JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY,

VOLUME VII—PART FIRST.

JANUARY–JUNE.

1890.

PERMANENT SECRETARY:

F. P. VENABLE, . CHAPEL HILL, N. C.

E. M. UZZELL, STEAM PRINTER AND BINDER.
RALEIGH, N. C.
1890.

OFFICERS.

1889–1890.

PRESIDENT:

H. T. BAHNSON, M, D., ... Salem, N. C.

VICE-PRESIDENT:

H. B. BATTLE, PH. D., ... Raleigh, N. C.

RESIDENT VICE-PRESIDENT:

J. A. HOLMES, B. AGR., ... Chapel Hill, N. C.

PERMANENT SECRETARY AND TREASURER:

F. P. VENABLE, PH. D., F. C. S., ... Chapel Hill, N. C.

RECORDING SECRETARY AND LIBRARIAN:

J. W. GORE, C. E., ... Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.:

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

ON THE DETERMINATION OF AVAILABLE PHOSPHORIC ACID IN FERTILIZERS CONTAINING COTTON SEED MEAL.

BY F. B. DANCY, A. B.

The term *available* phosphoric acid is used to denote the difference between the *total* phosphoric acid in a fertilizer and the *insoluble*. The *total* phosphoric acid is the entire amount of phosphoric acid, of whatever kind, that the fertilizer contains. The *insoluble* phosphoric acid is, as generally accepted, that phosphoric acid which is left after two grams of the fertilizer, ground to pass a sieve of approximately twenty meshes to the linear inch, have had the *soluble* phosphoric acid extracted with cold water and then been digested for thirty minutes, with agitation every five minutes, at 65° C., with one hundred cubic centimeters of a strictly neutral solution of ammonium citrate of a specific gravity of 1·09, immediately after which digestion they have been thoroughly washed with cold water.

The *available*, then, being the difference between the *total* and the *insoluble*, it follows that *insolubles* being equal, the *available* varies exactly and directly as the *total;* and *totals* being equal, the *available* varies exactly, though inversely, as the *insoluble*.

The *total* is a definite and fixed quantity, and there should, therefore, be no material variation in its determination between the work of accurate analysts. Not so with the others. The *soluble*, *insoluble*, *reverted*, and *available* are not fixed and definite quantities. They are dependent on so many conditions of time, temperature, degree of fineness, quality and quantity of solvent, agitation, etc., that it is no matter of wonder that even skillful manipulators vary in their determination. They are the results of methods, and will vary according to the method or the manner of executing the details of the method. But, as has been remarked and as its name implies, the *total* is *all* the phosphoric acid in the material under examination, of whatever kind and in whatever shape or form. It is not what is gotten by a method, but *what there is there*, and any method, therefore, that fails to reach any part or kind of it is not a method for *total* phosphoric acid. It is sometimes said that discrimination is impracticable, and that all fertilizers should be treated equally and alike. The position is untenable. It might as well be urged that in order not to discriminate the plain soda-lime method for the determination of nitrogen should be used on all fertilizers, those containing nitrates as well as those containing organic nitrogen alone, when every one knows that it is inadequate in the presence of nitrates. So a *total* method which is adequate for some kinds of fertilizers, but not for others, cannot be applied to all on the above ground or any other ground, without manifest injustice to those fertilizers for which the method is inadequate.

The Association of Official Agricultural Chemists in their official methods (Bulletin 24, United States Department of Agriculture) give three alternate methods of determining *total* phosphoric acid. There is no distinction made between them, no indication that either is better adapted than the other for any particular class of fertilizers. The presumption is, that they are given as interchangeable and equally allowable for all classes of fertilizers, at the pleasure or option of the operator. It is the purpose of this article to show that one of them, at least, is entirely inadequate for fertilizers that contain cotton seed meal, and that any chemist who uses this method on such fertilizers is in almost certain danger of doing these fertilizers a great injustice.

The method referred to is the second of the three given, namely: "Solution in thirty c. c. of concentrated nitric acid with a small quantity of hydrochloric acid." The writer has not extended his investigation, except imperfectly, to the other two methods. It is only with this one, as applied to cotton seed fertilizers, that this article has to do.

Cotton seed fertilizers are comparatively unknown in the North. It seems, therefore, that the Southern members of the A. O. A. C. must not have been very wide-awake to the interests of a class of fertilizer manufacturers peculiar to their own section of country when they failed to have attached to this method, at the time when it was adopted by their Association as one of three alternate methods, the limitation "not applicable to fertilizers containing cotton seed meal."

Cotton seed meal is readily and entirely soluble in either "nitric acid with a small quanity of hydrochloric acid" or in nitric acid alone. *But such a solution does not give up its phosphoric acid to molybdic solution.* It would appear that certain nitro-organic compounds are formed which prevent the phosphoric acid in the solution from being yielded up to the molybdic precipitant. Whether this is effected by in some way rendering the menstruum a solvent for the phospho-molybdate of ammonia that ought to be formed, or, by holding the phosphoric acid in check, serves thus to prevent such a combination, is not clear. But the fact remains. The attention of the writer was first forcibly directed to it when a sample of cotton seed meal was submitted to him for a determination of the *available* phosphoric acid it contained. A nitric acid solution of two grams of it was made (using also a little hydrochloric acid), the solution being perfect, and a total phosphoric acid percentage of 0.51 found. A duplicate made in the same way yielded 0.54 per cent. Being convinced that there was much more phosphoric acid in the meal than this, and recalling that a short time previously a gentleman had remarked that a friend of his had found materially more phosphoric acid in the ash of cotton seed meal than by acid solution, two grams of the meal were ignited to perfect ash, the ash dissolved in acid, and a percentage of 3.24 of *total* phosphoric acid found; a duplicate in the same manner yielded 3.20, though in this case the incineration was not quite so perfect, a little char being left. The true per cent. of *total* phosphoric acid in the meal then was 3.24. A solution of two grams made by hydrochloric acid with chlorate of potash also failed by something more than half of getting the full amount. This yielded 1.45 per cent. Next two grams of the meal were taken, washed with cold water in exactly the same manner as when extracting the *soluble* phosphoric acid from an ordinary fertilizer, then digested with citrate solution and again washed exactly as is done in the determination of *insoluble* phosphoric acid. The residue was ignited and the phosphoric acid determined. It was found to be 0.24 per cent. So not only did a cotton seed meal which showed only half a per cent. of *total* phosphoric acid to a nitric acid solution contain in reality three and a quarter per cent., but three per cent. of this three and a quarter per cent. was *available* by the methods of analysis.

A cotton seed meal fertilizer may easily contain one-third cotton seed meal, and, if the meal had the composition of that examined above, would owe one per cent. of its *available* phosphoric acid to the meal. If, therefore, such a fertilizer were to be analyzed by the nitric acid method, it would theoretically show a shortage of nearly one per cent. of *available* phosphoric acid (0.90 exactly). While none of the experiments herein given exhibit as great a disparity as this, some approximate it, and it is believed that a disparity fully equal to this is quite possible. Whether the entire disparity is always due to the retention of the phosphoric acid of the meal alone, or whether in some cases the meal, while holding some of the phosphoric acid of the phosphate in check, gives up more of its own, or whether, in other cases, the phosphoric acid of the phosphate in precipitating carries more of the meal's phosphoric acid down with it than would otherwise go and thus lessens the disparity, is not clear. I am inclined to think that new and fresh meal will exhibit this peculiarity in a greater degree than old meal, though of that I cannot speak definitely. However that may be, there seems to be not much doubt that the disparity will be greater or less according to various conditions not well understood, and may vary from a third or a half of a per cent. to even as much as one per cent.

Six fertilizers containing cotton seed meal were chosen. They were not laboratory mixtures, but *bona fide* commercial fertilizers on sale in North Carolina. They will be distinguished as 56, 76, 77, 78, 110 and 57. In each the phosphoric acid was determined by dissolving two grams in nitric acid plus a little hydrochloric acid with protracted heating. This is designated in the table below as "acid solution." Then in each the phosphoric acid was determined by incinerating two grams and dissolving the ash in nitric acid. This is designated in the table as "incineration." Following are the results:

Total Phos. Acid....	56	76	77	78	110	57
Incineration.........	10.04	9.77	9.16	9.93	10.07	9.97
Acid Solution.......	9.49	9.13	8.66	9.25	9.56	9.95
Difference...........	.55	.64	.50	.68	.51	.02

No. 57 was an old cotton seed meal fertilizer that had been carried over from last season. The meal had completely changed color to a dark brown, so that to the eye the fertilizer would never have been judged to be a cotton seed fertilizer. In this one alone was there no difference in the results of the two methods.

It is believed that the disparity in all these cases is probably not so great as it should be; that is to say, that the incineration method as here used probably does not give the full content of phosphoric acid, for this reason. The inferiority of the solvent power of nitric acid for phosphates to that of hydrochloric acid is well recognized. I believe that this inferiority is greater when the phosphate has been ignited. To test this an acid phosphate was chosen, of which two grams were dissolved in nitric acid and hydrochloric acid, and the total phosphoric acid found to be 14.56 per cent. Another two grams were then ignited for about the same length of time that it requires to incinerate two grams of a cotton seed meal fertilizer to complete ash, and then dissolved in nitric acid. The determinations were parallel, so that each received the same amount of heating with acid, which was protracted. In the case of the ignited phosphate, undissolved portions were plainly manifest to the eye, and the percentage found was only 13.62. The undissolved portions were filtered out and readily yielded to hydrochloric acid, giving fulsome precipitate of phosphoric acid. Next, another two grams were ignited and dissolved in hydrochloric acid, when the full content of phosphoric acid was readily yielded. Hence, it is concluded that had hydrochloric acid been used to dissolve the six incinerated fertilizers employed in the above experiments, higher percentages would in all probability have been found. Fusion would have furnished an absolutely certain means of arriving at the undoubted maximum content of phosphoric acid, but time was limited and simple incineration was resorted to on account of expedition; and solution in nitric acid instead of hydrochloric acid was employed after incineration because, as the results were to be compared, it was advisable to employ the same solvent power in each case.

In addition to the six experiments described above attention is called to the following: Two samples of cotton seed fertilizers were procured in which another chemist had made determinations of *total* phosphoric by the nitric acid method. His *totals* were 9.13 and 9.33. I found by incineration and solution in hydrochloric acid 9.85 and 10.13, a difference of 0.72 per cent. and 0.80 per cent. respectively. Taking his own determinations of *insoluble*, the *available* by his analysis was 0.72 per cent. short in the first instance (7.40 per cent. when it should have been 8.12 per cent.), and 0.80 per cent. short in the second instance (7.50 when it should have been 8.30 per cent.). The disparity here is excessive, but the fault is not due to the chemist but to the method. Being one of the alternate methods of the A. O. A. C., he had no reason to doubt its adequacy.

Having looked at one side of the determination of *available* phosphoric acid in fertilizers containing cotton seed meal, let us turn to the other, namely, the determination of *insoluble*. As almost the entire content of phosphoric acid in the meal has been shown to be available, it might be anticipated that there would be likely not to be much difference in the determination of *insoluble* whether the citrate-extracted residue is first incinerated or dissolved directly in acid. Such was found by experimentation to be the fact. In fact, in every case but one (and this was the same fertilizer that was the exception to the *total* rule, namely, the old one brought from the previous season) a slightly higher *insoluble* was found by dissolving in acid directly than after incineration.

The details of the two methods of determining the *insoluble* were these: After filtering from the citrate and thoroughly washing, the filter and contents were in the first instance incinerated and the ash dissolved in nitric acid (designated in the table below as "incineration"), and in the second instance the filter and contents were introduced directly into flasks and completely dissolved with nitric acid and a little hydrochloric acid (the "acid solution" of the table below). The samples used were the same as those used in the total experiments, with the exception of 110, which was not used.

Insoluble Phosphoric Acid...	56	76	77	78	57
Incineration	0.84	1.80	0.86	0.87	1.59
Acid Solution.....................	1.00	1.91	1.28	1.05	1.42
Difference.........................	.16	.11	·42	.18	....

Whether the excess of *insoluble* by direct acid solution was due to mechanical loss in the incineration by the other method (which in these instances is not at all apprehended, though it is believed that care is necessary to with certainty guard against such loss), or whether, as is much more likely, it was due to imperfect solution of the ignited phosphate by nitric acid (a danger already pointed out), is not positively shown. But it should be remarked that in the case of 77, which is the case of greatest disparity, the undissolved portions were manifest to the eye, and it is the writer's conviction that had hydrochloric acid been used instead of nitric, there would have been no material difference in the results of the two methods, either in these particular determinations, or in any other determinations. It is regarded as certain, therefore, that there will be found no material difference in the *insoluble* by which ever way determined. This being true, the *available* will vary directly and exactly as the *total;* and, therefore, by just so much as a *total* is short on account of the inadequacy of the nitric acid method when used on cotton seed meal fertilizers, by just so much will the *available* be short.

Now a few words as to what method *is* adequate and a very few experimental determinations on this point, and the subject will for the present be laid aside. It is a matter of regret to the writer that the time was not at his disposal for more extended experimentation on the subject. Nevertheless he is none the less convinced, on account of the limited number of experiments here presented, of the truth of the point urged.

In order to compare the *total* as made by several different methods sample 110 was chosen. This sample was sent by a fertilizer company, who took a fair sample of a large lot of goods at their factory, thoroughly mixed the sample and sent one-half to the writer and one-half to a chemist in another State. The *total* was determined first by fusing two grams of the fertilizer with a mixture of equal parts of carbonate of soda and nitrate of potash, as giving with certainty the maximum content, and furnishing a standard for comparison. It was then determined by incineration and solution in hydrochloric acid, by incineration and solution in nitric acid, by solution direct in hydrochloric acid with chlorate potash, and lastly, by solution direct in nitric acid and a little hydrochloric acid. Following are the results:

Fusion,	10.14	per cent.
Incineration and solution in HCl.,	10.09	"
" " " HNO_3,	10.07	"
Solution direct in HCl. + $KClO_3$,	10.11	"
" " HNO_3 + little HCl.,	9.56	"

From the above it seems that in this case all the methods save the nitric acid method were adequate, but it is not apprehended that this will hold good in all cases. For, while here incineration and solution in nitric acid sufficed, there is certainly the danger of imperfect solution already referred to; and while here also solution in hydrochloric acid with potassium chlorate sufficed, it has already been shown that this method failed to extract, from the meal alone, more than half its content of phosphoric acid. Fusion is, of course, always adequate, but too time-consuming, if any other adequate method less so is at hand. It seems probable that incineration and solution in hydrochloric acid furnishes all that could be desired.

It is in point to add that in this case the writer reported to the manufacturers a *total* of 10.11 per cent., this being an average of the first four determinations. The *insoluble* found by incineration and solution in hydrochloric acid was 1.47, making an *available* of 8.64. It is not known what method the chemist used to which the other half of this sample was sent, but his *total* was 9.72, his *insoluble* 1.50 and his *available*, therefore, 8.22. Note that the two *insolubles* are practically the same, and that, therefore, his *available* is less than the writer's by practically the same amount that the writer's *total* is greater than his.

ANALYTICAL LABORATORY,
RALEIGH, N. C.

[REPRINTED FROM THE JOURNAL OF ANALYTICAL CHEMISTRY,
VOL. IV, PART 2. APRIL, 1890.]

THE DISTRIBUTION OF BORACIC ACID AMONG PLANTS.

BY J. S. CALLISON.

Attention was first drawn to the possibility of boracic acid occurring as a normal constituent in certain plants by its discovery in normal California wine.

Baumert* first drew attention to this in 1885, and his results were confirmed by Rising† and Crampton.‡

These observations were extended to other vines by Baumert,§ Soltsein‖ and Ripper.¶

It was shown by Baumert and Ripper, especially, to be almost invariably present in wines of all countries, in the stalks, and even in the wild vine (Soltsein). As Crampton says, "There can no longer be any question, therefore, in view of this mass of evidence, that boracic acid is a normal and frequently occurring constituent of the grape plant." He then asks the question, if boracic is so universal a constituent of the grape plant, why not of other plants as well? In answering this question he examined certain plants, as the peach, water-melon, apple, sugar-beet and sugar-cane. Thinking this distribution of boracic acid to be a question of decided importance, I have extended the examination, to many other ashes than those mentioned by Crampton, coming from other classes of plants than fruits, though including also some of the fruits.

The results of my work have confirmed the conclusions that boracic acid is very widely distributed in the vegetable kingdom,

*Landw. Versuchstat. **33,** 39–88.

†Report of Sixth Viticultural Convention, 1888.

‡Amer. Chem. Journal, Vol. II, 227.

§Zeitschrift fur Naturwissenchaften, 1887, and Ber. d. deutsch. Chem. Ges. **21,** 3290.

‖Pharmaceutische Zeitung **33,** No. 42, p. 312.

¶Weinbau und Weinhandel: Organ des deutschen Weinbauvereins, No. 36, 1888.

and that there seems to be a power of selection on the part of the plants, some having no affinity for and not taking up the boracic acid, though growing on the same soil from which other plants absorb it. We are forced to the belief that it is contained in the soil and that the plants draw it from that source, yet in no case could I detect its presence in the soil, and in no well water examined could I get a test for it. It is easily possible that other waters might contain it. It would be of great interest to extend this examination of natural waters so as to see whether the boracic acid in the soil is in a soluble form or not. It may be present in a form soluble in plant solvents and insoluble in natural waters. Of course it is possible, also, that it is present in such great dilution that the amount of water evaporated failed to give the qualitative tests. My examination of different fertilizing materials revealed the fact that several of the commonest contained boracic acid in appreciable amounts, and hence, by this means, it is being constantly added to soil under cultivation.

Of course stable manure, coming from grain and straw, restores to the soil the boracic acid contained in these.

A further important fact brought out by this research is that every sample of caustic alkali examined contained boracic acid. These samples were from the best known manufacturers, and were marked chemically pure. As these alkalies, especially potassium hydroxide, are used in most of the methods for determining boracic acid, it is manifestly of great importance to secure them free from it as an impurity. I think it possible that the boracic acid in these samples, or at least in some of them, may have come from the glaze of vessels used in their manufacture or from the bottles containing them.

The method of testing was that used by Meisell for the detection of boracic acid in milk.* About one gram of the ash was treated with strong hydrochloric acid and boiled a few minutes to insure solution. It was then filtered from the unburnt carbon, insoluble silica, etc. The filtrate was evaporated to dryness

*Konig's Nahrungsmittel, **2**, 250.

on a sand-bath and the heat continued until the excess of acid was driven off and the residue assumed a white appearance. This was then moistened with very dilute hydrochloric acid (1 : 100), a few drops of tincture of turmeric were added, and the entire mass dried down on a water-bath. The appearance of the cherry-red or cinnabar-red color was taken as an evidence of boracic acid. The residue was then used for the flame tests. This was made by placing a part of it upon a strip of platinum, moistening with alcohol and igniting. The green flame flashes, best observed by blowing out and relighting the alcohol, were regarded as confirmatory of the turmeric tests. The flame test is, however, not so delicate as the latter, as has also been observed by Crampton.

The relative and absolute delicacy of these tests was also approximately determined. The flame reaction was still clear with .01 gm. of boracic acid, but could not be gotten with .001 gm. This latter amount gave the color reaction, but .0001 gm. failed to give it.

These figures apply, of course, only to boracic acid treated under like circumstances to the ash. 10 cc. of a solution of boracic acid of known strength was evaporated in a small porcelain dish and the residue manipulated exactly as in Meisell's test.

The porcelain dishes used in this research, and other apparatus where the presence of boracic acid might be suspected, were carefully tested and shown free from anything that could conflict with the tests.

The appended table gives the substances examined and the results of the tests. In many cases the tests were carefully repeated to insure accuracy. The specimens were chosen so as to represent as many different classes of plants as possible. In the case of caustic alkalies the evaporation and testing were done in platinum vessels.

The experiments with various chemicals, pure and commercial, were begun with the idea of seeing whether those which might have come from some plant source, contained this substance so generally present in the plants themselves. The caustic alkalies were examined with a view to their use in the quantitative determination of boracic acid. Some other chemicals, as ferric oxide, were examined to see if they would in any way interfere with the test when present.

The table which follows will need no further explanation. I wish to express my obligations to Dr. F. P. Venable for his guidance and supervision of my work in this research.

Fruits.

No.	Common Name.	Botanical Name.	Flame Reaction.	Color Reaction.
1	Fig, green	Ficus Carica	Yes (faint)	Yes
2	leaves		No	No
3	branches		Yes	Yes
4	Persimmon, green	Diospyros Virginiana	Yes (faint)	Yes
5	leaves		No	No
6	Pear, branches	Pyrus Communis	Yes (faint)	Yes
7	leaves		Yes	Yes
8	Apple, pulp	Malus	Yes (faint)	Yes
	seed		Yes (faint)	Yes (faint)
9	Peach, branches	Prunus Communis	Yes (faint)	Yes
10	leaves		Yes	Yes
11	Honey Locust, pods	Gleditschia triacanthos	Yes	Yes
12	Lemon, pulp	Citrus Limonum	No	Yes
13	rind		Yes	Yes
14	Orange, pulp	Citrus Aurantium	Yes	Yes
15	rind		Yes (faint)	Yes
16	seed		No	Yes
17	Banana	Musa Sapientum	No	Yes
18	Dates, dried		Yes (faint)	Yes (faint)
19	seed		Yes (faint)	Yes (faint)
20	Cherry, branches	Prunus Ceracus	No	No
21	leaves		Yes (very faint)	Yes (faint)
22	Cocoanut, shell	Coco Nucifera	No	Yes (faint)
23	Raspberry, leaves	Rubus Strigosus	No	Yes
24	Blackberry, stalk	Rubus Villosus	No	Yes
25	leaves		No	Yes
26	Strawberry, leaves	Fragaria Vesca	Yes	Yes
27	Grape, Concord leaves	Vitis Labrusca	Yes	Yes
28	stalk		Yes	Yes
29	Wild, leaves	Vitis Cordifolia	No	Yes
30	stalk		No	Yes

Vegetables and Grains.

31	Pea	Pisum Arvense	Yes	Yes
32	Beet, root	Beta Vulgaris	Yes	Yes
33	leaves		Yes	Yes
34	Salsify, root	Fragopogon Porrifolium	Yes (very faint)	Yes (faint)
35	leaves		Yes	Yes
36	Celery	Apium Graveolens	Yes	Yes
37	Wheat, grain	Triticum Vulgare	Yes (faint)	Yes
38	green stalk		Yes	Yes
39	Oats, grain	Avena Sativa	No	Yes (faint)
40	green stalk		Yes	Yes
41	Corn, grain	Zea Mays	No	No
42	cob		No	Yes (very faint)
43	stalk		No	No
44	blades		No	No
45	Maple, branches	Acer Rubrum	Yes	Yes
46	leaves		Yes	Yes
47	Willow, branches	Salix Nigra	Yes	Yes
48	Mulberry, wood	Morus rubra	Yes	Yes (faint)
49	bark		No	No
50	Walnut, branches	Juglans Nigra	Yes	Yes
51	Sumach, berries	Rhus copallina	Yes	Yes
52	branches		Yes	Yes
53	Pine, long leaf, branches	Pinus Australis	Yes	Yes
54	leaves		Yes (faint)	Yes
55	short leaf branches	Pinus Mitis	Yes	Yes
56	leaves		Yes	Yes
57	Dogwood, branches	Cornus Florida	Yes (faint)	Yes
58	Cedar, branches	Juniperus Virginiana	Yes	Yes
59	leaves		Yes	Yes
60	Oak, branches	Quercus alba	Yes (faint)	Yes
61	leaves		Yes	Yes
62	acorn		Yes (faint)	Yes
63	Sycamore, branches	Plantanus Occidentalia	Yes	Yes
64	Elm, branches	Ulmus	Yes	Yes
65	Black How, branches	Viburnum Prunifolium	Yes	Yes
66	fruit		Yes	Yes

67	Hickory, branches	Carpa	Yes	Yes
68	nut		Yes (faint)	Yes (faint)
69	Magnolia, branches	Magnolia Grandiflora	Yes	Yes
70	leaves		Yes	Yes
71	Holly, branches	Ilex Opaca	Yes	Yes
72	leaves		Yes	Yes
73	berries		Yes	Yes
74	Paulonia, buds	Paulonia imperialis	Yes	Yes
75	pods		Yes	Yes
76	Osage Orange	Maclura Aurautiaca	Yes (faint)	Yes

Miscellaneous Plants.

77	Tobacco, stalk	Nicotiana Tabacum	Yes	Yes
78	leaves		Yes	Yes
79	Cotton, lint	Gossypium herbaceum	Yes (very faint)	Yes (very faint)
80	seed		Yes (very faint)	Yes
81	stalk		Yes	Yes
82	Azalea Indica, leaves	Azalea Indica	No	Yes (faint)
83	root		No	No
84	Chrysanthemum, stalk	Chrysanthemum Pompone	No	Yes (faint)
85	flower		No	Yes (faint)
123	Rose, branches		Yes	Yes
86	Bamboo	Smilax Rotundifolium	Yes	Yes
87	Sorrel	Oxalis Stricta	Yes	Yes
88	Lucerne	Medicago Sativa	Yes	Yes
89	Clover, red	Trifolium Pratense	Yes	Yes
90	white	Trifolium Repens	Yes	Yes
91	Orchard Grass	Dactylis Glomerata	Yes (faint)	Yes
92	Blue Grass	Poa Compressa	Yes	Yes

Soils, Waters and Fertilizers.

No.	Common Name.	Remarks.	Flame Reaction.	Color Reaction.
93	Alluvial	2 kilos taken	No	No
94	Sandy, rich	" "	No	No
95	Sandy, poor	" "	No	No
96	Red Clay		No	No
97	Well Water, No. 1	48 liters taken	No	No
98	No. 2	56 " "	No	No

99	Water from small stream	36 litres taken	No	No
100	Bone and Peruvian Guano		Yes	Yes
101	Peruvian Guano		Yes (faint)	Yes
102	Bone Ash		No	No
103	Sodium Nitrate	Crude	No	No
104	Muriate of Potash	From Stassfurt	Yes	Yes
124	Kainite	For Fertilizers	No	Yes
125	Kelp		Yes	Yes

Chemicals.

105	Potassium Nitrate	C. P.	No	No
106	Potassium Carbonate	C. P.	No	No
107	Potassium Chlorate	C. P.	No	No
108	Potassium Carbonate	Commercial	Yes	Yes
109	Potassium Phosphate	C. P.	No	No
110	Sodium Nitrate	C. P.	No	No
111	Sodium Carbonate	C. P.	No	No
112	Calcium Carbonate	C. P.	No	No
113	Ferric Oxide		No	No
114	Concentrated Lye	Commercial	No	Yes (faint)
115	Potassium Carbonate	Pearlash	No	No
116	Potassium Hydroxide	C. P., Trommsdorf	Yes	Yes
117	" "	by alcohol, Marquart	No	Yes
118	" "	by baryta, Schuchardt	No	Yes
119	" "	" Eimer & Amend	No	Yes
120	" "	C. P., free from Al_2O_3, SiO_2 and SO_3, Eimer & Amend	No	Yes
121	Sodium Hydroxide C. P.		Very faint	Yes
122	" "		No	Yes (very faint)
126	Ammonium "		No	No

UNIVERSITY OF NORTH CAROLINA,
May, 1890.

ON THE OCCURRENCE OF BORACIC ACID AS AN IMPURITY IN CAUSTIC ALKALIES.

BY F. P. VENABLE AND J. S. CALLISON.

In the course of a research upon the distribution of boracic acid in the ashes of plants, it was decided to make some quantitative estimations of the boracic acid present. The reagents to be used were first themselves tested for boracic acid, and, much to our surprise, no sample of the caustic alkalies could be procured free from it. Specimens coming from some of the most noted manufacturers, Schuchardt, Marquart, and Trommsdorff, purified by alcohol or by baryta, were found to contain boracic acid, and sometimes in decidedly appreciable amounts. No quantitative determination has been made, but, judging from the known delicacy of the qualitative tests, the amount must have often exceeded 0.1 per cent., and was probably much greater.

As the caustic alkalies, especially potassium hydroxide, are frequently used in the methods for the quantitative determinations of boracic acid,* this presence of it as an impurity may be a serious source of error. The knowledge of it is important on other grounds as well.

*See, for instance, Morse & Burton, Amer. Chem. Jour. X, 154. Ztschr. and Chem. **25,** 202.

UNIVERSITY OF NORTH CAROLINA,
May, 1890.

THE DETERMINATION OF CRUDE FIBER.

BY W. A. WITHERS.

This was begun to ascertain, if possible, some of the causes of the discrepancy in results obtained by different chemists for crude fiber. The samples were Timothy hay and cotton seed meal. They were not extracted with ether previous to treatment with alkali and acid, as is customary in ordinary analyses. Except when so stated, the solutions used were 1¼ per cent. H_2SO_4, and 1¼ per cent. Na_2O solutions, the time of boiling 30 minutes, and the results in per cent. calculated on the dry sample.

The following questions were considered:

1. Amount of Na_2O neutralized.

By titration before and after treatment, an average of 5 different determinations gave an equivalent of .114 grams Na_2O neutralized by Timothy hay for every gram of substance taken, showing that only a very small portion of the Na_2O added enters into chemical combination, and part of this is in the saponification of the fat which would usually be extracted with ether.

2. Sulphuric acid neutralized.

Residues from Timothy hay, after treatment with Na^2O solution, were taken. It was found that for each gram of substance originally taken, .01 gram of H_2SO_4 was neutralized, showing that the H_2SO_4 does not enter into chemical combination at all.

3. Effect of different strengths of Na_2O solution.

This was tested on Timothy hay with the following results:

Time of treatment	45 minutes.		1½ hours.	
Na_2O (grams) used per gram of substance	2.34	1.27	1.27	1.00
Residues	33.67	35.26	33.34	35.06
	33.28	35.36	33.70	35.30
	...	...	33.88	...
Average	33.48	35.31	33.64	35.18
Difference due to different strengths of Na_2O solution	1.83		1.54	

This shows that the stronger the solution, or the more of the same solution used, the smaller is the per cent. of fiber.

4. Effect of time in treatment with Na_2O solution.

In the filtration a simple asbestos filter was used. After boiling the substance for 30 minutes with the alkali, the residue was detached from the filter as completely as possible, and subjected to another similar treatment with a new portion of the reagent. This method avoids very largely errors of analysis that would be shown had different samples been taken and treated for different lengths of time. Duplicate determinations A and B were made:

Treatments with Alkali.	Timothy Hay.				Cotton Seed Meal.			
	A.		B.		A.		B.	
	Res.	Dis.	Res.	Dis.	Res.	Dis.	Res.	Dis.
1........	36.96	63.04	36.21	63.79	4.46	95.54	4.66	95.34
2........	33.49	3.47	32.79	3.42	3.95	.51	4.14	.52
3........	31.85	1.64	31.17	1.62	3.26	.69	3.47	.67
4	30.53	1.22	29.82	1.35	2.99	.27	3.09	.38
5........	29.74	.79	29.03	.79	With H_2SO_4.			
6	28.78	.96	28.34	.69	2.39	.60	2.41	.68

These treatments represent about 50 minutes contact with the alkali, being about 10 minutes to raise to boiling, 30 minutes boiling, 5 minutes standing, and 5 minutes filtering. The first treatment required from 10 to 15 minutes in filtering, thus making the contact longer. In the case of Timothy hay, therefore, this difference is about .07 per cent. of fiber per minute, and of cotton seed meal .01 per cent.

5. Effect of time in treatment with H_2SO_4 solution.

The residue after treatment with alkali was treated in the same way as above. Timothy hay was used.

From Na_2O treatment with	34 70	65 30	33.92	66 08	28.78	71 22	28.34	71 66
acid ....1.	29.10	5.60	28.33	5 59	25.59	3.19	25 38	2.96
2.	28.20	.90	27.60	.73	24.79	.80	24.73	.65
3.	27.81	.39	27.25	.35	23 91	.88	24.08	.65
4.	27.32	.49	26.78	.47				

The time of contact with acid was about 40 minutes, which makes a difference of nearly .02 per cent. of fiber for every minute of treatment with acid.

Ladd (5th N. Y. Ex. Sta. Rep.) has shown that the degree of heat employed causes a difference in results. The above work shows that differences are also due to amount and to the concentration of the different reagents used, and to the time of contact. To secure agreement in results, uniformity in all these conditions must be attained.

Granting this can be done with different workers, the question of accuracy of results confronts us. Without going into a review of the work of different chemists bearing on this point, I should like to call attention to the above tables under 4 and 5. One of two conclusions must be drawn from this work, viz.: 1st, That if half an hour's treatment with each alkali and acid is sufficient to give the per cent. of crude fiber, then crude fiber is soluble in both alkali and acid, and that to a somewhat considerable extent; or, 2d, that if crude fiber is not soluble in these reagents, then 6 treatments with alkali, and 3 subsequent treatments with acid, are not sufficient to separate it. From either of these conclusions it is evident that the method lacks accuracy, and is at best only a rapid method of rough approximation to the truth.

6. Ash in the residue.

Six samples were taken for this:

2	treated	with	alkali	45	minutes	and	acid	1	hour.
2	"	"	"	1½	hours	"	"	½	"
2	"	"	"	"	"	"	"	1	"

In no case was any ash found in the residue.

7. Nitrogen in the residue.

The albuminoid equivalent of this was found to vary from 4 per cent. to 5 per cent. with one treatment with alkali. The acid subsequent treatment did not remove any more, but subsequent treatments with alkali left no nitrogen.

CHEMICAL LABORATORY,
CORNELL UNIVERSITY.

SOME MODIFICATIONS OF THE METHOD FOR DETERMINING CRUDE FIBER.

BY W. A. WITHERS.

With the method now in use for determining crude fiber (*vide* Bul. 19, 1888, U. S. Dept. of Ag.) there is little trouble in the manipulation, except in cases of feeding-stuffs, in which the percentage of albuminoids is rather large. In all such cases, however, the albuminoids precipitated by the treatment with H_2SO_4 seriously impede the filtration, rendering it very slow, and from this longer contact causes a part of the crude fiber to be dissolved.

This difficulty can be obviated by treating the substance with the Na_2O solution before rather than after the treatment with H_2SO_4 solution.

To test this modification, I compared it with the ordinary method, on samples of Timothy hay and cotton seed meal. In both cases clear filtrates were secured by the modification in from 15 to 30 minutes, while with the ordinary method the filtration with the hay required about the same time; but the cotton seed meal from 18 to 24 hours, and then the filtrate was not clear. With Timothy hay the two methods gave practically the same results. With cotton seed meal the ordinary method gave 2.68 per cent. and 2.91 per cent., an average of 2.80 per cent., while the modification gave, with five determinations, 3.63 per cent., 3.58 per cent., 3.69 per cent., 3.49 per cent., 3.44 per cent., an average of 3.57 per cent. The determinations in hay show the modification gives reliable results. In the case of cotton seed meal, however, we see that 77 per cent. crude fiber is dissolved by the ordinary method, on account of the longer contact produced by the slow filtration, being more than 20 per cent. of the whole amount.

For accuracy and, therefore, agreement of results, as well as time-saving, this modification seems to recommend itself.

Rapid Filter.—The asbestos filter gives good results if covered with a layer of glass wool. Care should be taken, however, not to add too much liquid at a time, as this may cause the glass wool to become displaced. The coarse asbestos gives the best results.

Ladd (N. Y. Ex. Sta. Rep., 1887, p. 378) finds that when the asbestos filter was returned with the residue a larger per cent. of fiber was found, and the two reasons given are that it prevents so thorough contact with the reagents, and that it necessitated lowering of the temperature to prevent bumping. When, however, the substance is first treated with alkali there is no tendency to bump in the acid treatment, and consequently no need of lowering the temperature. As to how much the first mentioned cause will affect the results, I have not tested.

Prevention of Frothing in Boiling.—This can be done by directing a moderate blast of air into the flask through a small glass tube (1.5 mm. diam.). The constant level of the liquid can be maintained by adding boiling water from time to time, or by a reflux condenser.

Chemical Laboratory,
Cornell University.

LINVILLE METEORITE.

[From the American Journal of Science, Vol. XXXVI, October, 1888.]

Art XXIX.

ON THREE NEW MASSES OF METEORIC IRON.

BY GEORGE F. KUNZ.

I. Meteoric Iron from Linville Mountain, Burke County, North Carolina.

A mass of meteoric iron* was found on Linville Mountain, Burke county, N. C. (long. 81° 35′ W. of Greenwich, lat. 35° 40′ N.), about the year 1882. It was handed to a country blacksmith in the vicinity, who sold it to a tourist miner, and by him it was sold to Mr. Norman Spang, of Etna, Pa., who, not being a collector of meteorites, has kindly allowed it to come into my possession.

This meteorite weighs 428 grams; the original weight was 442 grams (15½ ounces), the remainder having been used for analysis and for etching; it is $2\frac{3}{5}$ inches (65 mm.) long, $1\frac{2}{5}$ inches (35 mm.) high, and 2½ inches (38 mm.) wide. One side is rather rough, and the other pitted with very shallow pittings. Traces of the black crust of magnetic oxide of iron are still visible, and although the mass is not rusted, yet small drops of chloride of iron have collected in the deep clefts; in one of these was also found a spider's egg-case, suggesting that the iron is either a recent fall, or had been found on the surface of the ground.

In cutting a piece from the lower side, the blacksmith has destroyed a good deal of the surface as well as the crust, on account of the toughness of the iron. The iron admits of a very high polish, yielding a rich nickel color, which, under the glass and by reflected light, shows an apparent net-work of two distinct bodies.

*Exhibited at the New York Academy of Sciences, Dec. 5th, 1887.

When bromine water or diluted nitric acid is applied to a polished surface of the iron, it blackens and does not show the Widmanstätten figures. If this black deposit is washed off, an orientated sheen appears, which resembles that of the Green county iron, described by Blake,* and the iron in the Port Orford, Oregon, meteorite, as figured by Brezina and Cohen in "Die Structur und Zusammensetzung der Meteoreisen, etc."† Almost the entire surface has, under the glass, the appearance of a mesh-work of which the irregularly rounded centers have been eaten out. At a few places on both sides of a crack is a small piece of troilite 3 mm. by 1½ mm., through which are scattered small patches of meteoric iron that after etching exhibit beautiful octahedral markings so delicate as to be invisible to the naked eye, and somewhat like those of the Tazewell, Claiborne county, meteorite, though not more than one-tenth the thickness.

The following analysis was kindly furnished by Mr. J. Edward Whitfield, of the United States Geological Survey, through the courtesy of Prof. F. W. Clarke:

	Linville, Whitfield.	Tazewell,‡ Smith.	Bear Creek,§ Smith.
Iron	84·56	83·02	83·89
Nickel	14·95	14·62	14·06
Cobalt	0·33	0·50	0·83
Copper	0·0	0·06	trace
Sulphur	0·12	0·08	....
Carbon	trace	....	....
Phosphorus	"	0·19	0·21
Magnesium	....	0·24	....
Silica	none	0·84	....
	99·96	99·57	98·12

Dr. F. A. Genth has kindly furnished the following analysis:

Iron	85·83
Cobalt	0·73
Nickel	13·44
	100·00

*Amer. Journal Sci., III, Vol. xxxi, p. 41.

†Stuttgart, 1876, Lieferung I, Tafel VI.

‡Original Researches, 1884, p. 439.

§Amer. Journal Sci., II, Vol. xix, p. 153.

It most closely resembles the Tazewell, Claiborne, and Bear Creek, Col., meteorites in composition. I herewith take pleasure in thanking Mr. Norman Spang for his kindness in allowing me to secure the iron and for the facts of its discovery; also, Mr. J. Edward Whitfield and Prof. F. W. Clarke for the analysis.

II. On the Meteoric Stone from Ferguson, Haywood County, North Carolina.

Mr. W. A. Harrison, of Ferguson, North Carolina, says that about six o'clock, on the evening of July 18, 1889, he noticed a remarkable noise west of him, and that fifteen minutes later he saw something strike the earth, which, on examination, proved to be a meteoric stone, so hot that he could scarcely hold it in his hand five minutes after it fell. Two-thirds of its bulk was buried in the earth when found. This stone was sent to the writer, and was unfortunately lost in New York City during the month of December.

The stone was slightly oblong, covered with a deep, black crust, which had been broken at one end, showing a great chondritic structure with occasional specks of iron. Its weight was about eight ounces, and it very closely resembled the meteoric stone from Mocs, Transylvania. It remained in the writer's possession so short a time that it was not properly investigated; but still the mere mention of a fall, which had been so carefully observed, is thought to be well worthy of publication.

III. Meteoric Iron from Bridgewater, Burke County, North Carolina.

The Bridgewater, Burke county, meteorite was found by a negro plowman, two miles from Bridgewater Station, in the western part of Burke county, near the McDowell county line in North Carolina. Latitude, 35° 41′; longitude, 81° 45′ W. of Greenwich. The negro thought that it must be either gold or silver, and took it to some railroad laborers, who broke it in two pieces, one of which weighed ten-and-a-half, and the other eighteen-and-a-half pounds, together 30 pounds, equal to 13.63

kilos. The iron measures 22.5 x 15 x 10 cm. (9 x 6 x 4 inches).

Traces of black crust very much oxidized are still visible on the surface. The iron is highly octahedral in structure, and the mass was readily broken by the laborers who found it. Between the cleavage plates schreibersite is visible.

On etching a polished surface of this iron with dilute nitric acid, the characteristic Widmanstätten figures were shown. The iron belongs to the caillite group, and resembles those of the Cabin Creek and Glorietta Mountain in structure.

The specific gravity of a fragment was found to be 6.617. The following analysis was kindly furnished by Prof. F. P. Venable, of the University of North Carolina:

Fe	88.90
Ni	9.94
Co	·76
P	.35
Cl	.02
	99.97

The nickel is the mean of two determinations, 9.74 and 10.14, on different parts of the sample.

The cobalt also of two determinations, .85 and .67.

The iron is the mean of four determinations, some of which were not very closely agreeing, as the crust could not be entirely removed from the samples taken.

The phosphorus and chlorine are single determinations.

The author takes great pleasure in thanking Mr. T. K. Bruner for his courtesy in obtaining the information and the iron for him, and in thanking Professor F. P. Venable for furnishing the analysis.

BRIDGEWATER METEORITE.

TWO NEW METEORIC IRONS.

BY F. P. VENABLE.

I. FROM ROCKINGHAM COUNTY, N. C.

This mass was reported to have fallen about the year 1846, near the old "Mansion House," Deep Springs Farm, in Rockingham county, N. C. One of the old negro servants related to Mr. Lindsay, the present owner of the farm, that "the rock fell on a clear morning, and struck the ground about a hundred yards back of the garden. It frightened every one very much. Colonel Jas. Scales, the proprietor at that time, and Mr. Dillard took a man and went to the spot, dug in about four or five feet and got it out." It lay about the house as a curiosity for several years, when it ceased to be of any more interest, and was thrown aside. After Mr. T. B. Lindsay bought the farm he kept the meteoric mass for several years upon his porch. In the fall of 1889 he presented it to the State Museum. The indentation in the earth, where it is reported to have struck, is still pointed out.

The weight of the mass was 11.5 kilos. It had somewhat the outline of a rhomboid, measuring 270 x 210 mm., and having a thickness varying from 10 to 70 mm. It is coated with oxidation products to a depth, in places, of several millimetres. These give the whole mass a dull, reddish brown color. The surface is irregularly pitted with broad shallow pits. It is somewhat concave on one side. On being polished and etched it gave faintly the Widmanstätten figures. It belongs to the class of sweating meteorites, beads of deliquesced ferric chloride appearing on the surface. This lawrencite, so-called, is evidently unevenly distributed through the mass. Analyses from different portions gave different amounts of chlorine. In one boring it was noticed that the metal near the surface (within $2^{cm.}$) gave a decided percentage of chlorine, while that coming from the deeper part of the drill hole (3—5 cm. from surface) gave no appreciable amount.

The analysis gave :

Fe	87.01
P	.04
SiO_2	.53
Cl	.39
Ni	11.69
Co	.79
	100.45

II. FROM HENRY COUNTY, VA.

This meteoric iron was found by Nathaniel Murphy, in Henry county, Va., about four miles from the Pittsylvania county line, and one-half mile north of the dividing line between North Carolina and Virginia, near to Smith River. Murphy found the stone in a ploughed field in the latter part of the spring of 1889. He gave it to Colonel J. Turner Morehead, of Leaksville, N. C. Together with Colonel Morehead he searched over the farm, but could find nothing similar to this piece. Colonel Morehead sent the mass to Dr. H. B. Battle, of Raleigh, N. C. It weighed 1.7 kilos, and the detached pieces, mainly crust, weighed 0.22 kilos. This crust broke off along certain lines by a sort of cleavage, and the main mass is permeated with cracks, not irregular and zigzag, but as distinct and regular, almost, as if it were a piece of crystallized gypsum. This cleavage is in two directions. The laminae vary in thickness, but many are about ½ mm. The color of the surface is dark bluish black, mixed with much red-rust coming from the lawrencite. Parts of the soil apparently still clung to the mass. It measured 60 x 70 x 75 mm., taking the greatest lengths in the three directions. Here and there scales or spots of bright silvery sheen were to be seen. It contains a good deal of ferric chloride, and is rapidly crumbling. On polishing one of the faces, the Widmanstätten figures (coarse) came out very plainly, no etching being necessary.

The analysis resulted as follows :

Fe	90.54
Cl	.35
SiO_2	.04
P	.13
Co	.94
Ni	7.70
	99.70

UNIVERSITY OF NORTH CAROLINA,
May, 1890.

A LIST AND DESCRIPTION OF THE METEORITES OF NORTH CAROLINA.

BY F. P. VENABLE.

So far as can be learned, twenty-three meteorites have been reported as found in North Carolina. Facts with regard to these have been collected under many disadvantages and with great difficulty. A complete list of references in scientific literature has proved an impossibility; still a great many such references are given. It is also impracticable now to trace all of the possessors of portions of these meteorites. They have been divided often into many pieces, and widely scattered. Only occasional clues to their whereabouts can be gotten at the present time. One fact is made apparent, and that is, that nearly all have passed out of the State, not even fragments being preserved here.

It will be noticed that, with the exception of one from Nash county, all of the reported meteorites have come from Western North Carolina. That many of these came to the light at all has been due to the intelligent energy of General T. L. Clingman, to whom the State owes so much already for bringing to notice her minerals and other possessions.

It has been thought best to include in this list all reported falls and finds. In the case of all proved to be non-meteoric, or about which doubt exists, note is made under the proper heading. If these doubtful ones be eliminated, as well as those not belonging properly to the State, the number is reduced to about twenty. There is doubt, however, whether the number should be as great even as this, as there is cause for thinking the Madison county, and, perhaps, some of the Buncombe county finds may belong to the same fall. Still the number is large when we bear in mind the comparatively small number of recorded meteorites for the whole earth. Huntington in his catalogue (1887) places the number at 424.

I must express my acknowledgments to Mr. S. C. H. Bailey, of New York, for most valuable assistance rendered in this compilation.

1.

Alexander Meteorite.

Locality—Cedar Creek, Alexander county. Not analyzed.

This iron, weighing about fifty-six grams, was given by General T. L. Clingman to Mr. S. C. H. Bailey, of New York, about the year 1875. It has not been analyzed, nor have I been able to learn more of its origin. The piece, Mr. Bailey writes, is evidently a fragment from a larger mass, and is sufficiently characteristic to be distinguishable from any other iron, though it more nearly resembles the Sarepta (Russia) iron.

Literature—
Possessor—Bailey (56 grams).

2.

Ashe Meteorite.

Locality—Ashe county. *Analyst*—Shepard (?)

The only reference that can be found to this mass is the following, coming from the American Journal of Science:

"A fragment of meteoric stone from Ashe county, N. C., examined at the same time, was found to contain a marked quantity of this principle (chlorine), the presence of which, however, was accounted for by the fragment having been in contact with a bag of salt as it was carried home by the person who found it."

It is possible that this is the same as the Grayson county, Virginia, meteorite.

Literature—Am. Jr. Sc., 1st Ser. XLVIII, p. 169; Rep. Am. Met., p. 34; Buchner, p. 168.
Possessor—Unknown.

3.

Asheville Meteorite.

Locality—Asheville, Buncombe county. *Analyst*—Shepard.

This meteorite was presented by Dr. J. F. E. Hardy to Dr. C. U. Shepard for examination. It weighed between nine and ten ounces, and had been detached from a rounded mass nearly as large as a man's head, which mass was found loose in the soil about five or six miles west of Asheville, on the farm of a Mr. Baird, near the south-western base of an elevation of land five hundred feet high. Dr. Hardy was of opinion that other masses existed at the same place.

The specimen had a distinctly crystalline structure, approaching a flattened octahedron. The surface had a dissected or pitted appearance, occasioned by the removal of portions of the external laminæ during its separation from the original mass. The cavities were perfectly geometrical in shape, being rhomboidal, tetrahedral, or in the figure of four-sided pyramids. Sections of the external laminæ loosened broke up easily into regular octahedra and tetrahedra very exact in form. Some of the plates separated into leaves nearly as thin as mica, and delicately sticated in every direction.

The specific gravity of different pieces varied from 6.5 to 7.5, and even as high as 8.

ANALYSIS.

	I.	II.
Iron	96.5	94.5
Nickel	2.6	5.
Silicon	.5	0.3
Chlorine	.2	
Chromium, Sulphur, Cobalt, Arsenic — in traces.		
	99.8	99.8

Analysis I is taken from Am. Jr. Sc., Vol. XXXVI, p. 81. Analysis II is also credited to Shepard, and is taken from Clark's List, p. 55. It seems to be an analysis of the original lump, from which the smaller fragment described above was taken.

Literature—Am. Jr. Sc., 1st xxxvi, p. 81; Clark, p. 55; Rep. Am. M., 1848, p. 24; Buchner, p. 163; Partsch, p. 116; Jahresber, 1847–48, p. 1309; Huntington, p. 60; Smithsonian Report, p. 261; Min. and Min. Loc., p. 14.

Present Possessors—Amherst, 276 grams; Göttingen, 1.50; Shep. Cab. in National Museum, 2.95; London, 114.9; Vienna, 271; Berlin, 13.66; Paris (Nat. Hist.), 72; and in private collections: Gregory, 2; Siemascho (St. Petersburg).

4.

Black Mountain Meteorite.

Locality—Black Mountain, Buncombe county. *Analyst*—Shepard.

The Black Mountain meteorite was found at the head of the Swannanoa River, near the base of Black Mountain, towards the eastern side of Buncombe county. It was given by Dr. Hardy to Colonel Nicholson, of South Carolina. By the latter it was given to Dr. Barratt, of the same State, and from him it was secured by Dr. Shepard. It seems to have been picked up about 1839. The fragment weighed twenty-one ounces, and was evidently a portion of a larger mass. Its texture was highly crystalline, having all the laminæ (which were usually thick) arranged conformably to the octahedral faces of a single individual. There was evidence of the existence of very minute veins of magnetic iron pyrites. The mass contained several rounded and irregular nodules of graphitic matter, with which again were found large pieces of iron pyrites.

Specific gravity, 7.261.

Iron	96.04
Nickel	2.52
Cobalt	traces.
Insoluble matter, sulphur and loss	1.44
	100.00

Literature—Am. Jr. Sc., 2d Ser. iv, p. 82; Rep. Am. M., p. 28; Jahresber, 1847–'48, p. 1310; Buchner, p. 180; Clark, p. 34; Huntington, p. 56; Kerr Appendix, p. 56; Min. and Min. Loc., p. 14.

Present Possessors—Amherst, 243 grams; Yale, 15; London, 71.5; Vienna, 45; Paris (Nat. Hist.), 5; Dorpat, 19; Neville (now Calcutta), 29; and in private collections: Baumhauer, 44; Siemascho.

5.

Hominy Creek Meteorite.

Locality—Hominy Creek, Buncombe county. *Analysts*—Shepard and Clark.

The Hominy Creek meteorite, sometimes referred to simply as Buncombe county meteorite, was secured for Dr. Shepard by Hon. T. L. Clingman. The original discoverer was a Mr. Clarke, and the date of the discovery seems to have been 1845. It was found in a field near the base of Mount Pisgah, some ten miles west of Asheville. Another much larger piece was reported to have been found in the same field. The mass weighed twenty-seven pounds. It was rather flat on one side, while its other sides were irregular, with cavities and various inequalities. Externally, it bore resemblance to a cinder from a blacksmith's fire. It measured eleven inches in length by seven in breadth, and was four in thickness at the thicker end, while at the other extremity it is not above two and a half. On the lower edge it thinned down to about one inch. Its surface was rather jagged than pitted with regular depressions. In color it was various shades of brown to black, and somewhat variegated with an ash-colored earthy matter, derived undoubtedly from having served for a considerable time as a support for fuel in the fire-place of a farmer's kitchen. Upon the under side there adhered over a few inches a crust of an earthy, black amygdaloid nature, scarcely distinguishable, unless freshly broken, from the iron itself, and in one spot a few grains of a dull, yellowish gray olivine were noticed. Etched surfaces, excepting where the structure is highly vascular, exhibit the most delicate Widmanstätten figures. Specific gravity, 7.32.

SHEPARD.	
Iron	98.19
Chromium and Cobalt	traces.
Nickel	0.23
Carbonaceous, insoluble matter and loss	1.58
	100.00

CLARK.	
Fe	93.225
Ni. Co.	.236
Ca. Sn.	.099
Mn.	?
Si.	.501
Mg	?
P	?
S	.543
Graphite Schreibersite	4.765

The yellowish olivine grains consisted of silicic acid, lime, magnesia and ferric oxide.

This is placed among the pseudo-meteorites in the British Museum, and does not seem to be recognized as a meteorite by other authorities.

Literature—Am. Jr. Sci., 2d Ser. IV, p. 79; Rep. Am. M., p. 25; Jahresber, 1847 '48, p. 1310; Buchner, p. 175; Clark, 22; Min. and Min. Loc., p. 14; Kerr Appendix, p. 56.

Present Possessors—Yale, British Museum.

6.

Linville Meteorite.

Locality—Linville Mountain, Burke county. *Analyst*—Whitfield.

A mass of meteoric iron was found on Linville Mountain, Burke county, about the year 1882. It was handed to a country blacksmith in the vicinity, and, passing through several hands, finally came into the possession of Geo. F. Kunz, Esq., of New York.

The original weight was 442 grams. It was $2\frac{3}{5}$ inches long, $1\frac{2}{5}$ inches high, and $2\frac{1}{2}$ inches wide. One side was rather rough, and the other pitted with very shallow pittings. Traces of the black crust of magnetic oxide of iron were still visible. The mass was not rusted, and small drops of chloride of iron were noticed in the deep clefts, and in one of them was found a spider's egg-case, suggesting either that the iron was a recent fall, or that it had been found on the surface of the ground.

On being polished it gave a rich nickel color, and showed an apparent net-work of two distinct bodies. The Widmanstätten figures were not given on etching. The analyses gave:

Iron	84.56
Nickel	14.95
Cobalt	0.33
Sulphur	0.12
Carbon	trace.
Phosphorus	trace.
	99.96

Literature—Am. Jour. Sc., 3d Ser. XXXVI, p. 275.

Present Possessor—Geo. F. Kunz, Esq.

7.

Bridgewater Meteorite.

Locality—Bridgewater, Burke county. *Analyst*—Venable.

This meteorite was described by Kunz. It was found by a negro two miles from Bridgewater Station, in the western part of Burke county, near the McDowell county line. It was broken by some laborers into two pieces, one weighing ten and a half and the other eighteen and a half pounds. The original lump, therefore, weighed thirty pounds or 13.63 kilos. The iron measures 22.5 x 15 x 10 cm.

Traces of black crust, very much oxidized, are still visible on the surface. The iron is highly octahedral in structure. Between the cleavage plates schseibersite is visible. Widmanstätten figures gotten on etching.

ANALYSIS.

Iron	88.90
Nickel	9.94
Cobalt	.76
Phosphorus	.35
Chlorine	.02
	99.97

Literature—Trans. N. Y. Acad. Sci., Jan., 1890; Mitchell Soc., Vol. VII, p. 29.

8.

Cabarrus Meteorite.

Locality—Post Farm, Cabarrus county. *Analyst*—Shepard.

The fall of this meteorite was described by J. H. Gibbon, Esq., of the United States Branch Mint at Charlotte. On October 31, 1849, at 3 P. M., a sudden explosion, followed at short intervals by two other reports, and by a rumbling in the air to the east and south, was heard in Charlotte. Five days later news was brought of the fall of a meteoric mass on the farm of a Mr. Hiram Post in Cabarrus county, some twenty-five miles distant. This stone weighed nineteen and a half pounds, was bluish and gritty in appearance, of irregular form, eight inches long, six broad and four thick, bearing marks in spots of recent fracture, but otherwise black, as if it had been exposed to heat and smoke, the black color being relieved where the crust had been broken, and a little of the clayey soil in which it was buried in its descent still adhered to it. Lustrous metallic points appeared through the ground color. Mr. Post had heard the explosion and heard the stone strike about three hundred yards off with a dull, heavy jar of the ground. The stone had splintered a pine log lying on the ground. It was buried under some ten inches of soil.

It is further described in the Huntington Catalogue as a "stone—dark gray with light grains and thickly sprinkled with iron. Fragment showing dull black crust" (referring to the fragment in the Harvard collection).

The specific gravity was 3.60—3.66.

Nickeliferous iron (with chrome)	6.320
Iron sulphide	3.807
Silica	56.186
Ferrous oxide	18.108
Magnesia	10.406
Alumina	1.707
Lime, soda, potash and loss	3.394

Literature—Am. Jour. Sci., 2d Ser., IX, p. 143; X, p. 127; Buchner, p. 79; Kerr Appendix, p. 56; Huntington, p. 69; Smithsonian Rep., p. 263; Min. and Min. Loc., p. 16.

Present Possessors—Amherst (mass larger than two fists); Harvard, 168 grams; National Musuem (Shep. Cab.), 343.6; London, 385.5; Vienna, 138; Berlin, 133; Göttingen, 33; Paris, 42; Dorpat, 29; Dresden, 7; Bologna, 3; Yale, 2.31; Calcutta, 52; Gregory, 152; Baumhauer, 51; Siemascho.

9.

Caldwell Meteorite.

Locality—Caldwell county. *Analyst*—Venable.

A small piece of iron was found among the specimens for the State Museum, labeled, in Dr. Kerr's handwriting (roughly, on an old piece of paper), "Meteoric iron from Caldwell county." The reference in his note-book said it was received from a Col. Scilly. It has proved impossible to learn anything further about it. It was probably set aside by Dr. Kerr for examination, but the coming on of his final illness prevented it. The piece is about the size of a silver dollar, is still fairly bright; has evidently been hammered out thin and weighs five grams. It gave no figures on etching and a qualitative analysis revealed iron as the only metal present. It is probably of terrestrial origin.

Present Possessor—N. C. State Museum.

10.

Caswell Meteorite.

Locality—Caswell county.

This stone fell at 2 P. M. on 30th January, 1810. It was described by Bishop Madison (of Williamsburg, Virginia) as resembling other meteoric stones, especially the one which fell at Weston, Connecticut, in 1807. It was not only attracted by the magnet, but was itself magnetic.

Whether the stone is still preserved anywhere and who possesses it is as little known as anything further with regard to its characteristics.

Literature—Gilb. Ann., 41, 1812, 449; Chladin, 291; Buchner, 27; Kerr App., 56; Min. and Min. Loc., p. 13.

11.

Davidson Meteorite.

Locality—Lick Creek, Davidson county. *Analysts*—Smith and Mackintosh.

This was found on July 19, 1879, by Mr. Gray W. Harris on his land near Lick Creek, Davidson county. It was somewhat pear-shaped and weighed 2¾ pounds. Its outward color is dark brown, not rusty. The original crust was almost entirely hammered off by the finder, but a little remaining showed a peculiar slaty lamellar structure and readily broke into flakes. Some cavities in this crust were lined with mammillary forms, and it had many seams with a vitreous luster. It failed to give the Widmanstätten figures.

The analysis gave:

Iron	93.00
Nickel	5.74
Cobalt	0.52
Phosphorus	0.36
Sulphur	traces.
Chlorine	traces.
Copper	traces.
Carbon	not determined.
	99.62

From four analyses by Smith and Mackintosh. Meteorite in the possession of Hidden.

Literature—Am. Jour. Sci., 3d Ser. xx, p. 324; Min. and Min. Loc., p. 17.

Present Possessors—Main mass in Vienna, 887 grams; London, 20; Paris (Nat. Hist.), 41; Harvard, 6; Bailey, 38; Hidden, ? Nat. Mus. (Shep. Cab.), 9.72.

12.

Guilford Meteorite.

Locality—Guilford county. *Analyst*—Shepard.

This was secured by Prof. Olmsted in 1820 from a man who told him that it had been detached from a large mass weighing twenty-eight pounds, which was wrought by a blacksmith of the neighborhood into horse nails. The fragment weighed seven ounces. It was a distinct crystal in the form of an octahedron. The axis measured three inches, the angle at the summit was 60°, that at the base 122°. Its structure was distinctly foliated, the laminæ being uniformly one-twentieth of an inch in thickness and arranged parallel with the planes of the octahedron. The exact locality of the find is not given, but it was stated that it was found some ten or fifteen miles distant from the locality where the Randolph county specimen was found. It exhibited, when etched on tarnished or polished surfaces, very perfect Widmanstätten figures.

Analysis:

Iron	92.750
Nickel	3.145
Iron sulphide	0.750

Literature—Am. Jour. Sci., XVII, p. 140; XL, p. 369; Clark, 61; Rep. Am. M., p. 24; Partsch, p. 114; Huntington, p. 52; Min. and Min. Loc., p. 13; Kerr Appendix, p. 56.

Present Possessors—Amherst, 2.15 grams; Yale, 20; London, 15; Vienna, 8; Göttingen, 8; Calcutta, 10.5.

13.

Haywood Meteorite.

Locality—Haywood county. *Analyst*—Shepard.

This fragment, weighing one-eighth of an ounce, was sent to Dr. Shepard by Hon. T. L. Clingman, accompanied by the following remark: "It was given me by a person in Haywood county whose father had obtained it in that region, but without his being able to designate the locality. It is evidently meteoric iron, but is perhaps from some mass already known."

The fragment was highly crystalline and somewhat tetrahedral in form. One side was polished and etched. It displayed a marked character, and one which has no analogue among meteoric irons. It was irregularly veined by a black ore, which was not acted upon by acids and which presented all the properties of magnetite.

Specific gravity=7.419. It contained iron, sulphur, phosphorus, chromium, and was rich in nickel.

Literature—Am. Jour. Sci., 2d Ser. XVII, p. 327; Min. and Min. Loc., p. 15; Kerr Appendix, p. 56; Buchner, p. 189.

Present Possessor—Amherst, 10 grams.

14.

Haywood Meteorite.

Locality—Ferguson, Haywood county.

Mr. Harrison, of Ferguson, N. C., noticed about 6 P. M., July 18, 1889, a remarkable noise west of him. Fifteen minutes later he saw something strike the earth, and this on examination proved to be a meteoric stone, so hot that he could scarcely hold it in his hand five minutes after it fell. Two-thirds of its bulk was buried in the earth when found. The stone was slightly oblong, covered with a deep black crust which had been broken at one end, showing a great chondritic structure with occasional specks of iron. Its weight was about eight ounces and it very closely resembled the meteoric stone from Mocs, Transylvania. It was unfortunately lost in New York before examination.

Literature—Mitchell Soc., Vol. VII, p. 29.

15, 16, 17.

MADISON METEORITES.

Locality—Duel Hill, Madison county. *Analysts*—Smith and Burton.

There are several meteoric masses attributed to Duel Hill and to Jewel Hill, Madison county. The similarity of these names in pronunciation, and apparent confusion between them, led to inquiry as to their exact location. The result of the inquiry is that at present no Jewel Hill is known in this county. There was a Jewel Hill, at one time the county-seat, but its name was changed to Duel Hill and the county-seat removed to Marshall. These two are therefore one and the same locality.

Several masses have been found there.

No. 16. Found in 1856 and recorded as preserved in the Amherst collection. It weighed forty pounds. No analysis has been found. Amherst has two pieces—one of 600 grams and one of 167½ grams.

No. 17. This meteorite was presented to Dr. Smith in the year 1854 by Hon. T. L. Clingman. It came from Jewel Hill, Madison county, of that State. There was a great deal of thick rust on the surface, with constant deliquescence from chloride of iron. Its form and surface indicated that it was entire. Its dimensions were 7 by 6 by 3 inches, with a number of indentations. Its weight was eight pounds thirteen ounces. The analysis gave:

Iron	91.12
Nickel	7.82
Cobalt	.43
Phosphorus	.08
Copper	trace.
	99.45

Literature—Scient. Res., p. 317, 410; Min. and Min. Loc., p. 15; Kerr App., p. 56; Huntington, p.

Present Possessors—London, 130.2 grams; Vienna, 4; Paris (Nat. Hist.), 104; Göttingen, 38; Dorpat, 17; Harvard, 160; Yale, 5.610; Nat. Mus., 91; Nat. Mus. (Shep. Cab.,) 31.85; Calcutta, 16; Bailey, 11.4; Gregory, 40.

18.

Locality—Duel Hill, Madison county. *Analyst*—Burton.

This mass was found in August, 1873, on the land of Robert Farnesworth, near Duel Hill, Madison county. It was lying on a hill-side where it had been used in supporting a corner of a rail fence, which was quite decayed at the time of finding. It is said to have weighed, when first found, about twenty-five pounds. Two or three pounds were hammered off as specimens before it fell in the hands of Prof. Burton, who analyzed it.

Mr. Farnesworth reported that a similar mass weighing about forty pounds had been found about a mile farther west, probably about 1857, and had since disappeared. Efforts to find it again were unsuccessful.

This meteorite was of a rounded irregular shape, 9 x 6½ x 3½ inches, and weighed twenty-one pounds. On being etched, it gave the usual markings, though indistinctly. Distinct particles of schreibersite were irregularly disseminated over the surface. Deliquescent beads of lawrencite were also to be seen.

Specific gravity=7.46.

