area with the Black Buttes coal group.

Above his Laramie Smith recognizes two unconformities between which there are coal-bearing strata with a total thickness estimated at 8780 feet which he treats as "undifferentiated Tertiary." The lower part is conglomeratic, especially about 1000 feet above the base, where the conglomerate contains pebbles of both Paleozoic and Cretaceous rocks. Fossil plants recognized as Fort Union by Knowlton have been obtained from several horizons in this thick series.

Above the upper unconformity there are 900 to 1800 feet of coal-bearing beds referred by Smith to the Wasatch. The basal conglomerate is in large part derived from granite with some sedimentary pebbles. The most important paleontologic evidence as to the age of this formation consists of some teeth of *Coryphodon*, a mammalian genus characteristic of the Wasatch, and an unstudied flora which is said to be different from the Fort Union. The fresh-water shells obtained also indicate Eocene later than Fort Union.

Carbon County, Wyoming.—The area adjoining that mapped by E. E. Smith on the east and extending from Rawlins about 50 miles

east to Medicine Bow had been previously studied by A. C. Veatch,[48] and as Veatch at first had supervision of Smith's work the same stratigraphic units were recognized and used in both areas. With some variations in thickness and lithologic character the Mesaverde and the Lewis of the two areas correspond very closely. The "Laramie" of Smith's report was called "Lower Laramie" by Veatch and extends up to the same unconformity, with a reported thickness of 6500 feet. Veatch's "Upper Laramie" of this area with the addition at the top of 1200 feet of beds referred to Fort Union, apparently corresponds very well with Smith's "undifferentiated Tertiary."

The "Upper Laramie" has a basal conglomerate "composed largely of pebbles derived from the underlying Cretaceous rocks" and in part of the area it overlaps several of the older formations. It includes the coal beds mined at Carbon, Dana, and Hanna. The flora associated with the coal at Carbon has long been known and has been the subject of much discussion. It has usually been classed with the flora of Evanston as later than the other floras formerly referred to the Laramie, but the question whether it belongs to the Fort Union or to some other flora must wait until the plants have been thoroughly restudied with fuller collections made with careful reference to the stratigraphy of the region.

The invertebrate collections from both the "Upper" and "Lower Laramie" have been very meager. The localities and horizons of the different lots as given on the field labels have been compared with the published geologic map, and the evidence will be recorded as it stands.

A brackish-water fauna, represented by *Ostrea* and *Corbicula*, was collected at several localities in the "Lower Laramie" and also in the Lewis and Mesaverde. Only one lot is from a locality mapped as "Upper Laramie" and that is from sec. 21, T. 24 N., R. 81 W., at the lower boundary of the formation where lower beds are probably exposed. As brackish-water shells have not been found above this major unconformity elsewhere in the region it is fair to assume that this lot was collected below it.

A fresh-water fauna like that of Black Buttes is indicated by a

[48] Coalfields of east-central Carbon County, Wyoming, Bull. U. S. Geol. Survey, No. 316, 1907, pp. 244–260.

number of small lots from the "Lower Laramie." The largest of these, from sec. 16, T. 24 N., R. 84 W., contains

Unio couesi White
Unio verrucosiformis Whitfield
Unio sp.
Campeloma multilineata M. & H.
Cassiopella turricula White

At several other localities *Tulotoma thompsoni* White was collected with the other gastropods of this list. This fresh-water fauna was collected at but one locality mapped as "Upper Laramie." That is in sec. 10, T. 23 N., R. 80 W., near the contact where "Upper Laramie" is overlapping "Lower Laramie" and Lewis, making it probable that the collector was in error as to the line between the formations.

Other localities in the "Upper Laramie" yielded *Unio priscus* M. & H., *Unio* sp., *Viviparus raynoldsanus* M. & H., and *Campeloma multilineata*, all of which occur in the Fort Union, though the last named species is also widely distributed in the Laramie and "Ceratops beds."

In this area Hatcher[49] has recorded the presence of "horned dinosaurs and Hadrosauridæ on the North Platte River opposite the mouth of the Medicine Bow, about 35 miles below Fort Steele, Wyoming." This locality is mapped by Veatch as "Lower Laramie" and it is only about a mile from the place (sec. 16, T. 24 N., R. 84 W.) in the same formation where the fresh-water shells above listed were obtained. Mr. Veatch believes, however, that the dinosaurs were found in a bluff of "Upper Laramie" about a mile and a half above the mouth of Medicine Bow. His belief, it is said, is based on statements of a resident of the region, that large fossils were once collected there. The invertebrate fossils in the lower formation indicate to my mind that the dinosaurs ought to be where Hatcher said he found them, but the locality ought to be restudied.[50]

[49] Am. Naturalist, Vol. XXX, 1896, p. 118.

[50] This is perhaps an appropriate place to record another reported occurrence of dinosaurs in a high horizon. Last year Mr. James H. Gardner collected bones referred to *Triceratops*, *Trachodon*, *Tyrannosaurus*, etc., near Ojo Alamo on Coal Creek, northwestern New Mexico, at a locality where Mr. Barnum Brown had previously found dinosaurs. Mr.Gardner believes that the bed from which he collected belongs to the Puerco and that it is several

So far as it goes the evidence in the Carbon County field tends to show that the "Lower Laramie" is conformable and continuous with the marine Cretaceous and that it includes the equivalents of the Black Buttes coal group and of the "Ceratops beds" of Converse County. It is also probable that the "Upper Laramie" is Fort Union. In thickness of strata and in the number and character of its coals this formation seems to be strictly comparable with the Fort Union of the Sheridan and Red Lodge fields.

General Stratigraphic and Structural Relations

It has been shown that, within the large area considered, the "Ceratops beds" with the Triceratops fauna are always pretty closely associated with the uppermost marine Cretaceous strata or are separated from them by transitional brackish-water beds. They are always overlain by a thick series of rocks containing a Fort Union flora in which no dinosaurs have been found, and in the Fish Creek, Montana, region this overlying series also contains primitive mammals related to those of the Puerco and Torrejon faunas.

Throughout a large part of the area no evidence of an unconformity beneath the "Ceratops beds" has been found, while higher in the section unconformities have been demonstrated or suggested at a number of places. Unconformities have been reported below the "Ceratops beds" on Hell Creek, Montana, on the Little Missouri in North Dakota, and in Weston County, Wyoming, but in none of these cases has any proof been furnished that the erosion interval is important. The fact seems to be overlooked that in irregular non-marine deposits like these, which were in part at least fluviatile, an eroded surface should normally be expected at the base of a sandstone, but such an eroded surface may mean a time interval too brief to be worthy of consideration in geologic history. Because Ceratopsia were found in the Denver Basin above an unconformity that has been interpreted as representing an enormous time interval, is not a valid reason for

hundred feet above the unconformity separating that formation from the Laramie. If that is true it is somewhat remarkable that all the fossils found here are reptilian and show considerable variety, while other Puerco localities not many miles away yield chiefly mammals and no dinosaurs. Mr. Gardner proposes to restudy this section.

assuming that all Ceratopsia everywhere must be above such an unconformity, and especially has this ceased to be valid reasoning since it has been proved that the Judith River Ceratopsia are in a formation intercalated between marine formations of the conformable Upper Cretaceous series.

Physiographic Conditions Near the Close of the Cretaceous.

Before discussing the paleontologic evidence of the age of the "Ceratops beds" it is desirable to consider briefly the relations of land and sea and the general conditions of sedimentation in the great Interior Region in late Cretaceous and early Tertiary time. It is well known that during the Benton epoch the sea covered practically all parts of that region in which Cretaceous rocks are now found. Only locally along the western margin were there estuaries and marshes in which coal was formed and from which purely marine life was excluded. Soon after the Benton, however, large areas west of the Front Range in Colorado and Wyoming and west of the 108th meridian in Montana previously covered by the sea began to emerge, either by uplift or by filling of the basins with sediment, and as they came up to sea level or a few feet above it land and marsh plants became established and all the conditions became favorable for the formation of coal beds. Land animals also came in and the streams and fresh-water lagoons received their appropriate population from adjacent areas while the bays and estuaries were inhabited by brackish-water forms. Topographic conditions must have been such that sedimentation was practically continuous from the marine deposits to the land and fresh-water sediments. Such deposits are represented by the Mesaverde formation on the south and by the Eagle and Judith River formations on the north. The neighboring land masses must have formed large areas and have had considerable elevation in order to furnish the immense thickness of Upper Cretaceous sediments known in this region.