Iron	94.24
Nickel	5.17
Cobalt	0.37
Phosphorus	0.14
Copper	trace.
Residue	0.15
	100.07

The residue contained SiO_2, Fe., Cr., Ni. and P.

Literature—Amer. Jour. Sci., 3d Ser. XII, p. 439; Min. and Min. Loc., p. 15.

Present Possessors—London, 12 grams; Vienna, 160; Harvard, 222; Baumhauer, 29; Bailey, 3; Gregory, 1.

19.

Nash Meteorite.

Locality—Castalia, Nash county. *Analyst*—Smith.

This meteorite fell May 14, 1874, at 2:30 P. M, near Castalia (lat. 36° 11′, long. 77° 50′). Its fall was accompanied by successive explosions and rumbling noises, lasting about four minutes. The stones that fell must have exceeded a dozen or more—three only were found and they gave evidence that the territory over which the fragments fell was ten miles long by over three miles wide. Although occurring in the day, the body appeared luminous to some observers. The three stones found weighed respectively, one kilogram, 800 grams and five and one-half kilograms.

The exterior coating was dull. The interior in many parts is of a dark gray color, and in other parts quite light. The principal cause of the dark color is, doubtless, the larger amount of nickeliferous iron in that part. The specific gravity was 2.601.

Its composition was

Nickeliferous iron	15.21
Stony minerals	84.79

The nickeliferous iron consisted of

Iron	92.12
Nickel	6.20
Cobalt	.41

Copper and phosphorus not estimated.

The stony part, when treated with a mixture of hydrochloric and nitric acids, gave: insoluble part, 47.02; soluble part, 52.98. The former consisted of

Silica	52.61
Alumina	4 80
Ferrous oxide	13.21
Magnesia	27.31
Alkalies (soda, with traces of potash and lithia)	1.38
	99.31

and is essentially bronzite. The soluble portion gave:

Silica	38.01
Ferrous oxide	17.51
Magnesia	41.27
Alumina	.46
Sulphur	1.01

This is evidently olivine, with a small amount of sulphide of iron so disseminated through the stone that it is not easily separated by mechanical means. The meteorite then consists of nickeliferous iron, bronzite and olivine with small particles of anorthite and enstatite.

Literature—Amer. Jour. Sci., 3d Ser. x, p. 147; Min. and Min. Loc., p. 16; Smithson. Rep., 1885-'86, Part II, pp. 258, 262; Huntington, p. 94; Kerr, p. 314; Smith's Res., p. 478.

Present Possessors—Harvard, 211 grams; National Museum, 19.7; London, 29.4; Vienna, 285; Yale, 248; Bailey, 9.8; Baumhauer, 40; Gregory, 10.5.

20.

RANDOLPH METEORITE.

Locality—Randolph county. *Analyst*—Shepard.

This was first described by Prof. Olmsted in 1822, in a descriptive catalogue of rocks and minerals collected by him, during his geological survey of North Carolina. It is there spoken of as occurring in the vicinity of a bed of argillaceous iron ore. It is distinctly foliated, the laminæ being thin and much interlaced. It weighed originally about two pounds. When etched it presents very fine, almost invisible, feathery lines much resembling hoar frost on a window-pane. Hardness equal to that of the best tempered steel. Specific gravity=7.618. The only metal detected, besides iron, was cobalt, which was present in traces only. A reddish brown powder, insoluble in *aqua regia*, was considered to be silicon.

Literature—Amer. Jour. Sci., 1st v, p. 262; 2d IV, p. 85; Jahresber., 1847-'48, p. 1311; Clark, p. 75; Min. and Min. Loc., p. 13; Kerr Appendix, p. 56; Buchner, p. 160.

Present Possessors—This is reported by Buchner as in collection of Amer. Geolog. Society and in London.

21.

Rockingham Meteorite.

Locality—Smith's Mt., Rockingham county. *Analysts*—Genth and Smith.

This was found in 1866 at Smith's Mountain, two miles north of Madison, in an old field grown up with pines, but cultivated ten or fifteen years previously. It fell probably in the interval. The original weight was eleven pounds. It is highly crystalline and on etching gives fine Widmanstätten figures, showing that it consists of probably three kinds of iron. It contains also schreibersite in short, very minute quadratic crystals, and, according to J. L. Smith, solid chloride of iron. Specific gravity, 7.78.

Iron		90.41	90.88
Nickel		8.74	8.08
Cobalt			.50
Copper		.11	.03
Insoluble Phosphide	Iron	.27	
	Nickel (Cobalt)	.33	
	Phosphorus	.14	.03
		100.00	99.46

Literature—Min. and Min. Loc., p. 15; Kerr, p. 313; Kerr Appendix, p. 56; Scient. Res., p. 526.

Present Possessors—N. C. State Museum; Jardin des Plantes, Paris; London, 77.3 grams; Vienna, 124; Göttingen, 54; Harvard, 821; Nat. Mus., 58.8; Gregory, 8; Bailey, 128.

22.

Rockingham Meteorite.

Locality—Rockingham county. *Analyst*—Venable.

This mass was reported to have fallen about the year 1846 on Deep Springs Farm, Rockingham county. Its fall caused much terror among the negroes on the place. It was dug out immediately after falling, being buried four or five feet under the surface. After lying about the house for many years, it was in the fall of 1889 presented to the State Museum.

The weight of the mass was 11.5 kilos. It measured 270 x 210 mm., having a varying thickness of 10 to 70 mm. It is coated with a crust of several millimetres thickness. The surface is irregularly pitted with broad, shallow pits. On being polished it gave faintly the Widmanstätten figures. It belongs to the class of sweating meteorites.

Analysis:

Iron	87.01
Phosphorus	.04
Silica	.53
Chlorine	.39
Nickel	11.69
Cobalt	.79
	100.45

Literature—Amer. Jour. Sci., 3d Ser., 1890, p. 161; Mitchell Soc., VII, p. 29.
Present Possessor—N. C. State Museum.

23.

Rutherfordton Meteorite.

Locality—Rutherfordton, Rutherford Co. *Analysts*—Shepard, Rammelsberg.

This was analyzed by Shepard, who found Fe.=84.00, Si.=13.57, P.=1.31. He called it "ferrosilicine." A partial analysis made in Wöhler's laboratory gave Fe.=87.1, Si.=10.6, C.=0.4. Rammelsberg on examining it declared it to be nothing more than a piece of white pig iron of inferior quality.

This is placed among pseudo-meteorites in the Catalogue of the British Museum.

Literature—Amer. Jour. Sci., 2d XXXIV, p. 298; Kerr Appendix, p. 56; Clark, p. 67; J. prakt. chem., LXXXV, 87.
Present Possessor—Amherst (?)

24.

Rutherford Meteorite.

Locality—Ellenboro, Rutherford county. *Analyst*—Eakins.

This iron was found in the latter part of 1880, on a farm near Ellenboro, Rutherford county, N. C. Its nature remained unknown until February, 1890, when it was brought for examination to Mr. Stuart W. Cramer, of the U. S. Assay Office at Charlotte, N. C. It seems to have weighed about 2⅕ kilos. In shape it was roughly two globular ends with a connecting bar, the total length being about 150 mm. with end diameters 75 mm., and 50 mm. in the middle.

The iron is very tough and highly crystalline, the Widmanstätten figures showing distinctly on a polished, unetched face, and after etching they are unusually strong, Small, irregularly distributed patches of troilite are visible, and schreibersite also seems to be present. The analysis is as follows:

Fe	88.05
Ni	10.37
Co	.68
Cu	.04
P	.21
S	.08
Si	.02
	99.45

Literature—Amer. Jour. Sci., 1890, p. 395.

Present Possessors—Charlotte Assay Office and Geo. F. Kunz.

LIST OF WORKS REFERRED TO.

Some of these works are referred to from citations only. The limitation of library facilities prevented direct reference.

Amer. Jour. Sci.—American Journal of Science and Arts. Three Series.

Jahresbericht—Jahresbericht über die Fortschritte der, etc., Chemie, etc. Liebig and Kopp.

Rep. Am. M.—Report on American Meteorites. Shepard, 1848.

Clark—On Metallic Meteorites. Clark, 1852.

Huntington—Catalogue of all Recorded Meteorites, 1887.

Smithson. Rep.—The Meteorite Collection in the U. S. National Museum. F. W. Clarke, 1889. (Vol. II, 1885-'86, Smithsonian Report).

Min. and Min. Loc.—The Minerals and Mineral Localities of North Carolina, 1885.

Scient. Researches—Mineralogy and Chemistry, Original Researches. J. L. Smith, 1873.

Kerr—The Geology of North Carolina, Vol. I. Kerr, 1875.

Kerr Appendix—Appendix to Kerr's Geology.

Mitchell Soc.—Journal of Elisha Mitchell Scientific Society.

Partsch—Die Meteoriten in Hof-Mineralien-Kabinette zu Wien, 1843.

Buchner—Die Meteoriten in Sammlungen, 1863.

Gilb. Ann.—Gilbert's Annalen der Physik.

Chladni—Ueber Feuer-Meteore und über die mit denselben herabgefallenen Massen, 1819.

NO.	COUNTY.		ACCREDITED NAME.	DATE.	WEIGHT.	PAGE.
1	Alexander	Co.	....	secured 1875.....	56 grams..........	33
2	Ashe	"	....	....	....	34
3	Buncombe	"	Asheville..........	found 1839.......	13630 grams..........	35
4	"	"	Black Mountain..	" 1835.......	590 grams..........	36
5	"	"	Hominy Creek....	" 1845.......	2000–3000 grams..........	37
6	Burke	"	Linville..........	" 1842.......	442 grams..........	38
7	"	"	Bridgewater.......	" 1888.......	13630 grams..........	39
8	Cabarrus	"	....	fell 1849..........	8860 grams..........	39
9	Caldwell	"	....	....	$5\frac{1}{2}$ grams..........	40
10	Caswell	"	....	fell 1810..........	1360 grams..........	41
11	Davidson	"	....	found 1879.......	12720 grams..........	41
12	Guilford	"	....	described 1841..	1250 grams..........	42
13	Haywood	"	....	described 1854..	3.6 grams..........	43
14	"	"	Ferguson..........	fell 1889..........	227 grams..........	43
16	Madison	"	Jewel Hill..........	found 1856.......	18180 grams..........	44
17	"	"	" "	" 1854.......	4000 grams..........	44
18	"	"	Due! Hill..........	" 1873.......	11360 grams..........	45
19	Nash	"	....	fell 1874..........	(3) 1000, 800, & 5500 grams.	46
20	Randolph	"	....	described 1822..	900 grams..........	47
21	Rockingham	"	Smith's Mountain	found 1866.......	5000 grams..........	48
22	"	"	....	fell 1846..........	11500 grams..........	48
23	Rutherford	"	Rutherfordton....	....	....	49
24		"	....	found 1880.......	2500 grams..........	49

NEW AND IMPROVED METHODS OF ANALYSIS.

BY S. J. HINSDALE.

COLORIMETRIC METHOD FOR ESTIMATING THE MORPHINE STRENGTH OF LAUDANUM AND OTHER PREPARATIONS OF OPIUM.

Prepare an officinal tincture of opium with assayed opium. You will know the morphine strength of this tincture.

Make three dilutions of it with dilute alcohol, as follows:

One 3	parts	tincture	and 1	part	dilute	alcohol.
One 2	"	"	" 2	"	"	"
One 1	"	"	" 3	"	"	"

Put 12 cc. of the tincture and of the dilutions in vials, and add to each 12 cc. dilute alcohol—cork well and keep them as standard dilutions of known strength. Label them Nos. 1, 2, 3 and 4. Let the dilute officinal tincture be No. 1. Dissolve 0.04 gram potassic ferridcyanide in 500 cc. water, and add to it fifteen drops liquor ferri chloridi. Call this *Ferridcyanide Mixture.* (*This must be freshly prepared*). Prepare it in a glass-stoppered bottle, with water perfectly free of iron.

Place four 50 cc. clean glass tumblers or wine-glasses on a white surface, and deliver *with a pipette* (about one-third filled) one drop of the dilutions in the glasses, commencing with No. 4 (the weakest), blowing out the pipette after each dropping. (The pipette should be about four inches long, and made of one-quarter inch tubing, and should deliver drops of the dilutions weighing *about* .016 gram or one-fourth grain. To test the pipette, see how many drops will balance a .200 gram weight. The reason for using so small a drop, and for diluting the tincture, is because a full drop of the undiluted tincture would develop too deep a blue color).

Now add to each glass about 5 cc. ferridcyanide mixture (it is convenient to use a homeopathic vial as a measure), and in about one minute add 15 or 20 cc. water, and observe the shades of color. This observation must be made *within five minutes*, as the air and light will soon cause all to be uniformly blue.

By comparison with the shades of color produced by these standard dilutions, you can easily estimate the strength of any sample of laudanum with much accuracy. The sample must, of course, be diluted with an *equal part of dilute alcohol.* The presence of tannin interferes with this method, but opium does not contain tannin. Tannin is easily detected with a solution of a salt of iron. The ferridcyanide mixture *must be freshly prepared* and the glasses must be *clean and clear*, as the slightest bluish tinge interferes. Wash them with caustic soda and then with hydrochloric acid and rinse if they are soiled with Turnbull's Blue.

The ferridcyanide mixture is probably the best confirmatory test for morphine. If one drop of water containing .000001 gram of morphine is mixed on a white slab with one drop of the ferridcyanide mixture a blue color will be developed within *one* minute. With water alone the mixture will become of a bluish shade in about *ten* minutes, owing to the action of air and light.

P. S.—To estimate the strength of vinous or aqueous compounds of opium they must be brought to about the same specific gravity as the "standard dilutions" with alcohol, that the drops may be uniform in size.

COLORIMETRIC METHOD FOR ESTIMATING TANNIN IN BARKS, ETC.

Dissolve 0.04 gram potassic ferridcyanide in 500 cc. water, and add to it 1.5 cc. (about 22 drops) liquor ferri chloridi. Call this *Iron Mixture.*

Dissolve 0.04 gram "pure tannin (gallotannic acid) which has been dried at 212° F. in 500 cc. of water. Call this *Tannin Solution.*

Exhaust 0.8 gram oak bark with boiling water, and make it up to 500 cc. with cold water.

Place six two-ounce clear glass tumblers (or beaker glasses) on a white surface, and in one of them, *with a dropping pipette* (about four inches long and one-quarter inch wide) *about half filled*, put *five drops* of the infusion of bark, and in the others, *with the same pipette* (after rinsing), put 4, 5, 6, 7 and 8 drops of the "tannin solution." (The drops of the infusion and of the tannin solution must be uniform. The use of the same pipette, about half filled, *insures that*).

Now, add to each 5 cc. of "iron mixture," and in about one minute add to each tumbler about 20 cc. water, and *within three minutes* observe the shades of color. The number of drops of "tannin solution" used in the tumbler which corresponds in shade of color to the tumbler containing the infusion of bark *indicates the percentage of tannin in the bark; i. e.*, if it is the one in which seven drops were placed, the tannin strength of the bark is *seven per cent.*

It is best to observe the shades of color horizontally, rather than vertically, and to hold up the infusion tumbler, with the one which most nearly corresponds, opposite to a white wall, with your back to the light.

The above is written for *oak bark*, but the same process will answer for any substance containing less than ten per cent. of tannin.

For substances containing between about 10 and 20 per cent., it is best to dilute the infusion with an equal part of water and proceed as above, using *five drops* of the *dilute* infusion, and for the answer *double the result.* Thus, if the *diluted* infusion of tea required eight drops tannin solution to correspond, call the percentage *sixteen.*

For substances containing less than one, or one and a half per cent., exhaust 8 *grams* instead of 0.8 *gram*, and take *one-tenth* of the result for the answer. For substances containing more than twenty per cent., as galls, sumach, catechu, etc., you may dilute the infusion with two, three or more times its bulk with water, and calculate as above (as with tea), or you may use 1, 2, 3 or 4 drops of the undiluted infusion in the first glass and make the calculation thus, *i. e.:* As the number of drops of infusion used is to the number of drops "tannin solution" used (to correspond), so is 5 to the answer—thus, suppose *two* drops infusion were used and the corresponding tumbler contained *fifteen* drops tannin solution—2 : 15 : : 5, answer 37.5 per cent.

The object in diluting the infusions is because the infusion glass may be of too deep a blue shade. It is better that it should just produce a *light blue.*

The tumblers must be perfectly clear and clean.

The "iron mixture," "tannin solution" and infusion must be freshly prepared and not exposed to the rays of the sun.

The water used must be free of iron and tannin.

The results are necessarily in terms for commercial gallotannic acid, and not for those of pure tannin, or of the particular tannin in the material assayed.

TEST FOR IRON.

A solution of neutral sulphite of soda containing a little pyrogallic acid has been proposed as a test for copper. A few drops of it mixed with a dilute solution of a salt of copper produces a red color similar to that which is developed by the addition of sulphocyanide of potash to a solution of a persalt of iron. The test is much more delicate for *iron*, as the following experiment will show:

Dissolve 0.7 gram ammonia ferrous sulphate (= 0.1 gram iron) in a liter of water; it will be 1 part in 10,000. To 10 cc. of this solution add water to make 100 cc.; this will be 1 to 100,000. Dilute some of this by adding four times its bulk of water; it will then be 1 in 500,000.

Make a saturated solution of sodium sulphite, and separately a solution of pyrogallic acid 0.5 gram in 50 cc. water. Put some of the iron solution in a wine-glass, add 4 drops of the solution of sodium sulphite and afterward 2 drops of the pyrogallic solution and a purple color will be developed.

This test with distilled water alone develops a light pink shade, which, however, soon fades. This is due to the trace of free ammonia which it usually contains. Iron produces a purple tint. The test is so delicate that it will detect iron in 100 cc. of water, in which a bright cambric needle has been immersed for an hour.

FAYETTEVILLE, N. C.

(ISSUED SEPTEMBER 23, 1890).

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY,

VOLUME VII—PART SECOND.

JULY—DECEMBER.

1890.

POST-OFFICE:

CHAPEL HILL, N. C.

E. M. UZZELL, STEAM PRINTER AND BINDER.

RALEIGH, N. C.

1891.

OFFICERS.

1890.

PRESIDENT:

H. T. Bahnson, M. D., ... Salem, N. C.

VICE-PRESIDENT:

H. B. Battle, Ph: D., ... Raleigh, N. C.

RESIDENT VICE-PRESIDENT:

J. A. Holmes, B. Agr., ... Chapel Hill, N. C.

SECRETARY AND TREASURER:

F. P. Venable, Ph: D., ... Chapel Hill, N. C.

RECORDING SECRETARY AND LIBRARIAN:

J. W. Gore, C. E., ... Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.

5-9

TABLE OF CONTENTS.

60

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

SOME ERYSIPHEÆ FROM CAROLINA AND ALABAMA.

BY GEO. F. ATKINSON.

During the past four years the writer has collected occasionally species of this group in parts of North and South Carolina and Alabama, some of which are of interest in showing the extended range of species found elsewhere, while others throw some light on the relationships of imperfectly known forms.

The descriptions of the species enumerated are in reality notes upon the forms collected in this comparatively circumscribed region, so that in some cases the specific description may seem to lack the broader character which would be given from a description based upon a comparison of specimens from widely different latitudes and on a much greater variety of host plants.

The paper is not monographic, but professes the simple character of being a contribution to a knowledge of some Southern forms. Bearing this in mind, it is hoped the small contribution given will not be devoid of interest to students of this fascinating group of microscopic plants.

A list of the works consulted will be found at the close of the article. In prescribing the limitations of the species I have tried to follow the admirable work of Professor Burrill on the *Erysipheæ* of Illinois* so far as consistent with the characters of the specimens.

*Parasitic Fungi of Illinois, Part II. In Bull. Ill. State Lab., Nat. Hist. 1887.

Perhaps the chief point of departure from that work is in regarding *Microsphæra Van Bruntiana* Ger. as a distinct species and not one of the many synonyms of *M. Alni* (D C.) Winter. The appendages are totally different from the description there given or from those of the other species placed as synonyms. On the other hand, an examination of a large series of specimens of *Microsphæra* on different species of oak only confirms the correctness of the judgment displayed in uniting Peck's *extensa et abbreviata* into one variable species. It is doubtful, however, if *Microsphæra Quercina* (Schw.) Burrill can be morphologically distinct from *M. Alni* (D C.) Winter, since many of the intermediate forms between Peck's *extensa et abbreviata* agree perfectly with the description of *M. Alni* (D C.) Winter, and have constantly been referred by various authors and to *M. Hedwigia et penicillata* which are now regarded by many as synonyms of *M. Alni* (D C.) Winter. I prefer, however, to suspend a final judgment on this subject, considering the local character of this contribution.

There seems to be no necessity for a full presentation of the synonomy of all the species, and where synonyms are given it is only because of the peculiar value of these expressions in interpreting a few of the forms.

It is hoped that to members of the Society, and other readers in the South who are interested in microscopic study, this contribution will prove a stimulus and aid in the study, collection and determination of this common, easily recognized and interesting group of plants. For this reason the notes are so arranged as to enable one to determine the species presented here.

The *Erysipheæ*, or, as they are commonly called, the powdery mildews, are parasites growing generally upon the surface of the leaves, often on the stems, occasionally upon the fruits and deformities of plants. The vegetive condition from which they obtain the name of *mildew* consists of a loose weft of white fungous threads distributed over the affected parts, sometimes covering a large part or all of the leaf surface, or again confined to definite spots. The fungus derives its nourishment through the medium of short suckers, or haustoria, which here and there pierce through the epidermis of their host. The conidial stage consists of short branches arising perpendicularly to the weft of mycelium which abjoint serially oval or oblong *conidia*, which in numbers give a powdery appearance to the mildew.

The mature condition of the fungus is manifested to the unaided eye in the form of minute conceptacles of a dark color, which can be seen here and there to dot the surface of the leaf, sometimes very numerous and quite evenly distributed, or again loosely aggregated or very few in number.

It is outside the purpose of this paper to describe the rather complex development of these conceptacles which result from sexual organs. With proper magnification they are seen to be of a blackish, or various shades of a brown, color, the surface being more or less definitely reticulated, and in a single plane of the periphery they have a number of filamentous appendages of various forms of development, either hyaline or colored. The interior of a conceptacle, or *perithecium*, is occupied with one or several sacs, or *asci*, which themselves contain a variable number, two to eight, of one-celled spores.

It is a source of regret to myself that a greater number of species have not been collected, and the absence of some common ones will be noticed. In a number of cases the conidial stage of *Erysiphe graminis* and *Sphærotheca pannosa* have been very abundant, but I have not collected the fruit in the past four years.

During the past year the conidial stage of *Sphærotheca pannosa* has been very injurious to roses in Auburn, Ala.

The measurements are given in terms of the micromillemeter.

To serve in distinguishing the genera the following brief key will be found serviceable:

I. Appendages simple.
- *a*, Irregularly flexuous.
  - 1, One ascus—*Sphærotheca.*
  - 2, Several asci—*Erysiphe.*
- *b*, Coiled at the tips—*Uncinula.*
- *c*, Needle-shaped, swollen at base—*Phyllactinia.*

II. Appendages dichotomously branched.
- *a*, One ascus—*Podosphæra.*
- *b*, Several asci—*Microsphæra.*

III. Appendages percurrent, primary branching opposite—*Microsphæra.*

SPHÆROTHECA Lév.

Perithecium containing only one ascus; appendages simple, irregularly flexuous, frequently interwoven with the mycelium.

S. Castagnei, Lév.

Amphigenous; mycelium thin, evanescent. Perithecia scattered or subgregarious, numerous, small, 70–80, chestnut brown, reticulations large, distinct. Appendages few, flexuous, of uneven diameter, colored, in length one to four times the diameter of the perithecium, interwoven with the mycelium. Asci oval to suborbicular 45 x 50. Spores eight, oval, small, 14–15.

On *Bidens*, Auburn, Ala., October 20, 1889, 1020.

S. Humuli (D C.) Burrill (?).

Leaves of the common hop plant were collected at Auburn, Ala., in the autumn of 1889, which bore numbers of a specimen probably of this species. My laboratory not being ready at that time, the specimen was lost.

ERYSIPHE (Hedw.) Lév.

Perithecium containing several asci; appendages simple, irregularly flexuous and frequently interwoven with the mycelium.

E. communis (Wallr.) Fr.

Amphigenous; mycelium dense, persistent. Perithecia scattered or subgregarious, 80–120, reticulations distinct. Appendages few, long, hyaline when young, strongly colored when mature, frequently lying upon the mycelium. Asci three to eight 30–35 x 45–60, ovate, shortly pedicellate. Spores three to eight, 15–20.

On *Oenothera biennis*, Auburn, Ala., June 3, 1890, 1144; Columbia, S. C., November 25, 1888, 635; Champion of England peas, Auburn, Ala., June, 1890, 1135.

This is sometimes very injurious to cultivated peas in this part of Alabama, entirely covering the vines, leaves and fruit with the dense mycelium. In mature specimens the appendages are very dark, clearly showing that the form on peas cannot on account of hyaline appendages be separated from this species.

E. Cichoracearum D C.

Syn. *E. spadicea* B. & C. Grev. IV, p. 159. Amphigenous; mycelium abundant, persistent. Perithecia numerous, scattered or gregarious 100–140. Appendages numerous, two to three times diameter of perithecium, woven with the mycelium, colored. Asci six to ten, 30–40 x 50–70, ovate or oblong, pedicellate. Spores two to four, variable in size, oval to elliptical, 15–20.

On *Ambrosia trifida*, Chapel Hill, N. C., September 15, 1885, 626; Uniontown, Ala., July, 1890; *Ambrosia artemisiæfolia*, Auburn, Ala., June 3, 1890, 1193; *Verbesina Seigesbeckia*, Columbia, S. C., November 3, 1888, 624; *Xanthium Canadense*, Chapel Hill, N. C., autumn, 1885, 627; Auburn, Ala., October 21, 1889, 1018; *Helianthus*, Chapel Hill, N. C., September 7, 1885, 632.

The specimens on *Xanthium Canadense* collected at Auburn, No. 1018, seem to agree with *Erysiphe spadicea* B. & C., except that the perithecia are gregarious, and the spores vary to less than four. Berkeley's description is as follows:

"Perithecia scattered, rich brown, appendages flexuous, three times longer than their diameter; sporidia four." On leaves of *Xanthium*, Car. Inf.

The notes taken from my 1018 are as follows: Amphigenous; mycelium persistent, abundant, perithecia gregarious, 120–140, appendages two to three times diameter of perithecium, woven with the mycelium; perithecia and appendages rich chestnut brown. Asci six to ten, 30–40 x 60–70, pedicellate. Spores two to four, very often four, variable in size. For several of the first examinations the spores were quite uniformly four. Recognizing this variability which is known to occur in the species there is no reason why *E. spadicea* B. & C. should not belong to this species.

E. Liriodendri Schw.

Good specimens of this species were collected in the autumn of 1888 at Columbia on young twigs of *Liriodendron tulipifera*. The mycelium was very abundant both on the leaves and twigs.

The perithecia were only found on the twigs, imbedded in the dense felt of mycelium.

UNCINULA Lév.

Perithecium containing several asci; appendages coiled or incurved at the tips, free from the mycelium.

U. SPIRALIS B. & C.

*Syn. *U. spiralis B. & C.* Berkeley, Introduction to Cryptogamic Botany, 1857, p. 278, Fig. 64.

U. Ampelopsidis Peck, Trans. Albany Inst., Vol. VII, p. 216, 1872.

U. Americana Howe, Journal Bot., 1872.

U. subfusca B. & C. Grev. IV, p. 160, 1876.

Epiphyllous; mycelium thin, evanescent. Perithecia numerous, scattered, black, 70–100. Appendages twenty-five to thirty, three to four times the diameter of the perithecium, colored, faintly septate, tips loosely coiled. Asci five to eight, 30–40 x 50–65, ovate, pedicellate. Spores four to six, small.

On cultivated grape, autumn, Auburn, Ala., 1889, 1030. It appears to come too late to do harm, so far as I have observed here for two years.

U. MACROSPORA Peck.

Amphigenous, mostly epiphyllous; mycelium thin, persistent. Perithecia numerous, scattered, 100–120, globose biconvex, reticulations evident, but not very distinct, small. Appendages thirty to fifty, about equal to diameter of perithecium, radiating, or ascending to erect from crown of upper side. Asci five to ten, ovate or elliptical, pedicellate 25–30 x 60–65. Spores two to three, large, oval, 25–30.

On *Ulmus Americana*, Columbia, S. C., October 28, 1888, 622; *Ulmus*, Auburn, Ala., August 6, 1890, 1788.

U. FLEXUOSA Peck.

Hypophyllous; mycelium thin, evanescent. Perithecia scat-

---

*Prof. B. T. Galloway, who has recently made cultures of this species to determine the different hosts, kindly furnished me with the synonymy of this species.

tered, 100–130, black, wall tissue hard, brittle, reticulations obscure. Appendages twenty to fifty, hyaline, rough, short, flexuous and enlarged toward ends, coiled at tips. Asci five to ten, 30–35 x 50–65, ovate, pedicellate. Spores six to eight, about 20.

On *Aesculus*, Wright's Mill, Lee county, Ala., July 5, 1890, 1223; August 6, 1890, 1535.

U. PARVULA C. & P.

Hypophyllous; mycelium thin. Perithecia globose, lenticular, 80–100, soft, reticulations distinct. Appendages numerous, fifty to one hundred, or more, about equaling diameter of the perithecium, or less, arising in crown on upper side, somewhat scattered toward center, hyaline, slender, tips well coiled. Asci four to five, 35–40 x 50–60, ovate, pedicellate. Spores four to eight, about 20 long.

On *Celtis occidentalis*, Columbia, S. C., November 8, 1888, 621; Auburn, Ala., autumn, 1889 (Wright's Mill). All the specimens were collected on shrubs.

U. POLYCHÆTA (B. & C.) Masse (see Figs. 5, 11, Pl. I).

Syn. *Erysiphe polychæta* B. & C. Grev. IV, 159, 1876.

Uncinula Lynckii Speg. Fung. Arg. Pug. II, p. 17.

Pleochæta Curtisii Sacc. & Speg. Fung. Arg. Pug. II, p. 44; Sacc. Syll., Vol. I, p. 9 (in part).

Pleochæta Lynckii Speg. Sacc. Syll., Vol. II, Addend., p. 9.

Uncinula polychæta Ell. Jour. Mycol. 1886, p. 43 (in part).

Pleochæta Curtisii Sacc. & Speg, Sacc. Syll. Addit., p. 2 (in part).

Uncinula polychæta T. & G. Bot. Gaz., XIII, p. 29 (in part).

Uncinula polychæta Masse, Grev. XVII, p. 78, 1889.

Uncinula polychæta Rav. Fung. Car. ex. fasc. 4, 68.

Hypophyllous; mycelium in dense, definite patches, or distributed over a large part of the leaf surface. Perithecia generally numerous, scattered, brown, becoming black, globose, lenticular, 225–280, reticulations minute. Appendages numerous, two hundred or more, hyaline, about equal to diameter of perithecium, arising in circle toward one side, straight when young, to incurved or coiled at the tips when mature. Asci about fifty, cylindrical, clavate or rarely oblong, ovate, abruptly contracted into a prominent pedicel, 30–35 x 45–50. Spores two, about 30 long.

On *Celtis occidentalis*, Columbia, S. C., autumn, 1888, 620 and 634. Very common.

Plate I, Fig. 5, is from a camera lucida drawing of a mature perithecium on leaves of *C. tara* from Buenos Ayres, S. A., which was kindly loaned me by Rev. J. B. Ellis. A majority of the perithecia were young and possessed straight appendages. Figs. 6, 7 and 8 are from the same specimen. Figs. 9, 10 and 11 are from a South Carolina specimen; all from camera lucida drawings.

PHYLLACTINIA Lév.

Perithecium containing several asci; appendages needle-shaped, abruptly swollen at the base, free from the mycelium.

P. SUFFULTA (Reb.) Sacc.

Hypophyllous; mycelium abundant, persistent. Perithecia scattered, large, 180–200, reticulations small, distinct. Appendages seven to twelve, one to four times diameter of the perithecium, hyaline. Asci eight to twenty, irregularly ovate to oblong or elliptical, 25–30 x 70–80, pedicellate. Spores two to three, 30–35.

On *Ulmus Americana*, Columbia, S. C., October 13, 1888, 619; *Ulmus*, Auburn, Ala., October 20, 1889, 1017; *Alnus*, Columbia, S. C., November, 1888, 623.

Var. *macrospora*, perithecia 200–250; asci elongated, curved or straight, 40–50 x 70–120, long pedicellate; spores two, 35–50.

On *Quercus nigra*, Auburn, Ala., February, 1890, 1103; *Q. nigra* or *aquatica?* Auburn, Ala., November 25, 1890, 1799; *Q. phellos et aquatica*, December, 1890.

There is a second kind of appendage on the perithecia of this species. They are hyaline, knobbed at the end, the knobbed end bearing numerous slender flexuous short filaments. On

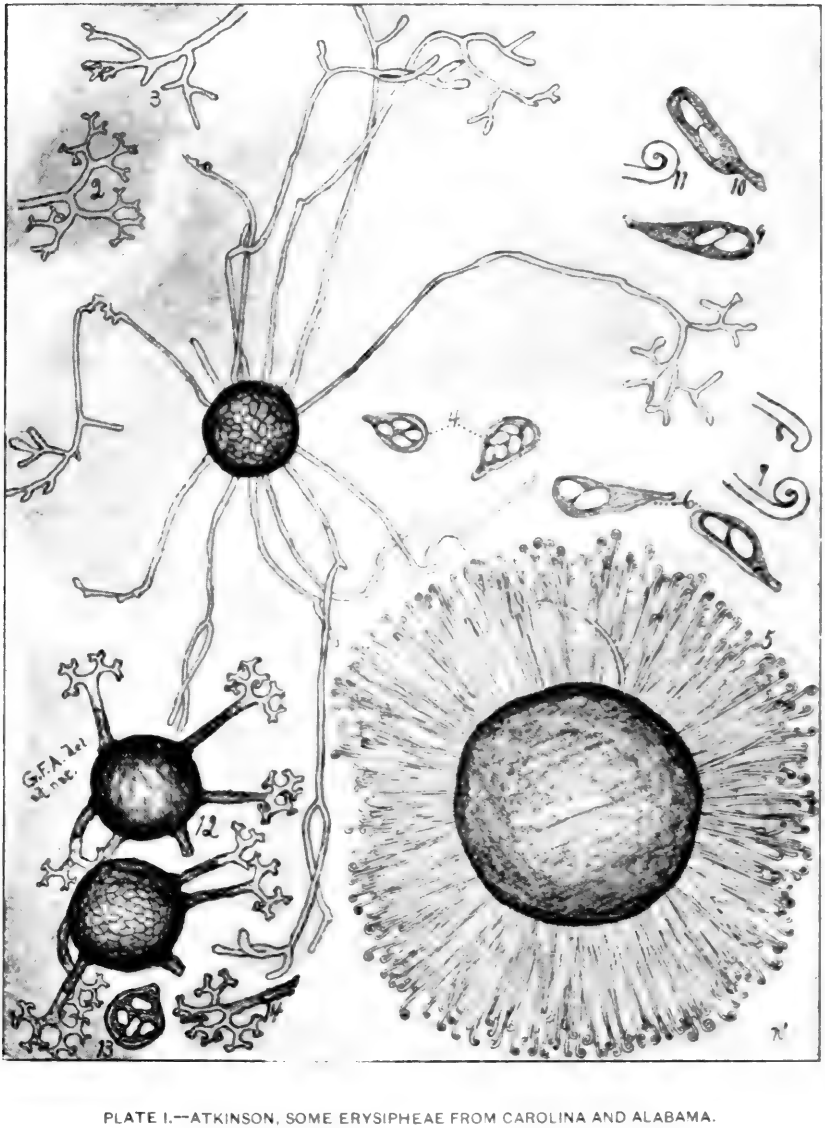


PLATE I.—ATKINSON, SOME ERYSIPHEAE FROM CAROLINA AND ALABAMA.

specimens from elm these appendages are quite equal to one-half the diameter of the perithecium; on specimens from oak they are quite short and apt to be overlooked.

PODOSPHÆRA (D C.) D BY.

Perithecium containing one ascus; appendages dichotomously branched, free from the mycelium.

P. BIUNCINATA C. & P.

Epiphyllous; mycelium abundant, thin, diffuse. Perithecia black, numerous, scattered, small, 65–70, reticulations rather large, distinct. Appendages five to ten, three to five times the diameter of the perithecium, hyaline, faintly colored at the base, rough, once dichotomous, tips rather long, strongly divergent, slightly recurved. Asci globose or oval, sometimes with a short broad pedicel, 45–50 x 50–55. Spores eight, 15–18.

On *Hamamelis Virginiana*, Blowing Rock, Watauga county, N. C., August 24, 1888, 613.

P. OXYACANTHÆ (D C.) D By.

Amphigenous; mycelium thin, not very persistent. Perithecia numerous, scattered, small, 65–70, dark brown. Appendages eight to twelve, about twice the diameter of the perithecium, dark brown for over half their length, three to four times dichotomously branched, branching compact, tips incurved. Asci suborbicular, 55 x 60, thick-walled. Spores eight.

On *Cratægus punctata*, Blowing Rock, Watauga county, N. C., August, 1889, 663.

MICROSPHÆRA LÉV.

Perithecium containing several asci, appendages dichotomously branched, or percurrent and then the primary branching opposite, tips of the branches dichotomous.

M. SEMITOSTA B. & C. (see Figs. 12, 13 and 14, Pl. I).

Hypophyllous; mycelium thin, evanescent. Perithecia scattered, usually numerous, small, black, about 80, reticulations obscure in age. Appendages rough, five to ten, about the length of the diameter of perithecium or sometimes very little longer, dark brown for about half their length, sometimes the color ceasing abruptly midway as if the appendage were septate, sometimes extending to near the tips, four to five times dichotomous. Asci four to five, obovate, about 35 x 50, shortly pedicellate. Spores three to four, mostly four, small, about 15.

On *Cephalanthus occidentalis*, Auburn, Ala., autumn, 1889, 1031.

M. DIFFUSA C. & P.

Amphigenous or mostly epiphyllous; mycelium thin, persistent or evanescent. Perithecia numerous, scattered or subgregarious, black, small, 100–120. Appendages ten to twenty-five, long, two to five times the diameter of the perithecium, sometimes colored at the base, loosely several times dichotomous, tips straight or flexuous. Asci five to ten, ovate or elliptical, 30–40 x 50–60, pedicellate. Spores six, small, 16–18.

On *Desmodium*, Auburn, Ala., autumn, 1889, 1019; *Lespedeza striata*, November, 1889, 1014.

On *Desmodium* the specimens were mostly epiphyllous, while on *Lespedeza* they were common on both sides of the leaf.

M. VACCINII C. & P.

Amphigenous; mycelium thin. Perithecia numerous, scattered, black, 100–130, reticulations distinct. Appendages six to fifteen, three to four times the diameter of the perithecium or longer, hyaline, colored at base, rough, slender, three to four times dichotomous, tips incurved when mature, branching usually compact, sometimes the first branches strongly divergent. Asci six to eight, 25–30 x 50–60, oval or elliptical, pedicellate. Spores four to six, 17–20.

On *Vaccinium*, Blowing Rock, Watauga county, N. C., August, 1888, 616.

M. EUPHORBIÆ B. & C. (see Figs. 1–4, Pl. I).

Amphigenous; mycelium dense, persistent. Perithecia numerous, scattered, soft, 80–100, reticulations distinct. Appendages five to fifteen, roughened, hyaline, two to six times the diameter of the perithecium or longer, short ones usually not branched, longer ones irregularly dichotomous, tips sometimes enlarged, sometimes irregularly lobed. Asci four to twelve, ovate to elliptical, pedicellate. Spores four to six.

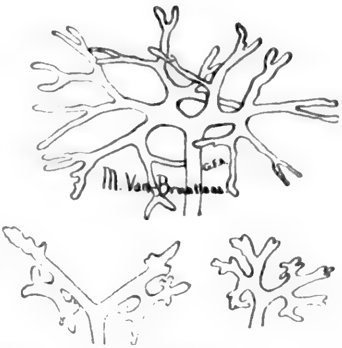
On *Euphorbia* (several species), Chapel Hill, N. C., autumn, 1885, 628; Auburn, Ala., November, 1889, 1023; June, 1890, 1143. This species is quite common throughout the greater part of the year. I have collected it maturing its fruit in January.

M. VAN BRUNTIANA Ger.

Syn. *M. Alni* Burrill, Bull. Ill. State Lab. Nat. Hist., Vol. II, Parasitic Fungi of Ill., p. 421 (in part).

M. Van Bruntiana Ger. Torr. Bull., Vol. VI, p. 31.

Amphigenous; mycelium abundant, rather thin and covering large part of the leaf surface, or in spots, persistent. Perithecia numerous, scattered or subgregarious, 90–100, reticulations distinct.



Appendages ten to sixteen, about equal to diameter of the perithecium or little longer, rough, slightly colored at base, stout, several times dichotomous, tips long and flexuous, or short and blount, sometimes toothed, never recurved. Asci four to five, 35–40 x 50–60, ovate, pedicellate. Spores four to eight, 18–20.

On *Sambucus Canadensis*, Blowing Rock, Watauga county, N. C., August, 1888, 615.

M. ALNI (D C.) Winter.

Amphigenous, or epiphyllous; mycelium abundant and persistent or thin and evanescent. Perithecia numerous, scattered, small, 80–100, black, reticulations rather distinct. Appendages eight to fifteen, one to two times diameter of perithecium, colored toward base, four to five times regularly dichotomous, tips incurved when mature. Asci four to five, oval, 30–45 x 50–70, pedicellate. Spores six to eight, about 20.

On *Castanea sativa*, Blowing Rock, Watauga county, N. C., August, 1889, 617. The asci are quite regularly eight-spored and larger than in the two following specimens. *Syringa*, Union Springs, Ala., May, 1890, 1146. (Sent by Rev. J. L. Moultrie). Asci six-spored. *Corylus Americanus*, Blowing Rock, Watanga county, N. C., August 24, 1888, 614. Asci six-spored.

These specimens do not represent the variation in numbers of asci in a perithecium (two to eight) nor spores in an ascus (four to eight) given by Burrill (*l. c.*). This is probably owing to the small number of hosts represented.

M. QUERCINA (Schw.) Burrill.

Amphigenous, sometimes entirely epiphyllous or hypophyllous, persistent or evanescent. Perithecia generally numerous and scattered, mostly small, 80–100–130, dark brown or black. Appendages eight to fifteen, from less than to three or four times the diameter of the perithecium, colored at the base, rough or smooth, four to five times dichotomously branched, branching regular and compact, or open or sometimes quite irregular, tips of mature specimens incurved, frequently an incurved tip is unpaired, its mate having divided and formed a pair of incurved tips. Asci three to eight, shape and size variable, 35–50 x 60–80, usually pedicellate. Spores two to eight, 20–30.

Var. *extensa*, appendages three to five times diameter of the perithecium, branching regular, compact; asci three to five, 45–50 x 65–70. Spores four to eight, 20–25. On *Quercus nigra*, mostly epiphyllous, Chapel Hill, N. C., autumn, 1885, 630.

Var. *abbreviata*, appendages about equal to diameter of the perithecium, branching open; asci three to eight, 40–50 x 60–70; spores four to eight, 20–30. On *Quercus nigra*, mostly hypophyllous, asci three to five, spores four to five, 30, Auburn, Ala., December 22, 1890, 1797; *Q. nigra*, hypophyllous, asci four to six, spores eight, Chapel Hill, N. C., autumn, 1885, 631; *Q. falcata* (*Q. triloba Michx*), amphigenous, mostly hypophyllous, branching appendages open and irregular; asci three to eight, spores six to eight, 25, Chapel Hill, N. C., autumn, 1885, 629; *Q. falcata*, hypophyllous, asci four to six. Spores four to eight, Columbia, S. C., October 13, 1888, 636.

Forms intermediate and varying to *M. Alni* (D. C.) Winter.

On *Quercus stellata*, amphigenous, mycelium dense, appendages one to two times diameter of perithecium, asci three to five, spores four to five, 25–30, Auburn, Ala., October, 1889, 1803; *Quercus rubra?* epiphyllous, appendages one to three times diameter perithecium, rough, asci three to five, 50–60 x 70–80, spores two to six, 30. Auburn, Ala., December, 1890, 1798.

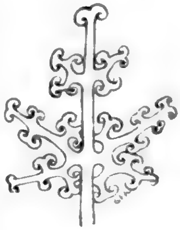
M. CALOCLADOPHORA Atkinson.

Syn. *M. densissima* E. & M. Journal Mycology, Vol. 1, 1885, p. 101.

M. densissima E. & M. N. A. F. No. 1538.

M. densissima Sacc. Sacc. Syll. Addit., p. 2 (in part).

Hypophyllous, mycelium thin, diffuse, or in orbicular patches, dense. Perithecia scattered, black, rather stout, 100–140, reticulations rather distinct. Appendages one to two times diameter of the perithecium, percurrent, primary branching opposite or nearly so, branches dichotomous, tips incurved, some of the tips unpaired as in *M. Quercina.** Asci four to six, ovate or elliptical, pedicellate, 35–40 x 65–80. Spores six to eight, 20–25, granular. Through the kindness of Dr. Charles Peck I have had the opportunity of examining specimens of *M. densissima* (Schw.) Peck. The specimens are very distinct from those of *M. densissima* E. & M. The appendages are dichotomous throughout and the orbicular patches of the mycelium are very different. The specimens in N. A. F. No. 1538 agree perfectly with those I have collected except that the mycelium is in orbicular patches, and more dense. This, however, is a very common variation in a number of species.



Some might think this species deserving to be the type of a new genus from the character of the appendages, but the dichotomous branching of the branches shows its close relationship to *Microsphæra*.

On *Quercus aquatica*, Columbia, S. C., October, 1888, 618; Auburn, Ala., December, 1890, 1804.

*This is not a peculiarity of the tips of specimens on oak. I have noticed it in *M. Alni* on *Syringa*.

LIST OF WORKS CONSULTED.

Berkeley—Grev. Vol. IV, 1876.

Burrill—Parasitic Fungi of Ill., Part II, Art. VI, Bull. Ill. State Lab. Nat. Hist., Vol. II, 1887.

Cooke—Grev. Vol. XI, p. 36, 1882.

Ellis—Jour. Mycol. Vol. II, p. 43, 1886.

Ellis & Martin—Jour. Mycol. Vol. I, p. 101, 1885.

Gerard—Torr. Bull. Vol. VI, p. 31, 1875.

Léveillé—Ann. Sci. Nat., Ser. III, T. XV, 1851.

Massee—Grev. XVII, p. 76–78, 1889.

Ravenel—Fung. Carol. Exsic, fasc. 4, No. 68.

Tracey & Galloway—Bot. Gaz. Vol. XIII, p. 29, 1888.

Saccardo—Syll. Fung. Vol. I, p. 9, Vol. II, Addend., p. 9., and Addit. p. 2.

Winter—Die Pilze. Rab. Krypt. Flora., 1888.

EXPLANATION OF FIGURES IN PLATE I.

Microsphæra Euphorbiæ B. & C. (from Alabama).

Fig. 1, Perithecium with appendages.

Fig. 2, End of appendage quite evenly branched four to five times.

Fig. 3, End of appendage quite unevenly branched.

Fig. 4, Asci.

Uncinula polychæta (B. & C). Massee.

Fig. 5, Perithecium from Buenos Ayres, S. A.

Fig. 6, Asci from Fig. 5.

Fig. 7, End of well coiled appendage of same.

Fig. 8, End of incurved appendage of same.

Figs. 9. and 10, Asci from specimen from South Carolina.

Fig. 11, End of well coiled appendage of same.

Microsphæra semitosta B. &. C. (from Alabama).

Fig. 12, Two perithecia.

Fig. 13, Ascus containing four spores.

Fig. 14, End of appendage.

All of the figures were drawn with aid of camera lucida, and the plate then reduced one-half in length and width in the process of photo-engraving.

Figs. 1, 5, 12 and 14 drawn by objective *A A* and compensation ocular 12.

Figs. 2, 3, 4, 6, 9, 10 and 13, objective *D*, comp. ocular 4.

Figs. 7, 8 and 11, objective *D*, comp. ocular 12.

Zeiss microscope used.

THE PROPER STANDARD FOR THE ATOMIC WEIGHTS.

BY F. P. VENABLE.

Among the important questions attracting the attention of chemists to-day is that of the proper standard to be adopted for the atomic weights. It is a question whose settlement cannot be much longer postponed without injury. It must be settled by careful consideration on the part of associations and individuals, and then by general usage—a sort of majority vote. I therefore venture to bring the question in its present status to the attention of chemists, asking a careful, thoughtful discussion and consideration of it.

Two elements lay claim to the position of standard for all other atomic weights, hydrogen and oxygen. Hydrogen is called by Meyer and Seubert the Dalton-Gmelin unit and oxygen the Wollaston-Berzelius unit. The contention is an old one then, and first one then the other has been forced to give way in the struggle. For a long time oxygen was the accepted standard of the only approximately accurate atomic weights—those of Berzelius. It was then displaced by hydrogen, and this element has so fixed itself in the literature that it cannot well be in turn displaced as the unit. But I would make a careful distinction between unit and standard. To make a radical change now would be inconvenient and difficult, and should be done only under stress of absolute need. When one considers the difficulty and tediousness of becoming accustomed to new numbers and the decrease in value and intelligibility of all the literature in the old notation that would follow a change of unit, one can properly realize the cost of such a change.

We are closing a century's labor, however, and a century's history, and it is important that we should come to some agreement on this point, and so be in a position to confer some degree of constancy upon our so-called constants. As it stands now each revision, or redetermination, is calculated by two standards, and the individual chemist is left to choose between them at his own sweet will. There is no necessity for this, and it is a blot upon our science. Other sciences, notably electricity, are getting their standards in order, their loins girt, as it were, for the race of the twentieth century. We must settle this question, as well as others, if we would move freely in the grand onward march.

The best settlement comes, as is often the case, in the way of a kind of compromise. Let oxygen be the standard and hydrogen practically the unit. This reduces the changes to the least possible, and tables arranged on this basis have been in use a long time. In fact, it was only with the idea of securing greater accuracy that this arrangement was ever changed. The use of $O = 15.96$ as a factor for calculation appeared about the time of the first appearance of Meyer's work on the Modern Theories of Chemistry, and is mainly due to his instrumentality. The pursuit of accuracy in that direction has proved an *ignis fatuus*, and the necessity for something more fixed becomes every day more and more apparent.

The extent of this need impressed me greatly while studying the various recalculations of the atomic weights as made by Clarke, Meyer and Seubert, Sebelien and Ostwald, and led to an article on the subject first published by the Elisha Mitchell Scientific Society, and afterwards by the *Chemical News* and the *Journal of Analytical Chemistry*.* This seems to have been the first article published in the discussion, but to Dr. Brauner, of Prague, belongs the credit of arousing the discussion which was carried on in the Berichte of the German Chemical Society during 1889, and which was participated in by Ostwald, Meyer and Seubert, and Brauner.† Meyer and Seubert alone opposed the adoption of $O = 16$ as the standard.

*See Vol. III, p. 48.

†See also Chem. Zeit. 1890, No. 13, where Dittmar says: "Ich wage zu hoffen dass diejenigen Chemiker, welche seither, nachdem sie die Ueberzeugung gewonnen hatten dass O:H kleiner ist als 16, darauf bestanden haben, dass $H = 1$ als einheit fur die Atomgewichte festgehalten werden musse, dese absurde Praxis aufgeben und die 16 Theil des Atomgewichtes des Sauerstoffs als einheit adoptiren werden."

Without dwelling separately on these articles, or the arguments adduced on one side and the other, I shall content myself with trying to state clearly the reasons for adopting O = 16 as the standard. Were it a mere matter of sentiment, of securing a larger number of integers in the table of atomic weights, or something of that kind, I think all will agree with me that the change would be mere folly. Such men as Ostwald and Brauner would not waste time quibbling over anything so insignificant. There must be and is something deeper, and it is strange to me that Meyer and Seubert seem unable to see the true point of contention.

The facts of the case are as follows: Hydrogen, as having the least atomic weight, seems, at first sight, the most appropriate unit for measuring the others. It admits of all being represented by numbers greater than unity, and none of them of such inconvenient size as in the Berzelius table with O = 100. If we could determine the ratio of the other elements to hydrogen directly, that is, if their atomic weights were determined by means of hydrogen, and hence were directly dependent upon this as unit, there would be nothing further for us to desire. Unfortunately, very few such direct ratios can be secured. Only three or four have been determined.

Under these circumstances, two things are possible. First find the ratio between hydrogen and oxygen, then, using this as a factor, calculate the other atomic weights. Could we find this ratio absolutely, there would be no objection to this method, but it is impossible to eliminate or allow for personal and experimental errors. The ratio found can at best be but an approximation. Evidently, by using an approximation to calculate other approximations, we get further and further from the truth. As Ostwald has said, we are introducing totally uncalled for and unnecessary errors, and he is right in styling it, in this stage of our science, a barbarism. As Brauner has pointed out these errors can easily amount to several integers in the higher atomic weights.

It is not for lack of skilled workers to undertake the determination of this ratio. Much excellent work has been done upon it, and especially in the last two or three years. Ostwald has summed these up, and says there is an error of at least 0.3 per cent. which has not been removed by recent workers. Brauner agrees with him that the variations are irreconcilable, and though Meyer and Seubert think the ratio can vary but little from that assumed by them as justifiable by the best determination, it is manifestly a point on which the best authorities differ and hence one of uncertainty.

Why should we then make use of the number 15.96 if it is not fixed by incontrovertible, unerring, universally accepted experiments? It makes the matter no whit better for Meyer and Seubert to profess their willingness to recalculate their table should a change in the number 15.96 prove necessary. It is merely a confession of the insecurity of their own position. We do not wish any recalculation. We wish a standard by which the calculations can be made once and for all, one that will give us the least possible error and is itself independent of other calculations. The present use of the double standard 15.96 and 16 seems puerile and leads to all manner of inaccuracies.

The second possibility is to use oxygen as the standard.

The question reduces itself, then, really to this: Shall we use O = 15.96 or O = 16? For oxygen must be used from very necessity. If O = 15.96 is not the absolute ratio or is not generally accepted as such then the reason for its use ceases.

It is not necessary to bring forward arguments as to the relative convenience of the two, nor as to their effect upon the periodic law. Such arguments have little weight or significance when it is seen that the question lies between O = 15.96 and O = 16, and that hydrogen can never be the actual standard or factor from purely chemical reasons. Nor yet is there much in any argument from analogy with other standards and units. Such only lead us away from the one all-important consideration—the avoidance of unnecessary errors.

I have said that the present proposition could be looked upon in the light of a compromise. If oxygen takes the place of hydrogen as standard, what falls to the share of the latter element? If oxygen were made 100, as in the Berzelius table, or 10 or 1, as have been proposed, then the present numbers, as referred to hydrogen, would be entirely changed and lost sight of. The plan is to change them as little as possible, giving oxygen the number sixteen, which was once regarded as the ratio between it and hydrogen, and, according to the views of some, may still be it. Then the number for hydrogen will vary very little from unity, and the whole table is nearly based upon it as the unit. This number will change from time to time with new determinations, but such changes will involve no others. Oxygen, the standard, will then be fixed, and our task lies in the accurate determination of the others by it.

Meyer and Seubert cling to the idea that if oxygen be adopted it must be taken equal to unity, maintaining that $O = 16$ is neither flesh nor fowl, and by no means a unit. It is true that the standard or basis of a series of physical constants has in the past usually been taken equal to unity, but I cannot conceive the power of this habit to be sufficiently strong to force us into inconveniences or inaccuracies. That it is not regarded as a binding rule has been shown by the choice of some recent standards, especially in the new science of electricity.

The atomic weights are but relative numbers. To be in any respect constants, they must be relative to but one single element. With but few exceptions the ratio to oxygen can be determined. In revision of atomic weights, then, this should receive the chief attention and the oxygen ratio should be most carefully and directly determined.

Where the intermediation of another element is made use of (even though this be one which "may be counted among those of which the atomic weights are already known with the nearest approach to exactness," as Dr. Mallet recommends) it must be borne in mind that the result is subject to a certain error, which is generally multiplied several times and hence cannot give concordant results with the direct oxygen ratio, and less stress must be placed upon it. If the well determined ratio $H:O$ is subject to an error of 0.3 per cent., how much greater is the error in the case of ratios less well known?

THE ACTION OF PHOSPHORUS UPON CERTAIN METALLIC SALTS.

BY GASTON BATTLE.

The action of phosphorus upon solutions of copper sulphate has been examined with some detail.* The precipitates given with certain metallic solutions by phosphorus dissolved in carbon bisulphide have also been noted.† But no account could be found of any research upon the prolonged action of phosphorus upon aqueous solutions of the ordinary metallic salts.

An investigation of these changes was, therefore, begun but interrupted and finally finished under pressure for time, consequently it cannot be looked upon as complete or satisfactory and is reported only to show the progress made and to place on record whatever new facts were observed. The solutions experimented upon and the results were as follows:

1st. *A solution of Silver Nitrate.*

The phosphorus was added in thin shavings and the whole placed in the dark. On the first day needle-like crystals were formed. By the third day these had lost much of their lustre and a dirty white residue began to be formed. On the fourth day a heavy spongy mass had formed over the phosphorus.

Qualitative tests showed the presence of nitric, phosphoric, and phosphorous acids in the liquid and in the solid residue silver and silver phosphide. A quantitative analysis gave 99.19 p. c. of silver. These tests were made after the solution had stood two months or more, and show that the silver was almost perfectly reduced from solution.

2d. *Solution of Potassium Bichromate.*

After two months' standing of a dilute solution of this salt over phosphorus it had turned green and there was a dirty greenish deposit over the phosphorus. The excess of phosphorus was

*Compt. Rend. 84, 1454. This Journal, Vol. II, p. 57.
†Zeit. Chem. IV, 161.

removed from the solid by washing with carbon bisulphide, and on analysis gave:

p. c. Cr = 21.98.
p. c. P_2O_5 = 29.20 or p. c. P. = 11.34.

The liquid contained both acids of phosphorus, chromic acid-potassium and chromium. Unfortunately the condition of the phosphorus in this residue was not determined. The amount on hand was insufficient and the changes took place too slowly for another supply to be secured. If possible the reaction will be investigated more closely at some subsequent time. Another solution exposed for a shorter period gave a brownish deposit which yielded an analysis

p. c. Cr = 41.48.
p. c. P_2O_5 = 7.96 or p. c. P. = 3.47.

3d. *Solution of Ferric Chloride.*

A very slight precipitate was given after standing several days. Finally a whitish pasty precipitate settled to the bottom. After washing, drying and powdering the color was yellowish white.

Much iron was left in solution along with hydrochloric and phosphorous acids. The dried precipitate contained

p. c. Fe = 42.90.
p. c. P. = 13.17.

This approximates to Fe_2O_3. 3 Fe PO_4. The drying was done at 115° C. and the precipitate was possibly not entirely dried. It can only be definitely stated then that a basic phosphate of something like the above composition was formed.

Phosphorus placed in a solution of ferrous sulphate became covered with a black, soot-like deposit which seemed to be iron phosphide.

4th. *Solution of Mercuric Chloride.*

A white precipitate was formed within the first twelve hours. This increased with time and proved to be mercurous chloride. The usual oxidation of the phosphorus took place and its oxy-acids could be detected in the solution.

When a solution of mercuric sulphate was used instead of the chloride a blackish deposit containing mercury and phosphorus was gotten and at the same time much metallic mercury was formed, showing a complete reduction.

A number of other solutions were tested in the same way, but lack of time prevented a thorough examination. No effect was noticed in the case of antimony chloride, bismuth nitrate, chromium sulphate, titanium chloride, manganous sulphate, sodium tungstate, zinc sulphate, potassium chromate and cobalt sulphate; with nickel sulphate a green amorphous deposit was gotten, containing nickel and phosphorus; with potassium permanganate a dark, heavy, green deposit was obtained; with lead acetate a white deposit, containing lead, and acetic and phosphoric acids; with uranium acetate there seemed to be first an oxidation of the phosphorus to phosphoric acid, this precipitating uranium in the well-known way. No phosphoric acid could be detected in the solution above the yellow deposit. In the case of ammonium molybdate the liquid went through many changes of color, indicating the stages of reduction, but the resulting products were not closely examined. This, then, cannot be looked upon as a report of work finished, but rather of work interrupted and necessarily given up for the present. The examination of these changes more thoroughly offers much of interest, and will be taken up again when opportunity offers.

The reducing action of phosphorous acid upon metallic solutions is known and often quoted. The formation of phosphorous acid is most probably an intermediate step here and the reactions are to be accounted for by its presence.

Chemical Laboratory U. N. C., May, 1890.

LEAD CHLORO-BROMIDES.

BY F. P. VENABLE.

The double compounds of the halogen salts of lead have commonly very simple and regular formulas assigned to them, often as if they occurred only with equal proportions of the constituents. In some previous work upon these compounds* it was seen that in several classes of compounds, at least, this was not the case. As a contribution to our knowledge of this combining power of lead some further experiments were tried upon the chloro-bromides of lead and the results are given in detail.

First Experiment. In the first experiment 13.2 gm. of lead bromide and 5 gm. of lead chloride were dissolved in hot water. This is in the proportion of two parts of bromide to one of chloride. A very small portion, less than one-tenth of a gram remained undissolved. Three crops of crystals were gotten from this. The following percentages of lead were obtained on analysis:

1st Fraction 62.48: 3 Pb Br_2. 2 Pb Cl_2 has 62.41 p. c. lead.
2d Fraction 64.80: Pb Br_2. Pb Cl_2 has 64.14 p. c. lead.
3d Fraction 62.50: 3 Pb Br_2. 2 Pb Cl_2 has 62.41 p. c. lead.

On evaporating further on a water bath three more crops of crystals were gotten.

4th Fraction contained 60.26: 3 Pb Br_2. Pb Cl_2 has 60.42 p. c. lead.
5th Fraction contained 59.48: 4 Pb Br_2. Pb Cl_2 has 59.26 p. c. lead.
6th Fraction contained 59.09: 5 Pb Br_2. Pb Cl_2 has 58.71 p. c. lead.

The next crop of crystals gotten on further evaporation was very evidently lead bromide mixed with a few crystals similar to fractions 5th and 6th.

Second Experiment. Two parts of chloride were taken to one of bromide. Four fractions of crystals were gotten and the percentage of lead in them determined.

*This Journal, V, 10.

1st Fraction contained 64.50; $PbBr_2$. $PbCl_2$ has 64. 14 p c lead.
2d Fraction contained 64.76: $PbBr_2$. $PbCl_2$ has 64.14 p. c lead.
3d Fraction contained 66.34: 2 $PbCl_2$ $PbBr_2$ has 66.16 p. c. lead.
4th Fraction contained 69.11: 3 $PbCl_2$. $PbBr_2$ has 68 97 p. c. lead.

When it is remembered that these various crops of crystals cannot be thoroughly washed and purified because of the ease with which they are usually decomposed by water, and furthermore that there is no probability of procuring absolutely distinct crystallization from one fractionation, the variations between calculated and observed numbers in the analyses will not appear large.

Of course it cannot be absolutely maintained from the agreement of the analytical numbers with those for certain formulas that such and such compounds were obtained. But the fact that these were well-formed crystals and that not even the magnifying-glass could reveal evidences of mixing lends strong probability to the view that lead chloride and lead bromide have the power of uniting in a great many distinct proportions, depending upon the relative amounts in solution and perhaps upon other factors, such as concentration and temperature.

That the crystals were very similar in appearance in all cases makes the solution of the question of the actual existence of these various compounds more difficult. It is hoped that some other double compounds may be found which lend themselves better to the decision of the question.

LEAD BROMO-NITRATES.

BY H. L. MILLER.

A solution of lead nitrate, containing also some lead bromide, on standing and slowly evaporating gave handsome clumps of needle-like crystals very different in appearance from crystals of lead bromide. Some of these were collected, washed, dried and on analysis gave 33.05 per cent. of bromine.

Attempts were then made to prepare this compound and so by determining its method of preparation and by further analyses to decide whether it could be called a definite compound or not. Three grams of lead nitrate were dissolved in hot water and ten grams of lead bromide added. The whole was filtered hot and allowed to cool. The bromide (as judged by the appearance of the crystals) crystallized out with very little admixture of nitrate.

Next a saturated solution of lead nitrate was taken and lead bromide dissolved in it while hot in such amount that it did not crystalize out immediately on cooling. Four crops of crystals were gotten from this mixture on its slow evaporation. These presented very much the same appearance, that of stellated groups of needle-like crystals.

On analyzing these after drying at 100° the following results were obtained:

1st	Crop	percentage	bromine	41.23.
2d	"	"	"	36.75.
3d	"	"	"	33.40.
4th	"	"	"	34.68.

There are reasons for thinking this last analysis faulty as the amount of substance at command was insufficient.

The percentage of bromine in lead bromide is 43.58; in $Pb\ (No_3)_2.\ 5\ Pb\ Br_2$ it is 36.92, in $Pb\ (No_3)_2.\ 3\ Pb\ Br_2$ it is 33.50.

The first crop of crystals then contained only a small amount of lead nitrate and this amount increases with each subsequent crop, approaching nearly to two definite compounds as far as the analyses can point out. It is of course highly improbable that one could secure pure compounds by one such fractional crystallazation, but the fact that figures approximately corresponding to $Pb\ (No_3)_2.\ (Pb\ Br_2)_3$ were obtained in each of the two experiments certainly affords ground for believing that such a compound is formed.

CHEMICAL LABORATORY U. N. C., May, 1890.

ADULTERATED SPIRITS OF TURPENTINE.

A CONVENIENT METHOD FOR DETECTING AND FOR ESTIMATING PETROLEUM IN SPIRITS OF TURPENTINE.

BY SAMUEL J. HINSDALE.

Put ten drops of the spirits to be examined in a (moderately concave) watch glass, and float the glass on about a quart of water which has a temperature of about 170° F. If the spirits is pure it will evaporate and leave the glass quite dry in seven minutes. If the spirits contains even five per cent. of petroleum it will not have completely evaporated in that time.