The uplift was not uniform nor continuous. There were oscillations so that occasionally brackish-water or marine deposits were brought above those of land and fresh-water origin, and it is probable that these oscillations were not always synchronous throughout the region. Even in areas where marine waters did not come in for a long

time there must have been local subsidence about equalling the rate of deposition, because these thick formations seem throughout to have been formed near sea level. Locally, as in part of Bighorn Basin, this non-marine sedimentation may have been almost continuous until the end of the Cretaceous, but over most of the area there was a more important subsidence which brought the marine sediments represented by the Lewis and Bearpaw shales over the coal-bearing formations above-mentioned. Again the uplift was resumed and there was another transition from marine to land conditions. In some areas this was gradual with alternations of brackish- and fresh-water beds through a considerable thickness, as in southern Wyoming. There is a similar transition with less fresh-water sedimentation in the Laramie of the Denver Basin, where marine conditions had prevailed continuously since Benton time, and there is such a transition beneath the "Ceratops beds" of Converse County. In other areas the change is more abrupt and the marine rocks are followed directly by land and fresh-water deposits.

The idea seems to be still prevalent that this latest Cretaceous sea was uplifted as a whole, its direct intercommunication with the ocean cut off, and its waters then gradually freshened so that its strictly marine animals were killed while those that could endure brackish waters survived. It has even been suggested that the change was so gradual that the brackish-water fauna may have adjusted itself to the changing conditions and continued to live after the waters became entirely fresh. Such a history seems to be implied in the statement of F. V. Hayden quoted on p. 250, and similar statements may be found in the writings of C. A. White. There is no evidence, however, in favor of this view. As far up in the series as brackish-water fossils are found they occur in usually thin beds intercalated amongst the fresh-water strata, showing that the two elements of the fauna had separate habitats. There is no more admixture of the two kinds of forms than is to be expected where slight oscillations of level alternately bring them over the same area and where currents may easily carry the fresh-water shells into brackish or even marine waters. "The intimate association of brackish- and fresh-water forms" may be found in printed lists and possibly in museum collections but it does not exist in the rocks, and this is as true of the brackish-water shells of the highest horizon at which they occur in the Inte-

rior Region as it is of those in the Mesaverde and Judith River. These mollusks evidently lived in tidal waters connected somewhere with the open ocean.

With all the oscillations the total result of the late Cretaceous movements was uplift[51] and this finally brought the whole Rocky Mountain and Great Plains regions permanently above sea level before the beginning of the Tertiary, for the nearest marine Eocene rocks now known are in eastern Texas, the lower Mississippi Valley, and on the Pacific Coast. Some areas in the Rocky Mountain region must have been subject to erosion for long periods before the close of the Cretaceous. The hypothesis that erosion did not begin until the close of the Laramie in the Denver region, for example, and that time must be allowed between the Laramie and the Arapahoe for erosion to cut down through the 15,000 or 20,000 feet of sediments to the granite in that region is to my mind incredible and unnecessary.

Age of the "Ceratops Beds."

Evidence from the vertebrate fauna.—The vertebrate fauna of these beds is large and greatly varied, including mammals, dinosaurs, amphibians, rhynchocephalians, turtles, crocodiles, and fishes. As a whole and individually it is very closely related to the Judith River fauna, which is known to be Cretaceous and to lie beneath a thousand feet or more of marine Cretaceous beds. On this relationship with the Judith River fauna Brown[52] says:

> The vertebrates are clearly of Mesozoic affinity. The dinosaurs here represented in the post-Laramie are the culmination of a practically uninterrupted line of highly organized vertebrates that have persisted with little change since the Judith River period, some like *Claosaurus*, extending as far back as the Niobrara, and their relation to the earlier Jurassic forms is well established.

[51] I owe to Mr. Bailey Willis the suggestion that the facts would be better explained by an *ebb tide* of continental extent due to deepening of the ocean basins rather than by continental uplift. The fact of importance to my argument is the change in relative positions of land and sea, and whether this is due to continental uplift or to oceanic depression the resultant retreat of the sea from the interior of the continent is the same.

[52] Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, p. 845.

[53] Williston, S. W.: The Laramie Cretaceous of Wyoming, Science, N. S., Vol. XVI, 1902, pp. 952–953.

Williston[53] states that this fauna has in some respects a startling resemblance to the Judith River fauna and argues that they were really contemporaneous. Perhaps the best general statement of the close relationship between these two faunas is that of Hatcher when he was bringing forward all the arguments he could find for their distinctness. The following quotations[54] indicate his views, when it is remembered that he uses "Laramie" for the beds in Converse County.

"When considered in its entirety, the vertebrate fauna of these (Judith River) beds is remarkably similar to, though distinctly more primitive than, that of the Laramie. Almost or quite all of the Laramie types of vertebrates are present, though, as a rule, they are represented by smaller and more primitive forms. The similarity between this fauna and that of the Laramie contrasts strongly with the great dissimilarity between the vertebrates of the Judith River and those of the Atlantosaurus beds, the next older fresh-water horizon in this region, containing also a rich and varied fauna, but quite distinct from that of the beds in question.

"Briefly, the Judith fauna, it is clear, is descended from the Jurassic and is the direct ancestor of the Laramie. Its relations with the former are not close, and several groups are absent in the one which are present in the other. Its relations with the Laramie are much closer, as should be expected, considering the stratigraphic position. With one or two possible exceptions all the families represented in either of these two later deposits are present also in the other. Although several genera and species now appear to be common to both these formations, it is probable that when more perfect material is available they will be found, in most instances, to be quite distinct, though some pertaining to more persistent types may prove to be identical."

Only two mammals have been reported from the Judith River formation and none from any other Upper Cretaceous horizon below the "Ceratops beds," and both of these according to Hatcher are closely related to forms in the "Laramie." According to Gidley there are two or three mammal genera in the "Ceratops beds" that range up into the Torrejon fauna of the Fort Union at Bear Butte, Montana, and one of these is represented by two species that may possibly be identical in both horizons. The turtles, rhynchocephalians, and crocodiles of the "Ceratops beds" may also be pretty closely related to those of the Fort Union, Puerco, and Torrejon, but the faunas are generally very distinct. Brown states[55] that the difference between the Puerco mam-

[54] Bull. U. S. Geol. Survey, No. 257, 1905, pp. 101–103.

[55] Op. cit., p. 840.

malian fauna and that of the "Laramie" is greater than that between the Puerco and Wasatch mammals.

The Puerco formation of New Mexico lies between the Laramie and the Wasatch and contains two faunal zones. To the upper of these the vertebrate paleontologists have applied the name Torrejon, restricting Puerco to the lower one. It has been shown that in Montana the Fort Union formation includes mammal-bearing beds with a fauna more closely related to the Torrejon fauna than to the restricted Puerco but this probably does not mean that only the upper zone is stratigraphically represented. It is fair therefore to say that the Puerco as a whole is in Montana stratigraphically above the "Ceratops beds." The Puerco is now generally treated as basal Eocene, though Cope called it Mesozoic and placed it with the Laramie in a separate system beneath the Tertiary, and if it is basal Eocene then the Ceratops beds should be Cretaceous on that showing alone.

Osborn[56] says of the restricted Puerco that its mammalian fauna is "wholly of Mesozoic origin, and mostly destined to disappear; not a single representative or ancestor of any existing orders of Tertiary mammals is certainly known" and that it has no representative in Europe. Concerning the Torrejon mammals he says that out of 40 species only one is of "modernized Tertiary stock," all the others being Mesozoic, i.e., derived from and related to the Mesozoic. The Torrejon is compared with the Thanétien or Cernaysien stage of France. Apparently it would do less violence to the vertebrate evidence to put the Puerco and Torrejon horizons in the Cretaceous than to put the "Ceratops beds" in the Tertiary.

In France the Montien stage now referred to the uppermost Cretaceous contains dinosaurs closely related to those of the Triceratops fauna, according to De Lapparent.[57]

The vertebrate evidence for Cretaceous age does not rest on a single dinosaur or a few members of that group associated with a Tertiary fauna. If this were the case it would be fair to argue that they were straggling descendants of an earlier fauna that had lived beyond their normal time. The whole fauna is Cretaceous in its affinities and the fair question is not *could* the dinosaurs have lived on into the Tertiary,

[56] Osborn, H. F.: Cenozoic mammal horizons of Western North America' Bull. U. S. Geol. Survey, No. 361, 1909, pp. 34, 35.

[57] Traité de Geologie, 5me ed., 1906, p. 1472.

but *did* they do so? The fact that ammonites, Inocerami, rudistæ, and many other groups of invertebrates have no descendants in the Tertiary does not disqualify them as characteristic fossils of the Mesozoic, neither does the fact that the Cretaceous dinosaurs left no Tertiary descendants disqualify them as characteristic Mesozoic fossils.