This experiment will prove the absence or presence of petroleum in the sample.

To estimate the *percentage* of petroleum, weigh a watch glass and put into it ten drops of the mixture, and weigh again. Put into another glass ten drops of pure spirits of turpentine and float both glasses on about a quart of water at about 170° F.

As soon as the pure spirits has evaporated take off the glass which contained the mixture and weigh it. The difference between this weighing and the weight of the glass will indicate the amount of petroleum in the mixture. Knowing the weight of the ten drops, the percentage can be calculated.

A bent loop of wire is convenient to place on and remove the watch glass from the water.

The hydrometer will detect adulteration with benzine or petroleum, but it cannot be used to estimate the amount of adulteration.

The specific gravity of pure spirits of turpentine is about 0.865.

Petroleum is the usual adulterant.

FAYETTEVILLE, N. C.

OCCURRENCE OF GOLD IN MONTGOMERY COUNTY, NORTH CAROLINA.

BY J. M. MOREHEAD.

In his Geological Report of the midland counties of North Carolina* Dr. Emmons says, concerning the origin of the gold in the Uharie Mountain region of Montgomery county:

"One of the most interesting instances of the occurrence of gold in consolidated sediments is at a place called Zion, twelve miles from Troy." And again in a following paragraph: "The gold which has been obtained was derived from the *debris* of the rock, but the rock itself sometimes shows particles of gold"; and further, "notwithstanding the evidences there are of the sedimentary origin of the gold it is a curious and interesting fact that it is visible in seams which traverse the rock."†

These quotations and the context show clearly Dr. Emmons' opinion to have been that the gold of the gravel of this region was deposited as a sediment contemporaneous with the rock, and along with the subsequent processes of weathering of the rock and the formation of the deposits that the gold which was formerly distributed in finer particles through the rock, later by the segregating process collected into larger particles and nuggets.

From observations made during the past summer at the Sam Christian Gold Mine and vicinity near Zion I am led to doubt the correctness of this opinion and to believe rather that at least much the larger part, if not all, of the gold found in these gravels came from the numerous small quartz veins which traverse the region in a N. W. by S. E. course and with a nearly vertical dip.

The reasons for this belief are as follows: No gold of any consequence has ever been found in places where there were no evidences of quartz veins either broken down or intact. The

*North Carolina Geological Survey, Emmons, New York and Raleigh, 1856, p. 135.
†Same as above, pp. 135-136.

gold is generally found in the immediate proximity of these broken down quartz veins or down, never up, the slope from them. In several cases good-sized nuggets have been found in the veins themselves. Large nuggets have been found with the edges sharp and angular, showing very conclusively that they had not been transported any distance by water. Quite a number of small nuggets have been found attached to fragments of the vein quartz.

These facts show that the larger part, if not all, of the gold of this region first occurred in the small quartz veins, and that with the breaking down of the veins the gold and the vein quartz settled down into and formed part of the gravel in the immediate vicinity or below it, and not, as Dr. Emmons had supposed, that the gold found in the gravels had existed originally in the country rock in minute quantities on a sedimentary deposit.

The Sam Christian Gold Mine property lies among the hills at the southern end of the Uharie Mountains. The characteristic rock of the region is quartzite in places quite cherty and so thoroughly altered as to leave the original bedding in places quite obscured. Here and there these rocks, everywhere quite obdurate, rise into steep and irregular hills traversed by numerous quartz veins, the great majority of which are small, but a few of which are several feet in thickness, though quite irregular. Only a few of the large, many of the small veins are gold-bearing. In depressions ("channels") on the slopes of these hills lies the auriferous gravel one to four feet thick, composed of numerous irregular angular fragments of vein quartz and a larger proportion of quartzite of from very small size to two feet and more in diameter and with a matrix of gritty sand, with a small portion of clay. These gravels lie on the irregular surface of the country rock and are in turn overlaid by one to six feet of a gravelly loam soil. The origin and distribution of the gravels has been due largely, if not entirely, to frost action.*

---

*Kerr, American Journal of Science, May, 1881 (reprinted as Appendix C, Ores of North Carolina, 1888, p. 329). Also Transactions American Institute Mining Engineers, Vol. VIII, p. 462 (reprinted as Appendix A in Ores North Carolina, 1888, p. 321).

MINERALOGICAL, GEOLOGICAL AND AGRICULTURAL SURVEYS OF SOUTH CAROLINA.*

BY J. A. HOLMES.

CONTENTS.

INTRODUCTION.

Several years ago, under instructions from the Director of the United States Geological Survey, the writer undertook the collection of materials for an historical sketch of the scientific surveys of North and South Carolina.

Records relating to such surveys in the first named of these States were found to be fairly well preserved, and an historical sketch of these surveys was prepared in 1888, and an abstract of the same was published in this Journal, Part I, for 1889. But the records relating to such surveys in South Carolina have been imperfectly preserved, and the collection of material for the following sketch has involved a considerable amount of labor, a large part of which has been attended with unsatisfactory results.

Nearly all of the citizens of the State who were interested in such matters during the surveys of Ruffin and Tuomey (1843–'47) have since passed away; and, although Lieber's survey (1856–'60) came at a later date, this was immediately followed by the civil war, during which Lieber him-elf was killed, and many of the records of the survey destroyed. Moreover, the thoughts of the citizens of the State were then drawn in other directions with such intensity that the details concerning a scientific survey were seemingly forgotten beyond recall.

*Published by permission of the Director of the U. S. Geological Survey.

Nevertheless, by applying to several hundred of the older citizens of the State, I have secured a considerable amount of information that could not otherwise have been obtained.

Among those who have contributed most to the supply of information, it is but just that I should mention the names of Professor L. R. Gibbes, of Charleston; the late Dr. H. W. Ravenel, of Aiken, and the late Col. James H. Rion, of Winnsboro.

The writer has in preparation also a sketch of the early geographical surveys of the Carolinas, but this is not yet ready for publication. Of the State surveys in South Carolina bearing on Mineralogy, Geology and Agriculture there have been made three that deserve consideration in the present sketch. These are in the order of their occurrence: The Vanuxem Geological and Mineralogical Tour (1825–'26), the Ruffin-Tuomey Agricultural and Geological Surveys (1843–'47), and the Lieber Geological, Mineralogical and Agricultural Survey (1855–'59).

Vanuxem Survey (1825 and 1826).

The survey by Professor Vanuxem deserves special consideration mainly by virtue of its early date, it having been preceded by but one of the State surveys, as far as I am informed—the Olmsted Geological and Mineralogical Survey in North Carolina (1824–'25).*

It may be considered as a geological and mineralogical tour through the counties (then called districts) in the upper portion of South Carolina. These tours were made by him during his vacations while he was connected with the South Carolina College as Professor of Geology and Mineralogy, during the years 1825 and 1826.

The survey was originated in the following manner: Lardner Vanuxem was elected Professor of Geology and Mineralogy in the South Carolina College in December, 1821, on a salary of $1,000 per annum. In April, 1824, he tendered his resignation

---

*See Jour. Elisha Mitchell Soc., 1889, Part I, pp. 5-8.

(to take effect in December following) on account of the insufficiency of the salary paid him. In the meantime, however, it was suggested to him by members of the Board of Trustees that there might arise an opportunity for him to make a geological and mineralogical survey of the State and thereby have his salary increased. Accordingly he indicated to the Board of Trustees his willingness to act on the suggestion and outlined the proposed work of the survey in a letter, of which the following is an extract:*

This idea I find meets with the sanction of many of the members of the Legislature;and it is thought that an application for funds for this purpose from your Honorable Board would meet with little or no opposition from the Legislature; I therefore request you, Gentlemen, before accepting my resignation to consider the propriety and expediency of making said application. I propose, Gentlemen, to make a thorough examination of *each District* of the State, as to its Rocks, Minerals and Fossils. To collect specimens of every different kind that comes under notice in the different Districts; and to arrange the same by *Districts* in the South Carolina College, giving to each specimen its *name* and its *location*. Likewise to mark on the map of the State the rocks as they exist, and also such valuable minerals as may have been noticed. As the mineral history of the State will be interesting at home and abroad, it is a part of my plan to prepare a work of the kind. It is thought that an examination of the State in the manner aforementioned, would occupy three years; giving to each year about six months, or as much of my time as could with convenience be taken from my present duties.

After consultation with Professor Vanuxem the Board of Trustees recommended to the General Assembly that he be placed "on equality with the other professors in point of salary and that he be required to perform the additional duties of a Geological and Mineralogical Survey of the State by Districts, collect and arrange the specimens, as proposed in his communication, during the summer months."†

The result of the above action was the insertion into that part of the appropriation bill for 1825, relating to the South Carolina College, the following: "* * * For the salary of the

*MS. Minutes of the Board of Trustees of the South Carolina College, 30th November, 1824, now in the College Library, Columbia.

†MS. Minutes of the Board of Trustees of the South Carolina College; proceedings of December 1 and 6, 1824, now in the College Library, Columbia.

Professor of Geology and Mineralogy, one thousand dollars; and five hundred dollars for making a Geological and Mineralogical Tour during the recess of College, and furnishing specimens of the same";* also the appropriation of a like amount for the year 1826.†

After 1826 the appropriation of the $500 for the support of the survey was discontinued. In November, 1827, Professor Vanuxem resigned his connection with the South Carolina College to accept a lucrative position as superintendent of a gold mine near the City of Mexico.‡

Concerning the extent and character of Professor Vanuxem's work and his methods of operation, we are left largely to conjecture, as but little information has been left on record. But as based upon the data given above and in the records referred to, the following statement may be considered as substantially correct:

The work of the survey extended over two years, occupying about one-half of each year.§ During this time Professor Vanuxem was regularly connected with the South Carolina College as Professor of Geology and Mineralogy and the remainder of his time was give to teaching work; and, indeed, his work on the survey was regarded as a part of his college duties. To his regular college salary of $1,000 per annum, the sum of $500 per annum was added for making the survey; and out of this additional $500 a year, or $1,000 for the two years thus added to his salary, Professor Vanuxem bore the entire expense of the survey.

Thus limited in time and money, working alone, with the science of Geology in its infancy, and with organized geological surveys almost unknown, but little could have been expected in the way of methods and results from the survey. It was in reality but a mineralogical or geological "Tour" or series of tours

---

*Laws of South Carolina, 1824.

†Ibid., 1825.

‡LaBorde's History of South Carolina College, Revised Edition, 1874, pp. 138-143, gives a brief sketch of Professor Vanuxem and his connection with the South Carolina College.

§In a letter dated March 29, 1845 (LaBorde's Hist. S. C. College, 2d Edi., p. 141), Professor Vanuxem alludes to the "only year given to the survey of the State," but he here probably refers to the two halves of two years.

through some of the Piedmont counties of the State (portions of Abbeville, Pickens, Spartanburg and York, and perhaps also of Pendleton and Greenville), during which Professor Vanuxem examined in a superficial way the rocks and various important mineral deposits which he found in these regions, and collected more than 500 specimens, which he placed in the cabinet of the college.

As a further result of his work, he located on a copy of the State map* the characteristic rock formations over which he passed in making his explorations, and also published them in *Mill's Statistics of South Carolina*, 1826, pp. 25-30.†

No formal report of his survey is now to be found, or was probably ever published other than this list. He subsequently presented a copy of his report, probably in manuscript, to Mr. Tuomey, who describes it as "little more than a descriptive catalogue of the rocks and minerals collected."‡

His work doubtless stimulated the search for valuable minerals among some of the citizens along the line of his tours; and his map and collections of specimens added to the teaching facilities of the college. But other than as to these general points there is little to be said as to the beneficial results or additions to science resulting from the survey. As to this latter point, however, it must be added that at some time during his stay in South Carolina Mr. Vanuxem determined the post-pliocene age of the deposits underlying Charleston, and along with Dr. Morton, in 1829,§ he pointed out the existence of tertiary formations in the eastern portion of the State.||

Ruffin Agricultural Survey, 1843.

The establishment of this survey, near the close of the year 1842, was "due to a movement altogether agricultural."

*As early as 1845 this map and many of the specimens had disappeared from the college cabinet. (LaBorde's History S. C. College, p. 141). All the specimens have since disappeared.

†See also Tuomey's Geology of South Carolina, 1848, Appendix, pp. XXXI and XXXII.

‡Tuomey's Report on the Geological and Agricultural Survey of S. C., 1844, p. IV.

§Silliman's Journal, July, 1829, pp. 254-256. Jour. Phil. Acad. Nat. Sci.

||For further discussions of Professor Vanuxem's life and work see LaBorde's History S. C. College, 1874, Revised Edi., pp. 138-143; Silliman's Journal of Science, May, 1848, pp. 445-446.

For a decade and more previous to this date the more intelligent planters in South Carolina had become deeply interested in the recent improvements of modern agriculture. A number of agricultural societies were organized in different regions of the State, and here these planters met together for discussions of various topics relating to their profession. The doctrines of modern agricultural chemistry concerning soils; the adaptability of crops, manures, and especially calcareous manures (marls, etc.), were taking root among a few of the more intelligent planters; but they felt the need of more information and of having some better informed person show how to put these doctrines into practice.

For several years an agricultural and geological survey of the State had been advocated by R. W. Roper, chairman of the legislative committee on agriculture; and now the demand for such a survey had become quite extended. Accordingly at the session of the Legislature of November and December, 1842, Governor James H. Hammond, one of the more intelligent and progressive planters in the State, in his annual message to the Legislature, urged the establishment of such a survey, and his recommendation was seconded by memorials from several of the agricultural societies (S. C. Agricultural Society, Wateree Agricultural Society and Milton Laurens Agricultural Society).

In December* (1842) the General Assembly authorized the establishment of an "Agricultural Survey of the State, * * * for the examination of our soil, discovery and application of marl lime, and developing all other resources and facilities of improvement"; and "as a means of testing this salutary measure," appropriated the sum of $2,000 a year for two years, authorizing the Governor to appoint the surveyor, "who shall report all geological information which may be incidentally collected."

It was further authorized in the establishing act that the results of each year's survey be reported to the Legislature, and that copies of the reports be distributed to every agricultural society in the State.†

---

*Dec. 14, in the House of Representatives, and Dec. 17, in the Senate.
†Extracts from the Acts of South Carolina, 1842, pp. 92 and 93.

Soon after the passage of the above act, Governor Hammond appointed to the position of "Agricultural Surveyor for the State" Mr. Edmund Ruffin, of Virginia, who, early in the year 1843, assumed the duties of his office.

A word or two will suffice to show the fitness of the appointment. It was Mr. Ruffin, who, in 1818, had discovered the agricultural value of marl and other calcareous manures, by the use of which the producing capacity of much of the land in Eastern Virginia was nearly doubled. In 1832 he published his "Essay on Calcareous Manures," which soon passed through three editions and was widely circulated. From 1832 to 1842 he edited and published the *Farmers' Register*, an agricultural periodical, which had a wide circulation and exerted an important influence, especially in Eastern Maryland, Virginia and North Carolina. In all of his writings Mr. Ruffin advocated the improvement of soils by drainage, by use of manures of all kinds, and especially by the use of marls and lime; and his opinions were based upon the fact that by the use of marl he and his neighbors in Virginia had nearly doubled the productive capacity of their lands.

All of this gave Mr. Ruffin a reputation second to none in the South Atlantic States in matters pertaining to agriculture.

In South Carolina a few leading planters, among them Governor Hammond, under the guidance of Mr. Ruffin's advice, had begun to use marl extensively and with success. It was believed that marl existed in abundance over the eastern part of the State, but a general ignorance prevailed with regard to it, and it was especially desired that the agricultural surveyor should examine this region and show the people where marl existed, and how to procure and use it.

Mr. Ruffin's appointment was then in every way a suitable one; and he accepted it for one year with the understanding that he should "direct his efforts, for the most part, to discovering and examining the beds of marl and other calcareous deposits, and urging their use upon the people of the State."* He devoted the

*DeBow's Rev. O. S., Vol. XI, 1851, p. 435.

year to this work, and at the end of the year he resigned and returned to Virginia. His work met with popular favor, and it was generally regretted that he could not be induced to continue it longer.

His methods of operation were simple. The occurrence of marl being limited to the eastern or southern half of the State (the coastal plain region), his work was largely confined to this area, all portions of which he traversed in search of marl, shell-rock and other sources of lime, and in explaining their use to the planters.

In locating marl beds he used (1) a long auger, boring through the overlying soil; and in some cases (2) a steel gouge attached to the end of a long measuring rod; in still other cases (3) he had holes dug through the overlying soil with ordinary farm tools; occasionally supplementing these methods by searching along the banks of creeks and larger streams. The presence or absence of carbonate of lime in specimens was determined by use of muriatic acid or vinegar. For a number of samples the percentage of lime present was determined by chemical analyses, made in part by Mr. Ruffin himself, and in part by Dr. J. Lawrence Smith,* who subsequently became so well known as a chemist.

The following extract from a letter written long afterwards by the late Dr. H. W. Ravenel, of Aiken, S. C., well illustrates Mr. Ruffin's general mode of procedure. He says:

> At the time of Mr. Ruffin's survey I was a planter in St. John's, Berkley Parish, about forty miles north of Charleston. We had a flourishing agricultural society, and my first acquaintance with him was at one of our anniversary meetings. He attended this meeting by invitation purposely to consult with the planters and to urge and recommend the use of calcareous marls, which were abundant in that region. He made a long address (or lecture) on the subject, and remained in our neighborhood for some weeks, going from place to place and assisting and suggesting how and where to obtain these marls.

Thus he traveled about from county to county, neighborhood to neighborhood, urging upon farmers the use of marl and other

*Prof. L. R. Gibbes, of Charleston, S. C., in a letter to the writer.

manures, a better drainage of the land and other improvements in agricultural methods.

In the prosecution of the survey Mr. Ruffin labored alone, except during December (1843), when other duties and ill health rendered necessary his stay in Columbia, he employed an assistant to examine for him calcareous deposits along the north-east border of the State. I am unable to obtain any information as to the name and history of this assistant. Mr. Ruffin says concerning him in a letter to Governor Hammond published in Tuomey's Report for 1844:* "But having had latterly the services of an assistant in whose care and accuracy I could implicitly rely, he was sent with special and particular instructions, to examine the most extensive and important of the omitted localities, as soon as it was certain that I could not perform the duty. The ground left for these last intended observations, and where calcareous deposits were expected to be found, was along Lynch's Creek, the Waccamaw River, and any other places on and near the line of route to the north-eastern border of the State, in which marl might be discovered, or heard of, on the journey."

No claim is made for additions to science resulting from this survey. Mr. Ruffin was an intelligent and careful observer, but he had enjoyed no training in any department of science, and his entire aim here was economic results; though in the prosecution of his work he added materially to the then existing knowledge as to the boundaries and character of the tertiary deposits and corrected many errors as to localities for characteristic fossils. As to material benefits resulting to the people of the State from his labor, it may be said (1) to have awakened a more general spirit of inquiry and experiment among the planters; (2) to have led to the more general adoption of some improved methods, such as ditching the lowlands, using green manure for a supply of vegetable matter, and (3) it led to a more general use of marl, which, in many cases at least, proved highly beneficial.

---

*Report on the Geological and Agricultural Survey of South Carolina, 1844, p. 57.

It must be admitted that the use of marl among the planters of the State has of late years been largely discontinued, owing to the cheapening of lime and the wide-spread use of phosphates and other concentrated commercial fertilizers, and further that the use of marl by many planters in years immediately following Mr. Ruffin's work proved a disappointment; but there can be but little doubt that on the whole such use was beneficial when the marl was judiciously applied.

The entire expense of conducting the survey was borne by Mr. Ruffin, the only appropriation made by the State being the $2,000 referred to above.

The publications of the survey consisted of a report of 175 pages submitted by Mr. Ruffin November 30, 1843, and published by the State, and a supplemental report of seven pages submitted January 12, 1844, and published as a part of Tuomey's first report, 1844.*

Tuomey's Geological and Agricultural Survey, 1844-'47.

When at the close of the year (1843) Mr. Ruffin resigned his position as Agricultural Surveyor to the State, he recommended as a suitable person to succeed him M. Tuomey, of Virginia. Mr. Tuomey was accordingly appointed to this position by the Governor (James H. Hammond) near the beginning of the next year and began to discharge the duties of his office about the end of February following (1844).

From the account which follows it will be seen that, notwithstanding the fact that the law under which Mr. Tuomey was appointed was that authorizing an agricultural survey, upon the assumption of his duties, and with the approval of the Governor, he at once began a geological exploration of the Piedmont region of the State, and that throughout the prosecution of the work of the survey he regards the geological examination as the more important part of his work and subordinates the agricult-

*See Bibliography, p. 113.

ural work to it. Hence I have considered it more appropriate to treat of these as two different surveys, having different objects in view, notwithstanding the fact that legally one was a continuation of the other.

This difference between the two surveys grew naturally out of the difference between the surveyors. Mr. Ruffin was a planter whose ambition was to improve the agricultural condition of the country by the introduction of better methods, and especially by the use of calcareous manures. Mr. Tuomey, on the other hand, was by profession a geologist and possessed also a fairly good knowledge of chemistry and botany. In his first Report on the Geological and Agricultural Survey of the State* he signs himself "Geological Surveyor"; and his work during this first year's connection with the survey was devoted to the examination mainly of the general and mining geology of the Piedmont region of the State.

In his Report of 1846† he gives the following statement of the objects of the survey:

> In the renewal of my commission, by his Excellency, Gov. Aiken, in 1844, I was directed to make a Geological and Agricultural Survey of the State. Such a survey, as it is at present to be understood, includes the following objects.
>
> 1. The determination and description of the various minerals and rocks of the State.
>
> 2. Their examination as to extent and relation to each other in their order of superposition, as well as their influence upon the physical features of the State.
>
> 3. The discovery of metallic veins, and beds of other useful substances, such as lime, rock, marl, etc., that they may contain.
>
> 4. The relations of the rocks to soils, and their chemical examination, to a certain extent.
>
> 5. The pointing out of such improvements in mining and metallurgy, as may be thought useful to those engaged in those operations.

Concerning the methods of operation followed by Mr. Tuomey in the prosecution of the survey, there is very little information to be had. But the following extract from his letter to

*Columbia, 1844.
†Geol. of S. C., Columbia, 1848, p. II.

Governor Hammond transmitting his report for 1844* throws some light on his operations during this the first year of his connection with the survey:

In accordance with my instructions, I hastened early in the spring, with all possible despatch, to the upper portion of the State, there to commence my labors. But before proceeding to a minute and systematic exploration, it was necessary that I should make myself acquainted with the general geological character of the region to be examined, for without such knowledge, I could scarcely know what to look for, and in science, it is a maxim that "what is not looked for is seldom found." By tracing a number of sections, at right angles with the general direction of the strata, and by determining carefully the strike of the rocks passed over, and by connecting these observations, I was enabled to determine, with some accuracy, the boundaries of the different formations.

While making this geological *reconnoissance* of the "hill country" of the State (the region of crystalline rocks) many observations were made as to the occurrence, distribution and extent of various ores and other minerals and rocks of economic value, and as to the character of the soils. Many specimens of ores, minerals and soils were collected for future analysis. Special attention was also given to the gold mines of the region.

During the two years following (1845 and 1846) Mr. Tuomey extended his explorations into every portion of the State, in the "hill country" continuing the work as indicated above, while in the "low country" or coastal plain region, he devoted himself mainly to a study of the stratigraphy and paleontology of the recent geological formations, his predecessor, Mr. Ruffin, having already investigated with considerable thoroughness the marls and soils of this latter region.

In his studies of the fossil forms found so abundantly in the coastal plain region of South Carolina Mr. Tuomey had the volunteer assistance of Professor F. S. Holmes, of Charleston, and of several other occasional collectors, and also of Professor Louis Agassiz, who visited Charleston in 1846, and who, during the ten years following, took great interest in and rendered great assist-

*Report on the Geological and Agricultural Survey of South Carolina, 1844, p. III.

ance in the identification and description of the fossil forms. The results of the combined labors of these gentlemen were published in two large and beautiful volumes, *Pleiocene Fossils* and *Post Pleiocene Fossils of South Carolina* (1857–'60).*

In his study of the soils of the several regions of the State, Tuomey collected a number of samples, and of many of these chemical analyses were made. In his reports he publishes a considerable number of these analyses of both soils and marls, made in part by himself and in part by Dr. J. Lawrence Smith, and Dr. Charles U. Shepard, of Charleston.

The economic results of Tuomey's works cannot perhaps be fairly or intelligently discussed at a time so long after the survey was made. But there can be no doubt that his survey was of considerable and lasting benefit to the State.

In the line of agricultural improvement he encouraged the farmers to adopt the improved methods which Mr. Ruffin had introduced. In person, as he traveled through the State, and in his reports, he instructed them as to the character of soils and their improvement by rotation of crops and manures of various kinds. He located and described the various sources of limestone rock in the "hill country," and instructed the people as to building furnaces and burning lime for agricultural and architectural purposes. He investigated with considerable thoroughness the gold mining interests of the State, and the results of this work published in his reports helped in bringing a considerable amount of capital into the State and in properly directing the investment of home capital. And so, also, his examination and advertisement of the iron ore deposits, building materials, material for millstones, and potters' clay deposits has at various times brought capital in considerable quantity into the State, and has saved to its citizens equally as great an amount by directing their own investments and thus preventing waste of money.

The results of the Tuomey survey are not rich in additions to science, but nevertheless some valuable advances were made along this line, especially as a result of the work done in the coastal

*See Bibliography at end of this paper, p. 113.

plain region. His work among the crystalline rocks of the "hill country" left to the public a better knowledge of the general character and distribution of these rocks, but the results involve nothing of importance in the form of either data or principles new to geologic science.

As to legislation relative to the Tuomey survey, it will be remembered (see p. 94) that the act of December, 1842, establishing the Ruffin survey, provided for a continuation of this survey for two years; and that Mr. Tuomey, having been appointed early in the year 1844, prosecuted his work during that year under the authority of this act.

In December, 1844, sundry petitions from the people of the State were submitted to the General Assembly, asking for a continuance of the "Agricultural and Geological Survey," and the General Assembly authorized "a continuance of the survey under the direction of the present incumbent, for a period of two years, and at an annual salary of two thousand dollars."*

In December, 1845, a resolution was adopted by the General Assembly authorizing a continuance of the Survey during the following year.† And again in December, 1846, a resolution was adopted authorizing that the "Geological Survey of this State be continued for four months from the first day of January next.‡ * * *" According to this, the existence of the survey appears to have ended with the last day of April, 1847. Soon thereafter Mr. Tuomey left the State and went to Alabama, where he was elected to the professorship of Geology, Mineralogy and Agricultural Chemistry at the State University.

The annual appropriation of two thousand dollars for the salary of the geologist, was the only appropriation made for the prosecution of the work of the survey, the geologist being expected to bear all of the expenses incurred, except for publication, out of his salary.

The publications of the survey consisted of two reports;§—(1)

*Proceedings of House of Reps. of S. C., Dec. 14, 1844.
†Reports and Resolutions of S. C., 1845, p. 195.
‡Ibid., 1846, p. 203.
§See Bibliography, p. 113.

the first a small report submitted for publication November, 1844, which contains, in addition to Tuomey's report of 48 pages, an appendix giving the "Prize Report of Agricultural Experiments, submitted to the State Agricultural Society of South Carolina," November, 1844, by F. S. Holmes, consisting of 7 pages, and a "Supplement to Mr. Ruffin's Report," by Edmund Ruffin, 7 pages. (2) The second, a "Report on the Geology of South Carolina," is a volume of larger proportions. It was submitted for publication November, 1846 (though not published until 1848), and contains a summary of what was known at that time relative to the geology of the State. In addition to Tuomey's report, covering 293 pages, it contains as an appendix a Catalogue of the Fauna of South Carolina, by Professor L. R. Gibbes (24 pages); Meteorological Tables (6 pages); and several lesser papers, among which is an abstract of "Vanuxem's Report" on minerals and rocks collected in the State, taken from "*Mill's Statistics of South Carolina.*"*

Lieber's Geological, Mineralogical and Agricultural Survey, 1856–'60.

The results of the surveys by Ruffin and Tuomey were such as to arouse a deeper interest in the development of the agricultural and mineral resources of the State. Among these results, and accompanying them, the development and successful working of various gold deposits of Chesterfield, Lancaster, York, Abbeville, Edgefield and other counties, and iron deposits of York and Spartanburg, served to increase this interest. And it was doubtless this growing interest in the mineral wealth of the State which led to the inauguration of the Lieber survey.

The immediate *establishment* of this survey is explained in the following Report and Resolutions adopted by the General Assembly of South Carolina, December, 1855:

The Committee on Agriculture and Internal Improvements, to whom was referred the memorial of sundry citizens of St. Helena Parish, on the subject of an Agricultural and Geological Survey of the State, and also a resolution

*Columbia, S. C., 1826, p. 25.

of the Senate on the propriety of selecting a suitable person to procure and effect a mineralogical survey, respectfully report: That they have considered the same, and now submit the following report with accompanying resolutions:

The limits of a report on the present occasion forbid your committee attempting anything more than an exhibition of those general results which have been derived from the numerous examinations and explorations which all the Governments of Europe and many States of the Union have ordered, under the guidance of men of high scientific attainments.

In 1823, our State took the lead (North Carolina only excepted) in giving direction for a Geological survey in charge of Professor Vanuxem, and although his explorations were unaccompanied by any of those notable discoveries, which tend to diversify the industrial pursuits of a people, yet the subsequent labors of a Ruffin and a Tuomey, are so full of hope in the future, that the State should feel encouragement in prosecuting immediately what she has already so well begun. * * *

Believing, then, that these enlightened examples of other countries can be advantageously imitated by us, your committee recommend the adoption of the following resolutions:

Resolved, That this General Assembly authorize the appointment of a Geological, Mineralogical and Agricultural Surveyor, whose services shall be engaged for four years, and whose duty it shall be to explore the several districts, make a geological map, analyze minerals, ores, soils, and manures free of charge, and submit an annual report to the Legislature for general circulation.

Resolved, That this officer shall receive a salary of three thousand dollars, to be appointed by joint resolution of the two houses, and that it shall be the duty of the joint committees of Agriculture and Internal Improvements of the Senate, and of Internal Improvements of the House, to nominate a suitable person to fill this office.*

In accordance with the above resolutions, and within a few days after their adoption, Oscar M. Lieber was nominated by the committees and unanimously elected by the General Assembly Geological, Mineralogical and Agricultural Surveyor of the State for a term of four years, and his election was confirmed by the Governor December 22, 1855.

As to other *legislation* concerning the survey, the following may be noted: By a resolution of the General Assembly, December, 1856, the State Geologist was instructed to endeavor

*This Report was adopted by the Senate Dec. 13, 1855; concurred in by House of Representatives Dec. 19, 1855. See also REPORTS AND RESOLUTIONS OF S. C. FOR 1855, pp. 324–327.

to discover a "hydraulic limestone" which could supply lime and cement for use in the building of the new State House at Columbia.*

At the annual meetings of the General Assembly, December, 1856, '57, '58 and 1859, resolutions were passed ordering the printing of the Reports of the Survey, and commending the work of the Geological, Mineralogical and Agricultural Surveyor.†

The survey having been established in December, 1855, for a period of four years, was to be discontinued after 1859, unless otherwise ordered by legislative enactment. At its annual session in December, 1859, the General Assembly ordered the continuance of the survey for another year, with Mr. Lieber in charge. At a later date in the same session, however, a resolution making the usual appropriation ($3,000) for the salary and expenses of the geologist for the year 1860 failed to pass the General Assembly; and the survey was necessarily discontinued. Lieber did not resign his position, however, until April 2, 1860, for reasons which can best be stated in his own language:‡

> My resignation has been postponed until the present time, because I desired first to complete my last Report in such a manner that it might, together with those previously published, embrace the statements concerning everything of any importance which had been observed or effected during the four years of my service. This fourth Report, therefore, contains several chapters of a general character, and others referring to portions of the State where the survey had not yet advanced to completion. Believing that such work of reference would be of little practical value without a glossary and index, I have prepared one for the four Reports, and now append it.
>
> The arrangement and writing these matters, and seeing the entire Report through the press, has occupied me three months.§

By way of further statement of the *objects of this survey*, I cannot do better than insert here a few extracts from the Intro-

---

*See Lieber's Second Annual Report, 1857, p. 117; and Senate Journal for 1856, pp. 142 and 143. At the same session of the General Assembly a resolution was adopted in the Senate, instructing the State Geologist to deposit in the cabinet of the S. C. College complete and duplicate sets of the rocks and fossils collected during the survey of the State, all to be properly arranged and labeled. But I find no record showing that the House of Representatives concurred in the resolution. (See Senate Journal, 1856, p. 146).

†Reports and Resolutions of S. C., 1856, pp. 317-319; and Ibid., 1858, p. 415.

‡Fourth Annual Report (1859), p. V.

§The General Assembly, at its session in December, 1860, appropriated the sum of $750.00 to pay Mr. Lieber for his services during these additional three months.

duction to Lieber's Fourth Annual Report, thus giving his own statement of the opinions which guided him in the prosecution of the survey. He says:*

The object of a survey of this description appears to me to be endowed with various and entirely distinct features. The primary cause of its institution is unquestionably the development of our natural resources; and this intention of its originators should always continue to retain its prominent position. But yet this commendable object by no means comprises all that should be embraced within the duties of a State Geologist. I think he should not merely endeavor to discover more occurrences of useful minerals and, here and there, labor to repress and prevent expenditure of private means in the search for such gifts of nature, where there is really no promise of sufficient importance to warrant it. Attentive as he ought to be to these more practical duties, whether of a positive or negative character, if interested in his own studies, he should not rest satisfied with them alone. His office empowers him with the means of extending a knowledge of the current progress of his science, and of aiding, often in no inconsiderable degree, in that field of research and exploration of nature, to which he has more particularly devoted his attention. For this purpose he must endeavor to obtain correct information of the latest developments in his department of science, and of the newest results of contemporary explorations of a cognate character.

Impressed with the conviction that the objects of a geognostic survey should be thus diversified, I have endeavored to explore and define our natural resources, to contribute as much as possible to the enlargement of knowledge in the particular department of science concerned, and to enable these Reports to become the vehicles for the distribution of that information on connected subjects, both technological and scientific, which is gradually accumulating elsewhere. * * * *

The only subject, apart from running notes on petrology, which I have deemed it expedient to enlarge upon more fully, on account of its immediate technological bearings, and the absence of its notice in almost all American and English books on geology, is the study of veins; and in this particular branch, I believe, indeed, that at least the general outlines have been presented in the different Reports.

The *special character* assumed by the survey was the resultant of the following conditions:

(1) Mr. Ruffin's work related to the agriculture of the "low country" more especially. Mr. Tuomey's work extended in a general way over the entire State, but a large share of his atten-

*Report on the Survey for S. C. for 1859, pp. 1 and 5.

tion was given to the stratigraphy and paleontology of the Low country. It seems now (1855) to have been generally conceded that the time had come for a more thorough survey of the general and economic geology of the "up country"—the region of crystalline rocks.

(2) Mr. Lieber's early training as a geologist and the work to which he seemed most devoted was petrology and "vein geognosy." His studies in Germany with Humboldt, Von Cotta and others, and his work on the geological survey in Alabama, under Tuomey, were along this line. And these features of his work in South Carolina were prominently in view during the entire existence of the survey.

(3) The smallness of the appropriation* prevented the employment of any regular assistants, by the aid of whom a larger amount and greater variety of work could have been accomplished.

As to the *area* covered by the survey, Lieber has left on record the following statement:†

The Districts (counties) which I have now surveyed and mapped out are: Chesterfield, Lancaster, Chester, York, Union, Spartanburgh, Greenville, Pickens, Anderson and Abbeville—my plan having been first to proceed along the North Carolina line from the margin of the sand region. As our metaphoric rocks strike very uniformly north-east, this plan enabled me to reach the heads of the columns as it were. Having effected this, and thus facilitated the mechanical part of the operation, I was engaged in proceeding down the Savannah, intending this year to have commenced filling up the intermediate Districts, when the Survey was stopped.

Edgefield has been partially surveyed and also, in part, reported upon; but I could not yet prepare a map.

Other Districts in which cursory or partial examinations have been made are: Lexington, Richland, Laurens, Newberry, Fairfield, and the Districts along the coast from the mouth of the Savannah to Bull's Bay. These observations on the coast were made during a portion of the winter (1859), but they are, as yet, quite incomplete.

Concerning the *methods of operation* followed by Lieber during the prosecution of the survey, but little can be said other

*$3,000 per annum.
†Fourth Annual Report, 1859, p. 146.

than what is given in his Reports, supplemented by private letters from persons who came in contact with him more or less during this time. A few interesting suggestions are given in the extract just quoted, and also in the extract quoted below relative to the making of maps.

The resolution establishing the survey (p. 104), in enumerating the duties of the State Geologist, specifies that he shall "explore the several Districts and make a geological map, analyse minerals, ores and manures, free of charge," etc. The chemical work here specified, Lieber does not appear to have undertaken at all. He was not a chemist by profession nor by training, and furthermore, realizing that the performance of this part of the work would require the whole time of a competent chemist, he proceeded with that part of the work for which he was the better qualified, and which, he believed, would result more beneficially to the State—the field explorations, and making the geological maps. During the progress of the survey, however, he collected, from time to time, numerous specimens of rocks, minerals, ores and soils, with the hope that the General Assembly would further provide for their analysis by the employment of a chemist.* This, however, was never done, and the specimens were subsequently destroyed by the burning of the capitol building at Columbia during the civil war.

In prosecuting his field explorations, Lieber traveled on foot or in a wagon. During much of the time he had as his headquarters a tent, which was removed from place to place as his field work demanded. His only constant assistant was a servant, usually a negro or an Indian, who served as cook and general attendant.

In the following notes concerning the maps accompanying his reports Leiber suggests some of his methods of operation:†

A word in regard to the maps may be suitably added. These have been engraved with so much care and beauty by Mr. Colton,‡ that it has been a

*See Report for 1856, pp. 101 and 108; Report for 1857, p. 117; Report for 1858, p. VIII.
†Fourth Annual Report (1859), pp. 6–8.
‡Mr. G. Woodworth Colton, formerly of the firm of J. H. Colton & Co., now (1859) of that of Thayer & Colton, New York.

great stimulus to me in seeking to increase to the utmost the accuracy of my portion of the labor. The manner of preparing the manuscript maps, by noting the points where different rocks present themselves, and afterwards connecting such points in accordance with nature, is too readily comprehended to demand farther explanation.

But there are instances where the maps might possibly engender the belief, that an amount of accuracy had been attained which would, under no circumstances, be within the reach of an examination of the surface. Where solid rocks are observed out-cropping near the margin of their area, the case is easy of solution; nor is the difficulty of the determination of boundaries much increased, where a conspicuous variation in the soil is seen, and the mother-rock of such soil is known; but many soils, derived from distinct rocks, are very similar in character (those of granite rocks and mica-slate, for instance), while some again, from their lightness, are drifted into the area of another rock. In these instances we are forced to rest satisfied with the utmost *attainable* accuracy. But as a uniform rule, precision in all details has been aimed at. Hence, the region around Limestone Springs, whose great scientific and technological interest appeared to demand the utmost care, was first drawn on a scale of one statute mile to two inches. From this manuscript, the plate XII was reduced by Mr. Colton. The ordinary scale on which the manuscript maps are drawn is that of two miles to the inch, the subsequent reduction being to a scale of five miles to one inch.

As the maps of Report I were the first regularly printed in colors in the United States, it was necessary to make a number of experiments in regard to the manipulation of the work, before arriving at that degree of excellence which, I certainly think, Mr. Colton has now successfully attained. A great difference is even observable between the maps accompanying the different Reports. Those of the First were engraved on stone; those of the Second on zinc, and those of the Third and Fourth on copper, without any increased expense, the recent improvements in the art of engraving having rendered the latter sufficiently cheap for the purpose. In comparing these maps with those colored by hand, the incomparably greater accuracy of the printed colors will appear at once, and it is, therefore, with gratification that we may perceive our State to be the first to introduce a new system, as it were, in a branch of engraving in which, until recently, almost all other countries have far surpassed us. These colors are applied in such a way that the blue, for instance, is employed for the blue, purple and green; the yellow for the yellow, orange and green; the red for the red, purple and orange—so that the impression of one and the same color applies to different rocks, by being used alone or in combination. In the maps of the present Report (for 1859), a great additional improvement will be seen in the representation of the gradual passage of one rock into another—a highly important feature, which it would be impossible to indicate with uniformity and precision by hand-coloring. The colors employed throughout have been the deep and decided ones seen in the geognostic maps of continental Europe, which appeared to me far preferable to the weak, watery and indefinite colors hitherto employed in our country and England, whose difficulty of discrimination and early fading are certainly very objectionable features.

The *expenses* incurred in conducting the survey were borne by Lieber out of the annual appropriation of $3,000 for the "salary" of the geologist; and the total cost of carrying on the survey (including the salary of the geologist) during the four years and three months of its existence amounted to the sum of $12,750.

The *personnel* of the Lieber survey can be briefly stated. No provision was made in the establishing act or in the appropriations for the employment of assistants on the survey; and in reality the survey was conducted by Lieber himself, working alone during the larger part of the time. I have found mention of only two persons who rendered him professional assistance, as follows:

During a portion of the year 1856, Mr. Abraham Hardin, at Lieber's request, made a "geodetic survey" of the itacolumite region of York and Spartanburg counties.*

Lieber has left on record the following note concerning the assistance rendered him by Mr. J. Friedeman during a portion of the year 1856:†

To J. Friedeman, Esq., I am, however, certainly most indebted, as he kindly accompanied me throughout the main portion of the field duties, which the great heat of last summer rendered more arduous perhaps than might be expected in other years. Mr. Friedeman's thorough knowledge of mining engineering, and mining geognosy—a fact which his having passed through the whole course of tuition, practical and theoretical, at the far-famed mining school of Clausthal, and elsewhere in Germany, would of itself insure—and his extensive experience in the mines of North Carolina, specially in the talcose slate mines, were of the greatest value in the investigation of the analogous occurrences of metals in our State. It would be difficult and, indeed, scarcely possible to distinguish his labors from my own since he attached himself to the survey, and I am under still greater obligations to him as his valuable services were gratuitously rendered, a fact which was unfortunately made necessary on account of the inconsiderabl**ə** amount of the appropriation and the necessary outfit expenses which, of course, fell somewhat heavily upon the first year.

---

*Lieber's First Annual Report, Survey of S. C., 1856, p. 23. I have no information as to the exact amount of time devoted to this work by Mr. Hardin. It is presumed that he was paid for his services by Mr. Lieber. See Biographical Notes, p. 115.

†First Annual Report, S. C. Survey, 1856, p. 4. I have no further information concerning Mr. Friedeman,s career.

The *reports* of this survey* consisted of four Annual Reports, one for each of the years 1856, 1857, 1858 and 1859. These were published in editions of 2,000 copies each, by the State printer, and distributed in accordance with the following resolution:†

Resolved, That two thousand copies of the Report be printed; that each member of the Senate and of the House of Representatives be allowed one copy, and that the remaining copies be placed in the hands of the Governor, and that he be requested to have twelve copies deposited in the Legislative Library, two copies in each college and Public Library in the State, and the remaining copies in the hands of the booksellers of Columbia and Charleston, and in one store at each Court House in the State, to be sold at fifty cents a copy, the same commissions to be allowed them as on the Statutes at Large, and they would further recommend that the copies now on hand‡ shall be sold at a like price.

Of the Report for 1856 at first only 1,000 copies were printed, but at the session of the General Assembly for 1857 1,000 additional copies were ordered, and were printed as a second (and somewhat revised) edition, in 1858.

During the civil war many copies of these reports were lost in the burning of Columbia and other towns, and they are now exceedingly rare.

The *economic results* of the Lieber survey were mainly in the line of mining enterprises. His investigations of the characteristics and distribution of metalliferous veins in the gold regions of South Carolina (and the neighboring portions of North Carolina), and the best methods of working the same, helped in bringing about the successful working of a number of these mines, such as the Brewer, Hale, Dorn, etc., and would have resulted much more advantageously in the development of these mines but for the untimely interruption of all such undertakings by the civil war. There was then every indication of growing industrial progress. Mr. Lieber's discussion of agricultural and other industrial matters in his reports exercised a beneficial influence, through the "hill country" especially.

---

*See Bibliography, p. 114.
†Third Annual Report of S. C. (1858), p. III.
‡Copies of the Reports for 1856 and 1857 had formerly been sold "at cost," distributed as above stated.

Something may be said by way of conclusion concerning the *additions to science* resulting from the Lieber survey, though it will be difficult to discuss these intelligently until the regions and problems he studied can be worked over again in the light of more recent investigations. The region in which he labored, embracing a considerable area of the crystalline rocks of the south Appalachian region, is one of great geologic and economic interest and importance. The general problems that interested Lieber more especially were the characteristics, classification, nature and origin of the metalliferous veins, the character and age of metamorphic rocks, including the age and history of the Appalachian mountain region and especially of the itacolumite formation, and the character and relative age of the eruptive rocks. It must be borne in mind that the science of petrography was in its infancy, and the use of the microscope in the study of crystalline rocks almost unknown at the time of Lieber's work; and yet it may be fairly claimed that he added considerably to our knowledge and understanding of these problems connected with the crystalline rocks and "vein geognosy" of the southern Appalachian regions. Those interested in the subject should read his four annual Reports where his conclusions are stated at length, as the limits of the present sketch preclude a full statement of them here. One of his conclusions—as to the age of the itacolumite series of rocks and the neighboring crystalline schists of portions of upper South Carolina, Western North Carolina and upper Alabama—may be stated here as of special interest; and it will be better to state it in his own words:*

If, then, we remember that in some localities the itacolumite, or rather the quartzite stratigraphically identical with it, has already been established to be of lower silurian age, and also take into consideration that appearances certainly favor the view that the crystalline slates of Alabama belong to that geologic period, we may, it is true, still justly regard the proof as imperfect, but we cannot deny that the weight of evidence is greater for than against the supposition that the itacolumite rocks of the South are lower silurian, and that such also is the probable age of all the crystalline slates of the Alleghanies in general.

*See THE ITACOLUMITE AND ITS ASSOCIATED ROCKS—Supplement to The Third Annual Report of the Survey of S. C., (1858) p. 149.

Lieber devoted but little time to the investigation of geology of the coastal plain region, but, as stated above, during the winter of 1859 he examined the coast region from the Savannah river to Bull's Bay, and he has added somewhat to our knowledge of the recent geologic history of this region. He distinguishes five or six "prominent effects of change":*

1. An ancient depression along our coast.
2. A total change in the course of the portions of the rivers near the coast.
3. A more recent superficial elevation of the coast, and
4. Consequent gradual seaward extension of the land.
5. A present depression of the coast, and
6. A southward translocation of our littoral islands.

Bibliography of the Several Surveys.†

L. Vanuxem. Report on Geology, published in newspapers, and most of it in Mills' Statistics of South Carolina, 1826, 8vo., pp. 25–30; and in Tuomey's Geology of South Carolina, 1848, pp. XXXI and XXXII.

Report of the Commencement and Progress of the Agricultural Survey of South Carolina for 1843; by Edmund Ruffin, Agricultural Surveyor of the State. Columbia, 1843, 8vo., 120 and 55 pp.

Report on the Geological and Agricultural Survey of the State of South Carolina; by M. Tuomey. Columbia, 1844. 8vo., iv, and 63 pp.

Report on the Geology of South Carolina; by M. Tuomey. Columbia, 1848. 8vo., vi, 293, and lvi pp., plate and 2 maps.

Pleiocene Fossils of South Carolina: containing descriptions and figures of the Polyparia, Echinodermata and Mollusca; by M. Tuomey and F. S. Holmes. Charleston, 1857. Quarto, 152 pp. and 30 plates.‡

Post-Pleiocene Fossils of South Carolina; by Francis S. Holmes. Charleston, 1860. Quarto, 122 pp. and 28 plates.‡

*Fourth Annual Report (1859), p. 117; also Am. Jour. Sci., XXVIII (1859), pp. 354–59.

†A more elaborate list of publications relating to the geology, natural history and resources of South Carolina will be published in a future number of this Journal.

‡The propriety of placing these two publications among the reports of the surveys may be questioned, but they were published largely at the expense of the State, and much of the material was originally intended for Tuomey's Report (1848).

Report on the Survey of South Carolina: being the first annual report to the General Assembly; by Oscar M. Lieber. Columbia, 1856. 8vo., viii, and 136 pp. and 9 plates.*

Report on the Survey of South Carolina: being the second annual report to the General Assembly; by Oscar M. Lieber. Columbia, 1858. 8vo., viii, and 145 pp. and 5 plates.

Report on the Survey of South Carolina: being the third annual report to the General Assembly; by Oscar M. Lieber. Columbia, 1859. 8vo., xv, and 223 pp. and 3 plates.

Report on the Survey of South Carolina: being the fourth annual report to the General Assembly; by Oscar M. Lieber. Columbia, 1860. 8vo., ix, and 194 pp. and 4 plates.

[The last four reports are bound in one volume, with the title, Reports on the Geognostic Survey of South Carolina; by Oscar Montgomery Lieber, State Geologist of S. C., I, II, III, IV. 1856–1860. Columbia, 1860, with an index and glossary to the four Reports.]

Biographical Notes.

Lardner Vanuxem.—See notes and references, pages 90–93, above. He was born in Philadelphia, 23d July, 1792, and died in Bristol, Pa., 25th January, 1848. He was graduated at the École des Mines, Paris, 1819, and soon thereafter (1821) accepted his position in the South Carolina College. While connected with this institution he devoted his vacations during 1825 and 1826 to making geological tours through various portions of the State. After his return from Mexico, during 1827–'28, under the auspices of the State of New York, he studied the geological features of the States of New York, Ohio, Kentucky, Tennessee and Virginia; and in 1836 the geological survey of New York was established and Vanuxem was placed in charge of the third geological district, where he remained in active service until 1841, and published his results in the Geology of New York, Third District (Albany, 1842). Subsequently he spent some time in arranging the collections of the survey, in Albany. In 1838 he sug-

*A second (and slightly revised) edition of this report was published in 1858.

gested a meeting of geologists from Virginia, Pennsylvania and New York for the purpose of devising and adopting a uniform geological nomenclature for use among the several State geologists, which meeting was held in 1840, when the Association of American Geologists was organized. He published numerous papers on scientific subjects in the *American Journal of Science*, *Journal of the Philadelphia Academy of Natural Sciences;* and "An Essay on the Ultimate Principles of Chemistry, Natural Philosophy and Physiology" (Philadelphia, 1827).

Edmund Ruffin.—See pages 93–98, above. He was by profession an agriculturist; born in Prince George county 5th January, 1794; died at Redmore, Amelia county, Virginia, 15th June, 1865. During 1810–'12 he attended William and Mary College. In 1813 he took charge of the estate left him by his father, at a time of general agricultural depression; and at once began various experiments looking to the improvement of soils. In 1848 he tried the first experiment in the use of lime (marl) as a supposed counteractant of the acidity of the soil, and found the results greatly beneficial.

During the few years following this the use of marl, through Mr. Ruffin's exertions, extended rapidly throughout Eastern Virginia, generally with like beneficial effects. During 1841 and 1842 he was a member (and Secretary) of the Board of Agriculture of Virginia, and for several years he was President of the State Agricultural Society. During 1843 he served as "Agricultural Surveyor" of South Carolina, and published a report of his results (Columbia, 1843). From 1832 to 1842 he edited the *Farmers' Register*, a journal which exerted a wide-spread and beneficial influence on the agriculture of Virginia and other Southern States. He was also the author of "An Essay on Calcareous Manures" (Richmond, 1832), an "Essay on Agricultural Education" (1833), and "Sketches of Lower North Carolina" (Raleigh, 1861).

Michael Tuomey.—Pages 98–103, above. Born in Cork, Ireland, September 20, 1805; died at Tuscaloosa, Ala., March 30, 1857. Came to New York, and studied at the Troy Polytechnic School, where he graduated in 1835. He subsequently conducted a school in Petersburg, Va., where he lived when early in 1844 he was appointed State Geologist of South Carolina. In 1847 he resigned this latter position and was elected Professor of Geology, Mineralogy and Agricultural Chemistry in the University of Alabama. From 1848 to 1854 he acted as State Geologist in addition to his duties at the University; 1854 and 1855 he gave all of his time to the survey, and afterwards returned to his professorship at the University, which he held until the date of his death. In addition to his two Reports on the Geology of South Carolina (1844 and 1848) he published two Biennial Reports on the Geology of Alabama (1850 and 1858) and several papers on geological subjects. At the time of his death, in connection with Professor F. S. Holmes, he had in hand the publication of a "splendid work on the Fossils of South Carolina, which has not been surpassed in the country for the beauty of its palæontological illustrations. Geological science is greatly indebted to Professor Tuomey's zeal and fidelity."*

Professor Tuomey was a member of the Boston Society of Natural History and the American Association for the Advancement of Science.

Oscar Montgomery Lieber.†—Pages 103–13, above. He was born in Boston, Mass., September 8, 1830; was educated in Boston, at the South Carolina College—where his father, Francis Lieber, was a member of the faculty—and at the Universities of Berlin and Göttingen (1847–'48). In 1851 he was elected Assistant Professor of Geology in the University of Mississippi, his duties being confined to the work of making a geological survey, and extending over but seven months, when he resigned. In 1854–'55 he was Assistant Geologist on the Alabama survey, under Tuomey. In December, 1855, he was elected by the Legislature of South Carolina Geological, Mineralogical and Agricultural Surveyor of the State, which position he held for

*Am. Jour. Sci., XXIII, 1857, p. 448.

†A more elaborate sketch of Lieber will be published in a future number of this Journal.

four years and three months, the survey being discontinued by the failure of the Legislature to make the necessary appropriation. In July, 1860, he accompanied the U. S. Astronomical Expedition to Labrador as Meteorologist and Geologist, under Professor Charles S. Venable. At the breaking out of the late civil war in 1861 he joined the Confederate army, was fatally wounded in the retreat from Williamsburg, Va., and died in Richmond, June 27, 1862.

In addition to his South Carolina Reports Lieber was the author of "The Assayer's Guide" (Philadelphia, 1862); "The Analytical Chemist's Assistant," translated from the German of Wöhler's "Beispiele zur Uebung in der Analytischen Chemie," with an introduction (1852); Der Itacolumit, Seine Begleiter und die Metallführung desselben, in Von Cotta's Gangstudien (Freiburg, 1860), Vol. III, pp. 309–507; and numerous papers on scientific subjects published in the *New York Mining Magazine*, and other journals in this country and in Germany.

Abraham Hardin.—See page 110 above. Born in what is now Cleveland county, N. C., 22d June, 1789; died at Black's Station, S. C., 11th July, 1881. In 1836 he was elected to the Legislature of South Carolina and served for three terms. In 1856 he was employed by Lieber to make a "geodetic survey" of the King's Mountain and adjoining itacolumite regions.

J. Friedeman.—See page 110 above.

RECORDS OF MEETINGS.

FIFTIETH MEETING.

PERSON HALL, January 14, 1890.

Professor Holmes called the meeting to order. The following papers were read:

1. How the Distance Between the Sun and Earth is Measured. Professor J. W. Gore.

2. A Sketch of Pasteur's Life and Work. Mr. W. H. Shaffner.

3. Pasteur's Treatment of Rabies. Mr. V. S. Bryant.

The following were read by title:

4. Some Modifications of the Method for Determining Crude Fiber. Professor W. A. Withers.

5. The Determination of Crude Fiber. Professor W. A. Withers.

These are published in this number of the Journal.

FIFTY-FIRST MEETING.

PERSON HALL, February 18, 1890.

6. The Chemical Problems of To-day; A Resumé of Professor Victor Meyer's Address. F. P. Venable.

7. The Recent Geologic Formations on the Roanoke River. J. A. Holmes.

8. Recent Progress in Electricity. J. W. Gore.

FIFTY-SECOND MEETING.

PERSON HALL, March 4, 1890.

9. On the Great Ship Canals. Wm. Cain.

FIFTY-THIRD MEETING.

PERSON HALL, April 1, 1890.

10. Note on Work on New Elements. F. P. Venable.

11. Abundance of the Elements. J. S. Callison.

12. Occurrence of Boracic Acid in the Caustic Alkalis. J. S. Callison.

13. On the Suez Canal. Wm. Cain.

14. Exhibition of some Minerals from the Mica Mines and of some Fine Crystals. J. A. Holmes.

FIFTY-FOURTH MEETING.

PERSON HALL, May 7, 1890.

15. Sanitary Disposal of the Dead. H. L. Miller.

16. Inter-oceanic Canals Crossing the Isthmus of Panama. Wm. Cain.

Read by title:

17. On the Determination of Available Phosphoric Acid in Fertilizers Containing Cotton Seed Meal. F. B. Dancy.

18. The Distribution of Boracic Acid Among Plants. J. S. Callison.
19. Three New Masses of Meteoric Iron. Geo. F. Kunz.
20. Two New Meteoric Irons. F. P. Venable.
21. New and Improved Methods of Analysis. S. J. Hinsdale.
22. List and Description of North Carolina Meteorites. F. P. Venable.

The Secretary reported as the result of the meeting of the Council the election of the following Corresponding Members:

Marcus Benjamin, Esq., New York City.
Geo. F. Kunz, Esq., New York City.
Professor A. Giard, Paris.

By order of the Council all officers were to continue holding their offices until the December meeting, so that in the future their terms should begin and close with the year.

FIFTY-FIFTH MEETING.

PERSON HALL, September 16, 1890.

23. On the Germination of Some of the Gramineæ; A Resumé of the paper by Brown and Morris. F. P. Venable.
24. Report on the Meeting of the American Association for the Advancement of Science. J. W. Gore.

FIFTY-SIXTH MEETING.

PERSON HALL, October 14, 1890.

26. The Discoverer of Oxygen; A Discussion of Berthelot's paper and Thorpe's reply. F. P. Venable.
27. A Raining Tree in the Campus of the University. P. Dalrymple.
28. Some Notes on Aluminium. J. V. Lewis.
29. The New Object Glass for the Great Telescope at the University of South California. J. W. Gore.
30. Exhibition of Specimens and Photographs. J. A. Holmes.

FIFTY-SEVENTH MEETING.

PERSON HALL, November 11, 1890.

31. Reports as to Koch's Lymph. V. S. Bryant.
32. Improvements in Explosives. F. P. Venable.
33. The Croton Aqueduct. Wm. Cain.
34. A New Method of Propelling Ships. J. W. Gore.

FIFTY-EIGHTH MEETING.

PERSON HALL, December 2, 1890.

35. Problems of the Atlantic Coastal Plane. J. A. Holmes.
36. Some Erysipheæ from Carolina and Alabama. Geo. F. Atkinson.
37. Action of Phosphorus on Certain Salts. Gaston Battle.
38. Lead Bromo-Nitrate. H. L. Miller.
39. On Lead Chloro-Bromides. F. P. Venable.
40. Adulterated Spirits of Turpentine. S. J. Hinsdale.

REPORT OF TREASURER FOR 1890.

Received from associate membership fees	$ 7 50	
Received from full membership fees	96 00	
Received from subscriptions	2 00	
Received from special contributions	115 00	
Balance unexpended from 1889	69 37	
	$289 87	
Expended for postage		$ 22 35
Expended for express and freight		16 13
Expended for engraving		29 00
Expended for printing		224 75
Miscellaneous.		3 40
Expended in excess	5 76	
	$295 63	$295 63

F. P. VENABLE,
Treasurer.

DECEMBER, 1890.

DONORS TO THE LIBRARY.

RICHARD P. ROTHWELL, ESQ .... New York.
MARCUS BENJAMIN, ESQ. .... New York.
DR. H. CARRINGTON BOLTON. .... New York.
GEO. F. KUNZ, ESQ .... New York.
DR. WM. B. PHILLIPS .... Tuscaloosa, Ala.
PROFESSOR J. A. HOLMES .... Chapel Hill, N. C.
PROFESSOR F. P. VENABLE .... Chapel Hill, N. C.

LIST OF MEMBERS.

ADDITIONAL CORRESPONDING MEMBERS.

PROFESSOR A. GIARD .... Paris, France.
GEO. F. KUNZ .... New York, N. Y.
MARCUS BENJAMIN .... New York, N. Y.

REGULAR MEMBER.

REV. JOHN H. CLEWELL, D. D .... Salem, N. C.

ASSOCIATE MEMBERS.

ALSTON, HOWARD .... Chapel Hill, N. C.
ANDREWS, A. B., JR. .... Chapel Hill, N. C.

Andrews, W. J .... Chapel Hill, N. C.
Claflin, Geo. H .... Chapel Hill, N. C.
Edwards, A. J .... Chapel Hill, N. C.
Ellis, Caswell .... Chapel Hill, N. C.
Gaither, J. F. .... Chapel Hill, N. C.
Green, B. T .... Chapel Hill, N. C.
Kenan, W. R .... Chapel Hill, N. C.
Lewis, J. V .... Chapel Hill, N. C.
Little, W. R .... Chapel Hill, N. C.
Miller, H. L .... Chapel Hill, N. C.
Morehead, J. M .... Chapel Hill, N. C.
Patterson, A. H .... Chapel Hill, N. C.
Pearsall, M. J .... Chapel Hill, N. C.
Rondthaler, H. E .... Chapel Hill, N. C.
Shaw, H. B .... Chapel Hill, N. C.
Smith, T. C .... Chapel Hill, N. C.
Toms, C. F .... Chapel Hill, N. C.
Wills, Geo. S .... Greensboro, N. C.

LIST OF EXCHANGES.

UNITED STATES.

Albany—New York Museum of Natural History.
Boston—American Academy of Arts and Sciences.
Boston Scientific Society.
Society of Natural History.
Brookville—Society of Natural History.
Cambridge—Entomological Club.
Charleston—Elliott Society of Science and Arts.
Cincinnati—Society of Natural History.
Davenport—Academy of Natural Sciences.
Denver—Colorado Scientific Society.
Granville—Denison Scientific Association.
Kansas City—Academy of Science.
Madison—Wisconsin Academy of Arts and Sciences and Letters.
Manhattan—Kansas Academy of Natural Sciences.
Meriden—Scientific Association.
Milwaukee—Wisconsin Natural History Society.
Minneapolis—Academy of Natural Sciences.
New Brighton—Natural Science Association of Staten Island.
New Haven—Connecticut Academy of Arts and Sciences.
New Orleans—Academy of Sciences.
Newport—Natural History Society.

New York—Academy of Sciences.
American Museum of Natural History.
Linnean Society.
Microscopical Society.
Torrey Botanical Club.
Peoria—Science Association.
Philadelphia—Academy of Natural Sciences.
American Philosophical Society.
Franklin Institute.
Wagner Free Institute of Science.
Providence—Franklin Geological Society.
Rochester—Academy of Science.
Rolla—Baccalaureus Scientiæ.
Saco—York Institute.
Salem—American Association for the Advancement of Science.
Essex Institute.
Peabody Academy of Science.
San Diego—Society of Natural History.
San Francisco—California Academy of Sciences.
St. Louis—Academy of Science.
Trenton—Natural History Society.
Tuscaloosa—Alabama Industrial and Scientific Society.
Urbana—Central Ohio Scientific Association.
Washington—Chemical Society.
National Academy of Sciences.
Philosophical Society.

EDUCATIONAL INSTITUTIONS.

Johns Hopkins University—Circulars.
Studies from Biological Laboratory.
Harvard University—Museum of Comparative Zoology.
Cornell University—Bulletins.
Columbia School of Mines—Chemical Society.
Washburn College—Laboratory of Natural History.
Denison University—Scientific Laboratories.
University of Michigan—Reports, etc.
Iowa State University—Engineering Society.
University of Virginia—Philosophical Society.
Massachusetts Institute of Technology—Technology Quarterly.

OBSERVATORIES.

Harvard University Observatory—Cambridge.
Leander McCormick Observatory—University of Virginia.
Lick Observatory—Mount Hamilton.
Meteorological Observatory—Blue Hill.

NAVAL OBSERVATORY—Washington.
WARNER OBSERVATORY—Rochester.
YALE OBSERVATORY—New Haven.

INDEPENDENT PERIODICALS.

THE ENGINEERING AND MINING JOURNAL—New York.
BOTANICAL GAZETTE—Crawfordsville.
MODERN LANGUAGE NOTES—Baltimore.
THE NAUTILUS—Philadelphia.
THE WESTERN NATURALIST—Minneapolis.
NORTH CAROLINA MEDICAL JOURNAL—Wilmington.

BOARDS OF HEALTH, ETC.

MAINE—Augusta—The Sanitary Inspector.
MASSACHUSETTS—Boston—State Board of Health.
MICHIGAN—Lansing—State Board of Health.
NATIONAL—Washington.
NEW YORK—Albany—State Board of Health.
NEW YORK—The Sanitary Era.
NORTH CAROLINA—Wilmington—State Board of Health.
OHIO—Columbus—Sanitary Record.
PENNSYLVANIA—Philadelphia—State Board of Health.
SOUTH CAROLINA—Columbia—State Board of Health.
TENNESSEE—Nashville—State Board of Health.
WISCONSIN—Appleton—State Board of Health.
NORTH CAROLINA MEDICAL SOCIETY—Wilmington.
NORTH CAROLINA PHARMACEUTICAL SOCIETY—New Berne.

AGRICULTURAL EXPERIMENT STATIONS, ETC.

ALABAMA—Auburn.
ARKANSAS—Fayetteville.
CALIFORNIA—Berkeley.
COLORADO—Fort Collins.
CONNECTICUT—New Haven.
CORNELL UNIVERSITY—Ithaca, N. Y.
DELAWARE—Newark.
GEORGIA—Athens.
ILLINOIS—Champaign.
IOWA—Ames.
KANSAS—Manhattan.
KENTUCKY—Lexington.
LOUISIANA—Baton Rouge.
MARYLAND—Agricultural College.
MASSACHUSETTS—Amherst.
MICHIGAN—Agricultural College.

MINNESOTA—St. Anthony Park.
MISSISSIPPI—Agricultural College.
MISSOURI—Columbia.
NEBRASKA—Lincoln.
NEVADA—Reno.
NEW HAMPSHIRE—Hanover.
NEW JERSEY—New Brunswick.
NEW YORK—Geneva.
NORTH CAROLINA—Raleigh.
OHIO—Columbus.
OREGON—Corvallis.
PENNSYLVANIA—State College.
SOUTH CAROLINA—Columbia.
SOUTH DAKOTA—Brookings.
STORRS SCHOOL—Mansfield.
TENNESSEE—Knoxville.
TEXAS—College Station.
VERMONT—Burlington.
VIRGINIA—Blacksburg.
WEST VIRGINIA—Morganton.
ILLINOIS STATE LABORATORY OF NATURAL HISTORY—Champaign.
MASSACHUSETTS HORTICULTURAL SOCIETY—Boston.
MICHIGAN HORTICULTURAL SOCIETY—Grand Rapids.
MINNESOTA HORTICULTURAL SOCIETY—Minneapolis.
MISSOURI BOTANICAL GARDEN—St. Louis.
NORTH CAROLINA HORTICULTURAL SOCIETY—Raleigh.
VIRGINIA DEPARTMENT OF AGRICULTURE—Richmond.
DEPARTMENT OF AGRICULTURE—Washington.

GEOLOGICAL SURVEYS.

ALABAMA—Tuscaloosa.
ARKANSAS—Little Rock.
CALIFORNIA—State Mining Bureau, San Francisco.
ILLINOIS—Springfield.
INDIANA—Indianapolis.
MINNESOTA—Minneapolis.
NEW JERSEY—New Brunswick.
NEW YORK—Albany.
NORTH CAROLINA—Raleigh.
OHIO—Columbus.
WYOMING—Cheyenne.
U. S. GEOLOGICAL SURVEY—Washington.

GOVERNMENT DEPARTMENTS.

FISH COMMISSION—Washington.
NATIONAL MUSEUM—Washington.

SIGNAL SERVICE BUREAU—Washington.
SMITHSONIAN INSTITUTION—Washington.
COAST AND GEODETIC SURVEY—Washington.
SURGEON GENERAL'S OFFICE—Washington.
DEPARTMENT OF STATE—Washington.

CANADA.

GRIMSBY—Fruit Growers' Association of Ontario.
HALIFAX—Nova Scotian Institute of Natural Sciences.
MONTREAL—Natural History Society.
OTTAWA—Field Naturalists' Club.
Royal Society of Canada.
Geological Survey of Canada.
Entomological Society of Ontario.
PORT HOPE—Canadian Entomologist.
TORONTO—Canadian Institute.
WINNIPEG—Historical and Scientific Society.

GREAT BRITAIN AND IRELAND.

BELFAST—Naturalists' Field Club.
BRISTOL—Naturalists' Society.
DUBLIN—Royal Dublin Society.
DUMFRIES—Natural History and Antiquarian Society.
EDINBURGH—Royal Society of Edinburgh.
GLASGOW—Geological Society.
Natural History Society.
HALIFAX—Yorkshire Geological and Polytechnic Society.
LEEDS—Philosophical and Literary Society.
LIVERPOOL—Geological Association.
LONDON—Royal Society of England.
MANCHESTER—Geological Society.
Literary and Philosophical Society.
NEWCASTLE—North Staffordshire Naturalists' Field Club.
PENZANCE—Natural History and Antiquarian Society.
Royal Geological Society of Cornwall.
ROTHAMSTED—Agricultural Experiment Station.
TRURO—Royal Institution of Cornwall.

ARGENTINE REPUBLIC.

BUENOS AYRES—La Sociedad Cientifica Argentina.

AUSTRIA.

BRUNN—Der Naturforschende Verein.
GRAZ—Der Naturwissenschaftliche Verein für Steiermark.
PRAG—Die k. k. Gesellschaft der Wissenschaften.

TRIESTE—La Societa Adriatica di Scienze Naturali.
WIEN—Der Naturwissenschaftliche Club.
Die Zoologisch-botanische Gesellschaft.

BELGIUM.

BRUXELLES—La Société Royale Malacologique de Belgique.
La Académie Royale de Medecine de Belgique.
La Société Royale Linneenne.

BRAZIL.

RIO DE JANEIRO—Museu Nacional.

CHILE.

SANTIAGO—Der Deutsche Wissenschaftliche Verein.

FRANCE.

AMIENS—La Société Linneenne de Normandie.
ANGERS— La Société d'Etudes Scientifiques.
AUXERRE—La Société des Sciences Hist. et Nat. de l'Yonne.
CAEN—La Société Linneenne du Nord de la France.
NIMES—La Société d'Etude des Sciences Naturelles.
PARIS—Bulletin Scientifique de la France et de la Belgique.
Le Laboratoire Municipal de Chemie.
ROUEN—La Société des Amis des Sciences Naturelles.

GERMANY.

AUGSBURG—Der Naturhistorische Verein.
ALTENBURG—Die Naturforschende Gesellschaft des Osterlandes.
BERLIN—Botanischer Verein fur die Provinz Brandenburg.
Entomologischer Verein.
Gesellschaft Naturforschender Freunde.
Naturae Novitates.
BONN—Naturhistorischer Verein.
BRAUNSCHWEIG—Verein fur Naturwissenschaft.
BREMEN—Naturwissenschaftlicher Verein.
BRESLAU—Die Schlesische Gesellschaft fur Vaterländische Cultur.
CARLSRUHE—Naturwissenschaftlicher Verein.
DANZIG—Naturforschende Gesellschaft.
DRESDEN—Naturwissenschaftliche Gesellschaft "Isis."
DURKHEIM—"Pollichia"—Naturwissenschaftlicher Verein des Bayr. Plalz.
EMDEN—Naturforschende Gesellschaft.
FRANKFURT AM MAIN—Senckenbergische Naturforschende Gesellschaft.
FRANKFURT AM ODER—Naturwissenschaftlicher Verein.
Societatum Literae.
GERA—Gesellschaft von Freunden der Wissenschaft.

GIESSEN—Oberhessische Gesellschaft fur Natur u. Heilkunde.
GREISSWALD—Naturwissenchaftlicher Verein fur Neu-Pommern u. Rügen.
HALLE—K. Leopoldinische-Carolinische Deutsche Akad. d. Naturforscher.
HANAU—Wetterauische Gesellschaft fur die Gesammte Naturkunde.
HANNOVER—Naturhistorische Gesellschaft.
HEIDELBERG—Naturhistorisch-Medizinischer Verein.
KASSEL—Verein fur Naturkunde.
KIEL—Naturwissenschaftlicher Verein fur Schleswig-Holstein.
KONIGSBERG—d. K. Physikalisch ökonomische Gesellschaft.
LEIPZIG—Die Naturforschende Gesellschaft.
LUNEBURG—Naturwissenchaftlicher Verein.
MAGDEBURG—Naturwissenschaftlicher Verein.
MUNSTER—Westfälische Provinzial-Verein fur Wissenschaft u. Kunst.
OFFENBACH—Verein fur Naturkunde.
OSNABRUCK—Naturwissenschaftlicher Verein.
REGENSBURG—Naturwissenschaftlicher Verein.
WIESBADEN—Nassauischee Verein fur Naturkunde.

ITALY.

CATANIA—Accademia Gioenia di Scienze Naturali.
NAPOLI—Societa Africana D'Italia.
PADOVA—Societa Veneto-Trentina di Scienze Naturali.
PERUGIA—Universita libera di Perugia.
PISA—La Societa Toscana di Scienze Naturali.
ROMA—R. Accademia dei Lincei.
TORINO—Musee di Zoologia ed Anatomia Comparata.

JAPAN.

TOKYO—Deutsche Gesellschaft fur Natur und Völkerkunde Ostasiens.

LUXEMBOURG.

LUXEMBOURG—Société Botanique.

MEXICO.

MEXICO—Observatorio Meteorologico-Magnetico Central.
Sociedad Mexicana de Historia Natural.
Sociedad Cientifica "Antonio Alzate."

NETHERLANDS.

AMSTERDAM—K. Nederlandische Akademie d. Wissenschaften.
HARLEM—Musee Teyler.
MIDDELBURG—La Société Hollandaise des Sciences.
NIJMEGEN—Nederlandische Botanische Vereenigung.
UTRECHT—La Société Provinciale des Arts et des Sciences.

PORTUGAL.

LISBON—La Academie Royale des Sciences.

RUSSIA.

DORPAT—Die Naturforchende Gesellschaft.
HELSINGFORS—Societas pro Fauna et Flora Fennica.
KHARKOW—La Section Medicale de la Société des Sciences Experimentales.
KIEFF—La Société des Naturalistes.
MOSCOW—La Société Imperiale des Naturalistes.
ODESSA—La Société des Naturalistes de la Nouvelle-Russie.
RIGA—Der Naturforschende Verein.

SYRIA.

BEYROUTH—Revu Internationale de Bibliographie (med. et pharm.).

SWEDEN.

LUND—Universitatis Carolina Lundensis Acta.
STOCKHOLM—La Société Entomologique.
Sveriges Offentliga Bibilothek.
Konegeliga Svenska Vetenskaps Akademie.

SWITZERLAND.

AARAU—Die Naturforschende Gesellschaft.
BASEL—Die Naturforschende Gesellschaft.
BERN—Die Naturforschende Gesellschaft.
CHUR—Die Naturforschende Gesellschaft Graubünden.
FRAUENFELD—Die Thurgauische Naturforschende Gesellschaft.
FRIBOURG—La Société Fribourgeoise des Sciences Naturelles.
GENEVE—L'Entomologiste Genevoise.
GENEVE—L'Institut Genevois.
LAUSANNE—La Société Vaudoise des Sciences Naturelles.
ST. GALL—Die St. Gallische Naturwissenschaftliche Gesellschaft.
ZURICH—Die Naturforschende Gesellschaft.
International Entomologischer Verein.

INDEX.

VOLUME V—VOLUME VII.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY.

VOLUME VIII—PART FIRST.

JANUARY—JUNE.

1891.

POST-OFFICE:

CHAPEL HILL, N. C.

E. M. UZZELL, STEAM PRINTER AND BINDER.
RALEIGH, N. C.
1891.

OFFICERS.

1890–1891.

PRESIDENT:

George F. Atkinson, ... Auburn, Ala.

VICE-PRESIDENT:

F. B. Dancy, A. B., ... Raleigh, N. C.

RESIDENT VICE-PRESIDENT:

William Cain, C. E., ... Chapel Hill, N. C.

SECRETARY AND TREASURER:

F. P. Venable, ... Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

DEMONSTRATION OF THE METHOD OF LEAST WORK.

BY WM. CAIN, C. E.; M AM. SOC. C. E.

1. A new method of ascertaining the stresses in elastic structures by means of the principle of "Least Work" has been elaborated by Castigliano, in his "Théorie de l'Equilibre des Systémes Élastiques" (Turin, 1879), who claims to have given the first complete demonstration of the theorem of least work, though several authors have touched upon it from 1818 to the present time.

In the "Transactions of the American Society of Civil Engineers" for April, 1891, the writer published an article entitled "Determination of the Stresses in Elastic Systems by the Method of Least Work," in which two new and complete demonstrations of the principle of least work are given, both being founded on the well-known principle of "virtual velocities" of mechanics "applied to framed structures."

The following article is an abstract of the briefer demonstration, given in the article by the writer before mentioned, and is based on "the theory of deflections," which will first be given. A few preliminary articles on "elastic work" of a bar in tension or compression, "superfluous" bars in trusses, etc., are added to make the paper sufficiently complete in itself; especially as the aim is to make the demonstrations as simple and elementary as possible.

2. If we call a the length of a prismatic bar, w its cross section, e its modulus of elasticity and k its change of length under the stress s, then, by the fundamental law of elasticity, when the resultant stress s acts along the axis and the limit of elasticity has not been exceeded, we have,

$$k = \frac{a\,s}{e\,w} = c\,s \ldots\ldots (1),$$

if for brevity, we put, $c = \dfrac{a}{e\,w}$.

If the bar lengthens or shortens the amount k by the action of a load P, acting in the direction of its axis, which *gradually* increases from o to its greatest value P, the stress likewise increases from o to its greatest value s, and at any instant the stress is exactly equal to the load. If in any small interval of time the average stress is s, whilst the length changes an amount $d\,k$, due to a slight increment of load, the work done is s. d k; therefore as the load changes from o to P, the total work done is the limit of the sum,

$$\Sigma\,(s.\ d\,k) = \Sigma\left(\frac{k.\ d\,k}{c}\right),$$

between the extreme values k = o and k = k, corresponding to s = o, and s = s.

∴ *The total work of deformation* for a *gradually applied* load is,

$$\frac{1}{c}\int_0^k k\,d\,k = \frac{1}{c}\,\frac{k^2}{2} = \frac{1}{2}\,c\,s^2 = \frac{1}{2}\,s\,k \ldots\ldots (2);$$

or since load P = s, *work* = ½ *load* × *change of length.*

For a *suddenly applied* load P, causing a change of length k^1 and maximum stress *s*, the work of the load is P k^1, and since the stress *gradually* increases from o to *s*, the work of deformation, by (2), is $\frac{1}{2}$ s k^1, and since these are equal s = 2 P, or the *maximum* stress is double the load; hence by (1) the change of length is double that for a gradually applied load. After a series of oscillations this change ultimately becomes that due to a gradually applied load and *s* reduces to P. As, in what follows, we are only concerned with the ultimate or statical stress, we shall always compute *the work of deformation* of a bar, as for a *gradually applied* load, by the formula (2),

$$\frac{1}{2} c s^2 = \frac{1}{2} \frac{a}{e w} s^2 \quad . \; . \; . \; . \; (3).$$

3. *Superfluous bars.* When the figure of a truss has more lines than are strictly necessary to define its form; *i. e.*, to fix its apices when the length of sides are given in order, the extra sides are said to be "*superfluous.*"

The relation between the least number of sides *m*, or the number of "necessary" bars in a truss and the number of joints or apices *n*, for *strictly* defining the form of a figure of invariable form, is easily arrived at.

Thus for plane figures (which we shall alone consider in this article) assume the position of one side, thus fixing the two apices at its ends. From these apices we can fix another with two new sides, then another with two new sides from two apices previously fixed, and so on; therefore to each of the (n—2) joints other than the first two corresponds two sides, so that the total number of necessary sides *m* = 2 (n—2) + 1 = 2 n—3. If the number of sides exceeds (2 n—3), the extra number are "superfluous" to strictly define the form. A less number will give a figure that can change its shape without changing the lengths of its sides.

It is well known that the laws of statics alone suffice to determine the stresses in any truss, whose pieces are free to move at the joints, when the number of bars is just that necessary to strictly determine the form. When there are superfluous bars or continuous members without free play at the joints, the theory of elasticity must be used to give the additional equations, which, added to those furnished by the ordinary laws of statics alone, give as many equations as unknown stresses, from which the latter are obtained by elimination. The theory of "least work" offers a direct solution of such problems.

It may be observed, if a truss is subjected to such *conditions*, that more than two joints are fixed in position, that there may be more bars than are strictly necessary to define the form, even when $m = 2n - 3$. It is always easy in such cases to ascertain the number of "superfluous bars" by supposing the truss built out from two joints taken as fixed, apex by apex, towards the other fixed joints.

The number of bars just sufficient to fix the position of each apex, other than the fixed ones, is easily seen; all other bars are superfluous to this end and must be so treated when applying the method of least work.

4. *Derivative of the Work of Deformation with respect to an external force. Deflection.* Consider a truss of invariable form, without superfluous bars, and let a force unity act in the direction of and along the line of action of any external force P. Then when all the original external forces, such as P, are removed and we have only the force unity acting on the truss, with the corresponding reactions, if any, call u the stress in any bar due to the force unity in question. Also call the length of this bar a, its cross section w and modulus e, and let us conceive it as elongating an amount $\triangle l = \frac{a s}{e w}$, or the exact amount

caused by the stress *s* due to all the external forces such as P (the force unity being omitted), and that this elongation alone causes the displacement $\triangle$ p[1] of force unity in the direction of that force. In applying the principle of virtual velocities we have the right to suppose any displacement $\triangle$ l we choose, and for convenience we take that the bar actually sustains when the truss is fully loaded and not what it would sustain from the force unity.

Now assuming *u* to be tension, the displacements of the ends of the bar are in the opposite directions to the forces acting, so that the virtual velocity is negative. We shall assume the displacement $\triangle$ p[1] to be in the direction of the force unity until otherwise ascertained.

We have now by the principle of virtual velocities,

$$1. \triangle p^1 - u. \triangle l = 0;$$

$$\therefore \quad \triangle p^1 = u \frac{a s}{e w}.$$

If *u* or *s* are compressive, it is evident that they must have the minus sign in the above equation. Should $\triangle$ p[1] thus become minus in any case, the displacement will be contrary to the direction of the supposed force unity.

Continuing thus to find the displacement of force 1, due to the change of length of each bar in turn, the other bars remaining unchanged, we have for the total displacement of the force unity, acting in the direction of external force P, the formula,

$$\triangle p = \Sigma \left(u \frac{a s}{e w} \right) \quad . \; . \; . \; . \; (4),$$

the sum extending to all the bars of the truss.

But since this displacement is that caused by the actual stresses in all the bars due to the original external forces, it must equal the actual displacement of force P along its direction or the deflection of the truss in the direction of force P.

This is a known formula, by means of which the *deflection* of any truss containing only "necessary" bars in the direction of any given external force or supposed force, can be computed. In using it, strict attention must be paid to the signs of u and s, plus for tension, minus for compression.

We shall now put this formula in a different shape and from it eventually deduce the theory of least work.

If we call X the stress (+ for tension, — for compression) in any bar due to all the loads and their corresponding reactions, when P is omitted, we have the stress in any bar,

$$s = X + u P;$$

whence, taking the derivative, since X is entirely independent of P,

$$\frac{d s}{d P} = u.$$

$$\therefore \quad p = \Sigma \left(\frac{a s}{e w} \cdot \frac{d s}{d P} \right) = \frac{d}{d P} \cdot \frac{1}{2} \Sigma \left(\frac{a s^2}{e w} \right) \quad . \ . \ . \ (5),$$

in which it is understood that s must be replaced by $X + u P$. Now by eq. (3), $\frac{1}{2} \frac{a s^2}{e w}$ represents the elastic work of one bar, so that in words (5) shows that *if we express the work of deformation of the bars as a function of the external forces, its derivative with respect to one of the forces gives the displacement, in the direction of the force, of its point of application.*

This is called by Castigliano "the principle of the derivative of work," or it may be termed the theorem of deflection. If we call the work of deformation of the system, F, it is plain, from the above that when $\frac{d F}{d P} = \Delta p$ is plus, the displacement is in the direction of the force; when minus, in a contrary direction. When two equal forces, directed both toward or both from each other, along the same line (as in the case of the horizontal thrusts of an arch hinged at the abutments), are designated by the same letter P, if we call P and P^1 the two forces and F the work of deformation of the truss, then $\frac{dF}{dP}$ and $\frac{dF}{dP^1}$ give the actual displacements of P and P^1, along the directions of the forces; both minus or both plus, according as the motion is opposed to the direction of the force or with it; so that $\frac{dF}{dP} + \frac{dF}{dP^1}$ gives the total relative displacements of P and P^1. In case we can regard the apex, at which either force as P^1 acts, as fixed, then $\frac{dF}{dP}$ represents, as usual, the displacement of one apex with respect to the other.

If a truss has *superfluous* members, we can suppose them removed and that two opposed forces act at either end of each bar, each equal to the final stress in the member and acting in the same direction. Then if we designate by P and P^1, the forces replacing the action of any one bar, at either end, upon the apices, then if F represents the work of the necessary bars, $\frac{dF}{dP} + \frac{dF}{dP^1}$ gives the total relative displacement of the apices. Now as we can regard $P^1 = P$ as a function of P, the total derivative of F with respect to P is $\frac{dF}{dP} + \frac{dF}{dP^1}\frac{dP^1}{dP}$; but since $P = P^1$, $\frac{dP^1}{dP} = 1$, therefore *the total derivative of F with respect to P* is equal to

$$\frac{dF}{dP} + \frac{dF}{dP^1};$$

which, from what precedes, is equal to the total relative displacement of the apices, where P and P^1 are applied. Hence, in any case, to find the relative displacement of two apices, between which two equal and opposed forces, P and P^1, act, we have only to take the total derivative of F with respect to one of the forces P, so that it is not necessary to designate the two opposed forces by different letters.

5. Demonstration of the Theorem of Least Work.

Let us suppose that we have a truss of any kind, with superfluous bars numbered n, n + 1, . . . , whilst the (n—1) necessary bars (system N) are numbered consecutively, 1, 2, . . . , (n—1).

Let,

$X_1, X_2, \ldots X_{n-1}$ = stresses in bars 1, 2, . . . , (n—1) of a frame supposed to consist of necessary bars alone (system N) subjected to the actual loading.

$u_1, u_2, \ldots u_{n-1}$ = stresses in bars 1, 2, . . , (n—1) of system N alone, by forces unity acting towards each other from either end of the original position of superfluous bar *n*, all the superfluous bars being removed.

$v_1, v_2, \ldots v_{n-1}$ = stresses in bars 1, 2, . . . , (n—1) of system N alone, caused by forces unity acting towards each other from the apices of superfluous bar (n + 1), all the superfluous bars being removed.

Similarly we proceed for other superfluous bars, if any. The stresses X, *u*, *v*, . . . , can all be found by the laws of statics alone. Now designating the length, cross section and modulus of elasticity of any bar, by *a*, *w* and *e*, respectively, with the same subscript as the number of the bar, we have the total elastic work of deformation of all the bars, including the superfluous bars, expressed by

$$G = \tfrac{1}{2}\,\Sigma\left(\frac{a\,s^2}{e\,w}\right) + \tfrac{1}{2}\,\frac{a_n\,s_n{}^2}{e_n\,w_n} + \tfrac{1}{2}\,\frac{a_{n+1}\,s_{n+1}{}^2}{e_{n+1}\,w_{n+1}} + \ldots,$$

in which the sum Σ extends to the necessary bars alone, or bars 1, 2, . . . (n—1). In this expression it is understood that for *s*, the actual stress in any bar, we must substitute expressions of the type,

$$s = X + u\,s_n + v\,s_{n+1} + \ldots,$$

on supplying the proper subscripts pertaining to the bar considered.

The last expression follows at once from the principle of "superposition of effects."

On designating by F the elastic work of the necessary bars alone, we have

$$F = \tfrac{1}{2}\,\Sigma\left(\frac{a\,s^2}{e\,w}\right);$$

the sum including only the necessary bars and *s* being expressed as a function of s_n, s_{n+1}, . . . , as above.

We shall next regard the superfluous bars n, n + 1, . . . , as temporarily removed and replace their action by two forces for each bar, each equal to the stress in the superfluous bar and acting towards each other, as all bars are assumed to be in tension until otherwise determined.

It has been shown above that treating these forces, s_n, s_{n+1}, . . . , as external forces and *independent of each other*, that $-\dfrac{dF}{ds_n}$ represents the increase in distance between the apices at the extremities of bar *n*, the minus sign being used, since the two forces s_n, s_n, replacing the tension of the bar upon the joints at its ends, act in the opposite direction to the displacements. Similarly for the other deflections. Again, since s_n is supposed to equal the actual stress in bar *n* in the complete structure under the loading, it follows that $-\dfrac{dF}{ds_n}$ must equal the elongation of the bar *n* under the stress s_n when all the superfluous bars are in place, since the real change of length of any superfluous bar n is a necessary consequence of the real changes of length of the necessary bars alone, and it can be found as above, without knowing the changes of length of the superfluous bars beforehand. The increase in distance between the apices at the extremities of superfluous bar n, as determined from "system N," must therefore exactly equal the elongation of bar n under the stress s_n when in place.

$$\therefore -\frac{d F}{d s_n} = \frac{a_n s_n}{e_n w_n}$$

or,
$$\frac{d F}{d s_n} + \frac{a_n s_n}{e_n w_n} = 0 \ldots\ldots\ldots (6).$$

A similar expression obtains for each of the superfluous bars, so that we always have as many equations as there are superfluous bars.

Now each equation of the type above (6), can be found by taking the partial derivatives of the expression for G above, successively with respect to s_n, s_{n+1}, . . . , *treated as independent of each other*, and placing the results separately equal to zero, so that the equations needed will be of the type,

$$\frac{d G}{d s_n} = 0, \frac{d G}{d s_{n+1}} = 0, \ldots\ldots\ldots (7).$$

From these equations we find, by elimination, s_n, s_{n+1}, . . . , and then substituting these values in equations of the form,

$$s = X + u\, s_n + v\, s_{n+1} + \ldots,$$

we find all the stresses, s_1, s_2, . . . s_{n-1}.

Theorem of Least Work. Therefore, *to determine the unknown stresses, we express the work of deformation of the whole system as a function of the stresses in the bars taken as superfluous, then treating these stresses as independent in the differentiation, we express that the work of* *the necessary bars and one superfluous bar at a time be a minimum; or preferably, that the work of all the bars be a minimum, provided we assume the fiction, that the stresses of the superfluous bars are entirely independent of each other.*

It is this which constitutes the method of "least work."

When there is but one superfluous bar, the true stresses correspond exactly to a minimum of elastic work, but for a greater number of superfluous bars this is not necessarily true, since the stresses in the superfluous bars are functions of each other and not independent, as we assume in forming eqs. (7). This consideration has not been pointed out by any previous author, as far as the writer knows.

The theorems of "deflection" and "least work" have now both been proved by aid of the method of virtual velocities, which, it is seen, is especially adapted to the object in view, as it leads easily and unmistakably to the theorems, and leaves, no doubt, whatsoever as to the exact interpretation of results.

The theorems are easily extended to solid beams, composed of molecules, resisting any change of distance apart by forces varying directly as the changes of distance, according to the law of elasticity first assumed; for such bodies can be treated, therefore, as articulated systems, whence the above theorems directly apply, the unknown stresses between certain molecules taking the place of the stresses in the superfluous bars of the preceding demonstrations. The theorems are therefore perfectly general and apply to solid beams, articulated structures, or combinations of the two, including structures having certain members continuous over certain apices ; but it would take us too far in this article to give the most convenient methods of dealing with such composite structures, which may be found, however, partly in the article by the writer in the April, 1891, Transactions Am. Soc. C. E., and very fully in Castigliano's very exhaustive treatise before mentioned.

ADDITIONS TO THE AVIFAUNA OF NORTH CAROLINA SINCE THE PUBLICATION OF PROF. ATKINSON'S CATALOGUE.

BY J. W. P. SMITHWICK.

1. *Alca torda.* Razor-billed auk. The head, wing and foot of one of this species were sent to the Department of Agriculture, Washington, D. C., for identification by Lieut. Foley, U. S. N. It was taken at Lookout Cove on February 15, 1890. Others were seen. (Auk, April, 1890).

2. *Branta leucopsis.* Barnacle Goose. "Has been taken in North Carolina." (Bul. Am. Mus. Nat. His., Vol. I, No. 7, July, 1886; Allen in "Birds of Massachusetts").

3. *Porzana jamaicensis.* Black Rail. Rare summer visitor in the middle and western sections. Found breeding in both places.

4. *Columbigallina passerina.* Ground Dove. Accidental summer visitor in the mountain region. So far two specimens have been seen and identified. (Cairns).

5. *Archibuteo lagopus sancti-johannis.* American Rough-legged Hawk. Seen occasionally in the winter and spring in the west. (Cairns).

6. *Strix pratincola.* American Barn Owl. One taken at Newport, N. C., by James Moore, Esq., November 7, 1889, and sent to Brimley to mount.

7. *Empidonax flaviventris.* Yellow-bellied Flycatcher. Rare transient in the middle section; one was taken August 11, 1890, in the mountains.

8. *Empidonax pusillus traillii.* Fraill's Flycatcher. One was taken in the mountain region in September, 1889. (Cairns).

9. *Otocoris alpestris praticola.* Prairie Horned Lark. Rare winter visitor in the middle and western sections.

10. *Quisculus quiscula æneus.* Bronzed Grackle. Tolerably common transient in the mountains. (Cairns).

11. *Ammodramus henslowii.* Henslow's Sparrow. One female taken in April, 1890, in the western section. (Cairns).

12. *Ammodramus maritimus.* Seaside Sparrow. One taken by myself, May 15, 1891, in a marsh near Plymouth, N. C. No others were seen.

13. *Chondestes grammacus.* Lark Sparrow. Rare summer visitor at Raleigh. Breeds. (Brimley).

14. *Clivicola riparia.* Bank Swallow. Rare transient in the middle and mountain sections.

15. *Helminthophila bachmani.* Bachman's Warbler. Probably a rare summer visitor. One taken at Raleigh, April 27, 1891. (Brimley).

16. *Helminthophila leucobronchialis.* Brewster's Warbler. Rare transient at Raleigh, N. C. (Brimley).

17. *Dendroica palmarum hypochrysea.* Yellow Palm Warbler. Tolerably common transient at Raleigh, N. C. (Brimley).

18. *Turdus aliciæ.* Gray-cheeked Thrush. Transient visitor, rare at Raleigh; tolerably common in the west.

SANS SOUCI, N. C.

THE ALEXANDER COUNTY METEORIC IRON.

BY S. C. H. BAILEY.

About the year 1875, General T. L. Clingman, of Asheville, presented me with a small piece of meteoric iron, concerning which he was able to give me little information further than that it had been found some years before in

Alexander county, and had been given to him by a Mr. Andrews. The piece was evidently a fragment that had been broken from a larger mass, was rather smoothly rounded upon its broadest surface, and, though wholly devoid of a proper crust, the exterior was quite protected from further oxidation upon that side by the alteration produced from weathering. It did not in any part show any evidence of the pittings common to all classes of meteorites. Its structure is coarsely granular, or made up of polygonal fragments, lightly adherent, with intervening thin folias of Schreibersite and cracks or veins of iron oxide, cementing the mass together. In some instances the Schreibersite also forms small blocks, with rounded outlines. The limited area of the surface cut is only sufficient to show that it belongs to the Braunite type of Meunier, or the "Grobe Lamellen of Brezina." It has a density of 7.635 and its composition, as shown by Venable, is

Iron	91.70
Nickel	5.86
Cobalt	.63
Phosphorus	.095
Oxygen and loss	1.72
	100.00

Where the iron is free from the Schreibersite it cuts easily, takes a good polish, is very light in color, and upon etching it shows neither the Newmann lines nor the figures of Widmanstädt, but it quickly blackens upon applying the acid, and is very slowly corroded. In grains it is quite malleable, but rather brittle in mass. It is most probable that the fragment in my possession came from near the surface of the main mass, and it may present different conditions from the interior portions, which have been protected from the action of the soil or atmosphere. From comparison with examples of the other North Carolina meteoric irons, it is seen to differ essentially from all of them, the only one which it at all resembles being that from "Duel Hill," found in 1873, but several marked differences are apparent upon direct comparison. While the Alexander county was found some years prior to that from Madison county, the places of find are widely apart, and the densities and analyses do not nearly approximate. This iron does not seem to be especially prone to oxidation, and while it belongs to a class that is not very compact in structure, yet the condition of a part of the surface of this specimen above mentioned would indicate that even when denuded of its natural crust its exterior (unless exposed in a very damp soil) would form a new protective coating of oxide which might preserve the parent mass for many years.

Unless it has been so destroyed, the original mass must still be in existence, and as has been the case with other meteorites found in that State, it may now be lying, unrecognized, about some farm building, instead of being where it properly belongs—in the State Cabinet. In a State that has been so favored in the number of its meteoric falls, it would seem to be natural that its people should be alert to gather and preserve these interesting objects. Professor Venable has recently shown that the authenticated fall within the State bears a strikingly large ratio to the entire number of all recorded meteoric falls. The recognition and preservation of the earlier North Carolina meteorites is almost exclusively due to the commendable zeal of General Clingman, and now that the intelligent effort of some of her citizens is directed to the subject it may safely be predicted that the list will soon be much extended.

OSCAWANA ON HUDSON, N. Y., August 19, 1891.

TREATMENT OF ZIRCONS IN PREPARING PURE ZIRCONIUM OXYCHLORIDE.

BY F. P. VENABLE.

Linnemann (Sitz. Ber. Kais. Akad. d. Wissens., Vol. II, 1885, translated in London Chemical News, LII, 233 and 240) has published an account of the "Treatment and Qualitative Composition of Zircons." All previous methods of breaking up the zircon and purifying the zirconia have presented numerous difficulties and proved decidedly unsatisfactory.

Having occasion to prepare some of the compounds of zirconium in considerable quantity and of chemical purity I adopted the methods of Linnemann. In the course of my work I have found it advisable to modify the process in several respects, and I make this publication in order that my experience may be available, and perhaps serviceable, to others.

In the first place, I have found the mechanical preparation can be simplified. I have used North Carolina zircons and have found it sufficient to pulverize them roughly in an iron mortar and then grind in an agate mortar until the powder passed through a 100 mesh sieve. The preliminary exposure during ten days to vapor of hydrofluoric acid and the grinding until the powder passed a silk sieve seemed both unnecessary. The fine powder was repeatedly boiled with strong hydrochloric acid and washed with water. Five hundred grams treated in this way lost seventeen grams, the hydrochloric acid thus dissolving 3.40 per cent. of the whole. The fusions were made in nickel crucibles, which are very much cheaper and less attacked than the silver recommended by Linnemann. The loss comes chiefly in the cracking of the crucibles during the cooling after fusion. The crucibles used measured 10.5 c. m. in diameter by 8 c. m. in height and held a charge of 100 grams zircon, 400 grams sodium hydroxide and 20 grams sodium fluoride. This is one-half the amount of sodium fluoride recommended by Linnemann, but proved sufficient. The sodium fluoride should be dried beforehand. The sodium hydroxide is first thoroughly melted and the fluoride then added. The mass should be brought to a fairly high temperature and then the zircon powder added. A rapid evolution of gas follows the introduction of the powder. The mass should be well stirred by means of a nickel stirrer—a narrow strip of sheet nickel fastened to a glass rod answers the purpose and keeps the hands beyond the reach of hot alkali occasionally thrown out. If the bubbles threaten to rise over the edge temporary removal of the lamp secures their subsidence. The crucible should not be allowed to cool too far, however. Much seems to depend upon carrying through the reaction rapidly at a high temperature. I have at times doubled and even tripled the length of fusion at a lower temperature without securing the thorough breaking up of the zircon secured at a higher temperature. After the first violent boiling a quieter period follows. The end of the reaction is shown by a thickening of the mass and the rising of large bubbles here and there, also sometimes by a fine spitting or spray. In several instances where weights were kept the undissolved or unattacked portion of the zircon powder amounted to less than five per cent.

The melted mass was poured out upon pieces of sheet nickel for cooling. After solidifying enough to handle with tongs it was broken off and plunged in a beaker of cold water. Water was also put in the crucible after it had cooled, to dissolve off the portions adhering to the sides.

The water separates the sodium silicate from sodium zirconate, leaving the latter undissolved. This is dissolved in dilute hydrochloric acid and evaporated several times to dryness with fresh amounts of acid in order to drive off the hydrofluoric acid. The separation by means of water is far from perfect, some of the zirconate going into solution, though not enough, usually, to make it worth while to attempt to regain it. There is a good deal of silica left with the undissolved portion. This is separated after evaporation to dryness. The dried mass is reached with dilute hydrochloric acid. There is difficulty sometimes in extracting all of the zirconium chloride in this way. Of course the solution contains large quantities of salt, besides other substances. Zirconium hydroxide is precipitated away from these by ammonium hydroxide, and then thoroughly washed in large jars by decantation. The crude zirconium hydroxide is next dissolved in strong hot hydrochloric acid, using as small an amount as possible. This solution is evaporated to dryness and the crude zirconium chloride obtained placed in a large funnel and washed with a mixture of strong hydrochloric acid and four parts of alcohol. This mixture is poured upon the mass in the funnel and allowed slowly to drain through. Some zirconium chloride is dissolved, but can be recovered by evaporation. The mass in the funnel is left white and fairly pure. To complete the purification this mass is taken and repeatedly crystallized from boiling hydrochloric acid until the acid gives no test for iron, which seems the most persistent among the impurities. I have commonly found it well to repeat this crystallization more than twenty times. The pure oxychloride is gotten in well-formed crystals of glistening whiteness. This method of crystallizing from hydrochloric acid, used by Linnemann, is the only satisfactory one for purifying the zirconium chloride. I have tried the precipitation by hydrogen dioxide, as recommended by Bailey, but the consumption of pure dioxide is very large and a heavy source of expense, and the pentoxide or mixed oxides yielded is not nearly so convenient as the chloride for further working with. The method described above is shorter than the tedious and expensive treatment with hydrochloric acid, alcohol and ether. Judging from an attempt at carrying it out on a small scale, the amount of ether required in purifying the product from a kilo of zircons would be very large indeed.

The modifications in the process have throughout the aim of cheapening and shortening Linnemann's process, and were successful in both directions, at least under the conditions under which I worked.

A qualitative analysis of the different products obtained while thus decomposing the zircon was made under my direction by Mr. John M. Morehead. It differed in several noteworthy particulars from that made by Linnemann. In the first place, the hydrochloric acid used in the preliminary treatment of the zircon powder extracted a large part of the total tin present. Linnemann does not mention tin as occurring in this solution. No lithium was discovered in any of the solutions, nor any bismuth and zinc. The list of elements found by Mr. Morehead is therefore shorter than Linnemann, who reports sixteen. The list found was sodium, potassium, magnesium, calcium, aluminium, iron, lead, tin, uranium, erbium, silicon and zirconium. Undoubtedly a large proportion of these come from foreign matter mixed with the zircons and sifted into the cracks in the crystal, so as not to admit of separation. A number of the rare elements were looked for without finding them. No thorough spectroscopic examination was made, however.

Mr. Morehead also made several quantitative determinations of the iron, silicon and zirconium, resulting as follows:

Per cent. Zirconia	62.82; 62.59; 63.12; 62.80;
Per cent. Silica	34.10; 34.20; 33.52; 34.10;
Per cent. Ferric Oxide	3.29;

or, taking the means,

$$Z2\,O_2 = 62.83$$
$$Si\,O_2 = 33.98$$
$$Fe_2\,O_3 = 3.29$$
$$100.10$$

It is not right to calculate the iron as all in the oxidized condition, as much of it comes from the iron mortar and can be easily separated with a magnet.

QUANTITATIVE ANALYSIS OF THE ZIRCON.

BY J. M. MOREHEAD.

In the following analysis it was found most convenient to fuse a portion of the zircon by the Linnemann process, as modified in the preceding article, and from that portion to make the determinations of zirconia and iron. For the silica a second portion was fused with sodium hydroxide, without the use of fluoride. Several other modes of fusion were first tried without satisfactory results.

The method recommended by Classen was tried. One gram of the powdered zircon was fused with five grams each of sodium and potassium carbonate. Heating for one and a half hours with the blast lamp failed to effect thorough fusion. The cooled mass was leached out with water, acidified with hydrochloric acid and filtered away from the unattacked residue. This process was repeated four times, fusing in each case with the same weights of carbonates. It was then found that out of the original gram of zircon .36 gram remained undissolved. This method was abandoned.

The method finally used was to fuse one gram of powdered zircon with ten grams of sodium hydroxide in a nickel crucible, the fusion continuing with an ordinary burner for one-half hour, and then with a blast lamp for twenty minutes. The contents were then poured upon a piece of sheet nickel and cooled. During fusion the mass was occasionally stirred with a nickel stirrer, which must be thoroughly dry. The caustic alkali left on the rod rapidly attracts water on cooling. The cooled mass on the sheet nickel is transferred to a beaker of water and the crucible is rinsed into the same. This was acidified with hydrochloric acid, and in one case only was a residue left. This hydrochloric acid solution was evaporated to dryness and the silica determined in the usual way. Treatment with ammonium fluoride and weighing of the residue not volatilized is essential, as a small amount of zirconia was always found with the silica.

For the iron the solution freed from silica was made up to a known volume, definite portions withdrawn, and the iron determined by titration with a potassium permanganate solution.

In determining the zirconia, measured portions of the solutions were taken, rendered nearly alkaline with sodium carbonate (this is best done in the cold solution); sodium acetate was then added and the whole heated to boiling. After boiling ten minutes the main part of the zirconia will be found precipitated. This is filtered out. The filtrate is acidified with acetic acid, again raised to boiling and boiled for twenty-five minutes with sulphuretted hydrogen bubbling through. The nickel, coming from the crucible, is thus precipitated and is filtered off. The filtrate is acidified with hydrochloric acid and boiled until no further smell of sulphur dioxide is noticed. Then precipitate with ammonium hydroxide, wash thoroughly, dry and ignite. From the weight of this last precipitate must be subtracted the known weight of iron present. The sum of the weights of the first precipitate from the sodium acetate, and this last, as corrected, give the amount of zirconia.

The analyses were made from several fusions. The results were as follows:

	Silica.	Zirconia.	Ferric Oxide.	Total.
	34.10	62.82		
	34.20	62.59		
	33.52	63.12	3.285	
	34.10	62.80	3.29	
Mean	33.98	62.83	3.29	100.10

RECORDS OF MEETINGS.

FIFTY-NINTH MEETING.

PERSON HALL, January 16, 1891.

1. Reservoir Dams. William Cain.
2. Progress in Chemistry. F. P. Venable.

SIXTIETH MEETING.

PERSON HALL, February 10, 1891.

3. Vegetable Butter. H. L. Miller.
4. The Welsbach Lamp. J. M. Morehead.
5. Multiple Telegraphy. J. W. Gore.
6. Koch's Treatment of Tuberculosis. R. H. Whitehead.

SIXTY-FIRST MEETING.

PERSON HALL, March 10, 1891.

7. A Geological Trip Into Hyde County. B. E. Shaw.
8. Aluminium. J. V. Lewis.
9. Modern Myths. K. P. Battle.

SIXTY-SECOND MEETING.

PERSON HALL, April 21, 1891.

10. The Electric Motor. J. W. Gore.
11. Applications of the Electric Motor. A. H. Patterson.
12. Photography in Natural Colors. F. P. Venable.
13. A Brief Sketch of the Pea-nut Plant. Gaston Battle.

ADDITIONS TO THE EXCHANGE LIST.

ARGENTINE REPUBLIC.

National Department of Agriculture.

AUSTRIA.

BUDAPEST—R. Hungarian Academy of Sciences.
PRAG—Die Gesellschaft, "Lotos."

ENGLAND.

BIRMINGHAM—The Philosophical Society.
BURTON-ON-TRENT—Natural History Society.

FRANCE.

TOULOUSE—La Société des Sciences Physiques.

GERMANY.

ROSTOCK—Verein der Freunde der Naturgeschichte in Mecklenburg.

ITALY.

BOLOGNA—R. Accad. delle Scienza.
BRESCIA—Ateneo di Brescia.
GENOVA—Societa Letture e Conversazioni Scientifiche.
NAPOLI—Societa di Naturalisti.
PAVIA—Bolletino Scientifico, R. Univ. di Pavia.

LUXEMBOURG.

LUXEMBOURG—Verein Luxemburger Naturfreunde.

26

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY.

VOLUME VIII—PART SECOND.

JULY—DECEMBER.

1891.

POST-OFFICE:

CHAPEL HILL, N. C.

E. M. EZZELL, STEAM PRINTER AND BINDER
RALEIGH, N. C.
1892.

OFFICERS.

1890–1891.

PRESIDENT:

George F. Atkinson, - - - - - - - Auburn, Ala.

VICE-PRESIDENT:

F. B. Dancy, - - - - - - - - - - Raleigh, N. C.

RESIDENT VICE-PRESIDENT:

William Cain, - - - - - - - - Chapel Hill, N. C.

SECRETARY AND TREASURER:

F. P. Venable, - - - - - - - - Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.

31

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

SOME CERCOSPORÆ FROM ALABAMA.

BY GEO. F. ATKINSON.

The genus *Cercospora Fres.* comprises a great number of species of leaf fungi producing effects in their hosts frequently termed, in common parlance, "blight," or "leaf blight." The species are all probably more or less parasitic, varying in different degrees of intensity, as obligate parasites, from the forms occurring in dying parts of leaves, languid leaves, upon plants physiologically diseased or of low vitality, induced sometimes by overcrowding and thus preventing necessary circulation of air among the parts or entrance of sunlight; at other times through imperfect assimilation caused by defective drainage, careless preparation and care of the soil, so that the unfavorable physical condition of the soil prevents proper nutrition; by impoverished soil which predisposes the plant to a hastened and unnatural maturity: to perhaps a few cases of a more virulent nature where quite healthy plants are injured from their attacks.

The nature of this parasitism, in general as above described, would suggest to the thoughtful and progressive cultivator of the soil the necessary remedy in each case.

The genus belongs to one of the great groups of fungi known as the *Hyphomycetes*. Its members, along with many others, are sometimes termed "imperfect fungi," because they are not *autonomous; i. e.*, they represent, as is supposed, not complete individuals in themselves, but only a transitory form, or stage, of a polymorphic fungus, the perfect condition of the individual being some species of *Sphærella* or other ascomycetous fungus. Thus they stand only as the conidial stage of more or less complex life cycles. It is quite probable that in this respect they are analogous to other conidial forms, of the nature of which we have more positive knowledge, for example the Powdery mildews (*Erysipheæ*), Downy mildews (Peronosporeæ), etc., so that the conidial stage can reproduce itself successively for several generations without the intervention of the perfect, or ascigerous, stage. Therefore there is not a true, or strictly obligate, alternation of generations such as obtains in the *Muscineæ*, *Filices*, etc.

In but few of the species has the perfect stage been discovered. The writer has given an account of the perfect stage of *Cercospora gossypina* in the Bulletin of the Torrey Botanical Club, Vol. XVIII, p. 300 (*Sphærella gossypina* Atkinson). Pammel (Bulletin No. 13, Iowa Agr. Exp. Sta., May, 1891) is of the opinion that *Cercospora angulata*, on currants and gooseberries, is connected with *Sphærella Grossulariæ*, and that *Septoria Ribis* is also connected with the same perfect fungus. If this should be confirmed, then we have here a *Cercospora* forming one of the stages of a trimorphic fungus possessing conidial, spermogonial, and ascigerous stages. *Cercospora ariæ* Fkl. is considered the conidial stage of *Sphærella cinerascens* Fkl., and *C. radiata* Fkl. of *S. Vulneriæ* Fkl. (Sacc. Syl. Fung., Vol. I, pp. 493, 503). Probably one reason why the perfect stage of but few has been found lies in the fact that in many cases this stage is only developed after the leaves have fallen to the ground and become more or less disorganized or fragmentary and the evidences of the *Cercospora* have disappeared.

While the species are not autonomous, and we thus possess only fragmentary evidence, as it were, of the characters of the complete individual, the peculiarities of form, grouping, markings, color, dimensions and effect upon their hosts are such as to offer comparatively satisfactory data for the systematist to characterize and arrange them. It is fortunate that this is so, because of their parasitic habit it is quite important that we can arrive even approximately at the limitations of the species on the different hosts.

It may seem surprising at first, to one unfamiliar with the growth of these forms and the reactionary influence of their hosts, that so many species are at present known, and that the probability is the number will even yet be increased. The specific physiological differences of the various hosts as well as the structural variations of their leaves, the differences in texture, thickness, and the varying power which the different species possess through their vital processes to resist the growth of the parasite, all exert a powerful influence upon its form and characteristics. Here we have the coincidence of several quite effective agencies, all which tend to produce variations in the parasite. It is quite possible to conceive how during a long period of time a few forms widely distributed over a great number of hosts have become more and more unlike each other and finally more firmly fixed in the possession of peculiar characteristics. This is even more probable when we consider that quite likely during much of this time the hosts themselves have been differentiating more and more so that now well-marked specific differences appear in hosts that long ago were alike and harbored the parasite which has kept pace with them in descent.

The action of the Cercospora parasite on the host results in most cases in the death of the affected part of the leaf, producing a marked appearance in contrast with the unaffected portions, usually termed a "spot." One or more of these spots occur on a leaf, their form varying from circular to angular, or irregular to very indefinite. In many cases the resulting color changes, due to a partial disorganization of the chlorophyl, to a development of erythrophyl or other coloring substances, gives variety to the circumference of the diseased areas or to surfaces of the leaf opposite that on which the fungus is located. In a number of cases there are no well defined spots, but the fungus is diffused over small or large areas of leaf surface, giving to those areas the characteristic color peculiar to the species, being roseate in *C. effusa* (B. & C.) Ell., ferrugineous in *C. lateritia* Ell. and Hal., etc. In the case of *C. catenospora* Atkinson the fungus is diffused over large areas of leaf surface and quite injurious, producing a decided "leaf curl."

The vegetive portion of the fungus consists for the most part of colorless mycelium made up of filamentous, septate bodies irregularly interlaced among themselves and the cells on the interior of the diseased portions of the host. These contain protoplasm, they grow by longitudinal extension and division of their end cells and by branching. Further formation of cells probably takes place by the division of older cells. Their nourishment is obtained by absorbing materials from the cells of their host.

Following the vegetive condition is the conidial stage. Provision is made for the production of conidia and their easy dissemination by means of specialized fungus threads, or fruiting hyphæ, properly *conidiophores*, usually termed briefly by systematists *hyphæ*. These arise in more or less divergent or compact fascicles, which stand perpendicularly to the leaf su:face and project beyond it. In a few cases some of the vegetive threads ramify on the surface of the leaf and produce conidiophores in a diffuse manner. The fascicles, or tufts, of conidiophores arise from a more or less compact fungus body termed a *stroma*. This is formed at various points on the vegetive mycelium within the leaf tissue by a lateral growth of certain of the cells together with a conjunction of cells of adjacent threads. In *C. Bœhmeriæ* Pk. this consists of a prominent globose body; from this there are different degrees of compactness and rotundity down to a few closely associated cells which bear only a few conidiophores.

The conidiophores themselves vary greatly in length, size, general direction, markings and color. They may be continuous, septate, geniculate, flexuous, toothed, or cylindrical. The geniculations, the denticulation and much of the flexuous condition is brought about by the manner of growth of the conidiophore while it is bearing conidia. In nearly all the species the conidia are, as termed in some cases, lateral and acrogenous in their production on the conidiophores; *i. e.*, they are borne both laterally and terminally. This is not, strictly speaking, true, but only appears so to be after several conidia have been produced from a single conidiophore. Probably all of the conidia are primarily acrogenous and only later appear to be lateral after the conidiophore has grown at one side beyond the apex on which the conidium was developed. If the conidiophore is growing very rapidly the new growth, which pushes out at one side of the apex on which the conidium is situated, will extend to a considerable distance before another conidium is borne at the new apex. This again grows out past the new conidium, and so on. If the new growth of the conidiophore has been quite divergent from its primary direction a geniculation, or abrupt bend, will appear at the point where the conidium was attached. After the second conidium is borne the conidiophore will usually diverge in a different or opposite direction, giving a somewhat zigzag appearance. At each one of these angles will be a scar left by the abscised conidium. If the onward growth of the conidiophore is not divergent, but follows its primary direction, then a shoulder will frequently appear where the conidium was abscised, or the new growth may occur so soon as to turn the apex with its scar to one side, when the conidiophore will be nearly cylindrical with scars distributed along its sides. In some cases like the latter the production of conidia is very rapid also, so that no sooner has the conidiophore begun to grow past the conidium than it bears another conidium, and thus two or more scars may be left very near each other on a cylindrical conidiophore. If several conidia are thus borne very near one place the conidiophore is apt to be somewhat enlarged at this point, especially if it is characteristic for the species that the scar is left on a minute protuberance. A case of this kind has come under my notice in *C. papillosa* Atkinson. When the growth of the conidiophore beyond its fruiting apex is not very rapid and at the same time in a direction divergent from its primary direction it will appear denticulate or jagged.

The conidiophores are farther marked by *vacuoles* or *guttulæ* in some cases, as well as by the possession of some coloring substance, brown, reddish, olive, fuliginous, etc.

The conidia are usually elongated and filamentous, hyaline or colored, usually septate, cylindrical, terete, obclavate, or tereti-fusoid. In their early development from the apex of the conidiophore they are marked off from the latter by a strong constriction, the union between the two being quite frail. If it does not meet with any mishap it continues to grow by elongation, receiving its nutrition through the small point of contact with the conidiophore. At first it appears as a small oval or elliptical or clavate body, which as it grows elongates, loses it clavate form, and assumes one of the forms described above. The great variation in length of the conidia of the same species is influenced partly by the length of time during which it remains in communication with the conidiophore, but probably more by the climatic conditions, rainy, or damp, weather conducing to a very long growth. Even when conidia are separated from the conidiophores and placed under suitable conditions for germination they will frequently increase in length by apical growth or extension.

The conidia germinate readily in an abundance of moisture, a germ tube being put forth by any or all the cells. In my observations, and they have extended over several species, usually the cell first to produce a germ tube is the basal cell, and the primary direction of this tube is in a line parallel with that of the conidium but in an opposite direction from the apex. This is not universal, but occurs in such a great majority of cases as to be worthy of note. Since writing the above, in examining conidia of *Cercospora Petersii* (B. & C.) from Rav. Fung. Am., 166 (*Helminthosporium Petersii* B. & C.), kindly loaned me by Professor B. T. Galloway, I found a conidium which had germinated, a single germ tube from the basal cell was directed in the way mentioned above.

I have made several attempts to grow conidia of *C. gossypina* in nutrient agar, both with and without an infusion of cotton leaves. Mycelium is formed abundantly, which forms a dark olive-brown mass, many of the fungus threads cohering into stout compact strands several millimetres in length, but in no case have conidia been produced in such cultures with me.

Some remarks are necessary here upon one anomalous species described in the present paper, viz., *C. catenospora*. This is the first species of *Cercospora* that has been described with catenulate spores. Confined strictly to the limitations imposed by Saccardo (Vol. IV, pages 381 and 382, of his Sylloge Fungorum) this species would be placed in division C "*conidia catenulate*," and would there constitute a new genus, since it differs too widely from *Sporoschisma* or *Dendryphium* to be placed in those genera. It might with equal propriety be placed as a new genus among the phragmosporous division of the Family *Mucedineæ* (p. 188), near *Ramularia* or *Cercosporella*, the conidiophores being prominent and quite distinct from the conidia. With the exception of this last character it agrees well with *Septocylindrium*. Here we encounter one of the difficulties of the artificial system of classification which exists to a great extent in the arrangement of some of the *Hyphomycetes*, where such genera as *Ramularia* and *Cercosporella* structurally very closely related to *Cercospora* are made to do duty in an entirely different family. If we consider the variation allowed, and justly so I think, in the genus *Ramularia*, where the conidia are either single or catenulate, this species, in all other respects a true *Cercospora*, is properly located in that genus. This variation between catenulate or not catenulate conidia exists in this one species.

The species enumerated and described below have been collected in Alabama during the last two years, mostly in the vicinity of Auburn. For a short time during the summer of 1891, Mr. C. L. Newman was engaged in my laboratory and some of the collections were made by him. I have been greatly aided in the work of collecting material, preparation of notes and determination of host plants by my assistant, Mr. B. M. Duggar. For the determination of some of the more troublesome hosts I am indebted to Dr. Geo. Vasey, Botanist to the Department of Agriculture at Washington, and to Professor S. M. Tracy, Director of the Miss. Agr. Exp. Station.

Of the seventy-nine species enumerated twenty-eight are here described as new and three varieties are added. One European species (*C. cerasella* Sacc.) and one South American (*C. Bolleana* (Thüm) Speg.) are here described for the first time, I believe, in the United States. The latter I reported in the April (1891) number of the Agricultural Journal, Montgomery, Ala. Two species, one credited to Cooke & Ellis and the other to Ellis & Everhart, are, I believe, also described for the first time. One other species is added by reducing *Helminthosporium Petersii* B. & C. to synonymy.

One other species, heretofore described as *Cercospora persica* Sacc. and later as *Cercosporella persica* Sacc. (Fung. Ital., tab. 67; Sylloge Fung., Vol. IV, p. 218), is excluded. During September, 1890, I collected it at Gold Hill and recognized it as a *Fusarium*. It should read *F. persicum* (Sacc.).

The measurements of conidiophores and conidia are given in terms of the micromillimetre.

There are a few references to numbers of specimens collected by Langlois in Louisiana. These specimens were deposited in the herbarium of the Ala. Polyt. Inst. by C. L. Newman, who received them as exchanges.

Mr. J. B. Ellis has kindly favored me with several specimens for comparison and has examined notes and specimens of a few species. Like favors from others are mentioned in connection with the species.

1. CERCOSPORA CERASELLA Sacc. Spots amphigenous, rusty brown, brighter above with dark border, 2—4 *mm.* Hyphæ amphigenous, fasciculate, fascicles clustered in center of spot or in two or three clusters in different places, olive reddish brown, continuous, subgeniculate or dentate toward apex, 30—50 × 3.5—4. Conidia same color but of a lighter shade, obclavate to acuminate, 5—10—septate, guttulate, 40—75 × 3.5—4.5.

I have compared my specimens with No. 16 fascicle 1 of Brioso et Cavara's Funghi Parassiti delle Piante Coltivate od Utile, and they agree in all essential respects except that the spots in the latter are not well defined, but this may be due to the fact that the leaf in the fascicle I have had access to was probably quite well matured and somewhat yellowed when attacked.

On cultivated cherry (ox heart) leaves (*Prunus avium?*) 1835*a*, Gold Hill, September, 1890, Atkinson; 1968, Auburn, July, 13, 1891, Newman.

2. CERCOSPORA ZINNIÆ E. & M. Spots small, whitish, with broad indefinite dirty brown border, or numerous small white spots in large confluent brown areas. Hyphæ epiphyllous, loosely fasciculate, 40—80 × 4—4, 5, reddish brown, straight or abruptly geniculate and denticulate toward apex, septate. Conidia obclavate, hyaline, multiseptate, 50—100 × 4—4, 5.

On leaves of *Zinnia multiflora,* 2156, Auburn, summer, 1890, Atkinson.

3. CERCOSPORA CERCIDICOLA Ell. Spots amphigenous, dark brown to blackish with indefinite border of dirty yellow, suborbicular, veins of leaf prominent, 3—6 *mm.* Hyphæ mostly hypophyllous, fasciculate, lower half closely and compactly parallel, spreading above, where they are subflexuous, subnodose and prominently denticulate, reddish brown, septate and multiguttulate, 70—160 × 4, 5. Conidia faintly colored, obclavate to tereti-fusoid, 1—5 septate, guttulate, 30—50 × 5—6.

Agrees with N. A. F. 1246, but spots of the latter are darker bordered; the raised border seems to be due to the prominent veins which frequently limit the areas.

On leaves of *Cercis Canadensis*, 2016, Auburn, August 7, 1891, Newman and Duggar.

4. CERCOSPORA OMPHAKODES E. & Holw. Spots brown, black bordered, circular, 2—3 *mm.* Hyphæ amphigenous, fasciculate, subgeniculate and denticulate, bright reddish brown, 30—60 × 4. Conidia slender, terete, dilutely reddish, 4—6 septate, 50—60 × 3.

On leaves of *Phlox Floridana*, 1190, Auburn, June 23, 1890, Atkinson.

5. CERCOSPORA PERSONATA (B. & C.) Ell. Spots amphigenous, circular, dark brown, ususally darker below, frequently arched below, 2—4 *mm.* Hyphæ mostly hypophyllous, frequently also epiphyllous, densely fasciculate, reddish brown, usually short and continuous, toothed, or 50—70 long, septate and subgeniculate 5—7 in diameter. Conidia obclavate, 30—50 × 5—7, or up to 70 long, pale olive brown, 3—10—septate. Agrees in all respects with N. A. F. 2480.

On leaves of *Arachis hypogea*, 2157, Auburn, September 7, 1891, Atkinson, also collected at Columbia, S. C., November 17, 1888.

6. CERCOSPORA OCCIDENTALIS Cooke. Spots much as in *C. personata*, hyphæ amphigenous, paler than in specimens of *personata*. Conidia vary more, being up to 170 long, paler also in color and frequently cylindrical. The oblong spores are not all uniseptate as stated by Berkely (Grev. III, p. 106) but frequently 3—5 or more septate and the long obclavate ones are multiseptate. Thumen's specimens (1964, *C. personata* var. *Cassiæ* Thüm. Myc. Univ.) also agree with mine, the oblong spores not being one septate, but usually several times septate. I consider it quite distinct from *C. personata*.

On leaves of *Cassia occidentalis*, 1547, Auburn, July, 1890, Atkinson; 2128, Duggar. In the latter the clusters of hyphæ are in small patches or widely diffused, no distinct spots. In this respect all the specimens I have seen differ more or less from those of *C. personata* on *Arachis hypogea*.

7. CERCOSPORA MORICOLA Cke. Spots brown, large, irregular. Hyphæ hypophyllous, fasciculate, few in a cluster, reddish brown, septate, denticulate toward apex, 40—70 × 4, 5—5. Conidia hyaline, long, slender, terete, 10—20—septate, straight or curved, 70—200 × 4.

The leaves are injured by another fungus and the spots cannot be well defined. The conidia are stouter than described by Cooke (Grev. XII, p. 30) and Ellis (Jour. Mycol. I, p. 34) and many times more septate, but the septation of long conidia is very variable. It is probably only a variation of Cooke's species.

8. CERCOSPORA DIODEÆ Cke. Spots amphigenous, light brown with narrow raised border bounded by dark brown above, suborbicular or semicircular on edge of leaf. Hyphæ epiphyllous, rarely hypophyllous also, in dense tufts from a tuberculate stroma, short, 10—30 × 4—5, reddish brown, longer ones septate and toothed. Conidia slender, terete, fuscidulous, 3—5—septate, 30—100 × 2, 5—3.

On leaves of *Diodea teres*, 1987, Auburn, July 16, 1891, Duggar and Newman.

9. CERCOSPORA TEPHROSIÆ n. sp. Spots amphigenous, small, angular or suborbicular, 1—2 *mm.*, elevated, blackish brown. Hyphæ epiphyllous, fasciculate, fascicles crowded, reddish, flexuous or dentate, 50—100 × 4, 5—5. Conidia obclavate, subhyaline and tinge of same color as hyphæ, 5—8—septate, usually straight, 70—130 × 4—4, 5.

On leaves of *Tephrosia hispidula*, 2105, Auburn, September 14, 1891, Atkinson.

10 CERCOSPORA TRUNCATELLA n. sp. Spots amphigenous, suborbicular, whitish with narrow light brown border, 2—4 *mm.* Hyphæ amphigenous, fasciculate, reddish brown, septate, geniculate or nearly straight, conidial scars distributed along at geniculations, 70—250 × 4, 5. Conidia hyaline, faintly septate, tapering very gradually from truncated base to obtuse apex, rarely rounded at base, 50—150 × 3, 5—4. Very different from *C. fusco-virens.*

On leaves of *Passiflora incarnata*, 2025, Auburn, August 26, 1891, Atkinson.

11. CERCOSPORA AGROSTIDIS n. sp. Spots amphigenous, broadly elliptical, very light brown center with broad bor-

der of dull red brown, 3—5 *mm.* long. Hyphæ amphigenous, loosely fasciculate, tufts irregularly scattered and few in a spot, bright reddish brown, septate, nearly straight to subflexuous and sparingly toothed near apex, 40—65 × 3, 5—4. Conidia hyaline, 1—7—septate, terete, straight or little curved, 10—60 × 2, 5.

On leaves of *Agrostis*, 2036, Auburn, July 23, 1891, Duggar and Newman.

12. CERCOSPORA CITRULLINA Cke. On leaves of watermelon (*Citrullus vulgaris*), 1581, Sept. 3, 1890, Atkinson. Specimens are not now at hand, not having been preserved. It agrees well with Cooke's description (Grev. XII, p. 31). The only notes I have in my record are as follows: "Amphigenous, conidia several times (5—9) septate. Affects leaves near base of stem first and gradually progresses toward other extremity."

13. CERCOSPORA CUCURBITÆ E. & E. Spots suborbicular, amphigenous, subochraceous, then whitish bordered by brown, 2—4 *mm.* Hyphæ epiphyllous, fasciculate, dull olive reddish brown, lighter toward apex, septate, subgeniculate and sparingly toothed or scarred toward apex, 70—200 × 4—4, 5. Conidia hyaline, slender, terete, straight or curved, multiseptate, 50—120—200 × 3—4.

On leaves of "dish-rag" squash, (*Cucurbita?*) 2154*a*, Auburn, 1890, Atkinson; *Lagenaria vulgaris*, 2154, September 10, 1891, Duggar.

This may be identical with *C. citrullina* Cke.

14. CERCOSPORA PACHYSPORA E. & E. Spots amphigenous, dark brown with concentric elevated lines and indefinite yellowish border, suborbicular, 4—10 *mm.* Hyphæ amphigenous, more numerous below, fasciculate, stout, dilutely ochraceous, septate, flexuous, when young nearly hyaline, 50—100 × 5—9. Conidia hyaline or dilutely yellowish, obclavate, 3—8 septate, 25—100 × 8—10.

On leaves of *Peltandra alba*, 2193, Auburn, September 26., 1891, Duggar.

15. CERCOSPORA BETICOLA Sacc. Spots amphigenous, possessing a blistered appearance, grayish with dark border, 1—3 *mm.* Hyphæ fasciculate, cylindrical, fuscidulous, continuous, nodulose or scarred at or near apex, 70—200 × 4—5. Conidia slender, terete, hyaline, multiseptate, 70—140 × 3.

On leaves of cultivated sugar beet (*Beta vulgaris*), 1832, Auburn, November 28, 1890, Atkinson.

16. CERCOSPORA VERNONIÆ E. & K.? Spots amphigenous, dirty greyish brown with irregular, indefinite border, variable in size. Hyphæ epiphyllous, fasciculate, mostly hyaline when young to fuscidulous, subnodose and toothed, 20—40 × 4, 5. Conidia hyaline, obclavate, slender, 3—12—septate, 70—120 × 3, 5—4.

On leaves of *Vernonia noveboracencis*, 2073, Auburn, August 29, 1891, Atkinson.