Evidence from the invertebrate fauna.—The two elements of the invertebrate fauna, one inhabiting the brackish waters and the other the fresh waters, have already been discussed and the fact has been emphasized that their local habitats were really distinct, though they might be near each other and might alternately occupy the same territory many times. It is obvious then that an attempt to correlate one locality where there were only fresh-water deposits with another locality where the beds were chiefly of brackish-water origin by counting identical species and figuring percentages would lead to erroneous results. A comparison of the Laramie invertebrates of the Denver Basin with the invertebrates of the "Ceratops beds" of Hell Creek and Converse County is a case of this kind and is of no value whatever. A similar result would be obtained by comparing the fauna of the Potomac at Washington with that at the mouth of the same stream. At Washington, although within tidal waters, there is a varied fresh-water fauna, which includes many of the genera that lived in Cretaceous time, while in the lower course of the river and Chesapeake Bay there are beds of oysters and the few other brackish-water forms usually associated with them.

The invertebrates of the "Ceratops beds" and indeed practically all of the non-marine forms of the Cretaceous like the plants of the Upper Cretaceous belong to living genera and, taking the world over, it is probable that almost every specific type may be found represented by similar living species. It must be admitted that in themselves, without any reference to stratigraphic occurrence or local geologic history, these fossils could not be depended upon for the discrimination of horizons within the Cretaceous nor for distinguishing between Cretaceous and Tertiary. But when the investigation is confined to a single region and when the geographic and stratigraphic range of non-marine species has been determined their evidence is useful and important. When the brackish-water fauna of a locality like Point of Rocks, Wyoming, is studied and is proved to be of Cretaceous age by means of overlying marine faunas, and when a very similar assemblage

with several identical forms is found at a much higher horizon at Black Buttes, a few miles away, it is a fair inference that the Black Buttes fauna is directly descended from that at Point of Rocks and that both are of Cretaceous age. When the whole region is studied and it is learned that no marine Tertiary fauna ever entered it and that the Tertiary sea did not approach closely enough to the region to have been connected with these brackish waters, and when it is further learned that no such assemblage of non-marine forms is anywhere found intercalated in or closely associated with marine Tertiary rocks the truth of the inference that the brackish-water fossils of Black Buttes are Cretaceous is practically demonstrated and it may be confidently asserted that in this area all higher rocks in which such fossils occur are also Cretaceous. Of course isolated occurrences of *Corbula* and perhaps a few other genera that are known to range into purely fresh waters far from the ocean must be treated with caution. It is for these reasons that I have given much importance to the oyster bed reported by Leonard in southwest North Dakota above the Triceratops horizon and above an unconformity. It is in itself proof that the rocks are Cretaceous and that the unconformity has no significance in the matter of separating Cretaceous from Tertiary. The brackish-water fauna of the Upper Cretaceous has the same general character and many specific identities throughout its great vertical and geographic range.

The fresh-water mollusca include a few species that actually pass up into the overlying formation, but the majority of the species are confined to this horizon or occur in either identical or closely related forms in the Mesaverde, Judith River, and other Cretaceous formations. This element of the fauna is best developed in the Hell Creek and Converse County areas, where they are not associated with the brackish-water beds, but the distribution of some of the species is wide-spread in association with the dinosaur fauna, and a large proportion of them, including some of the more striking and characteristic forms, occur at Black Buttes in beds that contain intercalated brackish-water strata. These facts together with the absence of types similar to most of the forms from the Eocene and other Tertiary rocks of the region justify the reference of the fresh-water fauna to the Cretaceous.

Evidence from the flora.—Doctor Knowlton's statistics show a close

relationship between the flora of the "lower Fort Union" and the "upper Fort Union;" if, however, comparison were made between the "Ceratops beds" that have actually yielded dinosaurs and the typical, or "upper" Fort Union, the figures would possibly be different, because in many sections such as those of the Bighorn Basin, Red Lodge, Sheridan, Fish Creek, and probably along the Yellowstone, he has included much more than the "Ceratops beds" in his lower Fort Union. The value of the comparison with the Laramie flora is impaired also by the fact that it is restricted to the 80 species of the Denver Basin Laramie which is probably only a fraction of the whole flora. Even with that restriction 10 species, or 12½ per cent of the Laramie flora, occur in the "lower Fort Union" and only about the same percentage of "upper Fort Union" species occur in it, though they are 61 in number. It is of course true that a considerable number of Fort Union plants are found in the "Ceratops beds," but that does not necessarily prove that the latter are Eocene, nor that they belong to the Fort Union formation.