17. CERCOSPORA FLAGELLARIS E. & M. Spots amphigenous, at first small, whitish, 2—4 *mm.*, with raised and blistered margin, bordered with indefinite red, later larger and often then confluent over dead parts of the leaf and marked frequently with concentric lines. Hyphæ amphigenous, fasciculate, pale reddish brown, septate, nearly cylindrical, undulate and nodulose above, 30—50 × 4, 5. Conidia long, abruptly slender from near the base, hyaline, multiseptate, 30—120 × 4.

On leaves of *Phytolacca decandra*, 1947, Auburn, July 11, 1891, Newman.

18. CERCOSPORA ACALYPHÆ Pk. Spots on leaves amphigenous, small, numerous, with a 1—3 *mm.* white center bordered above by dark purple, below by light brown. Hyphæ amphigenous, loosely fasciculate, nearly straight or subflexuous or geniculate, prominently scarred, septate, olive brown with faint reddish tinge, 80—140 × 4, 5—5.

Conidia hyaline, terete, straight or curved, multiseptate, 50—200 × 3—4. On the stems the spots are elliptical to oblong, dirty white with dark border.

On leaves and stems of *Acalypha caroliniana*, 1998, Auburn, August 6, 1891; 2102, September 12, 1891, Newman.

19. Cercospora polygonacea E. & E. Spots ochraceous; suborbicular, 3—10 *mm.*, parts of the leaf often reddish. Hyphæ amphigenous, fasciculate, tufts numerous in center of spot, scattered toward border, when young faintly fuliginous and nearly cylindrical, in age plainly reddish brown, septate, subflexuous and denticulate, 30—80 × 4, 5. Conidia hyaline, obclavate, straight or curved, faintly septate, 50—100 × 4—5.

On leaves of *Polygonum dumetorum* var. *scandens*, 2225, Auburn, October 14, 1891, Duggar. Specimens were submitted to Ellis.

20. Cercospora Lobeliæ K. & S. Spots amphigenous, dirty white with dark indefinite purple border, usually small, irregular, 2-6 *mm.* Hyphæ amphigenous, more numerous above, fasciculate from tuberculate base, strongly denticulate, olive brown when young with reddish tinge to reddish brown in age, 10—150 × 4, 5—5, long ones subgeniculate. Conidia faintly colored obclavate, septate and sometimes constricted, 50—100 × 4, 5.

On leaves of *Lobelia amœna*, 2226, Auburn, October 14, 1891, Atkinson. Specimens of this were submitted to Professor Kellerman.

21. Cercospora rhuina C. & E. Spots amphigenous, above dull reddish brown bordered by black, or entirely black and often with indefinite red border, in age sometimes becoming greyish in center, light brown below, frequently arched upward, with or without a narrow elevated border. Hyphæ densely fasciculate, amphigenous, from tuberculate stroma, dull reddish brown, irregularly flexu-

ous, torulose, or denticulate 30–150 × 3—4. Conidia nearly cylindrical to very narrowly tereti-fusoid, or obclavate, and curved, 3–5—multiseptate, faintly olive–fuscidulous, 25—120 × 3—4.

On leaves of *Rhus copallina*, 1178, Auburn, June 30, 1890, *R. toxicodendron*, 1181, June 30, 1890; *R. venenata*, 1304, Shorter's Station, July 16, 1890; *Rhus* sp. undetermined, 1565, Auburn, August 6, 1890, Atkinson; *Rhus glabra*, 2014, Auburn, August 7, 1891, Duggar and Newman. On *R. toxicodendron* both the hyphæ and conidia are more slender than on the other species, and the conidia longer, many times more septate and very frequently guttulate. The variations, however, considering other very striking resemblances, do not seem sufficient to separate it.

22. Cercospora canescens E. & M. Amphigenous, in large dead areas, or spots 2—6 *mm.*, brown or dirty grey with narrow dark border above. Hyphæ amphigenous, fasciculate, brown, septate, nearly cylindrical, stout, 50—100 × 5. Conidia hyaline, obclavate, 3—8–septate, nearly straight, 30—120 × 4, 5—5, 5.

On leaves of cultivated bean (*Phaseolus vulgaris*), 1983, Auburn, July 25, 1891, Newman.

23. Cercospora avicularis Wint, var. sagittati n. var.? Spots amphigenous, light brown with narrow elevated margin frequently bordered by reddish brown, 2—3 *mm.*, Hyphæ olive brown, frequently with reddish tinge, fasciculate, septate, sometimes subgeniculate to denticulate, 70—170 × 4. Conidia faintly colored, septate, 100—300 × 3, 5.

On leaves of *Polygonum sagittatum*, 2201, Auburn, October 1, 1891, Duggar.

24. Cercospora Liquidambaris C. & E. Spots amphigenous, dirty white above, brown below, small, numerous, irregular with a blistered appearance. Hyphæ fasciculate from tuberculate base, dark reddish brown, short,

flexuous, torulose, septate, and minutely guttulate, 20—100 × 4—4, 5. Conidia subhyaline or tinged with olive, terete, straight or curved, 45—150 × 3, 5—4.

On leaves of *Liquidambar styraciflua*, 2227, Auburn, October 14, 1891, Atkinson. In Jour. Mycol., Vol. IV, p. 115, as a note appended to *C. tuberculans* E. & E., Ellis says: "This is very different from *Cercospora Liquidambaris* C. & E., which is on definite spots." This is the only published notice of the species of which I have any knowledge. Ellis writes me that he does not know whether a description has ever been published, but that there is a specimen in his herbarium marked *C. Liquidambaris* C. & E. This is probably the same as No. 77 of Langlois' collection, of which I have a specimen marked *C. Liquidambaris* E. & E. At first sight it would appear quite different from my specimens, for the spots are brown above, orbicular and quite large. There are, however, numerous whitish, small, blistered spots, and a few of these are changing to brown. I should say that Langlois' specimens were in a more advanced condition than mine. The chief difference in the fungus is that in my specimen the conidia are much longer and more nearly hyaline. This can be accounted for by the fact that I could find no conidia in my specimens until I had placed them for twenty-four hours in a moist chamber, where the conditions were favorable for rapid growth.

25. CERCOSPORA ANTHELMINTICA n. sp. Spots small, amphigenous, 1—3 *mm.*, white with narrow raised margin surrounded by dark border. Hyphæ epiphyllous, fasciculate, spreading, subflexuous, subnodnose and profusely toothed, septate, fuliginous with faint reddish tinge, 30—100 × 4—4, 5. Conidia hyaline, terete, 4—10 septate, 25 100 × 4—4, 5. Different from *C. Chenopodii.*

On leaves of *Chenopodium ambrosioides* var. *anthelminticum*, 2037, Auburn, August 27, 1891, Duggar.

26. CERCOSPORA JUSSLÆÆ n. sp. Epiphyllous, small white spots surrounded by indefinite reddish purple border. Hyphæ fasciculate, reddish, septate, geniculate and denticulate toward apex, 40—120 × 4—4, 5. Conidia hyaline, obclavate, 3—10—septate, 100—150 × 4.

On *Jussiæa leptocarpa*, 2159, Auburn, September 2, 1891, Duggar; *J. decurrens*, 2191, Auburn, September 29, 1891, Atkinson.

27. CERCOSPORA FUSIMACULANS n. sp. Spots amphigenous, light brown bordered by dark brown, broadly fusoid or elliptical, 3—4 *mm.* long, frequently confluent. Hyphæ epiphyllous, fasciculate, olive reddish brown, straight, subgeniculate or nodulose, sparingly denticulate toward apex, septate, 50—100 × 4—4, 5. Conidia small, hyaline, 3—4 septate, tapering little toward each end, 25—40 × 2.

On leaves of *Panicum dichotomum*, 2054, Auburn, August 15, 1891, Duggar.

28. CERCOSPORA SETARIÆ n. sp. Spots amphigenous, dark with indefinite pale border, elliptical. Hyphæ epiphyllous, dull reddish brown, fasciculate, sometimes very dense, others divergent, sometimes branched from near base, septate, with a few small guttulæ, scars small, giving denticulate appearance near apex, 50—100 × 4, 5—5. Conidia hyaline, 1—pluriseptate, cylindrical or obclavate, straight or curved, 20—150 × 4—5.

On leaves of *Setaria glauca*, 2120, Auburn, September 17, 1891, Duggar.

29. CERCOSPORA ASTERATA n. sp. Spots amphigenous, about 6 *mm.* in diameter, generally in edge of leaf, dirty grey bordered by black, exterior to this effused with reddish purple. Hyphæ amphigenous, fasciculate, dull reddish brown, subhyaline at tips, septate, geniculate, subflexuous, torulose to denticulate, minutely guttulate, 70—

120 × 4, 5. Conidia hyaline, nearly cylindrical, tapering gradually to each end, septate, 30—50 × 3.

On Aster, 2365, Auburn, November 25, 1891, Atkinson.

30. CERCOSPORA RICHARDIÆCOLA n. sp. Spots amphigenous, black with small white center and concentric lines suborbicular, 2—6 *mm.* Hyphæ epiphyllous, fasciculate, faintly fuliginous when young with reddish tinge, reddish brown in age, usually straight but sometimes geniculate or subflexuous to denticulate toward apex, 10—80 × 5. Conidia hyaline, obclavate, 4—10 or more septate, 50—100 × 3—4.

On leaves of *Richardia Africana*, 2111, Auburn, September 7, 1891, Atkinson. Very different from *C. Callæ* Pk. & Clint.

31. CERCOSPORA ALABAMENSIS n. sp. Spots amphigenous, dirty white definitely limited by dark purple or black with raised margin, 2—3 *mm.* Hyphæ amphigenous, loosely fasciculate, fascicles numerous, faintly septate, dilutely reddish brown, nearly straight, denticulate, or abruptly shouldered and prominently scarred at angles, 50—100 × 4, 5. Conidia long, slender, straight or curved, hyaline, closely multiseptate, terete, 70—250 × 3—4. This is quite different from specimens collected by Prof. Galloway in Missouri, which have been referred by Ellis to *C. Ipomœæ* Winter, and specimens of which have been kindly furnished me by Galloway and Ellis.

On *Ipomœa purpurea*, 1248, Uniontown, July 12, 1890, Atkinson.

32. CERCOSPORA FLAGELLIFERA n. sp. Spots amphigenous, suborbicular to angular 3—4 *mm.* or large and indefinitely limited (this may be due to presence of other fungus), dark brown above, lighter below. Hyphæ amphigenous, rather compactly fasciculate or spreading, reddish brown, prominently scarred and flexuous and denticulate toward tips, or cylindrical, 40—150 × 4, 5. Conidia

hyaline, very long and slender, multiseptate, 70—250 × 2, 5—3 at base.

On leaves of *Galactia pilosa*, 2180, Auburn, September 9, 1891, Atkinson; *Lespedeza?* 2117, September 17, 1891, Duggar. The spots are different on *Lespedeza?*, being angular and nearly black above, and rather small, while in *Galactia pilosa* they are quite large and indefinitely limited. The fungus, however, seems to be the same. It is quite different from *C. latens*.

33. Cercospora papillosa n. sp. Spots orbicular or irregular, sometimes in edge of leaf, dirty white, 2—5 *mm*. Hyphæ amphigenous, fasciculate, nearly straight, denticulate to papillate, the scars sometimes being on minute protuberances. In some cases I have seen them several in a whorl, reminding one of the appearance of some sexual shoots of some algæ of the family *Lemaneaceæ*, fuliginous with very faint brick-red tinge, 50—70 × 4, 5—5. Conidia hyaline, long, rather stout at base, usually tapering rather abruptly into slender, thread-like apical portion, multiseptate, sometimes faintly so, 80—200 × 4—4, 5 at base.

On leaves of cultivated *Verbena*, 2376, Auburn, December 24, 1891, Atkinson.

34. Cercospora Hydrangeæ E. & E. Spots large, angular, limited by veins, blackish above, frequently becoming whitish in center, light brown below. Hyphæ amphigenous, fasciculate from tuberculate base, olive brown with dull reddish tinge in age, subgeniculate and denticulate, 40—70 × 4—4, 5. Conidia hyaline, long, slender, terete, curved, multiseptate, 70—150 × 3—4.

On leaves of cultivated *Hydrangea*, 1013, Auburn, 1890, Atkinson. Specimens of this sent over a year ago to Ellis were marked *C. Hydrangeæ* E. & E. I think this is the first published description and Ellis' name is given.

35. CERCOSPORA DESMODII E. & K. Spots small, 2—3 *mm.*, angular, amphigenous, light brown, numerous, frequently confluent. Hyphæ mostly hypophyllous, fasciculate, 4—8 from tuberculate base, light reddish brown, septate, undulate and sometimes geniculate, 40—80 × 4—5. Conidia hyaline, terete, slender, faintly septate, 30—80 × 25—35.

On leaves of *Desmodium*, 1241, Uniontown, July 12, 1890, Atkinson; Cultivated *Desmodium* (Florida clover), Auburn, 1890, Atkinson.

36. CERCOSPORA SOLANICOLA n. sp. Spots small, white, dark border, or indeterminate on dead areas of the leaf. Hyphæ fasciculate, olive brown with faint reddish tinge, straight to flexuous or geniculate toward apex, 3—5 septate, 40—120 × 5. Conidia hyaline, terete, obtuse, 10—30 septate, 100—230 × 4, 5.

On leaves of *Solanum tuberosum*, 1922, Auburn, June 19, 1891, Atkinson.

37. CERCOSPORA GALII E. & Hol. Spots amphigenous, irregular, large, greyish brown. Hyphæ amphigenous, fasciculate from tuberculate stroma, septate, fuliginous, short, 15—20 × 4—5. Conidia straight or flexuous, faintly 1—6 septate, dilutely yellowish, terete, 40—70 × 3—4.

On leaves of *Galium pilosum*, var. *puncticulosum*, 1318, Auburn, July 22, 1890, Atkinson.

38. CERCOSPORA VIOLÆ Sacc. Spots amphigenous, white, 2—6 *mm.*, suborbicular, sometimes confluent. Hyphæ amphigenous, fasciculate, nearly straight, long ones sometimes subflexuous and subdenticulate, fuliginous, sometimes with reddish tinge, 30—70 × 4—5, in rainy weather frequently 150—300 long. Conidia hyaline, long, slender, terete, multiseptate and nearly straight, 100—200 × 3, 5—4.

On leaves of *Viola odorata*, 1946, Auburn, July 25, 1891; *Viola cucullata*, 2372, December 14, 1891, Atkinson.

39. CERCOSPORA NYMPHEACEA E. & E. Spots amphigenous, subcircular, 2—4 *mm.*, nearly the entire disk is of a leaden color from profuse development of the fungus, bordering this is a narrow ring of dirty grey color, margined by indefinite purple, which is separated from the grey ring by slightly elevated ring. Hyphæ epiphyllous, densely fasciculate, fascicles crowded, short 10—20 × 3, fuliginous with olive tinge. Conidia very slender, tapering very little toward apex, hyaline or subhyaline, 8—multiseptate, curved or flexuous, 80—120 × 2, 5—3.

On leaves of *Nymphea odorata*, 2160, Auburn, September 2, 1891, Duggar.

40. CERCOSPORA SAURURI E. & E. Spots black above, light brown below, suborbicular, 3—6 *mm.*, with a broad, ill-defined border of yellow. Hyphæ amphigenous, fasciculate, short, nearly straight, faintly fuliginous, 10—20 × 4—5. Conidia hyaline, terete, straight or curved, few to pluriseptate, 30—140 × 3, 5—4, 5.

On leaves of *Saururus cernuus*, 1303, Shorter's Station, July 16, 1890, Atkinson.

41. CERCOSPORA RUBI Sacc. Spots amphigenous, brown with frequently a light center, bordered by red above, irregular and frequently confluent. Hyphæ epiphyllous, fasciculate, spreading from tuberculate base, short, continuous, faintly fuliginous, tufts black, numerous, 3, 5—4 in diameter. Conidia acrogenous, terete, slender, faintly colored, 30—100 × 2, 5—3.

On leaves of *Rubus cuneifolius*, 1130, December, 1889; 1536, August 8, 1890; 1764, September 4, 1890, Auburn, Atkinson. In 1536 the red border of the spots is suffused with yellow.

42. CERCOSPORA BŒHMERIÆ Pk. Spots amphigenous, at first limited by the veins of the leaf, in age sometimes orbicular with indefinite yellowish border, 3—6 *mm.* Hyphæ hypophyllous from rotund tuberculate stroma,

fuliginous, nodulose, continuous, usually short, up to 50 long by 4—4, 5. Conidia fuliginous with faint olive yellowish tinge, 3—5 septate, guttulate, tapering little toward each end, but more toward apex, 40—75 × 4—4, 5.

On leaves of *Bœhmeria cylindrica*, 2321, November 7, 1891, Auburn, Atkinson. Also collected at Shorter's Station, July 16, 1890. These latter specimens were young and the spots distinctly angular.

43. CERCOSPORA HYDROCOTYLES E. & E. Spots amphigenous, light brown, orbicular, with narrow elevated margin and indefinite border of dark brown, 3—4 *mm.*, somewhat arched upward. Hyphæ amphigenous, fasciculate, tufts evenly distributed, faintly fuliginous, continuous or sometimes faintly septate, straight or subgeniculate to toothed near apex, 30—50 × 4—4, 5. Conidia hyaline or subhyaline, slender, terete, multiseptate, sparingly guttulate, 30—70 × 2, 5—3.

On leaves of *Hydrocotyle umbellata*, 1308, Shorter's Station, July 16, 1890, Atkinson.

44. CERCOSPORA MALI E. & E. Spots amphigenous, light brown below, greyish above, subcircular, 3—4 *mm.* Hyphæ amphigenous, fasciculate from dark tuberculate stroma, very short, fuliginous, 3, 5—4 in diameter. Conidia hyaline, very slender, terete, 3—7—septate, 30—75 × 2, 5—3.

On leaves of *Pirus malus*, Gold Hill, September, 1890, Atkinson. These specimens do not agree very well with N. A. F. 2478, the hyphæ being much shorter and the conidia not colored. The material is scanty and it does not seem best to separate it.

45. CERCOSPORA ELEPHANTOPODIS E. & E. Spots brown with dirty yellowish indefinite border, orbicular, less distinct on under surface. Hyphæ epiphyllous, very short, scarcely raised above the tuberculate stroma, faintly fuliginous. Conidia long, very slender, straight or curved,

pluriseptate, dilutely yellowish, 25—120 × 2, 5—3. This is probably a young stage, since in N. A. F. 1757 the hyphæ are amphigenous and well developed.

On leaves of *Elephantopus tomentosus*, 1179, Auburn, June 30, 1890, Atkinson.

46. CERCOSPORA ATRAMACULANS E. & E. Spots amphigenous, suborbicular, 4—8 *mm.*, light brown to nearly black. Hyphæ amphigenous, fasciculate, tufts distributed thickly over the spot, divergent, sometimes branched, subflexuous, irregular in outline, denticulate, septate and guttulate, olive fuliginous with reddish tinge in age, 30—80 × 4. Conidia very narrowly tereti-fusoid, or narrowly lanceolate, 3—10 septate, guttulate, faintly fuliginous, 20—70 × 3, 5—4.

On leaves of *Cassia Tora*, 2129, Auburn, September 10, 1891, Atkinson.

47. CERCOSPORA CRUENTA Sacc. Spots orbicular mottled by blood-red splotches. Hyphæ amphigenous, fasciculate, tufts distributed over spot, short or quite long, faintly olive fuliginous, not reddish brown when long, as in *C. Dolichi*, septate, flexuous, simple or branched, 40—150 × 4. Conidia faintly olive, frequently guttulate, septate, 40—120 × 4.

On leaves of *Dolichos sinensis*, 1238, July 18, 1890; *Phaseolus* (cultivated), 1236, July 18, 1890, Auburn, Atkinson.

48. CERCOSPORA VITICOLA (Ces.) Sacc. Spots suborbicular with indefinite ragged border, blackish above or brown in center with black border, light brown below, affected parts of leaf outside of the spots frequently changing to yellow. Hyphæ amphigenous, parallel and densely fasciculate in compact column 100—300 long, individual hyphæ septate, free for short distance at distal end where sometimes subclavate, abruptly subflexuous, jagged and denticulate when having borne many conidia, sometimes

divergent at distal end, though not nearly so much so as in *C. cercidicola* and *C. Petersii* (B. & C.), though the sterile part of the fascicle is much more compact than in the latter species. Hyphæ, where compacted into bundle 3, 5—4 in diameter, usually somewhat greater, 4—5, at the free ends, dark olive brown. Conidia obclavate, abruptly tapering at base, usually curved, 3—12 septate, sometimes very distinctly so, same color as the hyphæ, though more dilute, 40—70 × 4—7.

Common on cultivated grape leaves (Vitis), Auburn, Atkinson.

49. CERCOSPORA PETERSII (B. & C.). *Helminthosporium Petersii* B. & C., Grev. III., p. 102 (*ex-parte?*), *Helminthosporium Petersii*, Rav. Fung. Am. Ex., 166. Spots amphigenous, light brown in center, with blackish border, orbicular, 2—3 *mm.* Hyphæ amphigenous, mostly hypophyllous, fasciculate, very dark olive brown to nearly black, septate, 100—300 × 4—4, 5, for about two-thirds their length parallel and quite closely compacted into a bundle, not so much so as in *C. viticola*, distal one-third divergent and very profusely subflexuous, denticulate, torulose, jagged, and diameter somewhat greater than the straight portion. Conidia obclavate or narrowly teretifusoid, abruptly acuminate, resembling in form those of *C. cerasella*, but much darker in color, dark olive brown, 2—6 septate, 30—70, even sometimes to 100 × 5—6 at base.

This is very different from *C. smilacis*, Nos. 1676 and 1768 Myc. Univ., the conidia there being much narrower, the hyphæ shorter and otherwise quite different. It differs also from N. A. F. No. 1251. It also seems to be quite different from Saccardo's description of his *C. smilacina* (l. c.) and the figure in F. Ital., No. 681, but may be identical. I have not seen specimens of Peck's *C. Smilacis* and cannot say whether or not it is the same as this species, but I am inclined to think it is; the spores in a young condition may sometimes be hyaline. Prof. B. T. Galloway, Chief of the Division of Veg. Pathology, has kindly permitted me to examine the specimen of *Helminthosporium Petersii* in Rav. Fung. Am., 166, from *Smilax*. It is identical with my specimens from Alabama. I have no doubt that B. & C.'s specimens on *Smilax* are the same. I have not seen the fungus on *Laurus Benzoin* and I have arranged the synonymy for the specimens on *Smilax*.

On leaves of *Smilax glauca*, 1288, Shorter's Station, July 16, 1890; 2375, Auburn, December 20, 1891, Atkinson.

50. CERCOSPORA LUDWIGIÆ n. sp. Spots amphigenous, subcircular, irregular, reddish brown or purple, sometimes with white in center, 1—3 *mm*. Hyphæ epiphyllous, densely fasciculate from tuberculate base, short, olive brown or faintly fuliginous, straight or flexuous, 20—30 × 4, 5. Conidia slender, terete, straight or curved, sometimes guttulate, 3—10 septate, faintly colored, 25—100 × 2, 5—3.

On leaves of *Ludwigia alternifolia*, 2190, Auburn, September 29, 1891, Atkinson.

51. CERCOSPORA D. VIRGINIANÆ n. sp. Spots amphigenous, brown or dirty white with a broad, ill-defined purple border above, 2—5 *mm*. Hyphæ amphigenous, fasciculate, tufts numerous, fuliginous, nearly straight, denticulate, 40—250 × 4—5. Conidia hyaline, stout at base, tapering to long, slender apical portion, multiseptate, 80—350 × 4.

On leaves of *Diodia virginiana*, 2186, Auburn, September 26, 1891, Duggar.

52. CERCOSPORA CRINOSPORA n. sp. Hyphæ fasciculate, 3—6 in a tuft, undulate, sparingly toothed and nearly hyaline at apex, dark brown for nearly the entire length. Conidia very slender, straight, terete, hyaline, 4—6 septate, 20—60 × 1, 5—2.

On dead parts of leaves of *Rhyncospora glomerata*, 2034, Auburn, August 27, 1891, Atkinson.

53. CERCOSPORA ATRAMARGINALIS n. sp. Spots amphigenous, orbicular, 4—6 *mm.*, light brown or dirty grey with black border above. Hyphæ hypophyllous, fasciculate from stroma, short, flexuous or denticulate, continuous, faintly fuliginous, 10—30 × 4—4, 5. Conidia obclavate or cylindrical, 1—10 septate, guttulate, yellowish, 10—70 × 4—5. Different from *C. Physalidis* E. & E., N. A. F. 2299, and from other forms on *Solanum*.

On leaves of *Solanum nigrum* (?), 1359, Auburn, 1890, Atkinson.

54. CERCOSPORA TROPÆOLI n. sp. Spots amphigenous, very light brown with narrow elevated margin above, suborbicular, 2—4 *mm.* Hyphæ epiphyllous, few in cluster, stout, short, faintly fuliginous, 20—40 × 5, dentate. Conidia hyaline, rather stout at base and quickly tapering into long, slender apical portion, reminding one of *C. flagellaris*, multiseptate, 50—150 × 3, 5—4, 5 at base.

On leaves of cultivated *Tropæolum*, 2110, Auburn, September 7, 1891, Atkinson.

55. CERCOSPORA TESSELATA n. sp. Spots indefinite above, usually narrowly oblong, nearly black below with bluish tinge caused by numerous black tufts and bluish cast of leaf tissue affected. Hyphæ hypophyllous, densely fasciculate, fuliginous, short, 10—12 × 2, 5—3, denticulate, tufts in longitudinal and usually transverse rows, giving a checkered appearance to the group. Conidia slender, hyaline, terete, curved, septate, 50—90 × 2—2, 5.

On languid leaves of *Elusine Ægyptica*, 2306, Auburn, November 6, 1891, Atkinson.

56. CERCOSPORA SERIATA n. sp. Spots amphigenous, cinereous with definite brown border margined by indefinite yellow, irregularly oblong, sometimes confluent. Hyphæ epiphyllous, fasciculate, faint reddish brown, in age darker,

flexuous and toothed, 20—50 × 4, tufts in parallel rows. Conidia hyaline, nearly cylindrical, straight or curved, faintly 2—6 septate, 30—70 × 3—3, 5.

On leaves of *Sporobolus asper*, 2009, Auburn, July 24 and August 7, 1891, Duggar and Newman.

57. CERCOSPORA DAVISII E. & E. Spots brown, subcircular. Hyphæ amphigenous, brown, nearly straight, denticulate near tips, fasciculate, 30—90 × 5. Conidia subhyaline or very faintly yellowish, nearly straight, 5—8 - multiseptate, cylindrical or terete, 80—140 × 3, 5—4, 5.

On leaves of *Melilotus alba*, 1268, Uniontown, July 12, 1890, Atkinson.

58. CERCOSPORA ALTHÆINA Sacc. Spots angular, amphigenous, dirty white with narrow black border, 2—3 *mm.* Hyphæ amphigenous, fasciculate, fuscidulous, geniculate or toothed at apex, continuous, 30—50 × 4—5. Conidia hyaline, slender, terete, multiseptate, straight or lightly curved, 30—100 × 3, 5—4, 5.

On leaves of *Althæa rosea*, 1253, Uniontown, July 12, 1890, Atkinson.

Var. MODIOLÆ, n. var. Spots same but little smaller, with narrow raised margin. Hyphæ amphigenous, fasciculate, fuscidulous, continuous, cylindrical, 30—70 × 4, 5. Conidia hyaline, slender and tapering to very narrow apical portion, multiseptate, 50—100 × 3—4.

On *Modiola multifida*, 1253*a*, Auburn, 1890, Atkinson.

59. CERCOSPORA SILPHII E. & E. Spots angular, amphigenous, black or dirty grey with black border, 2—4 *mm.* Hyphæ amphigenous, fasciculate from black base, tufts numerous distributed over the spot, fuliginous with reddish tinge, toothed, longer ones septate, usually 15 25, but up to 70 × 4—5. Conidia obclavate, usually somewhat curved, faintly olive, yellowish tinted, 3—6—septate, .50—100 × 3, 5—5.

On leaves of *Silphium compositum*, 1198, Auburn, June 30, 1890, Atkinson.

60. CERCOSPORA THASPII E. & E. Spots angular, black frequently bordered by indefinite yellow, in age becoming lighter in center, bordered by veinlets frequently, thus giving the appearance of a narrow raised margin, 2—3 *mm.* Hyphæ amphigenous, subfasciculate, 3—8 in a cluster, dark reddish brown, stout, 5—8—septate, guttulate, 70—160 × 5—6, irregularly flexuous, geniculate and sometimes branched. Conidia obclavate, hyaline, stout, closely multiseptate, 60—120 × 5—6 at base.

On leaves of *Angelica hirsuta*, 1540, Auburn, July 22, 1890, Atkinson; 2042, July 23, 1891, Duggar and Newman.

61. CERCOSPORA DEPAZEOIDES (Desm.) Sacc. Spots amphigenous, angular or suborbicular, light brown below, black or greyish above with raised margin. Hyphæ amphigenous, fasciculate, not strongly divergent, distantly septate, dull reddish brown, irregularly flexuous, 100—200 × 4, 5. Conidia faintly tinged with same color, obclavate, septate, guttulate, 50—100 × 4, 5.

On leaves of *Sambucus canadensis*, 1760, Auburn, September 9, 1890, Atkinson.

62. CERCOSPORA SAGITTARIÆ E. & K. Spots amphigenous, angular or suborbicular, light brown, then blackish with indefinite border of a lighter color. Hyphæ epiphyllous, fasciculate, tufts few, fuliginous, simple, denticulate above. Conidia hyaline, straight or curved, obclavate, septate, stout, 40—100 × 4—5. This differs considerably from N. A. F. 1502, but is probably only a variation from that form.

On leaves of *Sagittaria variabilis*, 2039, Auburn, July 24, 1891, Duggar and Newman.

63. CERCOSPORA BOLLEANA (Thüm.) Speg. Spots yellowish and indefinite on upper surface, rusty beneath and

angular, darker in center. Hyphæ hypophyllous, fasciculate, light olive brown, flexuous or toothed, obscurely septate, 40—70 × 4, 5—5. Conidia lanceolate or teretifusoid, 1—5—septate, obtuse, faintly olive yellow, 20—45 × 5—8.

On languid leaves of *Ficus carica*, 1772, Auburn, September 4, 1890, Atkinson.

64. CERCOSPORA CLITORIÆ n. sp. Spots angular, rather large, 3—6 *mm.*, black or nearly black above, brown below. Hyphæ epiphyllous, fuliginous, short, projecting little above the tuberculate stroma, 5 – 10 long. Conidia long, slender, terete, faintly colored, straight or curved, several times septate, 50—70 × 3.

On leaves of *Clitoria mariana*, 2069, Auburn, August 29, 1891, Atkinson.

65. CERCOSPORA EFFUSA (B. & C.) Ell. Hypophyllous, diffuse, giving roseate color to large patches or entirely covering the under surface of the leaf. Hyphæ fasciculate, individuals sometimes creeping and producing numerous branches, geniculate, dentate, reddish, hyaline at tips, 45—100 × 4. Conidia cylindrical, tapering at each end, 1—3 septate, subhyaline, multiguttulate, 25—40 × 4 – 4, 5.

On leaves of *Lobelia amœna*, 2214, Auburn, October 11 and November 3, 1891, Atkinson.

66. CERCOSPORA DOLICHI E. & E. The leaf possesses suborbicular or angular spots mottled with blood-red much as in *C. cruenta.* The hyphæ are not confined to them, but distributed over the green areas of the leaf as well. Hyphæ amphigenous, loosely fasciculate, olive fuliginous, short, subflexuous, subdenticulate and usually somewhat pointed at the apex 20—40 × 4—4, 5, or up to 80 long, then with reddish tinge and plainly septate. Conidia olive, terete, 3—15—septate, curved, usually guttulate, 30 – 100 × 4.

On leaves of *Dolichos sinensis*, 1246, Uniontown, July 11, 1890, Atkinson.

67. CERCOSPORA DIOSPYRI Thüm var. FERRUGINOSA n. var. Hyphæ tufted, tufts numerous, collected into olive black orbicular patches on under side of the leaf. Leaves pale green above at the affected places. Hyphæ ferrugineous, irregularly flexuous, closely septate, often branched, rough, jagged, strongly notched and papillate, 50—150 × 4, 5. Conidia obclavate, tapering abruptly toward base, more gradually toward apex, faintly olive yellowish to ferrugineous and dark brown, 1—12 or more septate, septa close and more distinct toward base, in age strongly constricted at septa and nucleolate, 20—80 × 4, 5—5, 5 at base. The conidia are much stouter than in 1273 Myc. Univ. and darker colored even when young. Hyphæ there more slender and continuous as described by Ellis (Jour. Myc., Vol. 1, p. 51). His description is apparently taken from specimens in Thuemen's Myc. Univ., since it agrees with the ones I have examined from that work. Specimens collected by Langlois, 600, in Louisiana, agree with my specimens from Alabama.

On leaves of *Diospyros virginiana*, 2254, Auburn, September 26, 1891, Duggar.

68. CERCOSPORA SORDIDA Sacc. Tufts of Hyphæ forming angular patches limited by the veins, or covering larger portions of the under side of the leaves, dirty grey or nearly black, upper surface yellowish. Hyphæ subfasciculate, divergent, subflexuous, nodulose, denticulate, septate, guttulate, olive reddish brown, 20—70 × 4—4, 5. Conidia faint olive reddish tinge, multiguttulate, multiseptate, terete, curved or flexuous, 20—110 × 3, 5—4, 5.

On leaves of *Tecoma radicans*, 2149, Auburn, September 13, 1801, Atkinson.

69. CERCOSPORA FUSCOVIRENS Sacc. Hypophyllous, spots colored by hyphæ dirty yellowish green, limited by

the veins, indefinite yellowish spots above. Hyphæ fasciculate, faintly olive reddish brown, septate, frequently branched, subflexuous and denticulate toward apex, 30—70 × 4—4, 5. Conidia dilutely yellow, multiseptate and multiguttulate, very long and slender, terete, 70—150—300 × 3, 5—4, obtuse at distal end, abruptly tapering at base. The spores differ greatly in size from Ellis' and Saccardo's descriptions, but the great length of the conidia is probably due to different climatic conditions.

On leaves of *Passiflora incarnata*, 2198, Auburn, October 2, 1891, Duggar.

70. Cercospora Jatrophæ n. sp. Spots indefinite, at first yellowish above and dirty yellow below from hyphæ first developing below, when badly attacked and old hyphæ are amphigenous and then the spots dirty grey with indefinite yellow border. Hyphæ fasciculate from yellowish brown stroma, dilutely yellowish brown, short, subflexuous, 10—20 × 3. Conidia long and slender, hyaline or subhyaline, 5—12—septate, tapering little to distal end, 50—100 × 1, 5—2.

On leaves of *Jatropha stimulosa*, 1171, Auburn, July 2, 1890, Atkinson.

71. Cercospora macroguttata n. sp. Hypophyllous forming small oval or larger narrowly oblong patches, olive brown in color, from the profusion of the development of the fungus. Hyphæ long, flexuous, geniculate, sparingly toothed near apex, multiseptate and multiguttulate with large guttulæ, dark brown in age with olive tinge, growing tips and young ones decidedly olive green tinge, 100—250 × 5—6. Conidia nearly cylindrical, very narrowly tereti-fusoid, dilutely olive green, 3–8–septate, 10–80 × 4, 5—5.

On leaves of *Chrysopsis graminifolia*, 2138, Auburn, July 13, 1891, Atkinson.

72. Cercospora pinnulæcola n. sp. Diffuse, hy-

pophyllous, giving dirty appearance to under surface of the pinnules, which are usually paled above. Hyphæ in loose tufts distributed over affected area, reddish brown, septate, minutely guttulate, irregularly flexuous, geniculate and profusely denticulate, 100—200 × 4, 5. Conidia obclavate, hyaline, multiseptate and multiguttulate, 50—150 × 4—5.

On leaves of *Cassia nictitans*, 2197, Auburn, October 1, 1891, Duggar.

73. CERCOSPORA ERYTHROGENA n. sp. Hypophyllous, spots indefinite, usually reddening the leaf above, giving dirty appearance to large portion of under surface of the leaves. Hyphæ scattered, frequently creeping, often branched, septate, dull reddish brown, flexuous, denticulate, 50—70 × 4, 5. Conidia slender, usually curved, longer ones terete, faintly olive brown, multiseptate and usually guttulate, 30—100 × 3, 5—4.

On leaves of *Rhexia mariana*, 1541, Auburn, July 22, 1890; *Rhexia* sp. 1819, October, 1890; *R. virginica*, 2066, August 29, 1891, Atkinson.

74. CERCOSPORA RIGOSPORA n. sp. Spots indefinite or absent, but parts of leaf affected, usually obscurely yellowish above. Hyphæ hypophyllous, fasciculate, divergent, in sooty patches sometimes very indistinct, or distributed over large areas, fuliginous with olive tinge, subflexuous, denticulate or torulose, longer ones faintly septate and multiguttulate, 50—60 × 3, 5—4. Conidia straight or curved, subcylindrical, abruptly tapering at each end or terete, 3—10—septate, multiguttulate, dilutely olive yellow, 50—70 × 3—4. This is very different from *C. Solani* Thüm as shown in Myc. Univ., 270, and also from *C. diffusa* Ell., specimens of which I have seen, both of those being much stouter and the conidia quite different in texture, easily collapsing, while those of *C. rigospora* are quite firm. Ellis' *diffusa* seems to me on comparison

identical with Thümen's *Solani*. Specimens collected by Langlois, 1322, in Louisiana and marked *C. Solani*, agree quite well with Ellis' *diffusa* and are quite different from my specimens.

On leaves of *Solanum nigrum*(?), 1225, Auburn, July 5, 1890, Atkinson.

75. CERCOSPORA CATENOSPORA n. sp. Diffused in irregular patches or over large surface of under side of leaves, giving dirty green color. Hyphæ fasciculate from stomata of leaf, divergent, 20—30 up to 75 × 5—6, septate, nearly cylindrical, often toothed, bearing conidia laterally as well at the apex, olive yellowish, rarely darker and inclined to faint reddish tinge. Conidia lateral and acrogenous, concatenate or single, cylindrical when concatenate and then abruptly tapering each way to small truncate end, terete when single, more rarely slightly clavate, dilutely olive yellowish, often guttulate, 1—6 septate, 20—100 × 4—5.

On leaves of *Sambucus canadensis*, 2045, Auburn, August 27, 1891, Atkinson. The leaves are severely injured by the fungus, which causes them to curl and fall, so that in many cases the shrubs are entirely denuded of their leaves.

76. CERCOSPORA ERECHTITIS n. sp. On dead parts of the leaf. Hyphæ epiphyllous, fasciculate, reddish brown, geniculate or scarred, in which case hyphæ are cylindrical, frequently guttulate, 50 240 × 4. Conidia hyaline, septate and guttulate, 70—230 × 3—4.

On leaves of *Erechtites hieracifolia*, 2303, Auburn, November 5, 1891, Duggar.

77. CERCOSPORA GOSSYPINA Cooke. Spots light brown or dirty white, irregular, often bordered by a dark or purple color, frequently without spots appearing on large dead or dying areas of the leaf. Hyphæ amphigenous, fasciculate, brown, geniculate or toothed, 70—450 × 5—7.

Conidia hyaline, few to multiseptate, terete, 70 400 ×
3—4.

On leaves, bracts and cotyledons of *Gossypium herbaceum.*

78. CERCOSPORA LIRIODENDRI Ell. & Hark. I have not collected good specimens of this, but my notes read as follows: "Differs from *C. Liriodendri* (as described) in having conidia 70 long and several times septate."

On leaves of *Liriodendron Tulipifera*, 1951, Auburn, July 11, 1891, Newman.

79. CERCOSPORA CEPHALANTHI E. & K. I have several times collected specimens of this with characteristic spots, but the hyphæ and conidia were so poorly developed it was impossible to take any notes worthy of record.

On leaves of *Cephalanthus occidentalis.*

A NORTH CAROLINA CATALAN OR BLOMARY FORGE.

BY HUNTER L. HARRIS.

This forge is situated on Helton Creek, near its union with North Fork of New River, in Ashe county. It is remarkable as an example of a process for obtaining iron which is now becoming extinct. Briefly, it is the process by which a mass of malleable iron is obtained by heating together in an open hearth a mixture of a pure ore of iron with charcoal, until the carbon monoxide from the charcoal unites with the oxygen of the ore and reduces the ore. There were formerly a number of such forges in that region, but all others have long since disappeared.

This forge was built perhaps fifty years ago by John Ballou; was rebuilt by W. J. Paisley in 1871, and has since been in operation by him, supplying sufficient bar iron for the local demand for wagon tires, horse-shoes, etc.

The plant comprises a two-fire forge, a hammer and an ore crusher, the two latter being operated by separate overshot water-wheels, while the blast for the forge fire is supplied by a third water power arrangement. The forge

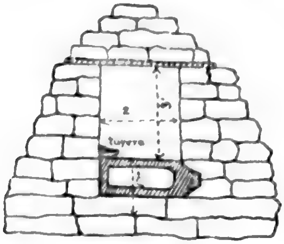


Fig. 1 Front view of Forge

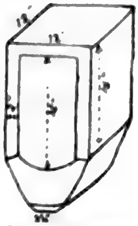


Fig 2. - Hammer.

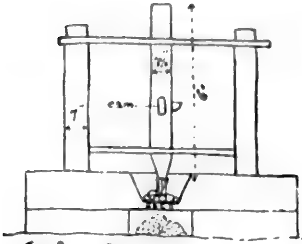


Fig 3 - Ore Crusher

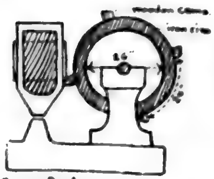


Fig. 4 Position of Hammer.

is an open hearth, rudely built of stone fragments. The tuyère communicating with the blast pipe enters this fire space from one side, and the hearth piece consists of a superannuated hammer head built in with the rock fragments.

The blower, said to be similar to the Catalan blower, is a large box, placed 8 or 10 feet below the water supply, and communicating with it by means of a wooden conduit which enters the blower from above.

The blast pipe, also of wood, leads from the upper part of the blower to the tuyère, and near the bottom of the blower at the end is an exit slit for water. When the gate above is opened and the water allowed to enter the blower, air is drawn in with it from openings arranged in the conduit above.

Once in the blower, the water escapes under pressure through the slit, while the air collecting above is forced through the blast pipe and tuyère into the forge hearth.

The hammer is a mass of iron, weighing perhaps 600 pounds, and mounted on the end of a beam, the other end of which is pivoted in an upright post. This post is deeply buried and braced with a heavy beam. The anvil is a similar mass of iron fastened in a wooden block, which is buried in the ground.

The hammer is raised by wooden cams fixed in the periphery of an iron ring mounted as a drum upon an axle. This axle is also the axle of a small overshot wheel, so that when the wheel is set in motion the drum revolves, and the cams engaging the hammer raise it to the height of ten or twelve inches and allow it to fall upon the anvil. The force of the blow is augmented by a spring beam acting downward upon the hammer as it is released. A similar arrangement of cams set in a drum and operated by a separate water-wheel works the ore crusher. This consists of an iron shod beam of about a hundred pounds weight, standing on end in a strong wooden trough, and having a vertical movement, in guys, of about one foot. The trough has an iron grating in the bottom through which the crushed ore (which has been first roasted) falls, and whence it is raked out. The accompanying figures give dimensions and show mode of operation.

Soft ore is washed in an inclined trough by stirring in gently flowing water.

About 100 bushels of charcoal is required to run 250 pounds of ore. Each fire will make three loops a day, each loop yielding from 75 to 80 pounds merchantable bar iron. The iron is wagoned over the surrounding country over a radius of 10 or 15 miles, and is much esteemed for its good working qualities. The whole thing is rude in construction and arrangement and is entirely exposed to the weather. The water supply is abundant and no attempt is made to economize in that particular. Suitable ore is found as friable magnetite in the near neighborhood, but the forge is worked only as the demand may arise.

NOTES ON THE FERTILITY OF PHYSA HETEROSTROPHA SAY.

BY W. L. POTEAT.

In the essay on the "Duration of Life" Weismann remarks that while the length of life of many molluscan species is well known, "any exact knowledge is still wanting concerning such a necessary point as the degree of their fertility."* Binney remarks of the family Limnæidae, to which our snail belongs: "From the fact of my finding young individuals only in the spring and numerous dead full-grown shells during the late autumn and winter, I presume they arrive at maturity in one season."† Of Physa heterostropha in particular he says that it deposits eggs the beginning of May.

In view of these statements I have thought it perhaps worth while to record in this place some observations made by me in the year 1886.

On the 8th of March I collected from a marsh near Wake Forest two specimens of Physa heterostropha Say.‡

*Heredity, p. 14.

†Land and Fresh-water Shells of N. Amer., p. 23, Vol. VII, Smiths. Misc. Coll.

‡Kindly determined for me later by Dr. Stearnes, of the National Museum at Washington.

On the 16th three thick nidamenta of some forty eggs each were seen loosely attached to the walls of the glass aquarium. A few days later four others had been deposited. Up to June 15th the aquarium was examined at intervals nearly every day. After that date it was not seen again until July 12th, when the water was changed. The next day both the snails were dead, probably as the result of the change of water.

In the period of four months—say March 12th to July 12th—the pair produced 43 nidamenta, which contained, on an estimate certainly not too high, an average of 30 eggs each. So that the number of their offspring for the period mentioned amounted to 1,290. There was no well-marked decline of the reproductive function toward the close of the period, which is perhaps another indication that they came to their death by violence.

From March 31st to June 6th inclusive, the pair were observed in coitu as many as 15 times, at hours ranging from 8:30 A. M. to 6:15 P. M., the coitus lasting sometimes but 20 minutes, sometimes more than an hour. The male function was performed alternately by the two snails. The eggs appear to have been laid only during the night.*

It was important to determine, if possible, the age at which sexual maturity is attained and reproduction begins. Accordingly, on the 12th of July I took out of the aquarium two of the largest of the young snails and put them

*It may be mentioned, however, in view of the similarity of the habits of Physa and of Limnæus, that I once observed a specimen of the latter depositing a nidamentum on the glass wall of the aquarium at 2:20 P. M. The work was about half done when it caught my eye, and I judge that two minutes were consumed in completing it. The eggs and the protecting jelly emerged at the same time from under the right side of the shell aperture and at right angles to its margin, the snail moving slowly sideways in the opposite direction. When the nidamentum was completed, the snail turned slowly round on the glass, made two or three rather aimless grazing movements of the mouth, and then crawled slowly over the nidamentum in the direction of its longer axis, completely covering it with the foot. That position was maintained but a moment or two; nevertheless the snail remained near by. When I lightly touched the nidamentum and the snail at the same time, the latter shrank a little, but immediately proceeded to cover the threatened nest. During the fifteen minutes that I watched further, the snail remained close to the nest—with the view of protecting it? I thought I detected that the jelly of this one freshly made was somewhat softer than that of an older one near by.

into another aquarium. They were presumably members of the first brood, the eggs of which were deposited near March 13th. Their age, reckoning from the time they were hatched, was about 3½ months; size—length of shell, 5 mm.; length of foot, 6 mm. In two days one of the snails was dead. On the 25th of July another snail of about the same size was introduced from the first aquarium. The next entry in my notes is under date of September 11th, when six nidamenta were observed attached to the fibrous roots of a water plant. They were, however, small, containing only from one to four eggs each, showing that the reproductive fuction at that age was feeble. Some of the eggs were already hatched, and the tiny grandchildren of my first Physas were going about the aquarium in search of food. Allowing, say, fifteen days for the intracapsular development of these snails of the third generation, I estimate that the isolated pair of the second generation attained sexual maturity at five months of age. The same day—September 11th—in the first aquarium I noticed a confirmation of my observation in the second, namely, the pairing of two of the oldest brood.

The maintenance of a species depends on the equilibrium between the forces tending to its destruction and those tending to its preservation. We may embrace the former under the general phrase, adverse external conditions. There are two different ways in which the destructive tendency of these adverse external conditions is opposed. The first is by adaptations of structure and habit. The second is by the production of new individuals to take the place of those that have been overcome. Now, as different animals exhibit varying degrees of ability to adjust themselves to their environment, so also their reproductive power may be small or great. In estimating this reproductive power four factors, as Herbert Spencer points out,*

*Biology, Vol. II, p. 395.

are to be taken account of, namely, (1) the age at which reproduction commences, (2) the frequency with which broods are produced, (3) the number contained in each brood, and (4) the length of time during which the bringing forth of broods continues.

Accordingly, for the special case of Physa heterostropha we have the following results:

1. Age at which reproduction begins, 5 months.
2. Frequency of broods, 1 in about $2\frac{7}{10}$ days.
3. Number in each brood, 30 average.
4. Reproductive period, 4 months, March to July.

Some addition ought to be made to this actually observed period, inasmuch as the snails had certainly already entered upon it at the time of their capture, and, further, instead of closing normally, it seems to have been violently interrupted. Just how much the period of reproduction is to be extended I have no means of determining, unless the fact that the young snails of the first brood were observed reproducing themselves in September warrants an extension of at least two months, making it six months instead of four.*

Assuming, then, that the reproductive season extends from March to September, and assuming, further, somewhat arbitrarily, that the snail lives but two years, we have, on the basis of facts above mentioned, the following estimate of the total number of the offspring of a single pair:

At close of first season	1,900
950 pairs at close of second season	1,805,000
Original pair at close of second season	1,900
Total number offspring in two years	1,808,800

*Packard (Zoology, p. 266) states that the "eggs of P. heterostropha are laid in the early spring, and three or four weeks later from fifty to sixty embryos with well-formed shells may be found in the capsule." The apparent inference that only a single brood is produced must of course be dismissed.

WAKE FOREST COLLEGE, N. C.

OCCURRENCE OF ZIRCONIUM.

BY F. P. VENABLE.

Zirconium occurs principally in the form of silicate in the hard, heavy mineral known as zircon.

That this mineral was known in very early times is highly probable from the number of localities where it may be found and its striking physical properties. Yet it is difficult to assert positively that Theophrastus referred to it under the name lyncurium, or Pliny under the various terms chrysolithos, melichrysos and crateritis. The evidence for the first is based mainly on the fact that it is spoken of as a material from which to cut cameos. Theophrastus says the lyncurium was used for engraved signets, was electric on friction and was often amber-colored.

Whether the ancients distinguished the zircon from other minerals and knew it under any of the above names or not it is certain that intagli of zircon are not at all uncommon among ancient gems.

Agricola and Interpe speak of the jacinth. The first mention of the Ceylonese name Jargon seems to be by Cronstedt in 1758. DeLisle in 1783 writes of the "Diamant Brut ou Jargon de Ceylon." This name Jargon was long used for the colorless and yellowish and smoky zircons of Ceylon in allusion to the fact that while resembling the diamond in lustre they were comparatively worthless. From this comes the name zircon. The colorless or only slightly smoky kinds seem to have often been sold for inferior diamonds.

Brownish, orange and reddish kinds were called distinctively *hyacinths* (topazes and garnets were sometimes called the same).

These zircons occur in crystalline rocks, especially in granular limestone, in chloritic and other schists, in gneiss, syenite, and also in granite and sometimes in iron ore beds. Zircon syenite is a coarse syenitic rock containing crystals of zircon along with oligoclase, aegirine, claeolite and epidote.

Crystals of zircon are common in most auriferous sands and sometimes are found in volcanic rocks.

In Ceylon they are mainly found in the alluvial sands. In the Ural Mountains mainly in the gold regions. In Norway sometimes in syenite, sometimes in the iron mines. Zircons are also found in Transylvania, in Bohemia, in Saxony and in the Tyrol.

The occurrence at Expailly, near Le Puy, in France is well known and of especial interest. Fourcroy says "the hyacinth from Expailly was formerly placed in collections of the Materia Medica to be used in some pharmaceutic compositions."

In Auvergne it is found in volcanic tufa. On Vesuvius it occurs with ryacolite in white and blue octahedrons. In Scotland it is found at Scalpay and in Argyleshire. In Ireland with the auriferous sands. In Greenland, in New Granada, and in the gold regions of Australia, it also occurs.

Coming now to North America we have a long list of localities. In Maine, at Litchfield, Paris, Mt. Mica, Greenwood, Hebron. In Vermont, at Middlebury. In Connecticut, at Norwich and Haddam. In New York, in Essex, Orange, Lewis, St. Lawrence, Warren and other counties. In New Jersey, at Franklin and Trenton. In Pennsylvania, near Reading, in magnetic iron ore; at Easton, in talcose slate. In California, in auriferous gravel in various localities, and in Canada, at several places. Very large crystals weighing as much as fifteen pounds have been found in Renfrew and adjoining counties, but they are so isolated that it would be impossible to obtain a large supply there.

Opaque green zircons have been found an inch long by one-half inch across in St. Lawrence county, N. Y., and five black ones of equal size near Franklin, N. J. One of the New York specimens was over four inches in length and is now in the United States National Museum. An interesting form of zircon is found near the Pike's Peak road, almost due west from the Cheyenne Mountains, following a vein-like mass of white quartz in granite. The crystals are generally deep reddish brown, pink, or pale honey-yellow; and a few crystals of deep emerald green are recorded. The largest observed were about one-third inch, but generally they are not more than one-tenth to one-sixth inch in length and would only cut into minute gems. They are, however, perhaps the most beautiful crystals of zircon known, owing to transparency, brilliancy and perfection. The finest gem stones come from Ceylon, Mudger, and New South Wales (Kunz).

The chief States for yielding zircons are South and North Carolina. At Anderson, S. C., the zircon is found loose in the soil and in large quantities. The containing rock is granulite, or gneiss devoid of mica, and according to Lieber this zircon-granulite corresponds to the zircon-syenite of Norway.

In North Carolina the zircon is abundant in the gold sands of Burke, McDowell, Polk, Rutherford, Caldwell, Mecklenburg, Nash, Warren and other counties in very minute yellowish brown and brownish white, sometimes amethystine, pink and blue crystals. It is mainly found, however, in large greyish brown crystals on the south side of the Blue Ridge near Green River, in Henderson county. Here, in a few weeks in 1869, General Clingman collected one thousand pounds of crystals. The presence of zircons there was known many years prior to this. The occurrence is mainly on what was known as the Freeman and Jones farms, about two miles distant from one another. The deposit runs north-east and south-west, and for many miles zircons can be found, but only at the Freeman and Jones mines in sufficient quantities to work. These are situated on a high ridge. The zircons seem as plentiful on the surface as lower down. The mines have been worked to about the depth of fifteen feet. Before 1860 the zircons were collected from the surface and sold to collectors for about ten dollars a quart. From sixty-five to seventy thousand pounds have since been raised and sold at prices varying from fifteen cents to one dollar per pound. The principal consumers of zircons assure me that there is at present no demand for them, they themselves having a number of tons in stock, all they will need for some years. They are worth about $250 a ton in large lots.

At the Green River mines the dirt is placed in rockers and washed, the zircons and grains of magnetic ore sorting out easily. The latter is separated by means of large magnets. The zircons are from the smallest sand to a quarter of a pound in weight. They are somewhat smaller than the zircons from Anderson, S. C., and easily distinguished from the latter by their form.

When zirconium began to be used a few years ago in incandescent lamps, it was thought to be a comparatively rare mineral. The new application and consequent demand caused a search to be instituted which has shown that in reality it is widely distributed and in places very abundant.

It is to be found in many cases along with titanium, which was to be expected from the chemical relationship existing between the two. Sandberger has observed transparent crystals of zircon in granite of many places; also in gneiss and mica, in diorite and porphyry. Microscopic crystals are widely distributed in the sedimentary rocks, the material of which has been mainly derived from the older rocks; for example, in the variegated sandstones of the Black Forest, in carboniferous limestones and in the sands of the valley of the Maine.

Thürach has shown that microscopic zircon is rarely absent from the archaean and sedimentary rocks. It also occurs in very many eruptive rocks, and it is widely distributed in basalts and dolerites.

Corse reports many localities where it is found in Italy, among them the auriferous sand of Ticino, volcanic sand, and the shore sands of the Tyrrhenian Sea.

The world's main supply, however, if the demand increases, must come from the enormous quantities in the Ural Mountains and in Norway, and from the great and easily workable deposits of Green River, N. C., and Anderson, S. C. Hitherto it can scarcely be said to have been mined in more than one locality, Green River, N. C.

As to other minerals besides the zircon containing zirconium, we have a few, but they are rare and apparently exist in small quantities.

First there are the altered zircons: Auerbachite, Malacone, Cyrtolite, Tachyaphattite, Oerstedite and Bragite.

It is also found in Eudialite, Polymignite, Aeschinite and Fergusonite.

THE MAGNETIC IRON-ORES OF ASHE COUNTY, N. C.*

BY H. B. C. NITZE.

At a time when the mineral resources of the Southern States are attracting such wide-spread interest and attention, I have thought it appropriate to give a short general description of the iron-ore deposits of a territory concern-

*Published in Transactions of the American Institute of Mining Engineers, 1892.

ing which little is as yet known and nothing published, so far as I am aware.

The data used here are due to the preliminary examinations of the North Carolina Geological Survey, on which work I was engaged during the past summer, and my acknowledgments are due to Professor J. A. Holmes, State Geologist, and Messrs. Harris, Ashe and Lewis, of the survey, for their co-operation in the work; also to Messrs. A. S. McCreath and C. B. White for analyses which they kindly furnished. Other analyses were made by Mr. Charles Baskerville, assistant chemist to the survey, and this may be understood where the name of the chemist is not mentioned.

All samples for analysis were dried at 212° F.

The accompanying map has been prepared from the revised sheets of the *United States Geological Survey* by Mr. H. L. Harris, and will be referred to throughout this paper.

Ashe county lies in the extreme north-western part of North Carolina, bordering on Tennessee and Virginia; it is drained principally by the north and south forks of New river and their tributaries, and is therefore on the eastern edge of the great Mississippi drainage-basin. The country is exceedingly rugged and mountainous, having an average elevation of about 2,900 feet above sea-level.

Jefferson, the county-seat, near the center of the county, is forty-five miles nearly due south from the Norfolk & Western Railroad at Marion, Va., and thirty miles northwest from the Richmond & Danville Railroad at Wilkesboro, N. C.

Geologically the ore-deposits described in this paper are situated in the area of the crystalline rocks, consisting chiefly of gneiss, hornblende-schist, and micaceous schists.

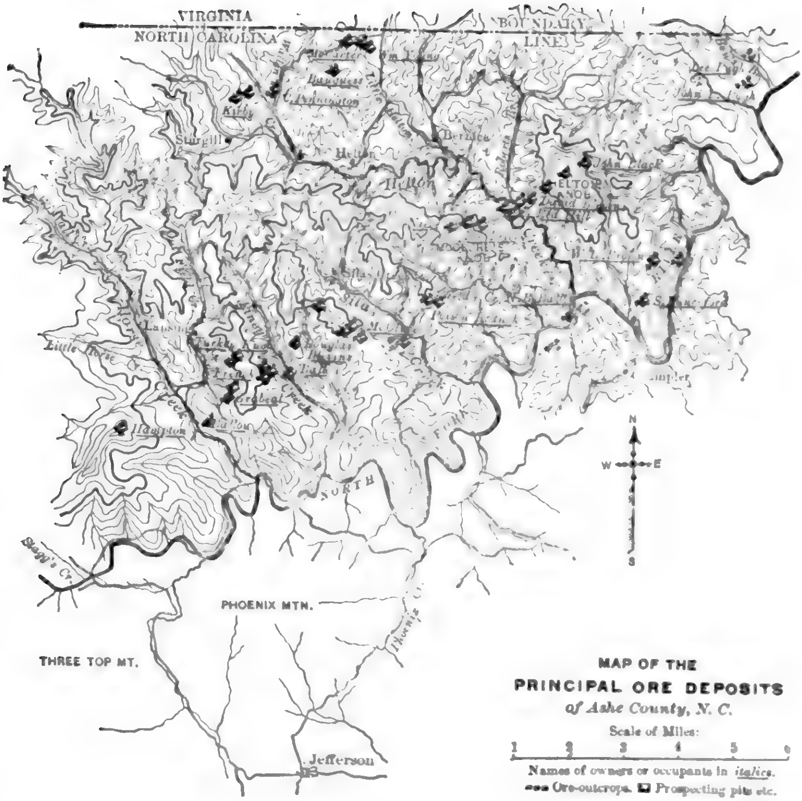
These iron-ore deposits, owing to their present inaccessibility, are practically entirely undeveloped. During the summer of 1890 considerable private prospecting was carried on throughout the county, and much of our knowledge concerning the ore-beds is due to this. Many of the openings, however, have caved in to such an extent that but little can be seen at present. More than fifty years ago there were a number of Catalan forges throughout the county, which smelted these ores into a very superior tough iron. One of these now known as Paisley's forge, at the mouth of Helton creek, is still in operation, and made in 1890 from twenty to thirty tons of bar-iron, used locally for wagon-tires, horse-shoes, etc. At present there are no mining operations whatever going on, excepting in a very small superficial way to supply the Helton forge.

The territory to be described in this paper, as including the principal ore-deposits of Ashe county, embraces about 150 square miles. The ores are principally magnetites, chemically suitable for the manufacture of Bessemer pig-iron. Some brown hematites and red specular ores are also found; but, although of excellent quality, their quantity will hardly place them in the category of economic raw materials.

The structure of the magnetic beds is decidedly lenticular, and as such they are distributed over a rather undefinable area, though there is some regularity in the direction of their outcrops, which have a general trend north-east and south-west.

In the following I shall divide them into three main belts, called according to the local nomenclature: The Ballou or River belt, the Red Hill or Poison Branch belt, and the Titaniferous belt.

Starting along the north-eastern extremities of these belts I shall describe the openings along the outcrops in regular order towards the south-west. By reference to the accompanying map their locations and relation to each other can be more easily comprehended than from mere description.



MAP OF THE
PRINCIPAL ORE DEPOSITS
of Ashe County, N. C.

I. THE BALLOU OR RIVER BELT.

This, the most easterly of the three ore-belts, crops out along the north fork of New river, and has been opened at several points on the farm of William H. Brown.

Opening No. 1 on the west bank of the river at the falls, about one mile north of Crumpler P. O., is a large cut, exposing probably 30 feet of ore-material, composed of hornblende, gneiss, and epidote, which is split up at three points by lenticular masses of magnetite. From the condition of the exposure it was not possible to determine the true thickness of the ore.

An analysis of an average sample from here shows:

	Per Cent.
Silica	27.59
Metallic iron	53.99
Sulphur	0.055
Phosphorus	0.063

The ore crosses the river north-easterly from here to the property of John C. Plummer, but no openings have been made.

Opening No. 2 is located about half a mile west of the river, near Mr. Brown's house.

This cut was also partially caved in and filled with water, so that a clear inspection was not practicable. The exposed material shows:

1. About 4 feet of soft decomposed schistose gangue, carrying finely disseminated grains of magnetite; above this,

2. About 5 feet of decomposed mica-schist and quartz; and above these, towards the face of the cut,

3. About 12 feet of mixed material containing strips of harder, richer ore, 2 feet and more in thickness.

Of the soft ore it has been found by washing that fully 50 per cent. is magnetite, an analysis of which by Mr. A. S. McCreath shows:

	Per Cent.
Silica	2.40
Metallic iron	67.35
Phosphorus	0.028

The unwashed material shows 43.50 per cent. of metallic iron.

An analysis by Mr. Baskerville of an average sample across the entire bed shows:

	Per Cent.
Silica	5.73
Metallic iron	60.48
Sulphur	0.003
Phosphorus	trace.

South-westerly the ore crosses the river about one mile from here, and makes its appearance in a very prominent outcrop over the property of N. B. Ballou, known as the "Home Place," on the east side of the river, between the mouths of Helton and Old Field creeks. It recrosses the river, which makes a large bend at this point, about half a mile from here, near Uriah Ballou's house, and near this second point of crossing some work was done a number of years ago for one of the old forges, showing the approximate thickness of the bed to be 12 feet. The dip is about 37° S. E., and the strike N. 45° E.

The ore is a hard, compact, fine-grained magnetite disseminated in a gangue of hornblende, epidote, and quartz. Higher up on the hill some small, superficial openings expose several smaller ledges of richer ore, comparatively free from gangue. But it is believed that the following analyses will represent the quality of the ore as it must be mined:

	I.	II.	III.
Silica	20.79	----	17.88
Metallic iron	45.50	49.06	50.68
Sulphur	0.002	----	trace.
Phosphorus	0.024	0.018	trace.

Analysis I. is by McCreath.
II. is from U. S. 10th Census Report.
III. is by Baskerville.

Towards the south-west the ore crosses and recrosses the north fork and becomes thinner-bedded. It crops out about one mile from Ballou's on the farm of Dr. Gentry in a high bluff along the east bank of the river, showing a maximum thickness of 2 feet, and apparently pinching out to considerably less than that. An analysis of an average sample taken here shows:

	Per Cent.
Silica	16.68
Metallic iron	47.22
Sulphur	0.063
Phosphorus	trace.

There is a second line of outcrop, about half a mile south-east of the above main outcrop, which has been traced from Brown's on the north fork, about half a mile above the river opening at the falls, in a south-westerly direction, crossing the river at Shubal Lunceford's, almost one mile due north from Crumpler P. O., and continuing through Ballou's and Gentry's lands. This has been opened on Lunceford's place, about a quarter of a mile north of the river, exposing a bed of soft, granular ore, disseminated in mica-schist, which measures 13 feet in thickness, and dips 52° S. E. An analysis of a sample taken across the bed shows:

	Per Cent.
Silica	38.73
Metallic iron	41.36

II. THE RED HILL OR POISON BRANCH BELT.

This belt extends from the north-eastern corner of the county in a general south-westerly direction, its several lines of outcrop crossing over Grassy creek, Helton knob, Red Hill, Helton creek, McClure's knob, Old Field, Silas, Piney and Horse creeks, a distance of some ten miles, as far as traced. It lies from two to three miles north-west of the river belt, and approximately parallel to it.

It has been opened at numerous points along its outcrop, beginning at its north-eastern end on the land of Lee Pugh on Ben's branch, about ⅓ mile north of New river, where a bed at least several feet in width is exposed, but is not fully uncovered. The ore is a friable magnetite of schistose structure. The dip is from 35° to 40° S. E.

An analysis of an average sample shows:

	Per Cent.
Silica	22.74
Metallic iron	45.44
Sulphur	0.049
Phosphorus	0.022

About 400 yards S. 40° W. from here the bed has been exposed on the land of John L. Pugh, on the summit of a high ridge, by a cut 105 feet long, the south-eastern end of which traverses a bed of soft mixed ore and gangue, reported to be 40 feet thick, while the north-western end cuts through about 30 feet of similar material, though harder. Between the two is a decomposed feldspathic mass, probably a local horse.

The cut was partially caved in, so that exact measurements could not be taken. The ore is a coarse-granular, friable, manganiferous magnetite, and the gangue is hornblende, epidote, quartz, and feldspar. Several analyses show the ore to contain:

	I. Per Cent.	II. Per Cent.
Silica	21.11	---
Metallic iron	43.17	44.13
Metallic manganese	4.62	1.42
Sulphur	0.048	0.126
Phosphorus	0.006	0.008

I. by Baskerville.
II. by C. B. White.

The bed is again opened on the properties of W. W. Smith and Noah Dancy, lying successively to the south-west of Pugh's, but the exposures are incomplete and offer no definite data. Several analyses by Mr. C. B. White show the quality of these ores to be:

	Iron. Per Cent.	Phosphorus. Per Cent.
"Smith" ore	55.76	0.040
"Dancy" ore (surface sample)	63.49	0.176

The next notable exposure occurs on the Black property, on the north-eastern slope of Helton knob, on the waters of Grassy creek, where several old "forge" banks are located, whence the Paisley forge still draws its limited supply. The old openings are now completely fallen in, and nothing can be seen excepting the fact that there seem to be two beds about 30 feet apart, the upper one of which is reported to be 2 feet thick. The ore is soft and decomposed, in a friable, schistose gangue; and it is on account of this softness that it was particularly prized by the forges.

Higher up on the same hill similar float-ore is repeatedly met with, scattered over the surface, and it seems to cover a large area.

About ¼ mile slightly south of west from these old "forge"-openings is a very prominent outcrop of hornblendic gneiss, at least 40 feet high, containing lenticular masses of hard, compact magnetite, showing a thickness of 3 feet at one point; and about 200 yards S. 60° W. from here, on another ridge, some heavy and exceptionally pure masses of float-ore were observed, indicating the existence of another parallel series of ore-beds. Unfortunately none of the analyses of these ores were completed in time for this paper.

The "soft" ore, as used in the Paisley forge, is first washed in an inclined wooden trough by a gently-flowing stream of water; and an analysis by myself of this washed product shows:

	Per Cent.
Silica	11.075
Metallic iron	58.930
Sulphur	0.068
Phosphorus	0.033

In explanation of the formation of these deposits of "soft" ore, such as occur on the Black, Red Hill, and other properties to be described hereafter, it may be said here that all indications go to show that they are undoubtedly due to the breaking down of the original outcrops of magnetite and magnetic rocks, subsequent to the erosion of the more readily decomposable surrounding strata, and their consequent spreading over large superficial areas of comparatively limited depths. At the same time their replacement may have been so regulated by nature that they still exist in workable deposits, and the original beds might be expected either directly beneath or in close proximity to them; but this can only be definitely settled by further exploitation.

As shown in several places much of this "soft" ore can be concentrated to a comparatively high-grade material by simple washing alone, and there is no reason why, by means of magnetic concentration, a highly desirable product should not be obtained. Even the hard ores, high in silica, are susceptible of concentration, after previous crushing by this process; and at the well-known Cranberry mines in Mitchell county experiments are being very successfully carried on in this direction.

By means of the dipping-needle the ore was traced across the summit of Helton knob, which rises to an altitude of 3,410 feet above sea-level. On the south-western slope of Helton knob several small openings on the property of Joseph Jones expose the ore-bed, but not sufficiently to furnish much definite information. On the western foot-hills of Helton knob, on Robert's branch, a tributary of Helton creek, an opening on David Blevins' land exposes an ore-bed, showing three streaks of ore, respectively 7½, 4½, and 2 feet in thickness, separated by a gneissoid material, probably a local horse. The dip is 40° S. E. The ore is a compact magnetite in a gangue of hornblende and epidote.

An analysis of an average sample shows:

	Per Cent.
Silica	29.901
Metallic iron	36.350
Sulphur	0.038
Phosphorus	0.022

Between here and Helton creek, a distance of about one-quarter of a mile across, is the Red Hill property, over which a number of openings have uncovered a rather intricate and distributed ore-formation.

The main opening, No. 1, is a trench through the comb of the hill, over 200 feet in length, through a decomposed schistose and argillaceous material, carrying almost throughout its entire extent mixed masses of soft ore, hard ore, and crystalline sandy ore, distributed irregularly through the gangue; it is evidently one of the broken-down re-deposits, before alluded to.

At the eastern end of the cut some pyrites was mixed with the material. An analysis of an average sample shows:

	Per Cent.
Silica	19.83
Metallic iron	51.55
Sulphur	0.137
Phosphorus	0.042

Opening No. 2, about 30 yards W. S. W. from the above, exposes a solid bed of magnetite in epidote and quartz, over five feet thick, dipping south-east. No pyrites was observed here. An analysis shows:

	Per Cent.
Silica	31.26
Metallic iron	36.21
Sulphur	0.07
Phosphorus	trace.

Opening No. 3, on the north-west side of the hill, shows a broken bed of ore in a gangue of hornblende and epidote, with concentrations of pyrites at several points. The entire thickness of the bed must be over 10 feet. An analysis shows:

	Per Cent.
Silica	32.59
Metallic iron	36.41
Sulphur	0.20
Phosphorus	trace.

On the immediate northern bank of Helton creek a small opening exposes a broken bed of compact magnetite, irregularly distributed through a gangue of hornblende and gneiss, split by a lens of pyritiferous ore about 5 feet thick. An analysis of a sample taken across the bed shows:

	Per Cent.
Silica	41.13
Metallic iron	23.39
Sulphur	1.67
Phosphorus	0.109

The conclusion is that there are streaks of pyritiferous ore throughout this part of the bed, which increase in sulphur with depth.

On the south side of Helton creek the ore crosses over McClure's knob, where a number of openings expose a series of three parallel beds, none of which show over 3 feet in thickness so far as developed. A number of analyses of samples taken from some of these openings show:

	I.	II.	III.	IV.
Silica	23.23	22.78	28.78	16.50
Metallic iron	44.87	43.03	42.39	45.87
Sulphur	0.036	0.02	0.03	0.025
Phosphorus	0.053	0.14	0.03	0.904

To the south-west the ore crosses Old Field creek, and has been opened again at the Poison branch bank, on the divide between the waters of Old Field and Silas creeks, where considerable work was at one time done for the old forges.

The main opening exposes a bed of magnetite consisting of two parts, the upper one being visible only in the upper end of the cut just below the surface-soil, where it measures about 4½ inches in thickness of friable crystalline magnetite, comparatively clean, below which is a bed of argillaceous schist and clay, of a deep vermilion color, containing fine shot ore disseminated through it, probably forming a more decomposable part of the same bed. Unfortunately the cut had not been extended far enough in this direction to determine its true thickness. The lower bed is seen some 30 feet below here, at the bottom of the cut, near its mouth. It is partially filled in here, but I have from good authority that its thickness is 6 feet, about 3 feet of which was visible at the time of my visit. It is a hard ore, and the gangue is entirely hornblendic, while in the upper bed it is micaceous. The dip is about 50° S. E., and the strike N. 40° E. Several analyses of the lower bed show:

	I.	II.	III.
Silica	12.31	...	
Metallic iron	56.05	56.00	50.77
Sulphur	...	0.05	0.076
Phosphorus	0.071	0.013	0.016
Titanic acid	...	trace.	

I. by McCreath.
II. by C. B. White.
III. from U. S. 10th Census Report.

Not over 100 feet south-west from here another old opening exposes the same bed 25 feet lower.

In a south-westerly direction the ore has been traced to Silas Creek, but no openings of importance have been made.

Some 2 miles S. W. from Poison branch bank a bed of soft schistose ore has been opened on the land of John Parsons, on Little Grapevine creek. The opening is a very narrow and shallow one. It shows not less than 3 feet of ore, but the bed is not fully exposed.

Less than half a mile north-west from here, on Douglas Blevin's land, an opening on the top of a high ridge exposes another ore-bed at least 8 feet thick. The ore is extremely hard, in a gangue of hornblende gneiss. The dip is 45° S. E.

About half a mile south-west from here, on Piney creek, 1½ miles above its mouth, at Ballou's mill, a large bed of manganiferous magnetite has been uncovered. The ore is very coarse-granular in a matrix of brownish-black manganese oxide. It is exceptionally pure and practically free from gangue throughout its entire extent. The upper part of the bed shows 6½ feet of solid hard ore, beneath which is about 1 foot of soft manganiferous ore. The bed is probably even thicker than this, as its full extent has not been uncovered. Several analyses show it to contain:

	I.	II.	III.	IV.
Silica	3.20	0.800	10.64	0.614
Metallic iron	65.40	65.65	39.35	65.090
Metallic manganese	2.58	3.83	9.63	3.98
Sulphur	----	----	----	0.0069
Phosphorus	0.011	0.004	0.022	0.019

I. by C. B. White.
II. "Hard" ore by McCreath.
III. "Soft" ore by McCreath.
IV. "Hard" ore by C. Baskerville.

Crossing Piney creek, the same bed has been uncovered about half a mile S. W. from here, on the land of Robert Francis, where a slope, 20 feet deep, exposes 10 feet of soft manganiferous ore on the outcrop, pinching out to considerably less than this at the face of the slope. Throughout this soft material are scattered grains of hard magnetite. There is evidently a roll or fold in the bed at this point, the dip being abnormally 20° north of east, and the strike N. 34° W. The foot-wall is a decomposed feldspathic material. The ore carries an excessive amount of hygroscopic moisture. Analyses of the natural and dried ore, by Mr. A. S. McCreath, show:

	Natural Ore.	Dried at 212° F.
Silica	3.496	6.090
Metallic iron	27.236	47.450
Metallic manganese	5.224	9.102
Phosphorus	0.058	0.102
Moisture at 212° F.	42.600	....

About half a mile due west from here, a bed of very hard, compact, crystalline magnetite has been opened at two points, differing 100 feet in elevation, on Jacob Stewart's land near the summit of Turkey knob. The gangue is hornblende and quartz. The openings were filled in, but the ore was reported to be 5 feet thick.

An analysis by Mr. White shows:

	Per Cent.
Metallic iron	63.501
Phosphorus	0.006
Titanic acid	trace.

The ore has been traced half a mile north-east from here to the William Hamm place.

About three-quarters of a mile south-west from the Francis opening, on the waters of Old Field creek, a tributary of Horse creek, a number of openings on the south-western spur of Turkey knob, on the land of Joseph Graybeal, have exposed a bed of magnetic ore, which was worked a number of years ago for some of the old forges. One of these old openings shows a great deal of soft, mixed shot-ore disseminated in decomposed schist, with a streak of manganiferous earth in the front part of the opening. The main opening is a cut about 50 feet long, exposing two beds of ore, respectively 4 and 18 feet thick, separated by a horse of clay. The 4 feet of ore in the front part of the cut showed some very compact, solid magnetite. The ore in the upper part of the cut was mixed with hornblende gangue. Between these two openings some manganiferous float-ore was observed, resembling very much that at the Piney creek and Francis openings.

Several analyses of the Graybeal ore show:

	I.	II.	III.
Silica	6.85	----	----
Metallic iron	63.55	67.18	64.04
Sulphur	trace.	----	----
Phosphorus	trace.	0.010	0.009

I. by Baskerville.
II. by White.
III. from U. S. 10th Census Report.

On Horse creek, about one mile above its mouth, a bed of magnetite, precisely similar to that at Piney creek, has been opened. It is a coarse-granular magnetite disseminated in a manganiferous matrix, which decomposes on long exposure into a soft, rich shot-ore. The opening is in the shape of an under-cut in the side of a hill, into which it extends perhaps 20 feet as a slope, the lower part of which was filled with water, preventing a close examination. As far as exposed, the thickness of the ore is at least 6 feet, the lower 2 feet being the harder. Analyses show:

	I.	II.
Silica	4.12	1.96
Metallic iron	64.58	62.48
Metallic manganese	2.21	3.66
Phosphorus	0.011	0.019

I. by White.
II. by Baskerville.

Over one mile south-west from here the ore-body rises over 500 feet above the level of Horse creek, on Hampton knob, over which it has been traced for considerable distance by the dipping-needle. But none of the openings give any idea of the size of the bed. Several analyses from the locality show:

	I.	II.
Silica	9.66	....
Metallic iron	61.58	65.63
Sulphur	0.06	...
Phosphorus	trace.	0.029

I. by Baskerville.
II. by White.

III. THE TITANIFEROUS BELT.

Starting at the northern edge of the county, on the Virginia line, on the waters of Little Helton creek, this, the most north-westerly ore-belt of importance in Ashe county, has been traced in a south-westerly direction, crossing Helton creek near Sturgill P. O., a distance of some 2½ miles. It lies, approximately, 3 miles north-west of the Red Hill belt, and parallel to it.

On the property of William Young, 150 yards west of the Jefferson-Marion road, and about ¼ line south of Virginia State-line, a very heavy outcrop of magnetite extends east and west along the crest of a ridge, with a width of at least 25 feet. There are no openings here, but all indications point to the existence of a large deposit. The ore is a coarse-granular, compact magnetite, practically free from gangue. It is titaniferous, and has a bright silvery luster. An analysis by McCreath shows it to contain:

	Per Cent.
Silica	4.35
Metallic iron	52.85
Phosphorus	0.013
Titanic acid	8.800

This outcrop is traced for over 150 yards in a westerly direction across Shippy branch, where it is opened on the McCarter place, showing a bed from 9 to 12 feet thick, dipping almost vertically. The local magnetic variation was 11° W.

An analysis by McCreath shows:

	Per Cent
Silica	5.37
Metallic iron	51.75
Phosphorus	0.018
Titanic acid	9.17

The bed is again uncovered, about 350 yards west from here, in front of Mr. McCarter's house, by a shallow cut showing about three feet of ore; but the bed is not fully exposed.

About half a mile farther south-west, an opening on the Bauguess place shows 5 feet of ore, having a reddish streak, an analysis of which by myself shows 4.80 per cent. of titanic acid.

The next notable opening, about one mile south-west from here, on Wallen's creek, a tributary of Helton creek, on the Pennington place, exposes a bed 8 feet thick, an analysis of which by McCreath shows:

	Per Cent.
Silica	5.07
Metallic iron	52.45
Phosphorus	0.022
Titanic acid	9 11

About half a mile north of Sturgill P. O., on the waters of Helton creek, on the Kirby place, a broken bed of hard, fine-gained magnetite of steel-gray color has been uncovered. Its extent could not be determined from the condition of the opening, but its thickness appears to be not less that 15 feet.

I am indebted to Mr. A. S. McCreath for the information that these titaniferous ores carry a small amount of chromium, and an average analysis of a number of samples shows 0.480 per cent. of chromium.

This concludes a description of the location and some of the economic features of the principal ore-deposits of Ashe county; and it is hoped that this region may become an important source of ore-supply in the near future.

In general, the quality of these ores is good; low in sulphur, and below the Bessemer limit in phosphorus.

The mined material will, in many cases, be high in silica, but there is no reason why, by means of magnetic concentration, a high grade product should not be obtained.

The titaniferous belt is by far the most persistent, and shows a large quantity of ore, but the percentage of titanic acid condemns this material for blast-furnace use, at least in competion with iron-ores less difficult to smelt to pig-iron.

There is little doubt that there are valuable, workable beds of ore throughout the other two belts, such as at Ballou's, Piney creek, Graybeal's, Horse creek, etc., but it will require much more extensive exploitation to define their true extent.

Other beds of ore have been uncovered throughout the county, but they are rather out of the range of what is considered to be the principal ore-region.

Such are, for instance, a bed of magnetite 9 feet thick, on the Ben Greer place, on the waters of Little Horse creek; and a belt of brown hematite along the north-western slopes of Phœnix and Three Top mountains, which is supposed to be a secondary formation, and of little importance as compared with the magnetic ores.

Nearly all of these ore-deposits, being situated on tributaries of the north fork of New river, would be accessible to a railroad built up that stream, which is a very feasible project.

Note by the Secretary.—Comments or criticisms upon all papers, whether private corrections of typographical or other errors, or communications for publication as "Discussion," or independent papers on the same or a related subject, are earnestly invited.

NOTES ON THE DEVELOPMENT OF SOME SPONGES.*

BY HENRY V. WILSON.

The following notes deal with the gemmule development of *Esperella fibrexilis* (n. sp.) and *Tedania Brucei* (n. sp.), to which are added a few observations on the egg development of *Tedanione fœtida* (n.g.) and *Hircinia acuta*. *Esperella fibrex.* is a small silicious sponge abundant near Wood's Holl, Mass. The others are Bahama forms found at Green Turtle Cay, the two silicious sponges, Tedania and Tedanione, being closely related.

During the summer, Esperella and Tedania contain great numbers of embryos in all stages of development, and if the sponges are kept in aquaria for a few hours, some of the embryos will pass out through the oscula. The embryos thus set free are solid oval bodies covered with cilia, and are quite like the egg larvæ of many silicious sponges. They swim about for a day or so and then attach themselves to the wall of the dish, flatten out and undergo a metamorphosis. When the embryos inside the mother are examined, they are found not to be egg embryos, but true gemmules; *i. e.*, internal buds.

I will first describe the development of Esperella. The mesoderm of Esperella contains cells, which differ greatly in size and general appearance, though they shade one into the other. Some of the cells are much larger than the rest and have plump bodies, which stain well. Such cells congregate together and form irregular groups, in which the cells are rather closely packed. The group of cells rounds itself off, the outer cells becoming flattened

*Published by permission of Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, in the Journal of Morphology, Volume V, No. 3.

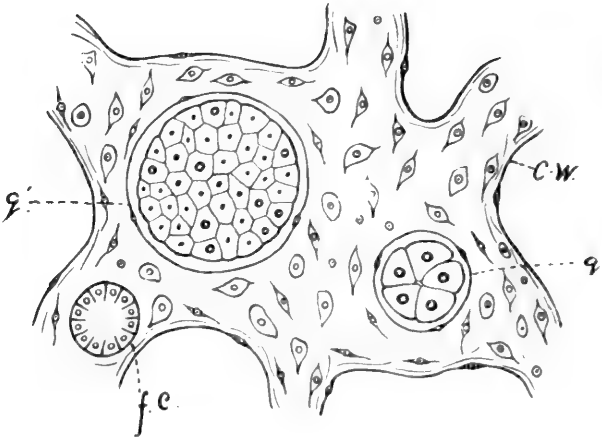


FIG. 1. Portion of Esperella mesoderm, showing two gemmules, *g* and *g'*, each surrounded by follicle of flattened cells. *g* is a very young gemmule; *g'*, considerably older; *c. w.*= canal wall; *f. c.*— flagellated chamber.

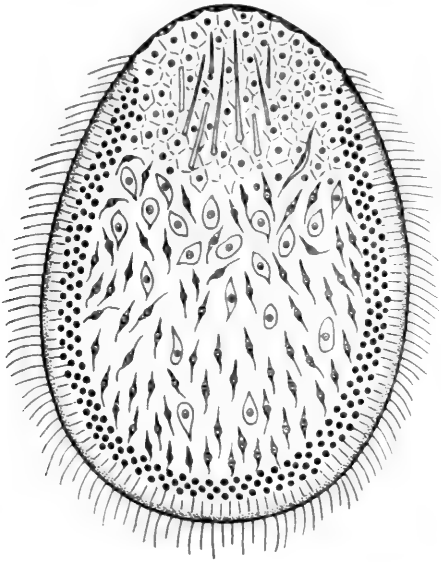


FIG. 3. Longitudinal section through the swimming larva of Esperella. The nuclei of the columnar ectoderm cells form a conspicuous zone. In the outer ends of these cells is orange pigment. The inner mass of cells (parenchyme), in the region of non-ciliated pole, differs from the parenchyme in the rest of the body.

FIGURES ILLUSTRATING "NOTES ON DEVELOPMENT OF SPONGES."

and forming a follicle. The gemmule, as thus formed, is at first quite small, often showing not more than five cells in section, though a considerably larger gemmule may be directly formed from a group of cells. The cells of the gemmule, once the follicle is formed, are very closely packed.

The increase in size of the gemmule takes place by means of cell growth and division, and by the fusion of neighboring small gemmules. The latter process throws into shade the seemingly important question, Does a gemmule ever start as a single cell? In regard to the actual occurrence of such an origin for gemmules, I may say that, after looking over a great number of preparations, my conclusion is, that perhaps a little group of mesoderm (gemmule) cells is so derived in very rare instances, but the case occurs so seldom as not to be worth consideration.

The gemmule continues to increase in size, without any striking change in its structure, until it is nearly as large as the swimming larva. In this condition it may be spoken of as the ripe gemmule. The ripe gemmule is spheroidal and is made up of cells so closely packed and so filled with fine yoke granules that the cell boundaries are indistinct. The nuclei of the cells are very small. During the growth of the gemmule the surrounding tissue becomes largely incorporated in the follicle; and whereas the gemmule in its early stages lay in the mesoderm of the sponge, in its ripe condition it lies in one of the larger canals, suspended by strands of tissue which now bind the follicle to the canal wall. The ripe gemmule next undergoes a process which presents a superficial analogy to segmentation. The solid gemmule splits up into irregular masses of cells. These continue to split up into smaller and smaller masses, the gemmule meanwhile increasing in size, owing to the absorption of fluid, so that the several masses of cells are distinctly separated from one another. The splitting up continues until the solid gemmule has been plainly resolved into its constituent cells. The outer cells of the gemmule, very early in this process of "segmentation," arrange themselves so as to form a continuous layer of flat cells round the periphery. This layer, for convenience's sake, may be spoken of as the ectoderm. Inside the ectoderm at the close of "segmentation" is found a mass of amœboid cells connected together by their processes and separated by fluid. The flat ectoderm cells next become long slender columnar cells, having pigment in their outer ends and bearing cilia. The metamorphosis of the ectoderm cells does not, however, take place over one pole. Over this pole the ectoderm cells remain flat and without cilia. Further, the inner mass of cells at this pole become steadily denser, until this region of the embryo is occupied by a mass of irregularly polygonal cells closely appressed. In the mass of polygonal cells a bundle of long spicules lying in the direction of the main axis of the embryo is developed. In the remainder of the inner contents of the embryo, the cells are less closely packed and are of various shapes. The unciliated pole is made the more conspicuous because of the pigment (orange) which covers the rest of the embryo. In this condition, the embryo breaks through its follicular wall, and passes out of the parent through one of the oscula.

The first step in the metamorphosis of the larva consists in the flattening of its ectoderm. The flattening begins before the sponge attaches itself, and *gradually travels from the non-ciliated or spicular pole backwards.* While there is still a considerable remnant of the columnar ectoderm, the larva attaches itself by the spicular pole, but obliquely, so that it lies somewhat on its side. The rest of the ectoderm then becomes flattened, and the lava is transformed into a thin, flat mass, circular in outline. The bundle of spicules, formerly at the non-ciliated pole, become distributed all over the body of the little sponge. The attached larva, at first circular in outline, speedily grows irregular in shape, and becomes surrounded by a thin ectodermal membrane. The subdermal cavities and canals appear as lacunæ in the substance of the larva, the surrounding cells becoming flattened to form the epithelioid wall. The various canals and cavities, originally independent, open one into the other, and to the exterior, by simple perforation of the intermediate tissue. The oscula and pores are at first indistinguishable, and are scattered over the surface of the sponge, with no attempt at arrangement. Even in the adult I can see no morphological distinction between the pores and oscula. The difference in size is the only difference, and that loses its significance because of the occurrence of apertures, which hold several intermediate positions in this respect between pores and oscula.

The flagellated chambers arise as independent structures, which subsequently acquire connection with the canal system.

There are in the larva, when it first attaches, a large number of mesoderm cells, distinguishable from the rest by their size and bulky shape. Such cells I may call formative cells. They diminish greatly in number, and grow smaller in size during the metamorphosis. The formative cells contain as a rule several nuclei, and are destined for the most part to split up into much smaller cells. The particular way in which the flagellated chambers are formed in any larva depends on the behavior of the formative cells. (All the cells of the larva, I may add, are connected together by fine processes). In some larvæ the formative cells arrange themselves round a central cavity (intercellular space) so as to form a hollow sphere. Numbers of such spheres, consisting of comparatively large cells, are found in some larvæ. Division of the cells then ensues, and the hollow sphere gradually assumes the nature of a flagellated chamber. In some larvæ, on the other hand, all the formative cells may break up into fine cells before the marking out of any flagellated chambers. The mesenchyme of such larvæ consists of a solid mass of fine cells, with here and there a formative cell. The flagellated chambers of such a larva must be formed directly from a group of fine cells, probably by some rearrangement of the cells round a central cavity. In other larvæ, both processes go on at the same time. Some of the formative cells arrange themselves in hollow spheres and form chambers directly, others break up into solid masses of small cells, which subsequently acquire a cavity. That a single formative cell itself ever forms a chamber, I do not believe.

In whichever way the flagellated chamber is formed, it at first has no connection with the canals. It, like any particular canal, is, in its origin, a lacuna, its cavity being an intercellular space.

In deciding phylogenetic questions, perhaps not much weight should be attached to a development like this; but whatever weight it has, is in favor of Metschnikoff's theory of the solid ancestry of sponges. The solid swimming larva itself, and the details of the metamorphosis (the origin of the flagellated chambers, excurrent and incurrent canals, and subdermal spaces, as independent lacunæ in a matrix of amœboid cells) are all understood on this theory. Conversely, if we hold to the view which regards the calcareous sponges (Ascons) as the primitive type, the development of Esperella may, of course, be regarded as an extreme case of coenogeny.

The development of Esperella, it seems to me, has perhaps a bearing on problems out of the range of pure morphology. Without discussing the matter in detail, I may point out the striking resemblance between this asexual development and the egg development of many silicious sponges. As in the egg embryo, there are formed in the gemmule embryo two germ layers. In the two embryos the layers are alike in many details of structure. The egg larvæ, again, are characterized by the absence over one pole of the columnar ectoderm (Isodyctia and Desmacidon, Barrois (1); Reniera, Marshall (2); Chalinula, Keller (3); Esperia, Schmidt (4), etc.). The account according to which the endoderm protrudes at this pole, is probably not correct, but it is likely that the ectoderm is only greatly flattened over this region. It is this characteristic more than any other, which I should pick out as a point of exact resemblance between the sexual and asexual larvæ. Barrois has described the egg development of two forms, in one of which (Isodyctia) the non-ciliated pole of the planula is never covered with columnar cells. This is paralleled by the Esperella larva. In another form (Desmacidon), the larva has at first a complete covering of columnar ectoderm (and cilia), which then disappears over one pole (and much later over the whole surface). This case is more or less similar to the gemmule development of Tedania; in this form, the embryo has at one time a complete covering of columnar cells (unciliated however), which *flatten out* over one pole, while over the rest of the body they acquire cilia. In the metamorphosis, also, the gemmule development resembles the egg development, in that the ectoderm of the larva is flattened to form the ectoderm of the adult. As regards the formation of the chambers, canals, etc., the egg larvæ differ too much among themselves to permit any such comparison as I am carrying out

Such a resemblance between the sexual and asexual larvæ as I have indicated, can, I think, only be explained on the supposition of some essential likeness between the mesoderm cells, which make up the gemmule, and ova.

If for convenience's sake we adopt the point of view of Weismann, and regard the egg cell as characterized by the possession of a "germ plasm," the gemmule cells too (unless the resemblances between the gemmule and egg embryo are accidental) have some claim to the possession of this plasm. By making a little further use of Weismann's theory, the nature of the gemmule cell (*i. e.*, a mesoderm cell, which, together with others, forms a gemmule) may perhaps be stated with some precision. Of the two polar bodies found in non-parthenogenetic eggs, Weismann believes that the first carries off ovogenetic plasm, the second carries off one-half the germ plasm. In the case of the sponge gemmule, a mesoderm cell does not itself become differentiated into an ovum, but the necessary amount of nutriment for the embryo is got by the association of numerous such cells. Hence there is in the gemmule cell no special histogenetic (ovogenetic) plasm, and consequently no first polar body. There is, of course, no fertilization, therefore no second polar body. The gemmule cell, according to this view, must be regarded as a true germ cell, in which all the germ plasm remains undifferentiated, viz., in which none of it is transformed into ovogenetic plasm. Further, the gemmule cell pursues the parthenogenetic course of development—it keeps all its germ plasm.

Gemmules apparently develop anywhere in the sponge mesenchyme. It must, therefore, be assumed that *any* mesenchyme cell may become a gemmule cell, and consequently that it contains germ plasm. The same conclusion is reached by the study of the egg development, for it seems that any mesenchyme cell may develop into an egg.

The gemmule development in Tedania pursues much the same course as in Esperella. The early stages in the formation of the gemmule, owing to the extremely small size of the cells, cannot be followed with the same accuracy as in Esperella, but the process can be seen to be essentially the same. The "segmentation," or gradual dissolution of the gemmule into its constituent cells, takes place in the same way. The swimming larva is, except in a few details, like the larva of Esperella, and the metamorphosis takes place on the same lines.

In the egg development of Tedanione, there is a total segmentation, resulting in the formation of a solid morula. The larva, when set free, is a solid oval body, completely covered with a layer of columnar ciliated cells. The metamorphosis was not observed. The segmentation of Hircinia is likewise a total segmentation, resulting in the formation of a solid morula. The development of the ovarian egg in these two forms is essentially alike. The follicle during the growth of the egg is surrounded by a large number of comparatively densely packed mesenchyme cells, the duty of which is presumably to bring nourishment to the growing egg (compare Fiedler's account for Spongilla). The nucleus of the very young egg contains a single large nucleolus more or less centrally placed. While the egg is comparatively small, before it has reached more than one-half its ultimate size, two small spherical masses of densely staining chromatin are found adhering to opposite sides of the inner face of the nuclear wall. As a rule, in eggs which have reached the full size, only one or neither of these chromatine balls is present.

Occasionally, however, an egg is found of the full size and still with both of the chromatin balls. One of the masses is probably lost (thrown out ?) about the time when the increase in size is completed. The remaining mass is thrown out of the nucleus, and may sometimes be observed lying in the egg yoke near the nucleus. The nucleus of the ripe egg thus left without chromatin mass, is a poorly defined body in which neither nuclear membrane nor chromatin is visible. The maturation of the egg in these two sponges is seen to be very like that of Spongilla, as described by Fiedler (5). Fiedler regards the two chromatin balls as polar bodies; but as an objection to this view it must be urged that they are formed (though not discharged) long before the egg has reached its full size.

My observation that layers similar to germ layers are developed in the asexual embryos of certain sponges recalls the account given by Dezsö (6), of the formation of buds in Tethya. Dezsö claims that these buds develop from single cells, and that in them germ layers are formed. The construction he puts upon certain cells seems, however, an arbitrary one, and I find it difficult to carry out a detailed comparison between his observations and my own. Oscar Schmidt, as Dezsö calls to mind, described in 1878, germinal layers in the buds of Loxosoma, and emphasized the biological significance of the phenomenon.

In his paper, "Zur Orientirung über die Etwicklung der Schwämme" (*Zeit. f. w. Z.*, 1875), Oscar Schmidt makes the statement that in the silicious (and horny) sponges there is no true segmentation, the ovum very early losing its cellular character. To many others besides Barrois (1) this must have seemed a remarkable statement, and it would be interesting to know if the observations which led Professor Schmidt to this view were not made on a gemmule development resembling that which I have described.

University of North Carolina,
Chapel Hill, N. C., October 17, 1891.

PAPERS REFERRED TO.

1. Barrois. Mémoire sur l'embryologie de quelques Éponges de la Manche. *Ann. d. Sci. Nat.* 1876.
2. Marshall. Die Ontogenie von Reiniera filigrana. *Zeit. f. w. Z.* 1882.

3. KELLER. Studien über die Organisation und Entwicklung der Chalineen. *Zeit. f. w. Z.* 1880.
4. SCHMIDT, OSCAR. Zur Orientirung über die Entwicklung der Schwämme. *Zeit. f. w Z.* 1875.
5. FIEDLER. Ueber Ei und Samenbildung bei Spongilla fluviatilis. *Zeit. f. w. Z.* 1888.
6. DEZSÖ. Die Histologie und Sprossenentwicklung der Tethyen. *Archiv Mikr. Anat.*, Bd. 16 and 17. 1879 and 1880.

THE TRANSITION CURVE.

BY WM. CAIN, C. E.

The ideal transition curve for railroads, to pass from a tangent to a circular curve of given degree, is one whose degree of curvature is zero at the point where it leaves the tangent (P. C.) and increases directly as its length, measured along the curve from the P. C., to where it connects with the circular curve, at which point it should have the same tangent and rate of curvature as the circular curve. By the use of such curves on railroads, street-car lines, etc., to ease off the ends of circular curves, the super-elevation of the outer rail is gradually attained without shock; and the sudden change from the tangent to the circular curve so often experienced on unadjusted circular curves, with its annoying and damaging lurch, is avoided.

Mr. A. M. Wellington (see *Engineering News* for January 25th and February 8th, 1890) was the first to propose this particular curve, which he regarded as practically identical with the cubic parabola. Recently, Mr. Conway R. Howard has published in his *Transition Curve Book* an analysis of the subject founded on known principles of the cubic parabola, which this curve closely approximates to for flat arcs.

In this paper an *exact* and thorough solution of the problem will be given, which is believed to be simpler and more satisfactory every way than the approximate solutions hitherto presented.

Referring the curve above defined, to rectangular axes

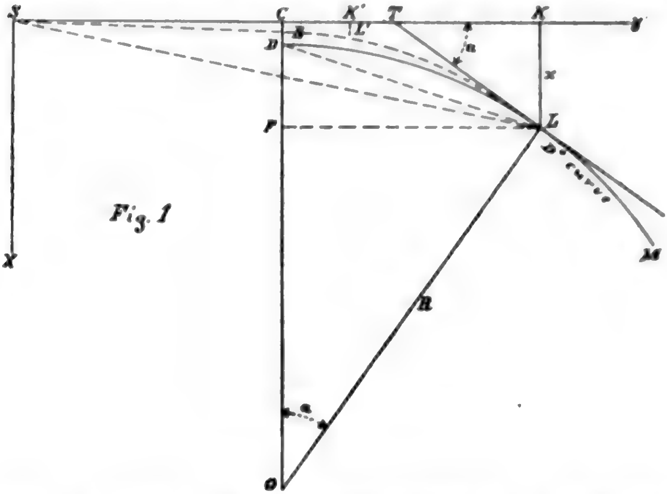


Fig. 1

X and Y (figure 1), call the co-ordinates of L, x and y, the length of curve SEL being called s. At the point $(x + \Delta x,\ y + \Delta y)$ the length of curve from $S = s + \Delta s$; the tangent at the last point making the angle $a + \Delta a$ and at (x, y), the angle a with the axis of Y. Then by the definition of curvature, the curvature at the point (x, y) is represented by limit $\frac{\Delta a}{\Delta s} = \frac{da}{ds}$ and this by the definition of the curve, must equal a constant $(2a)$ times s.

$$\therefore \frac{da}{ds} = \frac{1}{r} = 2\,as \ldots\ldots (1);$$

whence,

$$a = as^2 \ldots\ldots (2),$$

since $a = o$ when $s = o$. Also from (1) $r = \infty$ when $s = o$. From the differential triangle we have,

$$dx = ds \sin a = \sin (as^2).\ ds \ldots\ldots (3),$$

$$dy = ds \cos a = \cos (as^2).\ ds \ldots\ldots (4);$$

but unfortunately we are not able to integrate these expressions in finite terms, so that the equation of the curve in terms of x and y cannot be obtained.

In practice the curve SL will be run by measuring N chords of c feet each along the curve. When these chords are sufficiently short they can be regarded as of the same length as the arcs subtended by them, hence we shall always write,

$$s = \mathrm{N}c \ldots\ldots (5),$$

for the length of curve from S to any tangent point considered as L.

The degree of curve at L, $D°$ being equal to the radius of a 1° curve divided by r, we have, since the radius of a

$$1° \text{ curve} = \frac{50}{\sin (\tfrac{1}{2})°} = \frac{50}{\left(\dfrac{\pi}{360}\right)} \text{ (as the sines of small an-}$$

gles can be taken as equal to the arcs themselves),

$$\mathrm{D}° = \frac{18000}{\pi r} = \frac{36000}{\pi} as \ldots\ldots (6).$$

To express the arc a (eq. 2) in minutes, we notice that its ratio to a semi-circumference whose radius is one, is $\frac{a}{\pi}$ and multiplying this by 180×60 we find a in minutes. Hence from (2) and (5),

$$a \text{ (in minutes)} = \frac{a}{\pi}\, 180 \times 60 = a\, \frac{180 \times 60}{\pi}\, c^2 \mathrm{N}^2$$

We shall assume with Mr. Howard, no matter what the length of chord c is, that,

$$a \text{ (in minutes)} = 6\ N^2 \ldots\ldots (7).$$

This assumption is warranted by the previous equation, as a varies as N^2; hence equating these two values of a, we deduce,

$$a = \frac{\pi}{1800\ c^2} = \frac{.0017453}{c^2} \ldots\ldots (8).$$

On substituting this value of a in (6), we have,

$$D^\circ = \frac{36000}{\pi} \cdot \frac{\pi}{1800\ c^2} \cdot s = \frac{20\ s}{c^2} = \frac{20\ Nc}{c^2} = \frac{20\ N}{c} \ldots\ldots (9).$$

This is a fundamental equation of the transition curve and gives the degree of curvature at any point of the curve. Where it "connects" with the circular curve, of course D° must be the same for both curves.

By multiplying both sides of eq. (9) by $\frac{s}{200}$ we have,

$$\frac{D^\circ\ s}{200} = \frac{D^\circ\ Nc}{200} = \frac{20\ N}{c}\ \frac{Nc}{200} = \frac{N^2}{10}.$$

But a in degrees from (7) $= \frac{6\ N^2}{60} = \frac{N^2}{10}$; hence, a (in degrees) is given by the formula,

$$a \text{ (in degrees)} = \frac{D^\circ s}{200} = \frac{D^\circ\ Nc}{200} \ldots\ldots (10).$$

In figure 1 at O, the center of the circular curve DLM, having at L the same tangent and degree of curvature as the transition curve or spiral SEL, drop a perpendicular OC upon the tangent SY, cutting the spiral at E and the circular curve produced at D, and draw the chords SL and

DL. Then LOC $= a =$ LTK and $\frac{\text{DL}}{100} =$ number of 100 feet stations in arc DL $\therefore$ D° $\frac{\textit{arc}\ \text{DL}}{100} =$ total angle turned in length DL $= a = \frac{\text{D}^\circ s}{200}$ by (10); whence,

arc DL $= \frac{1}{2}\, s = \frac{1}{2}$ length of spiral SEL . . . . (11).

From this we have, since for flat arcs, LD = LE nearly, LE = ½ SEL, or point E is nearly at middle of spiral. The distance CD = q between SY and the circular curve, may then be regarded as the offset *at the middle* of the transition curve from circular curve to tangent SY.

By aid of (9) above we can deduce two more useful formulas:

$$c = \frac{20\ \text{N}}{\text{D}^\circ} \quad . \ . \ . \ . \ . \ . \ (12),$$

$$\text{N}c = s = \frac{20\ \text{N}^2}{\text{D}^\circ} \quad . \ . \ . \ . \ . \ (13).$$

From eq. (3) we have, developing *sin* (as^2) by a well-known formula,

$$dx = ds\,(as^2 - \tfrac{1}{6}\,(as^2)^3 + \tfrac{1}{120}\,(as^2)^5 -, \text{etc.});$$

whence integrating and noting that the constant is zero, since $x = o$ when $s = o$, and placing for brevity a for its equivalent as^2 (eq. 2), we have,

$$x = sa\,(\tfrac{1}{3} - \frac{a^2}{42} + \frac{a^4}{1320} -, \text{etc.}) \ . \ . \ . \ . \ . \ . \ (14).$$

Developing $dy = ds\ cos\,(as^2)$ we deduce similarly,

$$y = s\,(1 - \frac{a^2}{10} + \frac{a^4}{216} - \frac{a^6}{9360} +, \text{etc.}) \ . \ . \ . \ . \ . \ (15).$$

From (8) $a = \dfrac{\pi}{1800c^2}$; hence a in eqs. (14) and (15) is given (in length of arc on a unit circle) by

$$\alpha = as^2 = ac^2 N^2 = \frac{\pi}{1800} N^2 = .001745329 N^2;$$

$$\therefore \log \alpha = 7.2418774 - 10 + \log (N^2) \; . \; . \; . \; . \; . \; . \; . \; . \; (16).$$

The above value of α can be obtained likewise from eq. (7). It is independent of c, as in fact was assumed from the first; but since $s = Nc$, the values of both x and y above, vary directly as c.

Therefore if we compute from (14) and (15) successive values of x and y for $c = 100$, corresponding to $N = 1$, 2, 3, 4, . . . , 15, and denote these values by,

$$X_1, X_2, X_3, \ldots , X_{15},$$
$$Y_1, Y_2, Y_3, \ldots Y_{15},$$

the subscripts denoting the station to which they refer; then when c has any other value than 100, we have by (14) and (15),

$$x = \frac{Xc}{100} = \frac{0.2\,NX}{D^\circ} \; . \; . \; . \; . \; . \; (17),$$

$$y = \frac{Yc}{100} = \frac{0.2\,NY}{D^\circ} \; . \; . \; . \; . \; . \; (18);$$

the last forms being derived by substituting for c its value $\dfrac{20\,N}{D^\circ}$ given by (12).

The results of the computation are given in the adjoining table under the corresponding values of N given at the tops of the columns.

N	1	2	3	4	5	6	7	8
X	.058178	.46542	1.57074	3.72316	7.27121	12.5628	19.9445	29.760
Y	100.000	199.999	299.993	399.969	499.904	599.763	699.488	799.002
F	.25000	.25000	.25000	.25000	.25001	.25002	.25005	.25011
Q	.002909	.046542	.235611	.744632	1.81785	3.7692	6.982	11.910
a	6′	24′	54′	1°36′	2°30′	3°36′	4°54′	6°24′
Δ	2′	8′	18′	32′	50′	1°12′	1°38′	2°07′59″

N	9	10	11	12	13	14	15
X	42.351	58.051	77.188	100.078	127.024	158.310	194.197
Y	898.201	996.958	1095.104	1192.442	1288.735	1383.706	1477.033
F	.25018	.25026	.25038	.25056	.25077	.25104	.25137
Q	19.071	29.056	42.519	60.180	82.819	111.278	146.448
a	8°06′	10°00′	12°06′	14°24′	16°54′	19°36′	22°30′
Δ	2°41′58″	3°19′57″	4°01′55″	4°47′51″	5°37′45″	6°31′37″	7°29′25″

The numerical values in the table were computed by me and checked by Mr. H. B. Shaw, so that it is believed no error exists in them.

In computing the values of X given by (14) it was found that the results could be found correctly to the last figure given, for N = 1, 2, by taking only the first term of the parenthesis and neglecting the others; for N = 3 to 11 inclusive, two terms are needed and for N = 12, 13, 14, 15, only three terms are required. For the values of Y, two terms of the parenthesis in (15) were used up to N = 9 inclusive; for greater values of N three terms only are required.

A six figure table of logarithms was used except for the larger values, where a seven place table proved desirable.

The series is very converging for the small values of a used, and in fact would answer for much larger values of a if desired; hence we see that we are concerned here with a very converging series; in fact, the same series used in computing a table of sines and co-sines, so that we can find x and y accurately to any desired number of decimal places.

The angle made by a chord from station o to station n with the axis of Y will be designated by Δ_n. This angle is readily found from the formula,

$$\tan \Delta_n = \frac{X_n}{Y_n}.$$

Thus for Δ_{12}, we have $\tan \Delta_{12} = \frac{100.078}{1192.44}$, whence $\Delta_{12} = 4°47'51''$.

The angles made by the chords from sta. s to the successive stas. 1, 2, 3, ... , 12, with the Y axis are given in the previous table, and the values of $a = 6\ N^2$ (in minutes), eq. (7), are placed above for comparison.

It will be observed from this table that if we express Δ to the nearest minute that we have, except for N = 15,

$$\Delta = \frac{a}{3} = 2\ N^2\ (\textit{in minutes}) \ldots \ldots (19).$$

If we include N = 15, the extreme error made by using the formula $\Delta = \frac{a}{3}$ is 35 seconds corresponding to N = 15, a matter of no practical importance.

If we should continue the table for greater values of N than 15, we should find the error in using (19) to increase, which explains why N = 15 is taken as the extreme limit of the table; besides we rarely have need for more than 15 stations of a transition curve. For greater values of N, (19) should not be used at all and the angles Δ must all be computed by the strict method.

The angle made by any chord connecting any two stations of the curve with the Y axis, will be designated by i with two subscripts, giving the station numbers through which the chord is drawn; thus i_{3-9} indicates the angle made by the chord joining stas. 3 and 9 with the Y axis. Its value is readily found from the equation,

$$\tan i_{3-9} = \frac{X_9 - X_3}{Y_9 - Y_3} = \frac{40.7803}{598.208},$$

to be, $i_{3-9} = 3°54'00''$. Similarly we find the inclinations of the chords, to the Y axis, connecting *any* two stations.

In the general table given at the end of this paper the values of X, Y, a, Δ and i are inserted corresponding to the stations given at the tops of the vertical columns.

[NOTE.—The general table does not give the quantities X, Y, and Q as closely as the preceding table, and the values of Δ and i in it are only expressed to the nearest minute.]

The angles given below the horizontal row Δ, are the values of i for the chords joining the stations in the vertical columns to which they refer. Thus line (2) column (4) angle $0°56' = i_{2-4}$ or the inclination of chord (2) (4) to SK.

The angle $a_5 = 2°30'$ is that which the transition curve at sta. (5) makes with SK. Also the angle between chord (5) (8) and tangent at sta. (5) $= 4°18' - 2°30' = 1°48'$ and the angle between chords (5) (8) and (2) (5) $= 4°18' - 1°18' = 3°00'$.

Similarly we can find any angle needed in running the curve.

The quantity Z of the table $= D°s = 20\ N^2$, whence

$$s = \frac{Z}{D^\circ},\ D^\circ = \frac{Z}{s}, \ldots\ldots \quad (20).$$

Line C gives the semi-chord of the arc of a 1° circular curve, of which a subtends half that arc $\therefore$ C = 5729.65 sin a. For a D° curve, divide by D° expressed in degrees and decimals.

Line Q gives the product q D°, where q is the distance CD (fig. 1) and D° the degree of circular curve LA. We find this product as follows: Call, for brevity, R_1 the radius of a 1° curve (5729.65 was used), then in fig. 1, $R = \frac{R_1}{D^\circ}$ and $q = KL + OF - OD = x + R \cos a - R$. Therefore, from (17),

$$q = \frac{.2\ NX}{D^\circ} + \frac{R_1}{D^\circ} \cos a - \frac{R_1}{D^\circ}$$

$$\therefore Q = q\ D^\circ = .2\ NX + R_1 \cos a - R_1 \ldots\ldots \quad (21).$$

Hence, calling the ratio of q to x (the ordinate at L) F, we have,

$$F = \frac{q}{x} = \frac{q\ D^\circ}{.2\ NX} = \frac{Q}{.2\ NX} \ldots\ldots \quad (22)$$

from these formulas, rows F and Q of the tables were computed. It is seen that this ratio is ¼ or nearly so throughout.

From the above *exact* formulas, the table of "Equivalents" given below is made out. They are identical with the formulas given by Mr. Howard, though the latter were deduced in a totally different way.

$$c = \frac{s}{N} = \frac{Z}{D^\circ N} = \frac{20\ N}{D^\circ} = \frac{20\ Nq}{Q} = \frac{100\ x}{X} = \frac{100\ y}{Y},$$

$$s = cN = \frac{Z}{D^\circ} = \frac{20\ N^2}{D^\circ} = \frac{200\ a}{D^\circ},$$

$$D^\circ = \frac{Z}{s} = \frac{Q}{q} = \frac{20\ N}{c} = \frac{200\ a}{s},$$

$$x = \frac{cX}{100} = \frac{.2\ NX}{D^\circ} = \frac{cY}{100} \tan \Delta = \frac{Q}{D^\circ F},$$

$$y = \frac{cY}{100} = \frac{.2\ NY}{D^\circ} = \frac{cX}{100} \cot \Delta,$$

$$Q = q\ D^\circ = .2\ NXF,$$

$$q = \frac{Q}{D^\circ} = \frac{FXc}{100} = \frac{sQ}{Z} = \frac{cQ}{20\ N} = \frac{.2\ NXF}{D^\circ}.$$

In these formulas,

c = chord length between consecutive stations;

$x = \frac{cX}{100}$, $y = \frac{cY}{100}$, are the co-ordinates of stations corresponding;

s = length of curve from S to station N.

When $c = 100$, $x = X$ and $y = Y$.

TO LAY OFF THE TRANSITION CURVE.

1. *By offsets from the tangent.*

Example. Let $c = 20$, $N = 8\ \therefore\ y = \frac{c}{100} Y = \frac{1}{5} Y$, $x = \frac{c}{100} X = \frac{1}{5} X$; where Y and X, for N = 1, 2, 3, . . . , 8, are to be taken from the general table.

$\therefore\ y_1 = \frac{1}{5}(100) = 20$, $y_2 = \frac{1}{5}(200) = 40$, $y_3 = \frac{1}{5}(299.99) \doteq 60$, etc.;

$x_1 = \frac{1}{5}(.06) = .01$, $x_2 = \frac{1}{5}(.47) = .09$, $x_3 = \frac{1}{5}(1.57) = .31$, etc.

Having computed all the ordinates for the eight stations, measure the successive values of y along SY from S and the corresponding ordinates or offsets x, at right angles to SY, until all the stations are located.

2. *By deflection angles.*

The method is similar to that of running in a circular curve with transit and chain.

Example. Let $c = 25$, $N = 7$.

Deflect from tangent SY, with transit at S, successively, $\Delta_1 = 2'$, $\Delta_2 = 8'$, $\Delta_3 = 18'$, $\Delta_4 = 32'$, $\Delta_5 = 50'$, $\Delta_6 = 1°12'$, $\Delta_7 = 1°38'$ and measure S 1 = 25 feet, 12 = 25 feet, and so on, to fix the stations 1, 2, 3, etc.

The degree of the circular curve connecting at station 7 is,

$$D° = \frac{Z}{Nc} = \frac{980}{7 \times 25} = 5°.6 = 5°36'.$$

If instrument has to be set at sta. (3) and the balance of the curve run in from (3), clamp vernier at $\Delta_3 = 18'$ before removing from S; then set över (3), verify reading and sight to S with angle 18′ on plate, deflect to $a_3 = 54'$ to sight on tangent if desired; then reversing telescope and taking from table, angles i_{3-4}, i_{3-5}, i_{3-6}, i_{3-7}, equal 1°14′, 1°38′, 2°06′ and 2°38′ respectively, deflect successively to these readings to locate stas. 4, 5, 6 and 7. At (7) with angle 2°38′ on plate, sight to (3) and turn off to $a_7 = 4°54'$ for the common tangent at (7). Reversing telescope, we run in the 5°36′ circular curve as usual from this tangent.

The curve is as easily run in *backwards.* Thus having run the circular curve and turned into tangent at 7, set vernier at $a_7 = 4°54'$, so that on turning to 0°00′ we sight along a line parallel to final tangent SY.

We then set vernier to angle $i_{6-7} = 4°14'$ to fix (6), $i_{5-7} = 3°38'$ to fix (5), $i_{4-7} = 3°06'$ to fix (4), $i_{3-7} = 2°38'$ to fix (3), etc. If we cannot see beyond (3), remove to (3) and with vernier reading as before $i_{3-7} = 2°38'$, sight to (7), reverse telescope and set to $a_{2-3} = 38'$, $a_{1-3} = 26'$, $a_{0-3} = \Delta_3 = 18'$ successively to fix stas. (2), (1) and (0).

Lastly, at sta. *o* or S, with last vernier reading $\Delta_3 = 18'$ on plate, sight to sta. (3) and turn to 0°00′ to sight along tangent SY.

Always set the angle off, that any chord makes with the Y axis, *on the proper side of the o point*, so that when we sight along that chord and then turn to 0°00′ the line of sight will be parallel to the tangent SY. This is best done by leaving the last angle turned clamped on plate, when we move up to a new station, at which point verify angle and *reverse* telescope to sight back to last station at which transit was set.

APPROXIMATE FORMULAS.

By referring to the general table, we see that the ordinate X at the middle of any length of curve is nearly 1/8 that at the end. Thus the ordinate $X_6 = 12.56$ and 1/8 $X_{12} = 12.51$, also $X_3 = 1.57$, and this is equal 1/8 $X_6 = 1.57$, etc.

If we use the approximate formula $x = \frac{1}{3}as^3$, found from (14) by neglecting all terms after the first and designate by x_0 the ordinate corresponding to $s_0 = \frac{s}{2}$ we have

$$x_0 = \frac{1}{8}\left(\frac{as^3}{3}\right) \text{ or } \frac{1}{8} \text{ the extreme ordinate } x.$$

The equation $x = \frac{1}{3}ay^3$ is that of the cubic parabola, and we see that the eq. $x = \frac{1}{3}as^3$ closely approximates to it for the very flat arcs considered, thus furnishing the basis for the approximate solutions before referred to.

Again in fig. 1, for flat arcs, we have seen that radius OD produced, drawn ⊥ SK, nearly exactly bisects the curve SEL, hence SG is nearly equal to LD (where G is the intersection of chord SL and OD), and since arc Δ nearly $= \frac{CG}{SG}$ and arc $\frac{a}{2} = DLF$ (in arc) $= \frac{FD}{LD}$ and $\Delta = \frac{a}{3}$ we have, nearly,

$$\frac{\Delta}{\frac{a}{2}} = \frac{CG}{FD} = 2/3;$$

or since $CG = \frac{KL}{2} = \frac{x}{2} \therefore FD = 3/4\ x$,

and $DC = FC - FD = x - 3/4\ x = 1/4\ x = q$.

From the table we see that $Q = \frac{x}{q} = 1/4$ nearly throughout.

We have shown above likewise that $CE = x_2 = 1/8\ x$ nearly, and as $q = 1/4\ x$ nearly, we have, nearly,

$$CE = 1/2\ C\bar{D} = 1/2\ q;$$

so that the curve SEL nearly bisects the gap q between the tangent and the circular curve.

We shall now deduce an approximate formula for finding the successive angles i in terms of N and N_1, the numbers of the stations between which the chords are drawn. Neglecting all terms of (14) after the first, and calling x^1 the approximate value of x, we have

$$\frac{x^1}{s} = 1/3\ a = \triangle \text{ (to nearest minute of arc).}$$

We should naturally infer, within this same limit of accuracy, that the arc i can be expressed by a similar approximate formula,

$$i = \frac{x_1{}^1 - x^1}{s_1 - s};$$

where $x_1{}^1 - x^1$ is the difference in the ordinates computed by the approximate formula above and $s_1 - s$ = length of arc between them.

We have just seen that this formula is true to the nearest minute of arc when x^1 and s are zero, in which case i reduces to $\triangle$, and we shall now reduce it and express i in terms of N and N_1 and test it for other values.

We have,

$$x^1 = \tfrac{1}{3}\,as = \tfrac{1}{3}\,as^3 = \tfrac{1}{3}\,ac^3\,N^3;$$

$$\therefore i = \frac{x_1{}^1 - x^1}{s_1 - s} = \frac{a}{3}\,\frac{c^3\,(N_1{}^3 - N^3)}{c\,(N_1 - N)} = \frac{ac^2}{3}\,(N_1{}^2 + NN_1 + N^2).$$

Replacing ac^2 by its value $\dfrac{\pi}{1800}$ (eq. 8) and multiplying both sides of the equation by $\dfrac{180 \times 60}{\pi}$ to reduce to minutes, we have,

$$i \text{ (in minutes)} = 2\,(N_1{}^2 + N_1\,N + N^2) \;.\;.\;.\;.\;.\; (23).$$

We find that this formula is correct to the nearest minute, or as accurate as the formula $\Delta = \tfrac{1}{3}\,a$, which is correct up to N = 14 (and practically to N = 15) to the nearest minute.

In the above, N_1 has been taken as the number of the forward station and N of the one nearest S; but if the reverse obtains, on interchanging N_1 and N in the first formula, we shall arrive at the same formula (23), which is thus perfectly general and applies whichever is the forward station.

As an application compute $i_{5\text{-}10}$: we have, putting $N_1 = 10$, $N = 5$,

$$i_{5\text{-}10} = 2\,(10^2 + 10 \times 5 + 5^2) = 350' = 5°50',$$

correct by the general table, and in fact differs only a few seconds from the exact value.

It is more expeditious, however, to compute the successive values of i by differences. Thus, if we change N to N + 1 in (23), we get the angle i made by the chord from sta. (N + 1) to sta. N_1 with the Y axis. Subtracting (23) from this we have the angle made by the two chords, from N to N_1 and (N + 1) to N_1 equal to

1st difference $= 2 (N_1 + 2 N + 1)$ *minutes* . . . . (24).

As N increases one at a time, the first difference changes four at a time,

$\therefore$ 2d difference = 4 minutes.

We observe from (23) that for N = 0, $i = \triangle = 2 N_1^2$, which agrees with (19); also for $N = N_1$, the right member reduces to 6 N^2, which by (7) is exactly equal to the a corresponding to the station.

Hence, starting with N = 0 in (23), which gives $\triangle$, and increasing N one at a time, we compute the corresponding i's until $N = N_1$ when the a at sta. N_1 is found. As N again increases one at a time, the following i's are found.

The formula (23) is found to be exact to the nearest minute, when compared with exact results, and is more nearly correct the less N and N_1 differ and for $N = N_1$ it is absolutely exact.

As an application, let $N_1 = 5$, whence first difference by (24) = 12 + 4 N and second difference = 4.

For N = 0, angle between chords 05 and 15 = 12′.
N = 1, " " " 15 " 25 = 16′.
N = 2, " " " 25 " 35 = 20′.

Similarly for the others.

Starting with $\triangle_5 = 2 N_1^2 = 50'$ and adding the successive differences above, we find, $i_{1-5} = 50 + 12 = 62'$, $i_{2-5} = 78'$, $i_{3-5} = 98'$, $i_{4-5} = 122'$, $i_{5-5} = a_5 = 150'$, $i_{5-6} = 182$, and so on.

As (23) reduces to a for $N = N_1$, the method of differences above evidently applies in finding a_5 from i_{4-5} and i_{5-6} from a_5.

We shall close by calling attention to one more interesting result. The angle i that a chord from station $N_1 - 1$ to station N_1 makes with the Y axis, is found from (23) by changing N to $N_1 - 1 \therefore i = 6 N_1^2 - 6 N_1 + 2$. Subtracting this from the a at $N_1 = 6 N_1^2$ and we have $a - i = 6 N_1 - 2$. If we regard N_1 as the point of connection with the circular curve, we have $D° = \frac{20 N_1}{c}$ and the first deflection from the tangent on the circular curve for a chord of c feet is $\frac{1}{2}$ 60 $D° \frac{c}{100} = 6 N_1$ minutes. This is always greater by two minutes than the angle between the tangent at station N_1 and the chord from station $N_1 - 1$ to station N_1, as we have just found the last angle to equal $(6 N_1 - 2)$ minutes. We should naturally expect such a result from the definition of the curve.

GENERAL TABLE.

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X	.06	.47	1.57	3.72	7.27	12.56	19.94	29.76	42.35	58.05	77.19	100.08	127.02	158.31	194.20
Y	100.	200.	299.99	399.97	499.90	599.76	699.49	799.00	898.20	996.96	1095.10	1192.44	1288.73	1383.71	1477.03
F	.25	.25	.25	.25	.25001	.25002	.25005	.25011	.25018	.25026	.25038	.25056	.25077	.25104	.25137
Q	.0029	.04654	.23561	.74463	1.8178	3.7692	6.982	11.910	19.071	29.056	42.519	60.180	82.819	111.28	146.45
Z	20	80	180	320	500	720	980	1280	1620	2000	2420	2880	3380	3920	4500
C	10	40	90	160	250.5	359.8	489.4	638.7	807.3	994.9	1201.0	1424.9	1665.6	1922.0	2192.6
a	06′	0°24′	0°54′	1°35′	2°30′	3°36′	4°54′	6°24′	8°06′	10°00′	12°06′	14°24′	16°54′	19°36′	22°30′
Δ	02′	0°08′	0°18′	0°32′	0°50′	1°12′	1°38′	2°08′	2°42	3°20′	4°02′	4°48′	5°38′	6°32′	7°29
	1	0°14′	0°26′	0°42′	1°02′	1°26′	1°54	2°26′	3°02′	3°42′	4°26′	5°14′	6°06	7°02′	8°02′
		2	0°38′	0°56′	1°18′	1°44′	2°14′	2°48′	3°26′	4°08′	4°54′	5°44′	6°38′	7°36′	8°38′
			3	1°14′	1°38′	2°06′	2°38′	3°14′	3°54′	4°38′	5°26′	6°18′	7°14′	8°14′	9°18′
				4	2°02′	2°32′	3°06	3°44	4°26′	5°12′	6°02′	6°56′	7°54′	8°56′	10°02′
					5	3°02′	3°38′	4°18′	5°02′	5°50′	6°42′	7°38′	8°38′	9°42′	10°50′
						6	4°14′	4°56′	5°42′	6°32′	7°26′	8°24′	9°26′	10°32′	11°42′
							7	5°38′	6°26′	7°18′	8°14′	9°14′	10°18′	11°26′	12°38′
								8	7°14′	8°08′	9°06′	10°08′	11°14′	12°24′	13°38′
									9	9°02′	10°02′	11°06′	12°14′	13°26′	14°42′
										10	11°02′	12°08′	13°18′	14°32′	15°50′
											11	13°14′	14°26′	15°42′	17°02′
												12	15°38′	16°56′	18°18′
													13	18°14′	19°38′
														14	21°02′

THE OCCURRENCE OF PLATINUM IN NORTH CAROLINA.

BY F. P. VENABLE.

The statement that platinum has been found and hence occurs in North Carolina is made in a number of text-books on chemistry, mineralogy and metallurgy. Statements so wide-spread and often repeated naturally lead to inquiries as to where it has been found, who found it, etc. That is, upon what authority is this claim made for the State and who can vouch for, or has seen, the platinum. I have, for a year or two, carefully investigated this question, and as I seem to have gotten all the information obtainable on the subject, I venture to present it before the Society, however unsatisfactory it may be.

It will be proper here to republish the first mention in a scientific journal of the finding of platinum in the State. Among the "Mineralogical Notes" appearing in the *American Journal of Science* for 1847 (2d Series, Vol. IV, p. 280), Dr. Charles Upham Shepard reports the following:

"*Native Platinum in North Carolina.*—In November last I received in a letter from Hon. T. L. Clingman, of Asheville, N. C., a small reniform grain of native platinum, with the following remark: 'The enclosed metallic grain was given me by a friend, who says it was found among the gold of one of his rockers. It looks like platinum.'

"Its weight was 2.541 grs. There was no difficulty, by means of its physical and chemical properties, in identifying it with the substance above suggested. Its specific gravity = 18. In a subsequent letter, dated January 3d (written before receiving my reply), Mr. C. adds still farther: 'Mr. T. T. Erwin, who presented it to me, says that his overseer, in whose veracity he has the fullest confidence, gave it to him with the gold obtained from the rocker, and that he (Mr. Erwin) does not entertain the smallest doubt of its having been found in his mine in the north part of Rutherford county. Should it prove to be platinum, it is of interest to me as the first specimen of that mineral found in the United States.'

"Fearing, however, that the grain might have originated in a foreign locality, I addressed particular inquiries to Mr. C. on this head and received from him the following additional statements: 'The platinum specimen formerly sent you was taken from the gold rocker by Mr. Lyon, the overseer of Mr. Erwin. Mr. L. is a man of good character, and all persons who know him entertain no doubt whatever of his having obtained the specimen as represented. Mr. L. had no suspicion of its being anything more than silver, which was known to be found with the gold. The place at which he obtained it was in Rutherford county, near the line of the new county of McDowell. I would have sent you his certificate, but I had no doubt that other specimens would be found. In fact, almost every miner to whom I described it said he had seen just such specimens, but they had supposed them to be fragments of steel or iron that had been broken from the edges of the mining tools.'"

In a foot-note referring to the above, Dr. Shepard adds the following statements. The foot-note is headed:

"*Bismuthic Gold.* In the letter from which the above is extracted, was forwarded to me a few grains of which the largest weighed only 0.907 grains of an alloy of bismuth and gold, to which faint traces of mercury were adhering. Concerning their origin, Mr. C. observes: 'They were brought me by a friend, Mr. Willis, under the impression that they might be platinum. They were mixed with the gold of several days' work, and I assisted him in picking them out from a parcel he brought to the bank in this place. They are evidently not grains of platinum.' "

A description of the grains is given: Structure, subfibrous; Hardness = 2.5 — 3.0; Gr. = 12.44 — 12.9; color that of palladium; malleable, etc.

I think most will agree with Prof. E. S. Dana, who writes, in a letter regarding the above note of Dr. Shepard: "The evidence upon which the statement rests, you will see, is not very conclusive."

I have been unable to find anywhere, either personally or through friends who have kindly searched for me, any other publication of a definite kind of platinum. All other public mention seems to refer to or rest upon the one given above.

In his Geology of North Carolina, Vol. I, Dr. Kerr says on page 55 of his appendix:

"The occurrence of grains of platinum among the sands of gold-washings of Rutherford and Burke counties was first brought to notice by General Clingman, who sent half a dozen grains from a mine near Jeanestown to Prof. C. U. Shepard. It has also been found on Brown Mountain, in Burke, according to the information received from Mr. E. Bissell. It is reported as having been found near Burnsville, Yancey county."