The difference between the Laramie and Fort Union floras was first emphasized by Dr. J. S. Newberry, who studied and described[58] the early collections of Fort Union plants which he then considered Miocene. The Fort Union known to him, as indicated by the localities, is all "upper Fort Union." His final views concerning the Fort Union and Laramie floras are shown by the following extracts from two of his latest papers, which also clearly show that the "Laramie" as known to Newberry included Colorado, Mesaverde, Laramie, Denver, and possibly later beds:[59]

Between the foot hills of the Rocky mountains and the summit of the Wasatch the older Cretaceous rocks are covered by sandstones and shales which contain beds of coal so numerous and important as to give to the formation the name, sometimes applied to it, of the Lignitic Formation. This, the true Laramie group, is distinct from the so-called Laramie of the upper Missouri, named by Hayden the Fort Union group, and which, in my judgment, should be considered the basal member of the Tertiary. Large collections of fossil plants made by Dr. Hayden and others in the country bordering the upper Missouri

[58] Annals Lyceum Nat. Hist. N. Y., Vol. 9, 1868, pp. 1–76.

[59] The Coals of Colorado, School of Mines Quarterly, Vol. IX, 1888, p. 329. The Laramie group, its geological relations, its economic importance and its fauna and flora, N. Y. Acad. Sci., Vol. IX, 1889, pp. 27, 31, 32.

have passed through my hands, and have been described by me in a memoir to be published by the U. S. Geological Survey. This flora has also been carefully studied by Prof. L. F. Ward, who has published an important paper upon it which forms part of the Sixth Annual Report of the Director of the U. S. Geological Survey. It is entitled "A Synopsis of the Flora of the Laramie Group," but it really contains few of the Lower or true Laramie plants, and is chiefly descriptive of the Upper Laramie or Fort Union flora, of which it affords the most important review yet published. In this flora are a number of living species, such as *Corylus americana, C. rostrata, Onoclea sensibilis,* etc., and many species found in the Tertiary rocks of northern North America, Greenland, and Europe, in strata called Micoene by Heer, but shown by J. Starkie Gardner to be Eocene.

The flora of the Lower or true Laramie has been made known to me by collections from Evanston, Black Butte, Bitter Creek, Fisher's Peak, Walsenburg, Canon City, Crested Butte, etc. These show that there is almost nothing in common between the Fort Union and Laramie floras, and that the two divisions of the so-called Laramie group, judging from their fossil plants, which are very numerous, must be regarded as distinct formations. The older flora contains no living species, but has many things in common with the Upper Cretaceous coal-bearing rocks of Vancouver Island and Washington Territory, is associated with marine and brackish water shells among which *Inoceramus* is conspicuous, and I have, therefore, called it Cretaceous and the upper member of that system.

The following is from the second paper cited:

The term Laramie Group was first used by Mr. Clarence King, who applied it to a series of sandstones and shales containing beds of coal exposed at Point of Rocks, Black Butte, and other places along the line of the Union Pacific Railroad, and having great development in Colorado and Wyoming. Mr. King considered this the uppermost member of the Cretaceous system, and excluded from it the Fort Union beds of Hayden, which, on the evidence I furnished him, he agreed with me in considering Tertiary. I called the Fort Union group Miocene because I identified it with the plant-bearing beds of Mackenzie's River, Disco Island, Greenland, etc., of which the flora had been studied by Prof. Oswald Heer and was by him called Miocene. This flora, to which I shall again refer, has since been shown by Mr. J. Starkie Gardner to be Eocene. The Fort Union flora has many species in common with the Eocene beds of the Island of Mull, Bournemouth, etc., and holds undoubtedly the same geological position. Dr. Hayden accepted the term Laramie Group, but made it include his Fort Union beds.

The Laramie group is a formation that is essentially confined to the Rocky Mountain region; it forms a marginal belt on the east side of the mountains, extending from Central Mexico far into the British possessions. On the west side of the Rocky Mountains, it stretches over to the Wasatch, but has not been recognized at any point west of the summit of that range. Everywhere it contains coal, frequently in large quantity and of excellent quality. These coals are opened along the eastern side of the Rocky Mountains at Erie, Marshall's, Florence, Walsenburg, Trinidad, etc.; and from these sources the rapidly growing towns of the prairie region are receiving most of their fuel. On the west side of the Rocky Mountains, in Colorado, the Laramie coals are more important than elsewhere; the aggregate thickness in some places of several beds is fifty feet or more; the coal varies in composition from hard anthracite to open-burning bituminous, and much of it is of excellent purity, the amount of ash ranging from 2 to 5 per cent, the sulphur often less than half of one per cent.

It is from this formation that coal is taken at various points along the Union Pacific Railroad at Coalville, Pleasant Valley, and Castle Valley in Utah. . . . .

Most of the so-called Denver Tertiary beds really belong to the Laramie group, at least those beds which contain the remains of *Ceratops* and the stratified ash-beds of South Table Mountain. These represent the upper part of the formation, and fully one-half of the fossil plants contained in them are also found in the Lower Laramie at Golden, Florence, Trinidad, etc.

In Europe, the formations which indicate by their fossils the nearest approach to the Laramie are the Paleocene plant-bearing beds of Sézanne, Gelinden, and Alum Bay. It is not known that any species found in these localities is represented in the Laramie flora; and in the absence of all connecting links, we should be unwarranted in calling the Laramie Paleocene from its fossil plants, while its mollusks and vertebrates forbid this.

The floras of Sézanne and Gelinden are cited by Knowlton as related to the Fort Union flora and this relationship is one of the arguments for referring the latter to the Eocene. Lesquereux[60] compares the flora of Point of Rocks, now known to be Cretaceous, with the same European Eocene floras, as well as with that of Black Buttes. He says:

Of the thirty species enumerated in the table, two appear identical with, and one is related to, Canadian species, recognized as Tertiary,

[60] Tertiary Flora, U. S. Geol. Survey Terr., Vol. VII, 1878, pp. 342–344, 347–351.

as seen below from quotations of Prof. G. M. Dawson's report. Six are identical with, and seven are analogous to, those of the Lower European Miocene; two are identical with, and one allied to, Arctic Miocene[61] species. Seven have a close relation to plants of the Lower European Eocene, Sézanne and Gelinden, two localities composing a subdivision separated at the base of the Tertiary, under the name of Paleocene. Three are identified and one analogous in the flora of Golden; nine identical and one analogous in that of Black Buttes; and four have analogy with Cretaceous forms. . . . .

The groups of plants at Point of Rocks has, besides the Eocene representatives, six species identified with, and as many related to, those of the Miocene of Europe. Therefore, we see here, what has been remarked in other localities of the Lignitic, a compound or admixture of old and young Tertiary types, in comparison at least with the fossil floras of Europe, and thus a general character which does not distinctly relate our first group to any peculiar stage of the European Tertiary. We have the Paleocene by relation to species of Gelinden and Sézanne; the Upper Eocene, especially the Ligurian, or Oligocene, by the Palms; and the Miocene by a number of common and generally distributed forms, which, like *Sequoia brevifolia*, *Sequoia langsdorfii*, *Populus mutabilis*, *Ficus tiliæfolia*, *Rhamnus rectinervis*, *Juglans rugosa*, etc., are persistent types of wide distribution, indicating merely the Tertiary age for the Lignitic flora. For this reason, I shall continue to carefully record its points of affinity with the divers groups of the geological floras of Europe; but at the same time, denying as yet sufficient evidence for its identification to any of them, I persist in considering it simply as the Lower Eocene flora of this continent.

Mr. J. Starkie Gardner, who is cited by Newberry as authority for the reference to the Eocene of certain Arctic American floras that are related to the Fort Union flora, had such peculiar views concerning the characteristics of Cretaceous floras that his opinions on correlations of formations outside of Great Britain have little weight. His study of British floras led him to conclude that there are no Cretaceous dicotyledons.[62] He therefore regarded the floras of the Dakota sandstone, of Vancouver Island, and of many European localities usually called Cretaceous and

[61] Knowlton's review of the Montana flora, including the Point of Rocks species (Bull. U. S. Geol. Survey, No. 163, 1900), does not recognize close relationship with Tertiary floras and discredits most of Lesquereux's identifications in it of European Eocene and Miocene species.