These statements are copied in all subsequent reports on the Minerals of North Carolina. Even in the last report by Prof. Genth, published as a Bulletin of the United States Geological Survey, No. 74, 1891, the same wording is followed, but Prof. Genth adds, "Hidden, after much searching, failed to discover platinum at any of the reported localities." As to palladium, which Dr. Kerr reports also as occurring in Burke and Rutherford, Genth says "very doubtful."

Taking Dr. Kerr's statements about platinum in detail, the first must refer to the account already quoted of Shepard's identification of one grain sent him by Clingman. I can find no account of other finds. Nor is any published mention to be found of Bissell's discovery. There is no record of a scientific examination nor any scientific authority supporting it. Mr. Bissell is himself long since dead. There is the same lack of authenticity and scientific authority for the report from Burnsville.

It is a great pity that these reports, etc., were not examined into and definitely settled as to authenticity while those finding or acting as experts were yet alive. Dr. Shepard seems to have left no trace of his connection with the find beyond the note quoted.

Something so unique as the only specimen of native platinum found in the United States up to that time would surely have been preserved in his collection of minerals, yet Prof. Harris, of Amherst, where the collection is preserved, writes me that there is no record of it there.

General Clingman, now very old, has kindly written me his recollection of the matter:

"In the year 1846 I found platinum in the gold washings of Rutherford county, and sent specimens to Prof. C. U. Shepard, then in Charleston, S. C., and part of the year in Connecticut. I also sent some to Prof. Dana. It was found in small pieces among the gold grains. I also obtained some in McDowell and in Burke, also some in the western part of Rutherford, now Polk county, and a little in the eastern part of Henderson county, near the Polk line. I am told that some was also found in the southern part of Jackson county in the washings of the Gold Spring tract."

Prof. E. S. Dana has written me that his father, Prof. J. D. Dana, who is referred to above by General Clingman, "has no recollection in regard to the subject."

Dr. F. A. Genth, who has done so much for the mineralogy of the State, and is so thoroughly conversant with it, writes:

"I regret that I cannot give you any additional information about the occurrence of platinum in North Carolina. I have no personal knowledge of any find, and it seems that General Clingman is the only person who can authoritatively speak of its occurrence. I would like very much to see and examine some of the grains which he is said to have sent to the late Prof. Shepard."

Dr. C. D. Smith says: "I do not know of the occurrence of platinum anywhere in the State. Many years ago it was claimed to have been found in some gold placers in the Piedmont region of the State. I, however, have no knowledge of just ground for such claim. I very much desire that it might be found in North Carolina." Dr. Smith has spent his working years among the minerals of Western North Carolina and has had every opportunity of hearing of such a find if one had been made.

Mr. Edison was attracted by the reported occurrence of platinum here and hoped to find a source of supply of the costly metal for his incandescent lamps. He advertised for large quantities, hoping thus to stir up private investigators, and at the same time sent trained experts to look for it. The following brief note, received from his laboratory, gives the results:

"Mr. Edison has instructed me to inform you that his assistants panned in every gold stream in North Carolina without ever getting a color of platinum."

Mr. Hidden, who was one of these assistants, has given me a short account of his investigations:

"As to platinum in North Carolina and my search for veins of it in 1879: The localities visited comprised those mentioned in 'Dana,' and nearly all the 'placer gold diggings' of North Carolina, South Carolina, Georgia and

Alabama. I was most thorough in and around Rutherfordton and up to Jeanestown and Brindletown. The lamented Prof. Kerr gave me personal instruction at the time, and through him I learned of the Shepard 'find' (of a few small nuggets of platinum), at a place near to 'old Whitesides settlement,' not far from Golden P. O., Rutherford county. Neither panning nor chemical tests showed any platinum in the concentrations of the auriferous gravels wherever operated. * * * I found no platinum on Brown Mountain. I know of no authentic finds of platinum in North Carolina and have no knowledge of any outside of the Clingman-Shepard statements, which are so universally quoted as facts.

"Do not understand me as believing for a moment that platinum does not exist in North Carolina, but only that I do not know of such occurrence. The extraordinary development of chrysolite-serpentine rocks in North Carolina may yet be shown to contain platinum in commercial quantity—who knows? When a nugget of platinum can be found enclosing a large per cent. of chromite, as was the case near Plattsburg, N. Y. (Collier), I begin to think that the chromite deposits of North Carolina may be profitably searched for the now very valuable metal.

"In 1879 I saw a good deal of lead (weathered bullets and shot) that passed as platinum from the gold gravels, but I repeat that I saw no platinum."

I have presented all the information that I can get on the subject. Only one scientific examination of the reported finds seems ever to have been made, and that of one grain "given by a friend" to General Clingman and sent by him to Dr. Shepard.

It is exceedingly strange that the other "finds" reported were not subjected to the examination of an expert, and that the specimens cannot be found in the museums of the country. General Clingman's reports would show it to be widely scattered through the gold region of the State. If so, some ought certainly to have been found since. Finds are indeed frequently reported now, but the grossest mistakes are made. Is it not probable that General Clingman was mistaken?

One cannot deny that platinum may occur in North Carolina, but the evidence for it is very slight. And this is said without any intention of throwing discredit upon General Clingman, who has done so much to make known to the world the mineral resources of the State.

REPORT OF TREASURER FOR 1891.

Received from fees of members	$ 68 00	
Received from fees of associate members	6 00	
Received from sales of Journals	1 50	
Received from contributions	105 00	
	$180 50	
Expended for postage		$ 14 45
Expended for express		50
Expended for binding		1 20
Expended for lamps, etc.		30
Expended for printing		118 27
		$140 48
Balance on hand		40 02
		$180 50

COUNCIL MEETING.

The reports of officers were accepted and approved.

The following officers were elected for 1892:

President	J. A. Holmes	Chapel Hill.
First Vice-President	W. L. Poteat	Wake Forest.
Second Vice-President	W. A. Withers	Raleigh.
Third Vice-President	J. W. Gore	Chapel Hill.
Secretary and Treasurer	F. P. Venable	Chapel Hill.

RECORDS OF MEETINGS.

SIXTY-THIRD MEETING.

PERSON HALL, September 15, 1891.

14. Preparation of Pure Zirconium Chlorides from North Carolina Zircons. F. P. Venable.

15. The Alexander County Meteorite. S. C. H. Bailey.

16. Additions to the List of Birds Found in North Carolina. Smithwick.

17. Phosphorescent Bacilli. H. V. Wilson.

18. Theorem of Least Work. Wm. Cain.

The Secretary reported 553 books and pamphlets received since the last report and thirteen additional exchanges.

SIXTY-FOURTH MEETING.

WAKE FOREST COLLEGE CHAPEL, October 23, 1891.

19. A North Carolina Catalan Furnace. H. L. Harris.

20. Twilight in High Latitudes. J. F. Lanneau.

21. The Development of Certain Sponges. H. V. Wilson.

22. Rain-making Experiments. L. R. Mills.

23. Notes on the Fertility of Physa Heterostropha Say. W. L. Poteat.

24. Drudgery in Science. F. P. Venable.

SIXTY-FIFTH MEETING.

PERSON HALL, November 17, 1891.

25. The Sun's Way. J. W. Gore.

26. A New Cosmic Theory. Chas. Baskerville.

27. A New Theory of the Origin of Petroleum. R. B. Hunter.

28. Metschnikoff's Theory of the Action of Phagocytes in Disease. H. V. Wilson.

The Secretary reported the receipt of 231 books and pamphlets and also the following new exchanges:

COLORADO—College Studies.

BUFFALO—Society of Natural History.

HAMBURG—Landwirthschaftliche Rundschau.

DUBLIN—Royal Irish Academy.

ROMA—Rassegna delle Scienze Geologiche.

Societé Francaise de Botanique.

MARBURG—Gesellschaft z. Beforderung d. Naturwissenschaften.

SIXTY-SIXTH MEETING.

PERSON HALL, December 8, 1891.

29. The Tunnel Under the St. Clair River. H. B. Shaw.
30. Does Platinum Occur in North Carolina? F. P. Venable.
31. Some Cercosporæ from Alabama. Geo. F. Atkinson.
32. Transition Curves. Wm. Cain.

The Secretary reported 108 books and pamphlets received.

The total number now in the library is 8,778.

The following additional associate members have been enrolled:

ANDREWS, A. B., Jr.,	ELLIS, CASWELL,
BASKERVILLE, CHAS.,	HARRIS, H. L.,
CONNOR,	HUNTER,
EDWARDS, A. J.,	RONDTHALER,

SMITH, T. C.

A report of the Council Meeting was read, announcing the election of officers for the year 1892.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY,

VOLUME IX—PART FIRST.

JANUARY—JUNE.

1892.

POST-OFFICE:

CHAPEL HILL, N. C.

E. M. UZZELL, STEAM PRINTER AND BINDER,
RALEIGH, N. C.
1892.

OFFICERS.

1892.

PRESIDENT:

JOSEPH A. HOLMES, - - - - - - - Chapel Hill, N. C.

FIRST VICE-PRESIDENT:

W. L. POTEAT, - - - - - - - - Wake Forest, N. C.

SECOND VICE-PRESIDENT:

W. A. WITHERS, - - - - - - - - Raleigh, N. C.

THIRD VICE-PRESIDENT:

J. W. GORE, - - - - - - - - - - Chapel Hill, N. C.

SECRETARY AND TREASURER:

F. P. VENABLE, - - - - - - - - Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

ON THE FUNDAMENTAL PRINCIPLES OF THE DIFFERENTIAL CALCULUS.

BY WILLIAM CAIN, C. E., MEM. AM. SOC. C. E.

There are probably no students of the infinitesimal calculus, who have seen its varied applications, that are not impressed with its immense scope and power, "constituting, as it undoubtedly does," says Comte, "the most lofty thought to which the human mind has as yet attained."

It was not to be expected that a science of reasoning, involving so many new and delicate relations between infinitely small quantities, should appear perfect, in its logical development, from the beginning, even with such men as Newton and Leibnitz as its creators. For a long time mathematicians were more concerned in extending the usefulness of the transcendental analysis than in "rigorously establishing the logical bases of its operations," though it has given rise at all times to a great deal of controversy, which has been of great aid to those geometers who concerned themselves particularly with establishing it upon a logical basis. Of this number none are more prominent than the French author, Duhamel. He proceeded by a rigorous use of "the method of limits," whose thorough comprehension he regarded as so important that he devoted the first half of his Differential Calculus to its numerous applications.

In the United States, after the appearance of Bledsoe's "Philosophy of Mathematics" in 1867, calling especial attention to Duhamel's elegant treatment and contrasting it with the false logic of various other schools, there have appeared a few good elementary books, nearly free from errors, though sometimes showing a trace of them; thus illustrating the tenacious grip of errors induced by early vicious training. With these fairly good books have appeared some as bad as have ever been written, from a logical stand-point, as well as others, where ingenious sophistry has done its utmost to try and blind the student (and possibly the author) to the false logic involved. The English as a rule have followed in the lead of Newton, perpetuating his error that a variable can reach its limit, and they have occasionally introduced a number of errors from the Leibnitz school, whose teachings still pervade most of Germany, the place of its birth.

If the above is true as to the persistent perpetuation of false logic in the treatment of the first principles of the calculus, it would seem that no apology was needed for a critical review of those first principles, particularly as no matter what school is followed in learning the calculus the scientific student will be sure to come across the teachings of various schools in the applications and thus should be prepared to take them at their true worth and modify them in statement or otherwise when necessary.

Although a good deal of old ground is gone over, it was essential to do so to bring out the points criticized in strong relief. The grouping of subjects is intended to be such as to enable the beginner in the calculus to see at once its truth and to catch on to its true spirit. The methods of Newton and of Leibnitz, with criticism, is given in fine print to avoid confusion, and can be omitted the first reading, without detriment to the rest, if preferred.

Definition of the Limit of a Variable. When a variable magnitude takes successively, values which approach more and more that of a constant magnitude, so that the difference with this last can become and remain less than any designated fixed magnitude of the same species, however small, whether the variable is always above or always below or sometimes above and sometimes below the constant, we say that the first *approaches indefinitely* the second and that the constant magnitude is the limit of the variable magnitude.

More briefly, this is often stated thus: The limit of a variable is the constant, which it indefinitely approaches but never reaches.

Definition of an Infinitesimal. An infinitely small quantity or an infinitesimal, is a finite quantity whose *limit* is zero. Hence the infinitesimal approaches zero indefinitely, but can never attain it, since zero is its "limit." As an illustration, take two straight lines incommensurable to each other. Mark the ends of the first line A^1, B^1, the ends of the second A, B. Now as we can always find a unit of measure that will go into A^1B^1 an integral number of times, apply such a unit to AB from A to C, as many times as possible, leaving a remainder over CB less than one of the parts. Then the ratio,

$$\frac{AC}{A^1B^1}$$

is less than the ratio of the two lines, but approaches it indefinitely as the unit of measure decreases indefinitely, since CB being always less than the unit, tends towards zero but can never reach zero; hence CB is an *infinitesimal* and AC approaches AB indefinitely without ever being able to reach it. By the definition therefore, the limit of CB is zero and the limit of AC is AB, hence the limit of the ratio above,

$$\text{lim.}\ \frac{AC}{A^1B^1} = \frac{AB}{A^1B^1}$$

is what is called the incommensurable ratio, $AB : A^1B^1$. It is assumed, of course, that the successive units of measure all exactly divide A^1B^1. It may happen that one of these units applied to AB will cause the point C to lie very near the point B, but for a smaller unit the distance CB will be greater than before, so that the variable CB is sometimes decreasing and then again increasing, but as it is always less than one of the parts into which A^1B^1 has been divided, it can "become and remain" less than one of the parts or less than any finite number that may be assigned, however small; hence zero is its limit by the definition.

If in the ratio above we take A^1B^1 as 1 (one foot say), we have, limit AC = AB from the last equation. AB and AC can thus be regarded as incommensurable and commensurable numbers respectively, and we see from the above that an incommensurable number, as AB, is the limit of a commensurable number as the number of parts into which unity is divided is indefinitely increased.

The student of algebra and geometry is familiar with many applications of the theory of limits, such as: limit of $(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \ldots) = 2$, as the number of terms of the series is increased indefinitely; the circle is the limit of a regular inscribed or circumscribed polygon, as the number of sides is indefinitely increased, etc., etc.; so that no more illustrations need be given if these are carefully studied in connection with the first definition given above to show that it is complete and meets fully every case that arises.

It may be observed, too, that although we can express the length of a straight line or the perimeter of a polygon, in terms of the length of a straight line, taken as a unit of measure, we are confronted with the difficulty, in the case of any curve line, that we cannot apply the unit of measure, or any fractional part thereof, to the curve. We can apply it, however, to the inscribed or circumscribed polygon, and by taking the limit to which these polygons approach indefinitely as the number of sides is increased indefinitely, we get what is called the length of the curve. Similarly no meaning can be attached to the expressions, area of a curve or area of a curved surface, unless we define them as the limit of the area of the inscribed or circumscribed polygon in the first case, or as the limit of the area of the surface of the inscribed or circumscribed polyedrons in the second case, the number of sides or faces, as the case may be, increasing indefinitely. In the case of volumes, too, neither the unit of measure nor any fraction of it can be directly applied when the bounding surfaces are curved, so that a volume must be defined as the limit of the variable volume of some inscribed or circumscribed polyedron as the number of faces is indefinitely increased. The difficulty of measuring curved surfaces, volumes, etc., occurs to every reflecting student, and it is strange that none of our geometries give any definitions but only methods of finding lengths, areas and volumes of curved lines, surfaces and volumes, assuming that the student will find out in some way what is meant by such terms.

The "Theory of Limits" will not be entered into here as it is sufficiently exposed in many text-books. Some strange definitions of infinity, though, appear in some excellent books. The following is a sample: "When a variable is conceived to have a value greater than any assigned value, however great this assigned value may be, the variable is said to become *infinite;* such a variable is called an *infinite number.*" As an "assigned value" means some finite value, it follows from this definition that an infinite number is only some number greater than some finite number, however large; in other words, an infinite number is a finite number! If such quantities have to be considered they should be given a different name and symbol to avoid confusing these with absolute infinity. The letter G is suggested to distinguish such finite quantities from absolute infinity ∞. We get our ideas of infinity from space and time, for finite as are our capacities, we cannot conceive of space or time ever ending; hence we speak of infinite space and infinite time. However far, in imagination, one may travel in a straight line in space, it is impossible to conceive of ever arriving at any point where there is not *infinite space beyond*. The consideration of a row of figures, 10000 . . . , extended without limit, gives one an idea of an infinite number.

Consider the quotient,

$$\frac{a}{100000} = .00001a,$$

where a is finite.

The number of noughts in the right member is one less than the number of noughts in the denominator, and successive divisions by ten show that the same law holds, no matter how great the denominator.

If we conceive the number of noughts in the denominator to be increased to several billion, the quotient is extremely small, as in the right member we have the same number of noughts less one before reaching the 1; thus as the denominator increases indefinitely the value of the fraction approaches zero indefinitely, and this is all that is meant by the abbreviated notation, $\frac{a}{\infty} = 0$.

Similarly it may be shown, if $\frac{a}{x} = y$ and x decreases indefinitely, that y increases indefinitely, and this is the meaning of the notation $\frac{a}{0} = \infty$, which has no sense by itself. Although the limit of x above is zero, the limit of y is not infinity, since if y had a limit it could be made to differ from it by as small a quantity as we wish, whereas any finite quantity (y) will always differ from infinity by infinity.

Thus the principle of limits, "if two variables are equal and *each approaches a limit*, their limits are equal," does not apply, as both variables do not approach limits.

Therefore the singular forms mentioned must always be regarded as abbreviations, having the meaning attributed to them above and not as meaning anything in themselves. We have an illustration of such forms in trigonometry. Thus,

$$\tan x = \frac{\sin x}{\cos x}$$

As x approaches 90°, sin x approaches 1, cos x, o, and the left member, though always finite, increases indefinitely. The latter is said to be infinite for $x = 90°$, though strictly, according to the usual definition, there is no tangent of 90°, as the moving radius produced, being parallel to the tangent, can never intersect it. As parallel lines are everywhere the same distance apart, they cannot meet, however far produced, so that the statement that two parallel lines meet at infinity is essentially false.

Similarly we can reason for all the functions that increase indefinitely, without ever ceasing to be finite, where the angle approaches some limit, or fixed value it can never attain, with any meaning corresponding to the functions. The above is still more evident when we regard the ratio definitions first given in trigonometry, for then, there can be no function without a right triangle can be formed and there is no triangle when one acute angle is either 0 or 90°; therefore we can only say that $\sin x$ approaches 0 as its "limit" as x indefinitely diminishes, and $\tan x$ increases indefinitely as x approaches 90°.

With this meaning to be given such expressions as $\sin 0 = 0$, $\tan 90 = \infty$, they can be safely used (and will be used in what follows), though there is really no sine corresponding to 0° and no tangent for 90°.

The next subject treated will be the general one of finding the limit of the ratio of two related infinitesimals, which is the principal problem of the differential calculus.

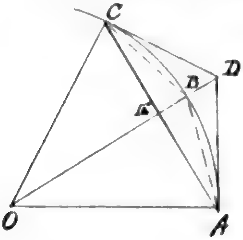


Fig. 1

As a special example, consider the circular arc ABC, fig. 1, of radius unity, whose length in circular measure is $2x$. Divide it into two equal parts, $x = \text{AB} = \text{AC}$ and draw tangents AD and CD, intersecting on radius OB produced. Call the *chord* AB = *chord* BC = c. Then since the radius is taken as unity, $\text{EA} = \sin x$ and $\text{AD} = \tan x$.

Now by geometry we have,

$$\text{AC} < 2c < 2x < \text{AD} + \text{DC};$$

whence, dividing by 2, we have,

$$\sin x < c < x < \tan x.$$

Also since,

$$\frac{\sin x}{\tan x} = \cos x \;\therefore\; \lim. \frac{\sin x}{\tan x} = 1,$$

as x *indefinitely diminishes*, since then, $\lim. \cos x = 1$, as $\cos x$ indefinitely approaches unity without ever attaining it.

Now since c and x are always intermediate in value between $\sin x$ and $\tan x$, it follows that the ratio of either to the other, or to $\sin x$ or $\tan x$, approaches indefinitely unity as a limit.

$$\therefore \lim. \frac{\sin x}{c} = \lim. \frac{\sin x}{x} = \lim. \frac{\sin x}{\tan x} = 1,$$

$$\lim. \frac{c}{x} = \lim. \frac{c}{\tan x} = \lim. \frac{x}{\tan x} = 1;$$

and it is the same for the reciprocals of the above ratios.

Any one of the above ratios approaches the form $\frac{0}{0}$ indefinitely, but can never attain it, as the functions cease to exist when $x = 0$ and the ratio ceases to exist; but the constant value which the ratio approaches indefinitely but never attains (*i. e.*, the limit) is at once found to be unity.

A function of x is some expression that contains x and is designated by some letter as f, F, . . . , with x in parentheses following. Thus $f(x)$, $F(x)$, . . . are read little f function of x, large F function of x, etc. If in any function, $f(x)$ of x, the variable x is changed throughout to $(x + h)$ so that the same operations are indicated for $(x + h)$ as in the original function were indicated for x, the result is written $f(x + h)$.

Thus if,

$$f(x) = x^2 \cos\left(\frac{x}{a}\right) + \log x,$$

$$\therefore f(x + h) = (x + h)^2 \cos\left(\frac{x + h}{a}\right) + \log (x + h).$$

The increase in x $(= h)$, is called the increment of x and is generally written in the calculus Δx, so that $h = \Delta x$. The symbol Δ (delta) indicates a difference, Δx signifying the difference between two states of x and the symbol Δx is regarded as an indivisible one and not composed of two factors Δ and x that can ever be dissociated. Similarly for Δy, Δz, etc., when the letters y, z, etc., occur in any expression. If $y = f(x)$ and we arbitrarily change x to $(x + h) = (x + \Delta x)$, then y will take a new value, designated by $y + \Delta y$, where Δy is the increase in y due to the increase in x.

Thus, if $y = f(x)$, ...(1),

$$y + \Delta y = f(x + h) = f(x + \Delta x) \; . \; . \; . \; . \; . \; (2),$$

x is here called the independent variable and y the dependent one, since the value of y depends on that of x, which we shall suppose to increase at will or independently of any other variable in the formula.

It is important to note here that although x is generally increased so that Δx is plus, yet the new value of $y (= y + \Delta y)$ may be either greater or less than before. In the last case Δy will be minus. Hence, if in any case, Δy is found ultimately to be minus, we shall know how to interpret the result.

In equatious (1) and (2), let x be first supposed to have a fixed constant value, then y will have a corresponding constant value. Subtracting (1) from (2) and dividing by Δx,

$$\frac{\Delta y}{\Delta x} = \frac{f(x + \Delta x) - f(x)}{\Delta x} \; . \; . \; . \; . \; . \; (3).$$

We shall presently show that this expression generally has a limit as Δx approaches zero. From (2) above, Δy approaches zero indefinitely at the same time that Δx does, so that (3) approaches indefinitely the form $\frac{0}{0}$, but the *ratio* $\frac{\Delta y}{\Delta x}$ can never reach this form, for where Δy and Δx are both zero there is no ratio. We can however find the *limit*, *or the constant value to which the ratio* $\frac{\Delta y}{\Delta x} = \frac{f(x + \Delta x) - f(x)}{\Delta x}$ *tends indefinitely without ever being able to reach as a ratio*, and this limit is known as the *derivative*, *derived function* or *differential co-efficient of the function* $f(x)$ *with* *respect to x as the independent variable.* We have hitherto supposed x to have a constant value, but the above method of finding the derivative is the same whatever value of x, giving real values to y in 0, we start from; hence the method is perfectly general.

As an illustration let,

$$y = f(x) = x^3 + b.$$

If x is changed to $(x + h) = (x + \Delta x)$, y will be changed to $y + \Delta y$.

$$\therefore y + \Delta y = f(x + h) = (x + h)^3 + h.$$

Expanding the right member of the last equation and subtracting the preceding equation from it, we have,

$$\Delta y = 3x^2h + 3xh^2 + h^3.$$

Dividing by $h = \Delta x$, we have,

$$\frac{\Delta y}{\Delta x} = 3x^2 + (3x + \Delta x)\,\Delta x \;.\;.\;.\;.\;.\; (4).$$

The limit to which the right member approaches indefinitely is $3x^2$, since as Δx diminishes indefinitely, so does the term $(3x + \Delta x)\,\Delta x$ in which Δx is a factor. Therefore the derivative of $f(x) = x^3 + b$ with respect to x is,

$$\text{lim.}\ \frac{\Delta y}{\Delta x} \doteq \text{lim.}\ \frac{f(x + \Delta x) - f(x)}{\Delta x} = 3x^2.$$

This limit $(3x^2)$ is true, no matter what value of x we start from, and its numerical value depends upon the value of x. It is seen to be perfectly definite and finite and to vary from zero to plus infinity according as x changes from zero to infinity. For a given value of x as 2, the limit has only one value = 12. Similarly for any other value. It is only in the case of the simpler functions that $f(x + h)$ can be developed readily, so that the derivatives can be easily found, but after *rules* for finding the derived functions of products, powers, etc., have been deduced (as given in elementary treatises on the calculus) the work of finding them by these rules is comparatively simple, however complicated the functions.

As $\lim. \dfrac{\Delta y}{\Delta x}$, $\lim. \dfrac{f(x+h)-f(x)}{h}$, are cumbersome symbols it is usual to put $\dfrac{dy}{dx}$ for them.

$$\therefore \frac{dy}{dx} = \lim. \frac{\Delta y}{\Delta x} = \lim. \frac{f(x+h)-f(x)}{h}.$$

In this expression *dy* is read differential of *y* and *dx* differential of *x*, and both *dy* and *dx* are to be regarded as indivisible symbols, so that *d* is not a factor but a symbol of operation. The differentials *dy* and *dx* are regarded as finite quantities, whose ratio, for any value of *x*, is exactly equal to $\lim. \dfrac{\Delta y}{\Delta x}$.

Thus even for the same value of this limit, *dy* and *dx* can be supposed to both increase or both decrease at pleasure, the only restriction being that their ratio shall always equal the value of the limit for the particular value of *x* considered. There is thus great flexibility in this conception of differentials. As a rule we shall consider the differentials as having appreciable values; in other cases it is convenient to treat them as *infinitesimals* or *finite quantities whose limits are zero*, but which consequently never become zero themselves, as then the ratio $\dfrac{dy}{dx}$ has no significance. In the same way Δx and Δy are infinitesimals. In the equation, derived from one above,

$$\frac{dy}{dx} = \lim. \frac{\Delta y}{\Delta x} = 3x^2,$$

it is understood that we can clear the equation of fractions and write,

$$dy = \left(\lim. \frac{\Delta y}{\Delta x}\right) dx = 3x^2 dx.$$

From this equation we see why $3x^2$ (in the particular example) or $\lim. \frac{\Delta y}{\Delta x}$ generally, is called a differential co-efficient.

On referring to the right member of eq. (4), we see that *regarded by itself*, it has no limit, since it is an essential requisite that a variable can never reach its limit, whereas by making $\Delta x = 0$, the right member becomes at once $3x^2$; but *considered in connection with the left member*, we see that although Δx must tend towards zero indefinitely, yet it can never be supposed zero, for then the ratio $\Delta y \div \Delta x$ has no meaning. With this restriction, then, the right member can approach $3x^2$ as near as we please without ever being able to reach it; hence $3x^2$ is the true "limit" of the right member when Δx is regarded as an infinitesimal whose limit is zero.

It is evidently immaterial by what law, if any, Δx diminishes towards zero. We can, if we choose, suppose Δx to diminish by taking the half of it, then the half of this result, and so on, in which case Δx will tend indefinitely towards zero, but can never attain it; or we can suppose Δx to diminish, in any arbitrary way, indefinitely towards zero without ever becoming zero. In any case the right member as well as the left has a true limit according to the strict definition.

It is to be observed, too, that this limit is found on the *one* supposition that Δx tends towards zero, for then Δy, as a consequence, tends towards zero indefinitely without ever being able to reach it.

We have emphasized this point, because some of the best known English writers, as Todhemter, Williamson and Edwards, following the lead of the great Newton, have assumed that a variable can reach its limit, so that (4) above should "ultimately become" $3x^2$.

That Newton failed to establish a true theory of limits is shown in Bledsoe's Philosophy of Mathematics. As it was, he made a great advance over previous methods; but now that a correct theory of limits is so universally known, there can be no excuse for later writers in perpetuating the same errors that seemed inevitable in the dawn of the infinitesimal method. The French writers (following the lead of Duhamel), and also some American writers, have been more logical in their development of the infinitesimal calculus.

The problem of tangents is one which gave rise to the differential calculus and needs to be carefully considered.

In fig. 2, let $y = f(x)$ be the equation of the curve DPS referred to the rectangular axes x and y. Suppose we wish to find the tangent of the angle PEX made by a tangent at a point P of the curve with the X axis or *the slope of the curve at P* whose co-ordinates are x and y. The co-ordinates of a point S to the right of P are $y + \Delta y$, $x + \Delta x$ so that, $PQ = \Delta x$, $SQ = \Delta y$ and,

$$\frac{\Delta y}{\Delta x} = \tan SPR.$$

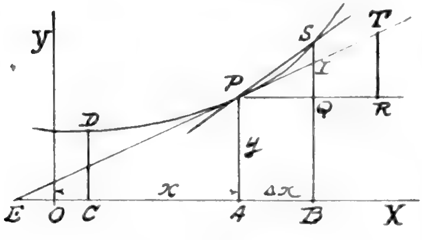


Fig. 2

This equation gives the slope of the secant PS which varies with the values of Δx and Δy. If PS regarded as a line simply, but not a secant, is revolved around P, in one position only, it coincides with the tangent, where it touches the curve in but *one* point. If it is revolved further, it cuts the curve on the other side of P whether the curve in the vicinity of P is convex to the X axis as drawn or concave. If the curve is convex on one side of P and concave on the other, the line PS will cut the curve in three points when it lies on one side of the tangent, and in one point when it lies on the other side of the tangent. When it coincides with the tangent it cuts the curve in but one point.

But in all cases, it must be carefully noted, that the *secant* PS as it revolves about P can approach the tangent PT as near as we choose, but can never reach it; for then it would cease to be a secant; hence the tangent is the limiting position of the secant. Therefore as Δx (and consequently Δy) diminish towards zero indefinitely, the point S will approach the point P indefinitely and angle SPR approaches indefinitely angle TPR as its limit; whence *tan* SPR approaches indefinitely tan TPR as its limit.

Therefore, taking the limit of the equation above,

$$\lim. \frac{\Delta y}{\Delta x} = \frac{dy}{dx} = \tan \text{TPR} \quad . \; . \; . \; . \; (5).$$

Hence if $y = f(x)$ is the equation of the curve, the derivative of $f(x)$ with respect to x is always equal to the slope of the curve at the point (x, y) considered. Thus the tangent of the angle made by the tangent line of the cubic parabola $y = x^3 + b$, already considered, with the axis of x, equals $3x^2$ at the point whose abscission is x.

This value was determined above and its meaning is that for x equal to 0, $\frac{1}{3}$, $\frac{1}{2}$, 1, etc., the slope of the curve is 0, $\frac{1}{3}$, $\frac{3}{4}$, 3, etc., and it increases indefinitely as x increases indefinitely.

In Edwards' Differential Calculus (second edition, 1892, page 20) we read, changing the letters to suit fig. 2, to which the theory applies: "When S travelling along the curve, approaches indefinitely near to P, the chord PS becomes in the limit the tangent at P." In ex. 2, page 21, the author, in getting the final equation, again says: "When S comes to coincide with P," etc. It is plain from these references that this most recent English author considers a variable to actually reach its limit—*a fundamental error* we have exposed above. The chord cannot reach the tangent without ceasing to be a chord, neither can the ratio $\frac{\Delta y}{\Delta x}$ (= slope of chord) reach its limit $\frac{0}{0}$ without the ratio ceasing to exist.

Let us take as another illustration the common parabola

$$y^2 = 2px.$$

When x increases to $x + \Delta x$, y changes to $y + \Delta y$

$$\therefore y^2 + 2y\,\Delta y + (\Delta y)^2 = 2p\,(x + \Delta x).$$

Subtracting the first equation from the second

$$2y\,\Delta y + (\Delta y)^2 = 2p\,\Delta x$$

$$\therefore \frac{\Delta y}{\Delta x} = \frac{2p}{2y + \Delta y}.$$

As Δx approaches zero, Δy tends in the same time towards zero, a limit which neither can attain however. The right member similarly approaches indefinitely the constant $\frac{2p}{2y}$ without ever being able to attain it, which is therefore its limit by the definition. Hence slope of tangent at point (x, y) is,

$$\lim. \frac{\Delta y}{\Delta x} = \frac{dy}{dx} = \frac{p}{y} = \pm \sqrt{\frac{p}{2x}}.$$

From this equation we see that the slope of the tangent varies from plus or minus infinity for $x = 0$ to plus or minus zero for $x = \infty$.

$$\text{As, } \lim. \frac{\Delta y}{\Delta x} = \frac{0}{0} = \frac{dy}{dx},$$

the dy and dx would appear to replace the zeros in the singular form $\frac{0}{0}$, which gave rise to Bishop Berkeley's witticism that the dy and dx were "the ghosts of the departed quantities Δy and Δx." As we have defined them above, dy and dx are finite quantities, of the same nature as y and x, whose ratio is always equal to the derivative, this ratio being variable when the derivative is variable. As $y = f(x)$ can always be represented by a locus (since for assumed values of x we can compute and lay off the corresponding values of y) and since $dy \div dx$ represents the slope of the locus at the point (x, y), we can represent dy and dx by the length of certain lines. Thus in fig. 2, from the point of tangency P, draw PR parallel to the axis of x *any* distance from P to R to represent dx and from the point R draw RT parallel to the axis of y to intersection T with the tangent, when RT will represent dy; for then

$$\frac{dy}{dx} = \tan \text{TPR} = \lim. \frac{\Delta y}{\Delta x},$$

as should be the case.

If we choose to make $dx = \Delta x = \text{PQ}$, then $dy = \text{QI}$, which is less than Δy when S is above I, for a convex curve to X, and greater than Δy when s is below, or for a curve concave to X, just to the right of P. It is only in the case where $y = f(x)$ is the equation of a straight line that for $dx = \Delta x$ we have $dy = \Delta y$, for here $\Delta y \div \Delta x$ represents the slope of the line.

Other important formulas can be deduced from fig. 2.

If we call the length of the curve from some point D to P, s, then the increment of the arc PS corresponding to the simultaneous increment Δx of x will be called Δs. Call the length of the chord PS $= c$.

Then we have,

$$\frac{\text{PQ}}{c} = \frac{\Delta x}{c} = \cos \text{SPQ},$$
$$\qquad\quad \Delta s\frac{c}{\Delta s}$$

$$\frac{\text{QS}}{c} = \frac{\Delta y}{c} = \sin \text{SPQ}.$$
$$\qquad\quad \Delta s\frac{c}{\Delta s}$$

Now we have seen before that $\lim. \frac{c}{\Delta s} = 1$, so that the middle terms above approach $\frac{\Delta x}{\Delta s}$, $\frac{\Delta y}{\Delta s}$ indefinitely and the right members approach, as their limits, cos IPQ, sin IPQ respectively, as Δx and consequently Δy and Δs approach zero indefinitely without ever reaching it. Hence taking limits and designating lim. $\frac{\Delta x}{\Delta s}$ by $\frac{dx}{dx}$ and lim. $\frac{\Delta y}{\Delta s}$ by $\frac{dy}{ds}$ we have,

$$\text{lim. } \frac{\Delta x}{\Delta s} = \cos \text{TPQ} = \frac{dx}{ds} \ldots (6)$$

$$\text{lim. } \frac{\Delta y}{\Delta s} = \sin \text{TPQ} = \frac{dy}{ds} \ldots . (7).$$

These equations are satisfied by representing ds by the hypotenuse of the right triangle of which dx and dy are the other two sides. Thus if PQ $= dx$ and QI $= dy$, then PI $= ds$; but if PR $= dx$ and RT $= dy$, then PT $= ds$.

In any case, we have the fundamental relation,

$$ds^2 = dx^2 + dy^2 \ldots .. (8).$$

It is usual to represent the derivative of $f(x)$ with respect to x by $f^1(x)$.

$$\therefore \text{lim. } \frac{\Delta y}{\Delta x} = f^1(x) = \frac{dy}{dx}.$$

If we call w an infinitesimal that tends towards zero in the same time as Δx, we can write,

$$\frac{\Delta y}{\Delta x} = f^1(x) + w \ldots .. (9),$$

for taking the limits of both sides, we reach the preceding equation. The variable w is indeterminate and may be plus or minus. Clearing of fractions, we have,

$$\Delta y = f^1(x)\,\Delta x + w\,\Delta x \ldots . (10).$$

In fig. 2, since $f^1(x)\,\Delta x = \Delta x \tan \text{IPQ} = \text{IQ}$, we see that the term $w\,\Delta x$ must represent IS.

Comparing the last equation with

$$dy = f^1(x)\,dx,$$

obtained from an equation above, we see that when $dx = \Delta x$,

$$dy = \Delta y - w dx.$$

Thus we have proved analytically, when $dx = \Delta x$ that dy is never equal to Δy (except when $f(x)$ represents a straight line) and the difference is exactly represented on the figure by the distance IS.

Many of the older writers, following the lead of Leibnitz, assumed that dy and Δy, as well as ds and Δs, were identical when $dx = \Delta x$, and the error is perpetuated to this day by possibly the majority of the most recent writers; thus Williamson, in his Differential Calculus (6th Ed., 1887), page 3, says, "When the increment or *difference* is supposed *infinitely small* it is called a *differential.*" Similarly in a recent American treatise on the calculus by Bowser, the same definition is given.

Professor Bowser defines "consecutive values of a function or variable as values which differ from each other by *less than any assignable quantity.*" He then adds, "A differential has been defined as an infinitely small increment or an infinitesimal; it may also be defined as the *difference between two consecutive values* of a variable or function."

As there are an infinite number of values lying between 0 and "any assignable quantity," however small, it follows that such differentials are simply *quite small finite* quantities.

The differentiation of a function, as $y = ax^2 + b$, would then proceed after the method of Leibnitz, as follows:

$$y = ax^2 + b.$$

Give to x and y the simultaneous infinitesimal increments dx and dy,

$$y + dy = a\,(x + dx)^2 + b.$$

Subtracting the first equation from the last, we have,

$$dy = a\,(2\,xdx + dx^2).$$

Now from the nature of infinitesimals, it is regarded by the followers of Leibnitz as evident that dx^2 can be neglected in comparison with $2\,xdx$, because the square of the infinitesimal dx is infinitely small in comparison with the variable itself, whence,

$$dy = 2\,ax\,dx.$$

It is scarcely necessary to remark to the reader that, for an *exact* result, we cannot make $dx = 0$ in part of an equation without making it zero throughout; so that the equation is fundamentally wrong.

When we go to the applications to curves, however, another error is made, of an opposite character to the first, so that by this secret compensation of errors the result is finally correct. Thus a curve is regarded as a polygon whose sides connect "consecutive points" and a tangent line at any point is the chord produced through this point and its "consecutive point," so that $dy \div dx$ gives the slope of the tangent at the point. This is of course wrong, but it exactly balances the other error above, for from the last equation we find the slope, so determined for the curve $y = ax^2 + b$, to be $(2ax)$, which we know to be correct by the strict method of limits.

The great French author, Lagrange, says in this connection, "In regarding a curve as a polygon of an infinite number of sides, each infinitely small, and of which the prolongation is the tangent of the curve, it is clear that we make an erroneous supposition; but this error finds itself corrected in the calculus by the omission which is made of infinitely small quantities. This can be easily shown in examples, but it would be, perhaps, difficult to give a general demonstration of it."

Bishop Berkeley, long before Lagrange, showed this secret compensation of errors in a particular example, his endeavor being particularly to "*show how error may bring forth truth, though it cannot bring forth science.*"

Leibnitz, in attempting a defense of his theory, stated that "he treated infinitely small quantities as *incomparables*, and that he neglected them in comparison with finite quantities 'like grains of sand in comparison with the sea'; a view which would have completely changed the nature of his analysis by reducing it to a mere approximative calculus." See Comte's Philosophy of Mathematics, Gillespie, p. 99.

The demonstration given above in the case of $f(x) = ax^2 + b$ can be made general, as follows:

From the exact equation (9) above, following the notation of Leibnitz where dy and dx are taken as identical with Δy and Δx, we have exactly,

$$\frac{dy}{dx} = f^1(x) + w.$$

The followers of Leibnitz, in differentiating, throw away the term w as nothing and pretend to write exactly,

$$\frac{dy}{dx} = f^1(x);$$

but as they make another error by calling the ratio of the *increments dy* and dx the slope of the curve, we thus find the latter to equal $f^1(x)$, which was assumed above to equal $\lim. \frac{\Delta y}{\Delta x}$ or the slope of the curve; so that the two errors, for any function, balance each other and we reach a correct result.

As the truth of any result, as given by the Leibnitz method, can only be tested, in a similar manner to the above, by comparing with a result known to be correct by use of the method of limits, it would seem to be inexcusable not to found the calculus upon this latter method. Afterwards a true "infinitesimal method" can be easily logically deduced (as Duhamel and others have shown) that will offer all the advantages and abbreviated processes of the Leibnitz method, with none of its errors of reasoning.

It is well to remark just here that because $y = f(x)$ can always be represented by a locus, and since its derivative with respect to x represents the slope of the tangent at the point (x, y), it will generally be finite. It is only at the points where the tangent is parallel or perpendicular to the axis of x that the derivative is zero or infinity. *Hence the ratio of* Δy *to* Δx, whose limit is the slope, *has generally a finite limit.*

We have studied now, with some thoroughness, the theory of tangents and will next take up, a no less important subject, *the method of rates.* When a variable changes so that, in consecutive equal intervals of time, the increments are equal, the change is said to be *uniform;* otherwise variable. For uniform change, the increment of the function in the unit of time is called the *rate.* Thus in the case of uniform motion, velocity = rate = $\frac{\text{space}}{\text{time}}$.

For a variable change, the rate of the function at any instant is what its increment would become in a unit of time if at that instant the change became uniform.

In looking for an illustration to show clearly the spirit and method of the calculus, perhaps none is more satisfactory to the beginner than the consideration of falling bodies in vacuo. If we call the space in feet, described by the falling body in t seconds, s and g the acceleration due to gravity, we have the relation between the space and time, as given by numerous experiments, expressed in the following equation,

$$s = \tfrac{1}{2} g t^2;$$

Fig. 3

g is a variable for different latitudes and is slightly over 32. Take it 32 for brevity.

$$s = 16\,t^2 \; . \; . \; . \; . \; (11).$$

In the time $t + \Delta t$ the space described would be $s + \Delta s$ (see fig. 3), and by the same law,

$$(s + \Delta s) = 16\,(t + \Delta t)^2.$$

Subtracting the preceding equation and dividing by Δt,

$$\frac{\Delta s}{\Delta t} = 16\,(2t + \Delta t).$$

This gives the average rate or velocity with which the small space Δs is described.

As the rate or velocity is changing all the time, call v_1 and v_2 the least and greatest values of the velocity in describing the space Δs; then the spaces which would have been described with uniform velocities v_1, v_2 in time Δt are $v_1\,\Delta t$ and $v_2\,\Delta t$, which are respectively less and greater than the actual space Δs.

Hence v_1, $\dfrac{\Delta s}{\Delta t}$ and v_2 are in ascending order of magnitude.

As Δt (and Δs consequently) is diminished indefinitely, these three quantities approach equality and the exact velocity the body has at the beginning of the space Δs is given by the constant to which they approach indefinitely but never attain. But lim. v_1 = lim. v_2 = limit $\dfrac{\Delta s}{\Delta t}$ = velocity or rate at the instant the space s has been described (see Edwards' Differential Calculus .

Hence in the particular example above, the *velocity* the falling body has, at the end of t seconds, when it has described the space s, is,

$$\frac{ds}{dt} = \text{lim.}\,\frac{\Delta s}{\Delta t} = 32t \; . \; . \; . \; . \; . \; (12);$$

i. e., the body at the end of 1, 2, 3 . . , seconds is moving with a rate of 32, 64, 96 . . , feet per second. The same conclusion follows if we give a decrement to t in eq. (11). Thus

$$(s - \Delta s) = 16\,(t - \Delta t)^2$$

$$\therefore \lim. \frac{\Delta s}{\Delta t} = \lim.\ 16\,(2t - \Delta t) = 32t.$$

The average velocity in describing the space Δs just above the point considered is $16\,(2t - \Delta t)$, that below, as found above, is $16\,(2t - \Delta t)$; the true velocity lies between them and is equal to the limit $16\,(2t)$ of either.

The above general demonstration can be adapted to the rate of increase of any function, $u = f(t)$, which does not change uniformly with the time, u representing a magnitude of any kind, as length, area, volume, etc.; for if Δu is the *actual* change of the magnitude in time Δt, and r_1 and r_2 the least and greatest values of the *rate of change* of u in the interval Δt, corresponding to the increments $r_1\,\Delta t$, $r_2\,\Delta t$, of the magnitude, if these rates were uniform for the time Δt, then $r_1\,\Delta t$, Δu and $r_2\,\Delta t$ are in the ascending order of magnitude; also r_1, $\frac{\Delta u}{\Delta t}$ and r_2 are in the same order. Hence, as these quantities approach equality indefinitely as Δt tends towards zero, the limit of any one of them is equal to the actual rate of increase of the magnitude u which is thus represented by lim. r_1, = lim. r_2, or,

$$\lim. \frac{\Delta u}{\Delta t} = \frac{du}{dt}.$$

Thus the derivative of *any* function, which varies with the time, with respect to t, gives the *exact* rate of increase of the function at the instant considered.

If u and x are both functions of t, connected by the relation $u = F(x)$, then

$$\frac{du}{dx} = \frac{\frac{du}{dt}}{\frac{dx}{dt}} = \frac{\text{rate of change of } u}{\text{rate of change of } x}.$$

As an illustration, find the rate at which the volume u of a cube tends to increase in relation to the increase of an edge x, due to a supposed continuous expansion from heat.

$$u = x^3 \therefore \frac{du}{dx} = 3x^2.$$

Therefore for $x = 1, 2, 3$, the volume tends to increase at a rate 3, 12, 27 times as fast as the edge increases. Numerous examples could be given of the application of the differential calculus to the ascertaining of relative rates, but the above will suffice to illustrate the principle.

It has been shown above that if $u = f(t)$, $\frac{du}{dt}$ represents the rate of change of u, if at any time t, the rate is supposed to become uniform; hence du represents what the increment of u would become in time dt.

As time must vary uniformly, dt is always a *constant*, though it is entirely arbitrary as to numerical value; hence the *differential of a variable can be defined, as what the increment of the variable would become in any interval of time if, at the instant considered, the change becomes uniform or the rate becomes constant.* If u is a function of several variables, then the differentials of each must be simultaneous ones, corresponding to the same interval of time.

Newton, in establishing his calculus of fluents and fluxions, conceived a curve to be traced by the motion of a point, an area between the axis of x, the curve and two extreme ordinates, to be traced by the motion of a variable ordinate to the curve and a solid to be generated by the motion of an area.

As a point traces a curve DPS (fig. 2), when it reaches the point P, it has the direction of the tangent PT at that instant; for we can make only two suppositions: (1) the direction coincides with that of some chord passing through P, whether the other end of the chord precedes or follows P, or (2) it coincides with the tangent; but it cannot have the direction of a chord at the point P without leaving the curve; hence this supposition is false, and as one must be true, it follows that the direction of motion at P must coincide with the tangent PT.

At the point P therefore, by the definition above of a differential, the simultaneous differentials of x, y and s are what their increments would become, during any time, if at P their rates of change should become constant. This can happen only where the motion takes place uniformly along a straight line and this line must be the tangent at P, as that is the direction of motion at that point. The differentials dx, dy and ds can thus be represented by PQ, QI and PI respectively, or by PR, RT and PT, for a uniform increase along the tangent would correspond to a uniform rate horizontally and vertically. This agrees with what has hitherto been established.

The *rates* of increase, horizontally, vertically and along the tangent, are $\frac{dx}{dt}$, $\frac{dy}{dt}$ and $\frac{ds}{dt}$ respectively.

The differential of an area is found as follows: Let area CDPA $= u$, then if $\Delta x = dx =$ AB, $du = ydx$; for although $\Delta u =$ area APSB, the increase of area will not be uniform if the upper end of the ordinate AP moves along the curve, but it will be uniform if it moves uniformly along PQR; for then equal rectangles, as APQB, will be swept out by the ordinate AP as it moves to the right, in equal times.

Therefore by the definition of differential above, du = area APQB = ydx. This is readily proved by the method of limits thus: Note that,

$$y\Delta x < \Delta u < (y + \Delta y)\,\Delta x;$$

hence dividing by Δx and observing that as Δx diminishes indefinitely, $(y + \Delta y)$ and hence $\frac{\Delta u}{\Delta x}$ (which is still nearer y) approach y indefinitely in value,

$$\therefore \lim.\ \frac{\Delta u}{\Delta x} = \frac{du}{dx} = y \ldots . (11).$$

Similarly we can prove, by either method, that if V represents the volume generated by CDPA revolving about oX, that dV is represented by the volume generated by APQB about OX $\therefore d\mathrm{V} = \pi y^2\,dx$.

Referring to eq. (11) and fig. 2 it is seen that if for any curve u = area CDPA can be expressed as a function of x, or $u = f(x)$, then by the usual notation,

$$\lim.\ \frac{\Delta u}{\Delta x} = f^1(x);$$

and this equals y by (11).

On calling w an infinitesimal that tends towards zero in the same time as Δx, we can write,

$$\Delta u = (f^1(x) + w)\,\Delta x,$$

since on dividing by Δx and taking the limit, we are conducted to the preceding equation. But by the Leibnitz method the term $(w\Delta x)$ is thrown away, on differentiating $u = f(x)$, when Δx and Δu are infinitely small, so that $\Delta u = f^1{}_x\Delta x = y\Delta x$.

Another error is made, however, by regarding the area Δu = APSB as equal to APQB, which, combined with the preceding result, gives correctly, area APQB $= y\Delta x$. As Leibnitz regarded du and dx as identical with Δu and Δx, when the latter were infinitely small, they should replace the latter in the above equations to express them by his notation.

Thus truth is again evolved from error, and it can be similarly shown in other cases, though a general demonstration seems difficult, if not impossible.

The "Method of Indivisables" by which "lines were considered as composed of points, surfaces as composed of lines and volumes as composed of surfaces, has not been alluded to, as it is not now found in any text-books. It is an exploded theory. Cavalieri, the author, was led to it by noticing, *e. g.*, that in fig. 2, area APQB was never exactly equal to area APSB; hence he made $\Delta x = 0$ and regarded the area Δu as a line AP, so that $u =$ area CDPA was made up of an infinity of lines, etc. This is analogous to the statement that a variable can reach its limit.

In conclusion, let us hope that soon, the false conceptions concerning the fundamental principles of the calculus may be eliminated from all text-books. The world is still waiting for the treatise on the calculus that is simple and clear and at the same time rigorous in its logic.

REMARKS ON THE GENERAL MORPHOLOGY OF SPONGES.*

BY H. V. WILSON.

I have shown† that in Esperella and Tedania the sub-dermal cavities, canals and chambers develop as separate lacunæ in the parenchyma or mes-entoderm of the attached sponge, subsequently becoming connected into a continuous system. As regards the development of the canal system such varying accounts are given by different authors that were it not for the help lent by comparative anatomy it would be quite impossible to form any idea of the fundamental morphology of sponges. Fortunately for the student entering this puzzling domain comparative anatomy has, in the hands of Haeckel, Schulze and Polejaeff, provided a stand-point from which the varying phenomena of

*These remarks were originally written as part of a paper on the embryology of sponges, which it is expected will soon go to the press. It has not been found possible to insert in the present text the wood-cuts with which the intention was to illustrate many of the facts referred to. The omission of the cuts, while it is to be regretted, will not be found to interfere with the intelligibility of the views expressed.

†Notes on the Development of Some Sponges. Journal of Morphology, Vol. V, No. 3.

development and structure may be viewed with at least a partially understanding eye. It may be that an increasing accumulation of facts will show that Haeckel's conception of the relation of the simple calcareous sponges to the complex horny and silicious forms is not well founded, and that Schulze's view of the parts played by the embryonic layers in producing the adult anatomy is not the true one. But at present it is only with the aid of these theories that one can form any clear conception of the sponges in general, and so provisionally at least we are bound to accept them.

Comparative anatomy points in no undecided manner to the phylogenetic path along which sponges have developoped, and so permits us to construct a standard of ontogeny, with which we may compare the actual development of each species as we witness it to-day, and so be enabled to note the amount and kind of divergence (coenogeny) exhibited. That coenogeny is exhibited to a great degree in the embryology of sponges is evident from the various types of development described, and in the future much may be hoped from the study of a group like this for the understanding of the laws of development. For the present all we can do is to accept what seems the most probable phylogeny, recording the instances of supposed coenogeny as they are observed. Adopting this method, I have to regard the development (*i. e.*, the later development or metamorphosis) of Esperella and Tedania as far removed from the phylogenetic path. Before pointing out the features in which the development of these sponges is so strongly coenogenetic, it will be worth while to review briefly the evidence on which rests the current view of sponge morphology.

Evidence from Comparative Anatomy as to Sponge Phylogeny. The strongest evidence offered by comparative anatomy lies in the series of forms, passing by gradations from very simple to complex types, found in the calcareous sponges,* and in the little group of silicious sponges, the Plakinidæ, described by Schulze.† A comparison of these forms goes to show that the simplest Ascon sponge (Olynthus) must be regarded as the ancestral type of the group, and that by the continued folding of the wall of this simple form were produced the more complicated sponges. Further, the exceedingly complex silicious and horny sponges must be interpreted as colonies in which the limits of the individual can in many cases no longer be recognized.

The calcareous sponges offer a series of increasingly complex forms, which Haeckel divided into Ascons, Sycons and Leucons. Haeckel's views on the relationship of these forms must in great measure be accepted to-day, though in certain respects, especially as regards the anatomy of the Leucons, later researches (Polejaeff, *l. c.*) have shown that he was not always in possession of the real facts of the case.

The simplest calcareous sponges, or Ascons, which serve as the basis for Haeckel's hypothetical sponge ancestor, the Olynthus, are too familiar to call for any description. The interesting form, *Homoderma sycandra* (von Lendenfeld) may, however, be mentioned, in which the body is surrounded by radial tubes, after the fashion of a Sycandra, but with this difference: The central cavity as well as the radial tubes is lined with collared cells. A figure of this interesting sponge is accessible in Sollas's article on Sponges in the Encyclopedia Brittannica, or in the Zoological Articles by Lankester, etc., page 40.

Homoderma bridges the way from the Ascon type to the simplest Sycons, in which the radial tubes are distinct from one another. A surface figure of such a Sycon (*Sycetta*

---

*Haeckel, Kalkspongien. Polejaeff, Challenger Report on the Calcarea.

†F. E. Schulze, Die Placiniden, Zeit. fur Wiss. Zool. Bd. 34.

primitiva) is given in Vosmaer.* In the majority of Sycons, however, the radial tribes are not distinct, but are connected together more or less by strands of mesoderm covered with ectoderm. The complicated ectodermal spaces thus formed, which lie between the radial tubes, are known as intercanals. Water enters the intercanals through the openings in the surface (surface pores) and passes into the radial canals through the openings in their walls (the primitive pores—so-called chamber pores). The embryology of the Sycons, as far as known, confirms the belief that they are derived from the Ascons. Thus *Sycandra raphanus* passes through a distinctly Ascon phase, the radial tubes appearing later as outgrowths. The actual development of complicated intercanals, such as those just mentioned, has never been witnessed, but the comparison of a large number of forms in which the connection between the radial canals varies within wide limits makes it pretty certain that they are homologous with the simple ectodermic spaces between the radial tubes of Sycetta. It is exceedingly probable that the actual development of the complicated Sycons will show that the radial tubes are in young stages distinct from one another, and only later become connected together by bridges of tissue so as to form complex intercanals. And so we must at present regard the intercanals as lined with ectoderm.

Coming now to the Leucons, we find that Polejaeff's description of the anatomy of this family accords with their derivation from the Sycons, quite as well as did Haeckel's more imaginative conception of the structure of these forms. Taking one of the simplest of Polejaeff's types, *Lencilla connexiva* (Pl. VI, fig. 1*a*, Polejaeff *l. c.*), let us compare it with a Sycon. Such a form is obviously derived from a Sycon by the evagination of the wall of the

*Vosmaer, Bronn's Klass. and Ordnungen, Spongien, Taf. IX. Schulze, Zeit. fur Wiss. Zool. Bd. 31.

paragastric cavity at certain points. These evaginations give rise to numerous diverticula of the central cavity, which constitute efferent canals. The radial chambers are at the same time thrown into groups, each group opening into one of the new diverticula. The intercanals penetrate as before between the several radial chambers, bringing water to the chamber pores, the complexity of their arrangement naturally being increased by the folding of the wall of the paragastric cavity.

The increasing complexity in the Leucon family is brought about by the ramification of the primitively simple efferent canals, the radial tubes growing shorter and becoming in the most complicated types spheroidal chambers quite like the flagellated chambers of the non-calcareous sponges. In *Leucilla uter*, for instance (Polejaeff, Pl. VI, fig. 2*a*), the efferent canals exhibit branching of a simple character. But in such a form as *Leuconia multiformis* (Polejaeff, Pl. VI, fig. 3*a*) the ramification of the efferent canals becomes exceedingly complex, and the radial tubes here appear as spheroidal flagellated chambers. The intercanals (or afferent canals, as they are called in all sponges but the Sycons) follow the efferent canals in all their windings, bringing water from the surface pores to the pores in the walls of the flagellated chambers.

The chief conclusions to be drawn from this anatomical comparison of the various forms of Sycons and Leucons are that the afferent canals of Leucons are homologous with the intercanals of Sycons and are lined with ectoderm; that the flagellated chambers are homologous with the radial tubes; that increasing complexity is brought about by the ramification (or folding of the wall) of the efferent canals.

The canal system of a complicated Leucon, like Leuconia, is essentially like that of a common silicious or horny sponge (having flagellated chambers, afferent and efferent canals) except in the one respect that in the Leucon there is a single central cavity opening by a terminal osculum, while in most silicious and horny sponges there are several orcula leading into as many spacious efferent cavities. But here the disposition of the calcareous sponges to form indubitable colonies helps us out, for if we compare the silicious or horny sponge with a colony of Leucons instead of with a single one, we find that its derivation from such simple symmetrical forms is made easy. We must suppose the complex non-calcareous sponge to be a colony, in which the limits of the individuals have been lost or obscured by the increasing thickness of the walls. This increasing thickness would finally result in a more or less complete fusion of the members of a colony into an undivided mass with oscula scattered over the surface. Each of the main efferent canals of the non-calcareous sponge is homologous with the paragastric cavity of a single Leucon. Both the canal and its set of branches, though, are extremely irregular, having completely lost the symmetry of the ancestral type. The flagellated chambers still bear the same relation to the efferent canals as they did in the Leucon; *i. e.*, they are simple diverticula of the canals. The system of afferent canals is obviously homologous with the same system in the Leucons, bearing identically the same relation as in the latter group both to the flagellated chambers and the efferent canals. The subdermal cavities (which are only modified portions of the afferent canal system), communicating with the exterior by numerous pores, though a late acquisition, are found in certain Leucons; *e. g.*, Eilhardia Schulzei (Polejaeff, Pl. IX).

In many of the Non-calcarea the colonial nature of the sponge is indicated by the presence of elevations (oscular tubes or papillæ), bearing oscula on their summits. But the number of oscula is not always to be taken as indicating the number of individuals of which the sponge is composed, for the colonies of calcareous sponges show plainly that the budding individuals do not always develop oscula. And on the other hand, there are certain indications in the silicious sponges that in the adult oscula may be developed almost anywhere. In spite of the difficulties, however, in fixing upon the limits of the component individuals the higher sponges are best regarded as colonies. Perhaps the nearest approach made in other groups to the formation of such colonies, in which the personality of the component individual is so nearly lost, is found in corals like Maeandrina, in which the united gastric cavities of the polyps form continuous canals perforated at intervals by mouths.

We therefore reach the conclusion that the higher sponges (non-calcareous) have been derived from colony-producing, symmetrical forms, in which the evaginations of the primitive paragastric cavity had already taken the form of efferent canals and flagellated chambers; that is, from forms allied to the existing Leucons. And we further come to the conclusion that the subdermal cavities and afferent canals are homologous with the intercanals of Sycons, and hence phylogenetically, at least, are infoldings of the ectoderm. The whole efferent system (canals and flagellated chambers both), on the contrary, is homologous with the same system in the calcareous sponges, and is endodermic.

This conclusion as to the parts played by the germ layers in producing the adult non-calcareous sponge, is the one enunciated by Schulze in his classical paper on the Plakinidæ (p. 438). In this little family of silicious sponges Schulze finds a genus, Plakina, the three species of which form links in a chain of increasing complexity, showing quite as clearly as did the calcareous sponges that the afferent system is derived from ectodermal infoldings, and the efferent from endodermal outfoldings.

The Plakinidæ are Tetractinellids. The three species of the genus Plakina are small encrusting sponges found in the Mediterranean, on the under side of stones, shells, etc. In the simplest species, *P. monolopha*, there is a continuous basal cavity crossed by strands of tissue. From the cavity run more or less vertical efferent canals, which are simple or very slightly branched, and into which open the flagellated chambers. The afferent canals are spacious cavities opening on the surface by wide mouths. The periphery of the sponge forms a continuous rounded rim, the "ringwall," and the oscula, one or several, are situated here. The surface of the sponge inside the "ringwall" is divided up into low rounded elevations, caused by the upper ends of the efferent canals, between which lie the wide apertures leading into the afferent canals. Schulze was fortunately able to observe the main features in the development of this interesting form. There is a solid swimming larva which settles down, forming a flat circular mass. A central cavity appears in the mass, the lining cells becoming columnar, and the sponge is thus transformed into a flat, three-layered sac, the three layers being respectively ectoderm, mesoderm, entoderm. The flagellated chambers appear in a single layer round the central cavity into which they open. They are very probably formed as diverticula of this cavity. Schulze did not follow the development further, but a comparison of the adult with the sac-like young form makes it pretty certain that the young form undergoes a process of folding, which gives rise to the efferent and afferent canals of the adult; or, in other words, the efferent canals arise as vertical evaginations of the sac-like stage. The afferent canals are consequently to be regarded as lined with ectoderm.

In the other two species (*P. dilopha* and *P. trilopha*) the oscula are not situated at the periphery as in *P. monolopha*, but at some distance internal to it; and the efferent canals do not form projections on the surface as in the first species. A comparison of the canal systems makes it evident that

P. dilopha has been derived from *P. monolopha* by an increase in the thickness of the mesoderm lying beneath the surface of the sponge. The wide afferent canals of *P. monolopha* become transformed into the narrow afferent canals of *P. dilopha.*

Plakina trilopha goes a step farther in the direction of complexity than does *P. dilopha.* It has probably been derived from the latter species by the appearance of secondary folds in the radial efferent tubes; by the transformation of the basal cavity into a system of lacunæ, owing to the increase in the number of the connecting strands of tissue between the basal layer and the part of the sponge containing the flagellated chambers; and by a complication in the afferent canals in consequence of which they do not open each by a single aperature, but by a number of small apertures the surface pores.

Schulze's conclusion that these species all lie in one line of descent—that is, that the second species has been derived from the first, and the third from the second—receives as much support from a study of the spicules as of the canal system, but here reference will have to be made to the paper.

From comparative anatomy, then, we conclude the phylogeny of the sponges to be something as follows: The Olynthus is the ancestor of the group. The outgrowth of radial tubes gave rise to the Sycon type. The growth of the mesoderm and development of new endodermic diverticula, coupled with the metamorphosis of the radial tubes into flagellated chambers, produced the Leucons. The non-calcareons sponges have been derived from types more or less like the Leucons. And the conclusion with regard to the germ layers is that the efferent system is entirely endodermic, and the afferent system entirely ectodermic.

Embryological Evidence. Let us see now how far the known facts of development support the above conclusions.

The evidence from the calcareous sponges (Sycandra passes through Olynthus stage) has already been given. Several of the non-calcareous sponges (*Oscarella lobularis*, *Reniera filigrana*, *Chalinula fertilis*, *Plakina monolopha*) run through a stage known as the rhagon (Sollas), which it is permissible to regard as the ontogenetic representative of the Sycon type.

The rhagon of Oscarella* is a three-layed sac with a terminal osculum. The flagellated chambers form a single layer round the central cavity opening into it by wide mouths, and opening on the surface by pores. Regarding this form, as seems best, as equivalent to the Sycon type, it will be noticed that the radial tubes of the Sycon are coenogenetically replaced by flagellated chambers. The rhagon of Oscarella is formed as an invaginate gastrula, which attaches mouth down. The gastrula mouth closes and the osculum is a new formation. The flagellated chambers rise as true diverticula from the central cavity. The adult Oscarella, the canal system of which is not far removed from that of *Plakina monolopha*, is very probably formed from the rhagon, by the development in the latter of a number of simple diverticula from the central cavity. These diverticula are the efferent canals into which open the flagellated chambers. The ectodermic spaces between the efferent diverticula become the afferent canals. The adult Oscarella, like *P. monolopha*, is directly comparable with a simple Leucon. The development of Oscarella, in large measures, confirms the conclusions drawn from comparative anatomy, and may therefore be considered as phylogenetic.

The development of *Plakina monolopha* (Schulze, *l. c.*) has already been described. The sac with its single layer of flagellated chambers round a central cavity is a rhagon, and may be taken as representing the Sycon stage. The adult Plakina itself is the Leucon stage.

---

*Heider. Zur Metamorphose der Oscarella lobularis. Arb. Zool. Inst. Wien. Bd. 6.