[62] Gardner, J. Starkie.: On the age of the Laramie formation as indicated by its vegetable remains, Am. Naturalist, Vol. XIV, 1880, pp. 565–569.

characterized by an abundance of dicotyledons, as belonging to a vast intermediate period which he called Cretaceo-Eocene. Speaking of the evidence for such an intermediate period he says: "Taking the floras of Cretaceous age in England, whose horizon is absolutely known, we see that they point to an even greater interval (between Cretaceous and Tertiary) than the fauna. Of course I leave out of the question the so-called Upper Cretaceous floras of Europe whose age, not based upon stratigraphic evidence, is even more a matter of doubt than those of America.

Later Gardner[63] again questioned the Cretaceous age of the Dakota flora. The following quotation has a bearing on the present discussion:

The Cretaceous series of America contains at its very base a flora composed of angiosperms so perfectly differentiated that they are apparently referable to existing genera. One of the oldest floras in Europe containing angiosperms is that of Aix-la-Chapelle, and even this we have seen is relatively modern; but these are not referable in at all an equal degree to existing genera, and even the coniferæ are embarrassing on account of their highly transitional character. The oldest Cretaceous flora[64] of America so far from possessing any Cretaceous characters, agrees in a remarkable manner with that of the English Lower Eocene, while the Laramie, or supposed Cretaceo-Eocene, flora has very much in common with that of our Middle Eocene, and marks a similarly sudden rise in temperature.

Gardner's views on the relationships of the Dakota and Laramie floras are presumably not now held by any paleobotanist. His statements are quoted here merely for the purpose of emphasizing the fact that in Europe there is no well-established standard series of Upper Cretaceous floras with which comparisons can be made and that too little is known about the geologic relations of the Arctic American floras to make them available for that purpose. It is probable that the most complete succession of Cretaceous and Tertiary floras in the world is preserved in the rocks of the United States and Canada, and when these are fully studied in all their biologic and stratigraphic relations they will form the standard for comparison and correlation.

[63] On the relative ages of the American and English Cretaceous and Eocene series, Abstracts in Nature, Vol. XXX, 1884, pp. 528–529. Rept. Brit. Assoc. Adv. Sci., Montreal, 1884, pp. 739–741.

[64] The Dakota flora was the oldest known at that time.

It is obvious from the testimony of the paleobotanists, and this testimony could be indefinitely increased by similar examples, that the modern flora in its essential features was well developed in Cretaceous time at least as early as the Dakota epoch (or approximately the Cenomanian of European geologists). The changes since that time have been mostly due to minor differentiations of the types then introduced. The floras therefore do not furnish competent evidence for discriminating between Cretaceous and Tertiary. These later floras are useful in local stratigraphy and in provincial or regional correlation in much the same way that the non-marine faunas are, though they are usually more important than the non-marine faunas because they are more numerous and more highly differentiated. They cannot be used in determining the boundary between Cretaceous and Eocene until the stratigraphic range of the species is thoroughly known and the evidence of the plants is checked by means of other criteria. The differences between late Cretaceous and early Tertiary floras are chiefly specific characters and modifications in the grouping of the types, both of which must have varied from place to place as well as from time to time. The method, often adopted by paleobotanists, of determining the relative stratigraphic positions of local fossil floras by ignoring all the undescribed and unidentified species, and reckoning percentages of identified species that are recorded in various horizons, is based on the unwarranted assumption that there were no variations in topography, soil, or other conditions affecting plants, and that the distribution and preservation of the species was uniform throughout their range. That this method should lead to errors in correlation is inevitable.

Conclusions.

In the Interior Region of North America the formations between the uppermost marine Cretaceous and the Wasatch together constitute a real transition from the Cretaceous to the Tertiary.

Notwithstanding the fact that there are several local unconformities at various horizons and perhaps some of more general distribution there is no conclusive evidence that any one of these represents a very long period of erosion not represented by sediments elsewhere in the region.

The Fort Union formation, properly restricted, is of early Eocene age, the determination resting chiefly on its stratigraphic position and its primitive mammalian fauna which is related to the earliest Eocene fauna of Europe. The very modern character of the flora tends to confirm this correlation.

The "Ceratops beds" are of Cretaceous age as decided by stratigraphic relations, by the pronounced Mesozoic character of the vertebrate fauna with absence of all Tertiary types, and by the close relations of its invertebrate fauna with the Cretaceous. The relations of the flora with Eocene floras is believed to be less important than this faunal and stratigraphic evidence. Taken in their whole areal extent they probably include equivalents of the Laramie, Arapahoe, and Denver formations of the Denver Basin.

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