In *Reniera filigrana** there is a solid swimming larva, which after attaching acquires a central cavity with an apical osculum. The flagellated chambers arise as diverticula from this cavity. Thus in this sponge also there is a rhagon stage. But in one matter we strike upon a coenogenetic modification. The afferent canals instead of being ontogenetically formed from the ectoderm, as they seem to have been phylogenetically, are really formed from endodermic diverticula, which grow outwards, meeting the surface epithelium.

In Chalinula fertilis† there is also a solid larva in which a central cavity is hollowed out. But in this sponge the flagellated chambers of the rhagon stage do not arise as endodermic diverticula, but are formed independently from solid groups of mesoderm cells. This origin of the flagellated chambers must be regarded as coenogenetic. The fact that the mesoderm may take upon itself the function of forming organs ordinarily formed by the entoderm, would seem to indicate that the two layers are of much the same nature. This essential similarity between the two layers has always been maintained by Metschnikoff, not only on the ground of development, but for physiological reasons as well. Thus in young Spongillas when the water became bad he witnessed the entire disappearance of the flagellated chambers, the sponge then consisting of ectoderm and mesoderm alone. With a fresh supply of water the chambers re-appeared.‡ Again, after feeding carmine in an excessive amount to *Halisarca pontica*, he found that the canals and chambers entirely disappeared, the whole body of the sponge inside the ectoderm consisting merely of a mass of amoeboid cells full of carmine (*ibid.*, p. 272).

*Marshall. Die Ontogenic von Reniera filigrana. Zeit. fur Wiss. Zool. Bd. 37.

†Keller. Stud. uber die Organisation und die Entwick der Chalineen. Zeit. fur Wiss. Zool. Bd. 33.

‡Metschnikoff. Spong. Stud. Zeit. fur Wiss. Zool. Bd. 32.

The development of the afferent system in Chalinula was not worked out with certainty.

The embryology of the preceding sponges in which a rhagon type is developed agrees pretty well with our general notions of sponge phylogeny. But there are other sponges, the development of which has been so excessively modified as no longer to be of any use as finger posts to phylogeny, but which afford an excellent field for the study of what may be called the methods of coenogeny. In *Halisarca Dujardinii* (Metschnikoff, *l. c.*), for instance, there is a solid larva in which the canals appear as so many separate lacunae surrounded by parenchyma (mes-entoderm) cells. The canals only subsequently acquire a connection with each other. In Esperia* the subdermal spaces, canals and chambers arise separately as lacunae in the parenchyma. The chambers are formed from aggregations of small cells in the parenchyma, which Maas believes, on what seems to me insufficient evidence, to be ectoderm cells of the larva that have migrated into the interior. The efferent canals, Maas thinks, are formed from similar cells. In Esperia, according to Yves Delage,† the chambers arise by division of special mesoderm cells. The epithelium of the canals comes from the larval ectoderm, which has migrated into the interior. In Spongilla, according to the same author,‡ the ectoderm cells of the larva are engulfed by mesoderm cells and then become the lining cells of the flagellated chambers. The observations of Delage on these points need to be confirmed before they can be taken as the basis for generalizations.

In young Stellettas§ the subdermal cavities seem to arise

---

*Maas. Die Metamorphose von Esperia Lorenzi, etc., Mith. aus dem Zool. Sta. zu Neapel, Bd. 10, Hept. 3.

†Sur le developpement des Eponges siliceuses, etc. Comptes rendus. T. 110.

‡Sur le developpement des Eponges (Spongilla fluviatilis). Comptes rendus. T. 113.

§Sollas. Challenger Report on Tetractinellidae, pp. XVI, XVII.

as lacunae in the parenchyma. And in the external buds of *Tethya maza** Selenka believes that the subdermal cavities have a similar origin.

In Spongilla, according to Götte†, the subdermal cavities and canals are formed as independent lacunae in the parenchyma, and the flagellated chambers are formed from groups of cells, each group (and chamber) being produced by the budding of a single large mesoderm cell. This account of the development of these structures in Spongilla, which is not very different from my own for Esperella and Tedania, is contradicted by Maas,‡ who brings Spongilla in line with the forms having a rhagon. Maas describes in the larva a central cavity from which the chambers arise as diverticula, the central cavity persisting in a modified shape as the efferent system of canals. The subdermal spaces arise as ectodermal invaginations, from which the afferent canals are formed as ingrowths. Thus, according to Maas in the ontogeny of Spongilla, the whole afferent system is formed from the ectoderm and the whole efferent system from the endoderm. Ganin's earlier account§ likewise describes the chambers as diverticula from a main endodermic cavity.

In the metamorphosis of a larva which probably belongs to Myxilla, Vosmaer finds that the subdermal cavities begin as fissures which gradually become wider, and that the canals and chambers likewise appear as intercellular spaces. Finally in the gemmule development of Esperella and Tedania, I find that subdermal cavities, both sorts of canals, and the flagellated chambers, all arise as independent lacunae in the parenchyma.

Accepting as ancestral the development of *Oscarella* and

---

*Zeit. f. Wiss. Zool. Bd. XXXIII.

†Untersuchungen zur Entwicklungs-geschichte von Spongilla fluviatilis, 1886.

‡Ueber die Entwicklung des Sursswasserschwamms. Zeit. fur Wiss. Zool. Bd. 50.

§Zur Entwicklung der Spongilla fluviatilis. Zool. Anzeiger. 1878.

Plakina monolopha, the various coenogenetic modifications which appear in other sponges may be classified as follows:

1. The efferent canal system, instead of arising as a single cavity which throws out diverticula, may be formed as so many distinct cavities, which subsequently unite (*Esperella*, *Tedania*, *Esperia lorenzi* and *lingua*, *Halisarca Dujardinii*, *Myxilla*).

2. The flagellated chambers, instead of arising as endodermic diverticula, may be formed from groups of mesoderm cells (*Esperella*, *Tedania*, *Chalinula fertilis*, *Myxilla* and probably in *Esperia lorenzi* and *E. lingua*).

3. The afferent canals, including the subdermal cavities, instead of being formed as invaginations from the ectoderm, arise as lacunae in the mes-entoderm (*Esperella*, *Tedania*, *Esperia lorenzi* and *lingua*, *Stelletta*, *Myxilla*). In *Reniera filigrana* they are formed as entodermic diverticula.

The coenogenetic development of the flagellated chambers and efferent canals suggests, as I have said, an essential similarity of nature in the so-called entoderm and mesoderm of sponges. This belief, so long upheld by Metschnikoff, derives some of its strongest support from this author's physiological investigations (see *ante*, p. 10), as well as from the fact first emphasized by Metschnikoff and Barrois, that in the most common sponge larva, *i. e.*, the solid larva, the mesoderm and entoderm form a single indivisible layer.

And likewise the development of the afferent system of canals in some sponges from the ectoderm, in others from the mes-entoderm, may possibly be taken as meaning that even these two primary layers (the outer and the inner) are not distinctly differentiated from each other in the sponges, or, in other words, that the mes-entoderm is still enough like the ectoderm to form organs ordinarily produced by the latter layer.

There is another (hypothetical) way of explaining these phenomena, which consists in supposing that ectoderm cells of the larva migrate into the interior, and though indistinguishable from the surrounding mes-entoderm cells, alone take part in forming the afferent canals. Similarly we may suppose that in the solid mass, which constitutes the parenchyma of Esperella, there are two radically distinct classes of cells, one of which is potentially gifted with the power of forming efferent canals and flagellated chambers, while the other has not the power, and must remain as amoeboid mesoderm. But this is pure hypothesis.

The result of this critical examination seems to be that the Olynthus must be regarded as the common ancestor of sponges (Haeckel, Kalkspongien), and that the entoderm and mesoderm are not sharply differentiated from one another as they are in the higher animals (Metschnikoff, Spong. Studien, p. 378).

Origin of the Olynthus. The prevalence of the solid larva in sponges and Hydromedusæ, coupled with the wide-spread presence of intracellular digestion in the lowest metazoa, led Metschnikoff years ago to the belief that the solid larva represents the ancestral form of the metazoa, while the gastrula is a coenogenetic modification.* To my own mind all the facts that we know indicate that Metschnikoff's conclusion is well founded. This hypothetical ancestral form is known as the Parenchymella (Phogocytella). I may be permitted to recall its leading features as deduced by Metschnikoff. The animal consisted of an outer layer of flagellated cells and an inner mass of amoeboid cells. The digestion was intracellular, the food being taken in through intercellular openings (pores) scattered over the surface. A central cavity having a special opening to the

*Metschnikoff. Spongiologische Studien. Zeit. f. Wiss. Zool. Bd. 32. Metschnikoff. Embryologische Studien au Medusen. Wien., 1886.

exterior (osculum) was a later acquisition, the osculum being in all probability one of the small apertures (pores) especially enlarged. Even after the formation of this cavity the division of the parenchyma into entoderm and mesoderm was not (and is not) in the sponges a rigid division, the primitive power of digesting food intracellularly having been retained by both layers. It was only with the appearance of the higher animals that the separation of entoderm from mesoderm became a perfect one. (Spongiologische Studien, p. 378). This solid ancestor of the metazoa, Metschnikoff derives from colonial forms like Protospongia. Barrois as early as 1876* stated his belief that the ancestor of the sponges was a solid animal, composed of two layers, the outer representing the ectoderm, the inner mass representing a parenchyma from which have developed the entoderm and mesoderm of higher animals (p. 78).

According to this view the early development of Plakina (or Reniera, Chalinula, etc.) gives the first chapters in the history of the group of sponges more faithfully than does a form like Oscarella (or Sycandra). In the former sponges it will be remembered there is a solid larva hollowed out to form a three-layered sac, which then breaks open to the exterior, forming the osculum. In the latter there is an invaginate gastrula, which settles mouth downwards, the gastrula mouth subsequently closing and the osculum appearing as a perforation at the upper end of the sac. In these forms (Oscarella, Sycandra) we have to suppose that the Parenchymella stage is skipped, the central cavity (which properly belongs to the Olynthus stage) being precociously developed coincidently with the immigration of the entoderm. The blastopore of the sponge gastrula, on

*Memoire sur l'embryologie de quelques Eponges de la Manche. Ann. Sci. Nat. T. 3. VI Ser.

this view, does not represent a primitive organ (Urmund), but merely comes into existence owing to the special, and highly modified, method of forming the entoderm. We do not, therefore, have to construe the Oscarella development (with Heider and Sollas) as meaning that a gastrula ancestor settled mouth downward, and that the mouth gradually became functionless, finally closing up, while a new series of openings, pores and osculum, were established.

The only remaining point I wish to speak of is the relation of the sponges to the Coelenterates. That the two groups have had a common ancestor in the Parenchymella is highly probable, but the similarity between the Olynthus and the simplest Coelenterates inclines one to go further, and at any rate homologize the paragastric cavity of the former with the gastric cavity of the latter. This, of course, is done by authors like Sollas, who derive both groups from a common gastrula ancestor. Whether the osculum of the Olynthus is also homologous with the gastrula mouth, as Haeckel originally held, is a question which needs for its answer more facts relating to the actual use to which the osculum is put in the simplest sponges. Sollas and Heider urge against the homology the fact that the Coelenterate larva attaches by the pole opposite the blastopore, while in the sponge larva the blastopore is at the pole of attachment. But this I cannot regard as a very strong argument, for (with Metschnikoff) I do not believe that the opening into the gastrula cavity represents a primitive organ (mouth of an ancestor). And if it does not, but is merely an incidental product of a particular mode of entoderm-formation employed by the animal, it has no bearing on the question of homology between osculum and mouth. Consequently the fact that in the attaching coelenterate and sponge larvæ the blastopore is at opposite poles is a curious phenomenon, but one aside from the problem.

I doubt very much, however, if any such radical distinction can be drawn between the larvæ of the two groups, for it is a question whether any sponge larva has a particular pole by which it must attach. Even in Sycandra, Schulze (*l. c.*, p. 270) records that exceptional cases occur, which cannot be regarded as pathological, in which fixation takes place not by the gastrula mouth but on the side. Fixation may also be delayed until the gastrula mouth has closed and spicules have begun to appear, in which case it is not stated by what part the larva attaches. In the solid larvæ of silicious sponges the variation is much greater. Such larvæ attach in some cases by the posterior pole, in others by the anterior pole, and yet in others on the side. All these variations may occur in larvæ of the same species. For instance, Maas records that in Esperia he observed fifteen individuals attach by the posterior pole, seventy individuals by the anterior pole, and five or six on the side. It thus appears that in the larvæ of silicious sponges at any rate there is no constant point of attachment.

UNIVERSITY OF NORTH CAROLINA, November 7, 1892.

RECORD OF MEETINGS.

SIXTY-SEVENTH MEETING.

PERSON HALL, January 19th, 1892.

President Holmes in the chair.

1. The Oyster Question. H. V. Wilson.

2. Magnetic Iron Ores of Ashe County. H. B. C. Nitze.

Report of the Secretary. One hundred and twenty-six books and pamphlets received and the following new exchanges:

New York Mathematical Society.

La Société Geologique du Nord du France.

SIXTY EIGHTH MEETING.

PERSON HALL, February 9th, 1892.

Called to order by the President.

3. The Greenwood Process for the Direct Production of Caustic Soda and Hydrochloric Acid. Chas. Baskerville.

4. The Determination of the Standards of Length. J. W. Gore.

5. Chinese Salt-making. F. P. Venable.

6. The Plan and Limitations of the N. C. Geological Survey. J. A. Holmes.

Report of the Secretary. Seventy-five books and pamphlets received.

New exchange: E. M. Museum of Princeton College.

SIXTY-NINTH MEETING.

PERSON HALL, April 12th, 1892.

Professor Gore presided.

7. Common Roads. Wm. Cain.

8. Igneous Rock Formation of North Carolina. J. A. Holmes.

New exchange: Institut Royal Grand Ducal de Luxembourg.

50

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY,

VOLUME IX—PART SECOND.

JULY—DECEMBER.

1892.

POST-OFFICE:

CHAPEL HILL, N. C.

E. M. UZZELL, STEAM PRINTER AND BINDER,

RALEIGH, N. C.

1892.

OFFICERS.

1892.

PRESIDENT:

Joseph A. Holmes, - - - - - - - Chapel Hill, N. C.

FIRST VICE-PRESIDENT:

W. L. Poteat, - - - - - - - - Wake Forest, N. C.

SECOND VICE-PRESIDENT:

W. A. Withers, - - - - - - - - Raleigh, N. C.

THIRD VICE-PRESIDENT:

J. W. Gore, - - - - - - - - - Chapel Hill, N. C.

SECRETARY AND TREASURER:

F. P. Venable, - - - - - - - - Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.

53

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

STATISTICS OF THE MINERAL PRODUCTS OF NORTH CAROLINA FOR 1892.

BY H. B. C. NITZE.

The difficulties attending the collection of exact statistics of the various mineral productions are very great, often insurmountable; and especially difficult to obtain are those of the gold, corundum and mica mines, which form the greater part of North Carolina's mining industry.

The following statistics have been collected from the most reliable sources available, under the direction of the *North Carolina Geological Survey*, and although often lacking in detail they will serve to show very nearly what the mineral production of the State has been for the past year.

Of the metallic products gold and iron stand alone. Under the list of non-metallic products we have iron ore, copper ore, bituminous coal, corundum, mica, talc and kaolin.

GOLD.

During 1892 there were fifty-six gold mines, distributed over eighteen different counties, in operation in the State: Of these, fifteen were placer and forty-one vein workings.

The total number of stamps in operation is estimated at 310, the total amount of labor at 500 men, and the total production at $65,000.

PIG IRON.

There was but one blast furnace in active operation in the State, namely, that at Cranberry, Mitchell county, belonging to the *Cranberry Iron and Coal Company.* This is a small brick stack of the following dimensions: Height 50 feet, diameter of bosh 10 feet 2 inches, diameter of hearth 3 feet, capacity 14 to 15 tons per day. It uses the low phosphorus magnetic ore of the Cranberry mine situated close by, magnesian limestone from Carter county, Tenn., and coke from Pocahontas, W. Va.

The total output of this furnace for 1892 was 2,902 gross tons, of which 313 tons were charcoal and 2,589 tons coke iron; the total product was valued at $52,000 at the furnace.

The quality of this product was a special Bessemer iron, averaging less than 1.00 per cent. silicon, and less than 0.025 per cent. phosphorus. It was shipped to steel works in Ohio and Pennsylvania.

The total production in gross tons (22,401 pounds) of the Cranberry furnace for the past nine years is shown in the following table:

1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
388	1,598	1,964	3,250	2,143	2,587	2,840	3,217	2,902

FORGE IRON.

The small amount of forge iron made for purely local purposes at Pasley's forge, in Ashe county, is rather of historical than commercial interest. This forge is situated at the mouth of Helton Creek, and consists of one fire blown by the water trompe, and one hammer operated by water-power. It is the only forge now in operation in the State, and makes annually about twenty to thirty tons of bar iron for local uses.

IRON ORE.

The total production of iron ore during 1892 is estimated at 23,433 gross tons, valued at $43,306.20 at the mines. Of this amount 17,088 gross tons, valued at $34,423.20, were shipped out of the State; the balance was turned into 2,902 gross tons of pig metal.

The only two mines in operation were the Cranberry mine in Mitchell and the Ormond mine in Gaston county.

The Cranberry Mine, operated by the Cranberry Iron and Coal Company, produced 18,433 gross tons, valued at $25,806.20 at the mines. Of this amount 12,088 tons, valued at $16,923.20, were shipped to furnaces in Southwest Virginia.

The ore is a magnetite, of which the following analysis by Mr. Porter W. Shimer shows the quality of the run of mine:

	Per Cent.
Silica	23.73
Metallic iron	45.90
Metallic maganese	0.44
Alumina	1.01
Lime	9.69
Magnesia	1.51
Sulphur	0.012
Phosphorus	0.007

The total output of the Cranberry mine in gross tons for the past nine years is shown in the following table:

1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
3,998	17,839	24,106	45,032	15,705	19,819	30,290	27,628	18,433

The Ormond Mine, situated in Gaston county, on the Charlotte & Atlanta Air Line, produced during 1892 about 5,000 tons of ore, valued at $17,500 at the mines. It was shipped to Birmingham, Ala., and Richmond, Va., for the fettling of puddling furnaces.

The ore is a mixture of hard, block hematite, or rather turgite, porous limonite, and soft, black, powder ore, slightly magnetic, of which the following are some representative analyses:

	I.	II.	III.	IV.
Silica	9.72	1.51		1.55
Metallic iron	52.39	65.79	47.10	65.35
Phosphorus	0.079	0.028	0.057	0.007

I. Lump ore; analysis by N. C. Geological Survey.

II. Lump ore; analysis by Carnegie Bros. & Co., Pittsburg, Pa.

III. Limonite; analysis by C. D. Lawton.

IV. Black powder ore; analysis by Carnegie Bros. & Co.

The mine was closed down in September, 1892, on coming into possession of the *Bessemer Mining Company*, which is remodeling the plant and making preparations for a large output in the near future.

The North Carolina Steel and Iron Company completed their furnace at Greensboro in June, 1892. The height of the stack is 70 feet, diameter of bosh 16 feet, and the calculated capacity 100 tons per day. The plant is fully equipped with all modern improvements, and, together with ore lands, town-site lands and other improvements, represents a total investment so far of $305,000. It is now expected to have this furnace in operation by the coming spring, the delay of putting it in blast having been caused by a deficiency of the necessary funds; and the present low price of iron has deterred the company from endeavoring to procure the requisite capital sooner. It is also proposed to erect a merchant mill, machine shops, foundry and car works during this year, the latter to have a capacity of ten (10) freight cars a day. The principal supply of ore will be obtained from the mines of the company at Ore Hill, Chatham county, about forty miles distant. This ore is a brown hematite of very fair quality, as shown by the following analyses, made in the laboratory of the *North Carolina Geological Survey:*

	I.	II.	III.	IV.
Silica	4.73	2.35	17.32	3.71
Metallic iron	47.87	47.23	42.88	49.79
Sulphur	0.034	0.280	0.230	0.170
Phosphorus	0.069	0.139	0.106	0.038

These deposits have been partially developed during the past year and about 700 tons of ore taken out. Besides this source magnetic ores from the western part of the State will be used. Limestone will be obtained from Virginia and coke from the Flat Top region in the same State.

In *Granville county* some recently discovered deposits of magnetic iron ore of good quality have been prospected with encouraging results, but no regular mining operations have yet been started, and no ore has been shipped.

COPPER ORE.

The Blue Wing Mine in Granville county was the only producing mine in the State during 1892. Up to October, when the mine and concentrator closed down indefinitely, the production of concentrates, shipped to the Orford Copper Works, N. Y., was valued at $15,000 (estimated).

The ore is chiefly bornite in a quartz gangue. The following analyses show the quality of the ore and concentrates:

	Copper. Per Cent.	Silver. Oz. Per Ton.
Run of mine ore	8.66	3.55
Cobbed ore	14.21	5.66
Jig concentrates	52.32	12.00
Frue vanner concentrates	36.87	12.60

COAL.

The *Egypt Coal Company*, operating the Egypt mine in Chatham county, shipped during 1892 6,500 tons of bituminous coal, valued at $7,475. Misfortunes by fire and water cut down the output to nearly one-half of what it was the year preceding. The company has been engaged in improving and increasing its plant during the past year by the addition of three pumps underground and further hoisting capacity. A second shaft, 8 by 12 feet, is being put down, to be used exclusively for ventilating purposes.

The following analysis by the *North Carolina Geological Survey* represents the quality of this coal:

Moisture	1.25
Volatile matter	33.35
Fixed carbon	49.18
Ash	16.22
Sulphur	1.72
Specific gravity	1.294

CORUNDUM.

The total corundum product for 1892 is estimated at 560 net tons. No estimate of the value can be made.

The chief producers were the Corundum Hill and Ellijay mines in Macon, and the Hogback mines in Jackson county. In Iredell county some private prospecting was carried on during the latter part of the year, two miles west of Statesville, and several veins were located, from which about 9,000 pounds of corundum were taken, but no regular operations have as yet been instituted.

MICA.

During 1892 there were in operation some ten or twelve mica mines, situated principally in Mitchell and Yancey counties. The total production of these mines is estimated at 10,000 pounds of cut mica, valued at about $35,000. The average price of 3 by 5-inch cut mica, at the mines, is put at $3.50 per pound.

During the year three mills, manufacturing ground mica from waste scraps, were in operation in Mitchell county, but no estimate can be made of their output.

TALC.

The total production of prepared talc (shipments from mills) for 1892 is estimated at 2,500 net tons, valued at about $19,000 at the mills.

The two principal producers were *The Notla Consolidated Marble, Iron and Talc Company*, of Cherokee, and *Messrs. Rickard and Hewitt*, of Swain county.

KAOLIN.

The total production of prepared kaolin for 1892 is estimated at 3,900 net tons, valued at $31,200 at the works.

The principal producers were the works at Sylva and Dillsboro, in Jackson county.

ADDITIONS TO THE BREEDING AVI-FAUNA IN NORTH CAROLINA SINCE THE PUBLICATION OF PROF. G. F. ATKINSON'S CATALOGUE IN 1887.

BY J. W. P. SMITHWICK.

1. Great Blue Heron (*Ardea herodias*). Young ones have been seen and taken in all sections.

2. Little Blue Heron (*Ardea cærulae*). Reported breeding in the west by Mr. John S. Cairns, Buncombe county.

3. Red-tailed Hawk (*Buteo borealis*). One nest containing two eggs was found by myself in Bertie county, 1888.

4. Broad-winged Hawk (*Buteo latissimus*). Breeds in middle and western sections. (Brimley and Cairns).

5. American Sparrow Hawk (*Falco sparverius*). Nests have been found in all sections; I have noted several in the east.

6. American Osprey (*Pandion haliaetus carolinensis*). Have noted two nests in Bertie county and seen young ones several times; reported breeding along the larger streams of the west by Cairns.

7. Black-billed Cuckoo (*Coccyzus erythrothalmus*). Reported breeding in Wake county by Brimley; Cairns says that it breeds during some seasons in the mountains.

8. Belted Kingfisher (*Ceryle alcyon*). I found a nest containing seven eggs in 1889, which was placed at the end of a burrow in a bank on the Cashie River near its mouth; breeds in the west. (Cairns).

9. Hairy Woodpecker (*Dryobates villosus*). Said to breed in the higher mountains of the west by Cairns.

10. Yellow-bellied Sapsucker (*Sphyrapicus varius*). Reported breeding by Cairns in Buncombe county on higher mountains.

11. Red-headed Woodpecker (*Melanerpes eryphrocephalus*). Found commonly breeding in all sections.

12. Red-bellied Woodpecker (*Melanerpes carolinus*). Rather rare breeder in all sections of the State.

13. Chuck-will's-widow (*Antrostomus carolinensis*). Three nests, containing two eggs each, were found by myself in Bertie county; one in 1888 and two in 1891.

14. Night-hawk (*Chordreils virginianus*). Found breeding in the eastern section by myself.

15. Least Flycatcher (*Empidonax minimus*). Reported as a rare breeder in mountains by Cairns.

16. American Crow (*Corvus americanus*). Found breeding in all sections, common.

17. Boat-tailed Grackle (*Quisculus major*). One nest containing four eggs was taken in Plymouth from an old elm overgrown with ivy, in 1889, by myself.

18. Towhee (*Pipilo erythrothalmus*). Reported by Cairns as breeding in Buncombe county.

19. Rose-breasted Grosbeak (*Habia ludoviciana*). Said to breed on craggy mountains by Cairns.

20. White-bellied Swallow (*Tachycineta bicolor*). Several nests containing eggs have been taken by my cousin (T. A. Smithwick) and myself in the last few years.

21. Logger-head Shrike (*Lanius ludovicianus*). Reported breeding in Iredell county by McLaughlin.

22. Warbling Vireo (*Vireo gilvus*). Reported breeding along the rivers in the mountain section by Cairns.

23. Yellow-throated Vireo (*Vireo flavifrons*). I have taken two nests in Bertie county; no others have been recorded.

24. Mountain Solitary Vireo (*Vireo solitarius alticola*). Found breeding in the higher mountains by Cairns.

25. White-eyed Vireo (*Vireo noveaboracensis*). Breeds throughout the State, common.

26. Prothonotary Warbler (*Protonotaria citrea*). I found one nest in 1888 in Bertie county which contained three eggs; this is the farthest north that any nest has been recorded on the Atlantic slope, so far, I think.

27. Worm-eating Warbler (*Helmintherus vermivorus*). One nest was found in Bertie county by T. A. Smithwick and one in Buncombe county by Cairns last spring; this shows that it may breed in all portions.

28. Blue-winged Warbler (*Helminthophila pinus*). Said to breed in the mountains by Cairns.

29. Magnolia Warbler (*Dendroica maculosa*). Breeds in the west; young ones have been seen in July by Cairns.

30. Oven-bird (*Seiurus aurocapillus*). One nest was found in Bertie county in 1892 by myself.

31. Hooded Warbler (*Sylvania mitrata*). I found one nest in 1888, and since that time a great many nests have been found by my cousin and myself in Bertie county. Not reported from any other section.

32. Winter Wren (*Troglodytes hiemalis*). Two nests were found by Cairns on the Black mountains in the spring of 1892.

33. Golden-crowned Kinglet (*Regulus satrapa*). Reported breeding on Black mountains by Cairns.

34. Olive-backed Thrush (*Turdus ustulatus swainsonii*). One nest has been reported, it being found on Black mountains by Cairns.

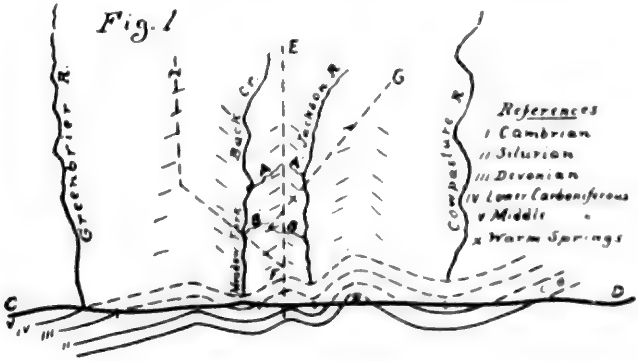
CONTRIBUTIONS FROM GEOLOGICAL DEPARTMENT UNIVERSITY OF NORTH CAROLINA.
No. I.

AN EXAMPLE OF RIVER ADJUSTMENT.

BY CHARLES BASKERVILLE AND R. H. MITCHELL.

One could scarcely find an example which more fully illustrates the principles involved in determining the courses of streams than the Jackson River in western Virginia. This is a small stream rising near Monterey, Highland county, flowing south-west through Bath into the James River at Covington, Alleghany county.

The existing topography is the result of the denudation following upon the great Permian deformation, which gave rise to the main ranges of the Appalachians. From this upheaval dates the beginning of the history of the rivers of this region.



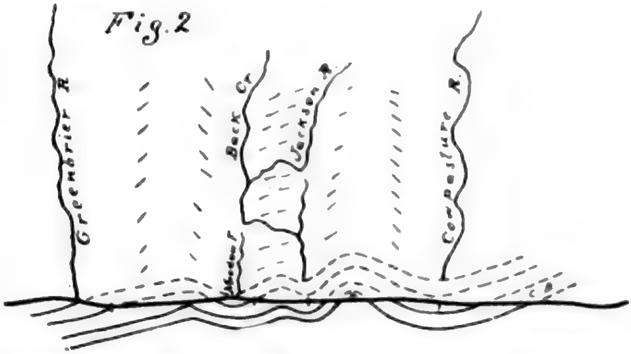


Diagram I gives a rough perspective of this immediate region, together with a vertical section in a north-west and south-easterly direction, just south of Warm Springs. In the vertical section the unbroken lines represent the geological structure of the present topography (heavy line CD) and the dotted lines the same in Permian time. The perspective shows the drainage consequent upon the deformation, and combining the two, it can be seen that the Jackson River flowed down a syncline in a south-westerly direction on a bed of the lower carboniferous rock. Parallel to this, and in a similar syncline on the same stratum with lower level, flowed now Back Creek, formerly Meadow Fork of the Greenbrier River, West Virginia. Tributary A of Back Creek, on account of steepness of slope, gnaws back, capturing headwaters of Jackson River by tributary A[1], causing the same to have its outlet in a north-westerly direction, thus throwing the water-shed east (GF) between Cowpasture and Jackson Rivers, which previously (EF) was between Jackson River and Back Creek. The base of the syncline, then the bed of Back Creek (Meadow Fork), was nearer base level than base of Jackson River syncline, consequently the softer Devonian slates were reached first by the latter. With conditions thus changed the tributary B of Jackson River captures in turn the headwaters (B[1]) of Meadow Fork (Back Creek), and the water-shed (HF) as now exists was shifted west between Greenbrier River and Meadow Fork of same and Back Creek. Diagram II shows the present flow of waters of Jackson River.

UNIVERSITY OF NORTH CAROLINA.

CHARACTER AND DISTRIBUTION OF ROAD MATERIALS.

BY J. A. HOLMES.

In the following discussion of the character and distribution of road material in the State it is thought best to avoid the use of technical terms as far as possible; and the names of rocks here used are those applied by the engineer rather than by the geologist. The character of the materials is discussed with a view to their fitness for use in the construction of broken-stone pavement, as used by Macadam and Telford on the public highways.

CHARACTER OF ROAD MATERIALS.

"In considering the relative fitness of the various materials," says Byrne,* "the following physical and chemical qualities must be sought for:

"(1). Hardness, or that disposition of a solid which renders it difficult to displace its parts among themselves.

"(2). Toughness, or that quality which will endure light but rapid blows without breaking.

"(3). Ability to withstand the destructive action of the weather, and probably some organic acids produced by the decomposition of excretal matters, always present upon the roadways in use.

"(4). The porosity, or water-absorbing capacity, is of considerable importance. There is, perhaps, no more potent disintegrator in nature than frost, and it may be accepted as fact that of two rocks which are to be exposed to frost, the one most absorbent of water will be the least durable."

The following table shows absorptive power of a few common stones:†

	Percentage of Water Absorbed.		Percentage of Water Absorbed.
Granites	0.06 to 0.155	Limestones	0.20 to 5.00
Marbles	0.08 to 0.16	Sandstones	0.41 to 5.48

Something of the quality and suitability of different materials for use in broken-stone pavements is shown in the following table:‡

Materials.	Co-efficients of Wear.	Co-efficients of Crushing.
Basalt	12.5 to 24.2	12.1 to 16.
Porphyry	14.1 to 22.9	8.3 to 16.3
Gneiss	10.3 to 19.0	13.4 to 14.8
Granite	7.3 to 18.0	7.7 to 15.8
Syenite	11.6 to 12.7	12.4 to 13.0
Slag	14.5 to 15.3	7.2 to 11.1
Quartzite	13.8 to 30.0	12.3 to 21.6
Quartzose sandstone	14.3 to 26.2	9.9 to 16.6
Quartz	12.9 to 17.8	12.3 to 13.2
Limestone	6.6 to 15.7	6.5 to 13.5

*Highway Construction, p. 24. †*Ibid.*, p. 26. ‡*Ibid.*, p. 172.

These "co-efficients," showing the relative quality of various road materials, were obtained by French engineers as the result of an extended series of tests, and were found to agree fairly well with the results arrived at by actual observation of the wear of materials in the roads. The co-efficient 20 is equivalent to "excellent," 10 to "sufficiently good," and 5 to "bad."

STONES NOT SUITABLE AS ROAD MATERIAL.—Before proceeding to the consideration of the stones found in North Carolina adapted to use as road material it may be well to consider briefly some of those that are not suited to this purpose. In general, it may be said that all *schistose* and *slaty* rocks, *i. e.*, all rocks which split or break easily into layers or flakes, should be discarded. No rock of whatever species which is already in the advanced stages of decay, so as to become crumbly and soft or porous, should be used in macadamizing roads, as the result in all such cases will be that, under the action of the wheels and hoofs, these materials become ground into fine powder, which becomes mud when wet, and dust when dry. There are many places, however, where a decayed granite or gneiss rock, when highly siliceous, will make a good foundation for a Macadam road, and will be found useful as a covering on clay in the improvement of dirt roads. There are other materials, like quartz ("white flint"), which are hard enough, but which are quite brittle, and hence easily crushed to powder, and which, consequently, should not be used when better material is available. Sandstones, as a rule, are unfit for use in macadamizing roads, as they are easily crushed and usually porous.

STONES SUITABLE AS ROAD MATERIAL.—"The materials used for broken-stone pavements must of necessity vary very much according to the locality. Owing to the cost of haulage, local stone must generally be used, especially if the traffic be only moderate. If, however, the traffic is heavy, it will sometimes be found better and more economical to obtain a superior material, even at a higher cost, than the local stone; and in cases where the traffic is very great the best material that can be obtained is the most economical."* In the middle and western counties of the State, in many places, stones now covering the cultivated fields will be found satisfactory for use on the roads, and in order to get rid of them farmers will haul and sell them for low prices.

Stones ordinarily used in the construction of Macadam and Telford roads are the following: Trap, syenite, granite, gneiss, limestone, quartzite, gravel and sand. The first three of these names are used here in a very general sense, and include several species of rock which, in technical language, would be known by other names. In general, it may be said that they rank in importance about in the order named, but several of them, especially the granite, gneiss and limestone, vary so much in quality that this general statement is subject to modification accordingly.

The term *trap*, as here used, includes not only the black, rather fine-grained, igneous rock known as diabase, which occurs in long dykes in the sandstone basins of Deep and Dan Rivers, but also the somewhat similar material which is to be found in the older crystalline rock of many other regions. In this State it is often known locally under the name of "nigger-head" rock. This rock does not usually split well into paving blocks, but when properly broken it is the most uniformly good material obtainable for macadamizing public highways, though sometimes it does not "bind" well.

Syenite, sometimes called *hornblende granite*, varies somewhat in quality and composition. It is a widely distributed rock in the midland and western counties of

---

*Byrne, Highway Construction, p. 170.

North Carolina, and is an excellent road material. The varieties which are finer in grain, and those having the larger proportion of the black mineral known as hornblende and are consequently of darker color, are best adapted for this purpose.

Granites vary considerably, both in quality and appearance, and in their value as road material. Those which are very coarse in grain, containing large and numerous crystals of feldspar, are, as a rule, more easily crushed and decay more rapidly, and should not be used in road construction when better materials are available. Those which contain a large proportion of mica split and crush more easily into thin flakes and grains, and for this reason are also less valuable. Those varieties which are of fine grain and contain an admixture of hornblende are best for road purposes.

Gneiss, which has the same general composition as granite, also varies very greatly in its quality and adaptability to road building. It usually has the appearance of being somewhat laminated or bedded, and when the layers are thin and the rock shows a tendency to split along these layers it should be discarded for road purposes. In addition to this, the statements made above with reference to the granites will apply also to gneiss.

Limestone suitable for road purposes is not an abundant rock in North Carolina, but it is found in a few of the eastern and a few of the western counties. It is a rock which varies very greatly in character, from the hard, fine-grained, compact magnesium limestone, which is a most excellent material for the Macadam and Telford roads, to the porous, coarse and partially compact shell-rock of recent geological formation, which is less valuable material. Practically all limestones when used as road material possess one valuable qualification, that of "binding"; the surface material which becomes ground by the action of the wheels settles among the fragments below and consolidates the entire mass. For this reason, in many cases, it has been found to be good policy to mix a considerable quantity of limestone with some siliceous and igneous rock, which though hard and tough does not consolidate readily.

Gravel and Sand are not used in the construction of stone roads as formed by Macadam and Telford, except as an excellent foundation, for which purpose they possess a very great value; and as a binding material, in small quantities, they are sometimes spread over the road surface between the layers of crushed stone. When used in this latter connection, however, the gravel must be quite free from round pebbles. Gravel is, however, used extensively in the construction of what are termed gravel roads; where there is no attempt at macadamizing the roads, but where the gravel itself is spread uniformly over the surface of a foundation road-bed which has been properly shaped and drained. Gravel like that which occurs so abundantly in many Northern States, where glaciers existed, is not found in North Carolina. But river gravels are found in a number of our counties; and, as suggested above, in the middle and western counties there are to be found in places decayed siliceous granite and gneiss which, though not suited for mixing with crushed stone in macadamizing roads, yet will be found to serve a useful purpose as a foundation for the broken stone on clay roads, and also as a top dressing on clayey dirt roads.

DISTRIBUTION OF ROAD MATERIALS.

A line drawn from Gaston to Smithfield, Smithfield to Cary, and from Cary to Wadesboro, separates the State into two general and well-marked divisions, the eastern of which may be called the Coastal Plain region, and the western may be termed Piedmont and Mountain regions.

In the Coastal Plain Region.—In the eastern counties, except along the western border of this Coastal Plain region at irregular intervals, we find none of the hard crystalline rocks suitable for broken stone roads. Over the larger part of the area we have sand, clays and loams, the sands becoming coarser and more gravelly along the western border and finer towards the eastern. At a number of points along some of the rivers and in some intervening areas is to be found a limestone rock which will serve a fairly good purpose in road-building.

Gravel.—The gravel along this western border can be used successfully in making a fairly good road-bed, and should be used extensively where the hard crystalline rocks cannot be obtained. It may be found at many places in counties between the line mentioned above, extending from Gaston to Wadesboro, and a line drawn to the east of this from Franklin, Virginia, by way of Scotland Neck, Tarboro, LaGrange and Clinton, to Lumberton; and in a few places also considerably to the east of this latter line. The gravel is more generally distributed along the borders of the river basins, where it occurs in extensive beds, a few inches to twenty feet in thickness, though along the western edge of the Coastal Plain region it is often found on the hill-tops and divides between the rivers.

In many places the gravel is suitable for use on the road-bed just as it comes from the pit, containing pebbles of the right size, from an inch down to a coarse sand, and a small percentage of ferruginous clay, just enough to make it pack well in the road-bed without preventing proper drainage. In many cases, however, the proportion of clay and loam and sand is too large and must be reduced by the use of fine screens; and in other cases many of the pebbles are so large that they must be separated by means of a one-inch mesh screen, and those too large to pass through this screen broken before they are used.

The railroads passing through this region long since discovered the value of this gravel as a road material, and have used it extensively as a ballast on their road-beds. The small percentage of ferruginous clay soon cements the gravel into a hard, compact mass.

Limestone.—In the south-eastern portion of this region limestone rock and calcareous shells from the oyster and from fossil mollusks from the marl beds constitute the only hard materials to be found there for road construction. In some places the limestone is fairly hard and compact, as at Rocky Point, on the Northeast Cape Fear River, at Castle Hayne and elsewhere, and this rock will make an excellent road. In other places it is made up of a mass of shells firmly cemented together, as on the Trent River, near Newbern, and elsewhere. At many other points beds of shells are so slightly cemented together that the material may hardly be called a rock, as the term is ordinarily used, and in this condition it is of less value as a road material, but may be used for this purpose to advantage. A careful search will show limestone of one of these grades to occur in considerable quantities at many points in these eastern counties, between the Tar River and the South Carolina line. The harder, the more compact, and finer grained this rock, the more valuable it is as a road material; but the loose shells from marl beds, when free from clay, and the oyster-shells from the coast, when placed on a road surface and ground into fine fragments by travel, will solidify into a hard, compact road, as may be seen in the case of the excellent "shell road" between Wilmington and Wrightsville, which was built of oyster-shells.

Clay and Sand.—The admixture of a small percentage of clay or loam with the sand on the surface of the road-bed will solidify it, and will thus very greatly improve the character of the road; and in this connection, and only in this connection, clay may be considered a useful road material. In whatever region the clay occurs in abundance the road will be greatly improved by the proper admixture of sand from an adjoining region, and by proper drainage.

Granites and other Crystalline Rocks.—These are found outcropping at intervals along the western border of the Coastal Plain region, and wherever found accessible this material should be used in the construction of roads. Near the northern border of the State they are found exposed in considerable quantity; along the Roanoke River, between Gaston and Weldon, in Northampton and Halifax counties; near Whitaker's Station, at Rocky Mount, just south of Wilson, and again a few miles north of Goldsboro on the Wilmington & Weldon Railroad. Another isolated and interesting occurrence of granite is near the junction of Pitt, Wilson and Edgecombe counties, where it is exposed over a tract of several acres. West of the Wilmington & Weldon Railroad, in the counties of Halifax, Nash and Johnston, the streams have removed the surface sands and clay in narrow strips along their borders, and have exposed at intervals the crystalline rocks; and in many places these rocks will be found to make good road material. Further south-west, in Wake county, on the Cape Fear River, and Upper Little River, in Harnett county, and again along the banks of the Pee Dee River and tributaries in Richmond and Anson counties, granitic and slaty rocks occur in considerable quantities, the former especially suitable for road material.

In considering the materials for good roads in the counties of this Coastal Plain region it must also be borne in mind that several large rivers connect this region with ample sources of granite and other good road materials which occur at the head of navigation on these streams and can be cheaply transported on flats; and further, that a number of railroads pass from the midland counties where the supply is abundant directly into and across the Coastal Plain region.

Plank Roads.—As suggested above, in deep sandy regions where timber is abundant the plank road may prove the most economical good road that can be built for temporary use, and some of them last six to ten years. But the greatest objection to them lies in the fact that when the timbers decay, whether this be at the end of four or ten years, the road is gone; and the entire cost in labor and money must be repeated.

IN THE MIDLAND AND PIEDMONT COUNTIES.—Throughout the midland and Piedmont counties of the State, west of the Coastal Plain region, rocks suitable for road purposes are abundant and widely distributed, so that no one can claim as an excuse for *bad* roads that the materials are not at hand for *good* roads. It will serve our present purpose to discuss these in the order of their geographic distribution, with but little regard to their geologic relations.

Trap Rock in the Sandstone Areas.—As stated above, sandstones possess very little value as road material, especially when broken into fragments, as is necessary in making Macadam and Telford roads, but fortunately in this respect the sandstones of North Carolina are quite limited in their distribution. The larger of the two areas begins near Oxford, in Granville county, and extends south-westward, passing into South Carolina below Wadesboro. It has its maximum width of about sixteen miles between Chapel Hill and Cary, and its average width is less than ten miles. It occupies the southern portion of Granville county, the southern half of Durham, the western border of Wake, the south-eastern border of Chatham, and portions of Moore, Montgomery, Anson and Richmond counties. The other sandstone area is much more limited in extent. It lies mainly in Stokes and Rockingham counties, along the Dan River, between Germantown and the Virginia line, a length of not more than thirty miles, and a maximum width of not more than five miles.

Fortunately for the roads leading through these sandstone areas there is an abundance of a hard, black, tough, fine-grained rock, known as diabase, or trap, occurring in dykes which have broken through the sandstone and now appear on the surface in lines of more or less rounded black masses of rock running nearly north and south. These dykes vary in width from a few feet to more than one hundred feet, and are separated from one another by distances varying from a few yards to two or three miles. A dozen or more of these dykes are crossed by the wagon road between Chapel Hill and Morrisville. Several dykes occur at and near Durham, and the rock has been used upon roads leading out from Durham, but unfortunately it has not been crushed into small fragments, as should have been done, and hence the result has not been altogether satisfactory.

There is, probably, in both these sandstone areas a sufficient amount of trap rock to properly macadamize every prominent road that crosses them, and, after this has been done, to furnish a top dressing for all public roads which are likely to be macadamized in the adjacent counties.

Trap Rock in Other Areas.—Fortunately this excellent road material is, in its occurrence, not limited to the sandstone regions. Dykes quite similar to those which abound in the areas just described are also found extending across the country in many of the midland and Piedmont counties, and also the region west of the Blue Ridge. Heretofore this black, "nigger-head" rock, as it is frequently called, has been regarded as a useless encumbrance of the ground; now, in connection with the move for better roads, it must be regarded as one of our most valuable rocks. The city of Winston has already made extensive use of it in macadamizing its streets, with excellent results.

The Eastern Granite Belts.—Granitic rocks are abundant over considerable areas in the midland and Piedmont counties, and especially in the former. One of these important areas may be called, as a matter of convenience, the Raleigh granite belt; which, in a general way, may be described as enclosed by lines drawn from Gaston to Smithfield, thence to a point midway between Raleigh and Cary, and thence a little east of north to the Virginia line. This belt occupies a considerable part of Wake, including the region about Raleigh, of Franklin, and practically the whole of Warren and Vance counties. The principal rocks of this belt are light-colored gray, comparatively fine-grained, granite and gneiss; on the whole a fairly good material for road construction. The rocks vary in composition and in appearance at different localities, but are fairly uniform in character over considerable areas. In some places the black or biotite mica is largely wanting, and the rock assumes a whitish feldspathic character; at other points the mica becomes abundant, and the rock assumes a dark gray color. In places the mica is so abundant that the gneiss becomes somewhat schistose, or laminated, and in this condition crushes easily, hence should not be used on the roads. Dykes of trap rock are occasionally met with, and these should be used in preference to the gneiss and granite wherever accessible.

The somewhat isolated patches of granite lying east of this belt in Halifax, Nash, Edgecombe and Wilson counties have already been referred to.

West of the Raleigh belt there is another granite area of limited extent which occupies the extreme north-eastern portion of Durham county and the larger part of Granville county. This may be called the Oxford granite belt. The rocks of this area resemble to some extent those of the Raleigh belt, but there is a larger proportion of syenitic and trap rocks, which make excellent road material.

The Central Granite Belt.—This belt extends obliquely across the State from near Roxboro, in Person county, to the South Carolina line along the southern border of Mecklenburg. Its width varies from ten to thirty miles, and it occupies a total area of about three thousand square miles in the following counties: Western half of Person, including the region about Roxboro; the south-eastern portion of Caswell, the north-western half of Alamance, the larger part of Guilford and Davidson, south-eastern portions of Davie and Iredell, Lincoln and Gaston and the larger part of Rowan, Cabarrus and Mecklenburg. In this belt throughout its entire extent road material of most excellent quality is abundant. The prevailing characteristic rocks are syenite, dolerite (trap), greenstone, amphibolite, granite and porphyry; and, as will be seen from this list, the tough hornblende and augite rocks predominate. Dykes of trap rock, some of them of considerable extent, are to be found in almost every portion of the belt. So uniformly tough and durable are these materials that one could hardly go amiss in making selections for road construction.

The Central Slate Belt.—This region lies just east of the central granite belt, and extends obliquely across the State from Virginia to South Carolina. Its eastern border lies against the Deep River sandstone basin described above (p. 23). It varies from twenty to forty miles in width and includes all or portions of the following counties: The eastern half of Person, the north-western part of Durham, the south-eastern part of Alamance, nearly all of Orange, Chatham, Randolph, Montgomery, Stanly and Union; the eastern part of Davidson and Rowan, and the north-western part of Anson. A considerable portion of this area is rich in other mineral products, but the entire belt, as compared with the central granite belt, is poor in road materials. The rocks are mostly siliceous and clay slates, with a considerable admixture of chloritic and hydromicaceous schists; all of which are at best inferior for road construction. Here and there, however, trap dykes are found in this belt; and in places the siliceous slates become somewhat massive, passing into hornstone and a quartzite, which, when crushed, will answer fairly well for macadamizing purposes. In other places the chloritic schists become somewhat massive and tough and can be used in the same way. In still other places, as about the State University, and along the eastern border of Orange county, the rock is a fine-grained, tough syenite, accompanied by trap dykes, and is eminently suited for road purposes; and again, as near Hillsboro, granite occurs in a limited area. Vein quartz ("white flint") is abundant in many parts of the belt; and, though not usually recommended as road material, is worthy of consideration. While, then, on the whole the rocks of this belt are not suitable for use as road material, yet a careful search will show the existence of a sufficient quantity of material of fair quality to macadamize all the public roads. And should this supply ever prove insufficient, excellent materials are to be found in abundance in the granite belt along the western border of this region, and in the trap dykes of the sandstone on the eastern border.

The Gneisses and Other Rocks of the Piedmont Counties.—West of the central granite belt as described above, and extending back to the foot-hills of the Blue Ridge, is the region occupied by the Piedmont counties—Rockingham, Stokes, Forsyth, Yadkin, Surry, Wilkes, Davie, Iredell, Alexander, Caldwell, Burke, McDowell, Rutherford, Polk, Cleveland, Catawba, Lincoln and Gaston. The rocks of this region resemble in many respects those of the Raleigh granite belt. They consist of a succession of gneisses, schists and slates, more hornblendic toward the east and more micaceous toward the west, with here and there masses and dykes of syenite, trap and other eruptive rocks.

In places, as at Mount Airy, the true granite occurs in considerable abundance. The granites and gneisses, except where the latter tend to split into thin layers and crush, are fairly good materials for road construction, improving as they become finer in grain and as the percentage of hornblende increases; but the best material for road construction is to be found in the trap dykes and syenite ledges which at intervals traverse this region, more especially its eastern half.

The Gneisses and Other Rocks of the Mountain Counties.—The rocks of this region are not greatly unlike those of the Piedmont counties just described. Over much the larger part of the area rock fairly well adapted to road construction is abundant, indeed so abundant that the laborers on the public roads in that region during the past half century have expended the larger part of their time and energy in endeavoring to get this rock out of the way. Had they expended this time and energy in crushing the rock and spreading it over a well-formed foundation, this region would possess at the present time a number of excellent macadamized highways.

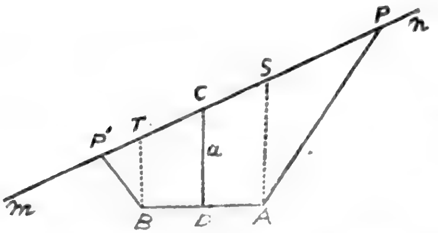
In the more northern counties—Alleghany, Ashe and Watauga—the predominating rocks are hornblende gneiss and slate, but massive syenites are abundant, especially between Rich mountain in Watauga and Negro mountain in Ashe county, and elsewhere. Further south-west, through Mitchell, Yancey, Madison and Buncombe counties, hornblende schists still continue, but they are more massive, and the gneisses predominate. These are, on the whole, compact and sufficiently tough for use in the construction of good Macadam roads. And the statement just made concerning these counties is also applicable to Henderson, Transylvania and Haywood counties, and in a measure to Jackson, Swain and Macon counties and the eastern half of Clay county, in all of which the supply of good road material is ample; but in these last three counties mica schist partially replaces the hornblende slate. In the western part of Swain, in Graham, Cherokee and the western part of Clay county good road material is not so abundant as in the other counties named, but nevertheless is to be found in considerable quantities. The rocks over a considerable portion of this last-named area are micaceous and hydromicaceous in character, and are practically worthless for the purposes of road-building, but the quartzite ledges and beds of limestone in these counties will furnish ample and suitable material.

In conclusion, it may be said that in the middle and western counties of North Carolina material suitable for macadamizing the public highways is abundant and generally accessible. It will be the exception, rather than the rule, that this material will have to be transported for any considerable distance. In the eastern counties materials suitable for this purpose are inferior in quality and only moderately abundant in quantity, but the extensive and intelligent use of even these materials would very greatly improve the public roads and thereby increase the prosperity of the people. And in many places where the Macadam road is at present out of the question on account of the lack of stone, other materials, gravel, clay, loam and plank will be found in sufficient abundance to make the construction of better roads practicable at reasonable cost.

TO SET SLOPE STAKES WHEN THE SURFACE IS STEEP BUT SLOPES UNIFORMLY.

BY J. M. BANDY.

Let mn represent the surface of the ground. Let C represent the position of the centre peg, and let CD ($=a$, the value of which is found from the level notes) represent the centre cut. The width of the road, BA, is b.



It is proposed to find what engineers designate as cuts at P, P^1, S, and T.

In the direction of P, and in connection with C, one setting of the rod determines the slope of the ground mn. Call this slope m. Now, since the cds. of C are (o, a), the equation of the surface, mn, is

$$y = mx + a, \dots\dots (1).$$

The quality of the soil determines the slopes of PA P^1B. Call this slope m^1. Then since the cds. of A are $(\frac{b}{2}, 0)$, the equation of PA is

$$y = m^1x - \frac{m^1b}{2}, \dots\dots (2).$$

Combining (1) and (2), the cds. of P are known. Hence the cut at this point is known.

Designating the cds. of P, just found, by (x^{11}, y^{11}) and the cds. of C by (x^1, y^1) [$=(o, a)$],

$$CP = \sqrt{(x^{11} - x^1)^2 + (y^{11} - y^1)^2}, \dots\dots (3).$$

Then measure this distance, CP, and fix stake at P.

The equation of SA is

$$x = \frac{b}{2}.$$

Substituting this value in (1), the cut S is at once obtained. Denoting the cds. of S by (x^{11}, y^{11}) and the cds. of C by (x^1, y^1), and substituting in (3), CS is known. Measure this distance, and fix stake at S.

The same course of reasoning applies in finding the cuts at P^1 and T.

The writer has found this method more expeditious than *trial* and *error* when the surface was much inclined. The numerical computations did not require as much labor as manœuvering with the rod and level.

Since he has not seen the above method in any of the books which have fallen under his eyes, he has been induced to give it in the hope that it might prove useful, as well as suggestive, to others under similar circumstances.

TRINITY COLLEGE, N. C.

ON THE DEVELOPMENT AND A SUPPOSED NEW METHOD OF REPRODUCTION IN THE SUN-ANIMALCULE, ACTINOSPHÆRIUM EICHHORNII.*

BY JOHN M. STEDMAN.

Early in March my attention was called to an aquarium which had been standing in my window during the winter, and which contained anacharas and algæ in great abundance, but which now suddenly presented a quantity of light pink substance on the sides of the jar. It was the appearance of this pink-colored material among the *debris* of decaying and growing algæ that attracted my attention. Accord-

*Amer. Soc. Microscopists, 1888.

ingly a small piece of the substance was spread out on a slide and examined, when, to my surprise, it was found to be composed of sun-animalculæ of various sizes, among which were other bodies, the true nature of which I did not at first quite understand, but which on close examination proved to be the young of the larger heliazoa. So numerous, indeed, were the young heliazoa that not a single field of the one-fifth objective and *a* ocular could be chosen in which there were less than half a dozen, and usually the number was very much greater.

Such an unusually great and rare opportunity to study these animals could not be neglected. Fortunately they were discovered in the morning, and by close and constant observation for several hours their true relations to the numerous small bodies were satisfactorily demonstrated and proven to be different stages of the same animal.

For a description of *A. Eichornii* and of its habits see "Fresh-water Rhizopods of North America," by J. Leidy, p. 259. Plate XLI.

We will pass at once to the special subject in hand, beginning, for convenience, with the simplest or youngest heliazoan.

Development.—Let it not be understood that the order in which I am now to describe the different stages of development is the order in which I observed them. On the contrary, what I shall first describe really came about last in my observations, since I did not at first take the youngest stages of this heliazoan to have any connection with the larger heliazoa. My observations began with an undoubted heliazoan of this species (Fig 13 of my plate), and from that I worked both ways, but principally to the younger. It would have been impracticable to have watched the development of a single heliazoan from the very youngest individual to the full-grown animal, since it would have required not only a constant observation for a much longer time than I could spare, but would also have needed some little care. As it was, I could watch a young heliazoan until it had developed a few stages, and had considerably lessened the near supply of food, and then I could find another heliazoan of the same stage as the one just discarded, but which was in more favorable circumstances for further growth. As indicated, the number of heliazoa was enormous, and the different stages were represented by the score. Had I suspected these various stages to have been what they were, there would have been no trouble in finding a complete set, for every gradation from the youngest to the adult was present in great quantities. Fortunately there were quite a number of worms—*Dorylaimus stagnalis*—in the water, and their constant wriggling about kept the heliazoa and other animals in perpetual motion, so that they came in contact with one another, where otherwise they would not have done so.

A far greater number of observations were made than I shall here describe. Enough were chosen, however, to form a complete series, and accurate drawings made of them. I shall, therefore, describe only those observations which I have illustrated, hoping that the series will be full enough for our purpose.

I think it is safe to say that were this minute mass of protoplasm which constitutes the youngest heliazoan observed by itself for a little while, no one would mistrust its true nature or relations. Indeed it was only after a long and continued observation, and that under the most favorable circumstances, that I became convinced of its true nature. It is nothing but a minute spherical mass of finely granular and hyaline protoplasm, 14.5 u in diameter, with a contained nucleus and a distinct nucleolus (Fig. 1). In appearance it resembles white blood corpuscles with a distinct and sharply defined nucleus. Later, however, a vacuole appears in its substance, and, increasing in size, often becomes larger than the original mass of protoplasm, so that the latter forms but a thin layer surrounding it (Figs. 2, 16, 12). In this stage a pseudopodeum or ray may be presented (Fig. 12).

Two heliazoa of the first stage were seen to come together, which, however, as in nearly all cases, was due to the agitation of the water by the worms, and immediately upon touching one another (Fig. 23), to fuse and run together just as a drop of water fuses with another drop of water. It is impossible to say which of the two was devoured; both appeared to play an equal part, the vacuole and nucleus of both being present, and the whole immediately assuming a spherical form and appearing (Fig 3) much like any one of the two of which it is now composed, except that it has two vacuoles and two nuclei. In the course of five minutes this young, two-vacuoled, heliazoan had developed a ray, and in its interior the characteristic axis thread could be distinctly seen (Fig. 20). The absence or the number of rays when present in the young heliazoa is of no special value, and varies with different individuals of the same age, as will be seen from the figures.

Whether this fusion of two individuals of the same species be called eating or not does not concern us, and I shall not attempt to discuss the subject here. As a matter of fact, however, it is not conjugation for purposes of reproduction or rejuvenescence, as will be seen later; and, since we have these animals developing by this method of increase as well as by that of an undoubted eating of other animals, it matters not, so far as development is concerned, whether they appropriate material so near like that of their own bodies that it needs no change to form a part of them, or whether the food be different and hence have to be changed or digested before it can be so appropriated. I have observed farther advanced heliazoa capture infusoria and amoeba and surround them, and draw them into their interior, where they remained to be digested; and at the same time I have observed those same heliazoa capture other heliazoa, and instead of drawing them into their interior and surrounding them as they did other bodies, they would draw them in until the two heliazoa touched, when there occurred a fusing and blending of the two animals into one just so much larger. My only explanation is that, as indicated, the protoplasm of the two animals is *exactly alike* and hence there can be no need of digestion. Were one of the heliazoa dead when it came in contact with another which would otherwise have fused with it, I have no doubt but that the dead heliazoan would be surrounded and drawn into the interior of the live one the same as other animals are and there digested, it being *not exactly like* the protoplasm of the one which is alive. For if this were not the case, if the dead heliazoan upon contact with the living heliazoan were to form a part of it as the living heliazoan did, then we should have a case where simple contact of the living protoplasm with the same but dead protoplasm would impart life to the dead, just as a piece of iron which is magnetized, if brought in contact with one which is not, will impart magnetism to it. But it is needless to say that such a phenomenon of life has never been observed.

While watching the heliazoan (Fig. 3, 20) which we have just described as being the result of the union of two of the youngest individuals (Fig. 2, 23), the water was stirred by a worm, and another heliazoan, of about the same size as the one under observation, but with three vacuoles and no rays, was brought nearer and nearer until finally they accidentally came in contact with one another and immediately united (Fig. 20) and assumed a spherical form. Presently the single ray disappeared and three more vacuoles made their appearance in the mass of protoplasm together with the development of a contractile vesicle

(Fig. 5). This individual was watched until it had developed three rays and several more vacuoles (Fig. 6), a process requiring about twenty-five minutes, during which time it had eaten nothing except one of the youngest heliazoa without a vacuole. Under the one-twelfth oil emersion I was able to detect the axis cylinder in two of the rays, but not without some doubt in the third ray.

Very near this individual (Fig. 6, 26) was another heliazoan of a much greater size (Fig. 25), and by touching the cover-glass with a needle I soon brought the two so near that the tip of one of the rays of the smaller heliazoan touched the larger animal. Wishing to observe the result of this contact I waited a few minutes, when it became apparent that the smaller individual was drawing in its ray, which was in contact with the larger heliazon, and was thus drawing itself towards it. The larger animal, offering the greater resistance, did not appear to move. Five minutes from the time the ray first touched the other heliazoan the two had come in contact, whereupon a union occurred and immediately the two blended into one. The smaller animal appeared to flow into the larger and to disperse itself through it in a manner which is common to all these animals, young as well as full-grown, and which will be described later when we reach a nearly mature heliazoan. Before the union of these two animals they appeared alike except in size and number of vacuoles, but shortly after the union the granules in the protoplasm gradually moved towards the center of the animal, where they became more numerous, and instead of being evenly distributed throughout the granular protoplasm now formed a central, more granular portion with an outer, clearer, and less granular zone. Three more rays were also developed, and the animal presented the appearance shown in figure 7, which, at this stage, would probably not be mistaken for any other species. Hundreds of individuals were to be found of this size and appearance, and hence it was not necessary to watch the development of this single individual longer, as other fields promised better results.

There was almost an unlimited supply of heliazoa intermediate in size between the two whose union produced the one just mentioned. They differed in no respect from one another or from the two just mentioned, except a slight difference in size, and every gradation between them was to be found. Merely for the sake of filling up the gap which exists in regard to size between the two individuals whose union we just referred to, I will cite one example out of many which I have observed. Two similar individuals, slightly larger than the smaller (Fig. 26) of the two just united were seen to come together (Fig. 22), and, as a result of their union, a heliazoan was produced so nearly like the larger (Fig. 25) of the two of the former individuals, that there was practically no difference between them.

Another field was now chosen in which were a number of heliazoa, similar in all respects to the one representing our last stage (Fig. 7). I had not waited long before it was evident that two of these animals were gradually approaching one another from some cause which I was unable to discover. When within a very short distance, in fact, almost ready to meet, there occurred a very singular movement on the part of both individuals—a movement which I can hardly account for—in which there was produced a swelling, as it were, in that part of the sphere of both animals (Fig. 8, 9) which was just about to touch the other, and by continued enlarging with increased rapidity soon met one another, thus uniting the two individuals much more quickly than they otherwise would have done. Immediately upon touching one another the at first narrow neck uniting them rapidly enlarged (Fig. 10), the protoplasm of the one flowing into the other and *vice versa* until the two animals had united into an oblong-shaped mass. The flowing of the protoplasm from one to the other was a most interesting sight, and could be distinctly seen, owing to the numerous granules which it contained. Both animals played an equal part in the union; a current of protoplasm could be seen streaming from the first into the second, and near it another current from the second into the first. There were as many currents as there were threads of denser protoplasm uniting them. Like all the observed cases the denser and more granular portions of the protoplasm separating the vacuoles from one another never mixed with anything but the corresponding protoplasm of the individual with which it united; hence there was no destruction of vacuoles, but merely an addition or union, and, moreover, the peripheral layer of vacuoles always remained on the periphery, while the central mass of vacuoles flowed to the center of the united mass. The heliazoan now gradually changed from the oblong or ellipsoid shape to that of a sphere (Fig. 11), and here I left it to seek other fields.

A nearly identical individual to the one just mentioned was found and seen to capture by one of its rays another but smaller heliazoan. As a result of a movement of the water the smaller individual chanced to come in contact with the tip of a ray of the larger animal and there to unite with it, whereupon the larger heliazoan gradually drew in its ray and the smaller creature with it. It was an interesting sight to see this process. The ray seemed rather to flow into the spherical mass or body of the animal, since a stream of protoplasm was rapidly and constantly flowing down its center into the animal, and the smaller heliazoan was likewise flowing into the larger by this means; but, nevertheless, the ray grew shorter and shorter until finally the heliazoa came in contact (Fig. 13), and then a union took place similar to the one described above, except that here the flow of protoplasm appeared to be solely from the smaller to the larger animal. Before the animal had become entirely spherical, the denser inner portions of the smaller heliazoan had united with that of the larger and appeared as a swelling upon it, while the peripheral zones of both animals had united. This appeared to be such a good example of the mode of union of the protoplasm of two heliazoa that I figure it (Fig. 15).

I have observed a number of large heliazoa capture the youngest individuals, and in all cases as soon as the young animal touched the ray of the larger it appeared, so to speak, to form a part of it, and would sometimes assume an oval form and remain on the ray, looking exactly like the little knobs of protoplasm which are frequently seen there, except that it would be larger; and then again I have seen them flow down the center of the ray, while the ray itself suffered no appreciable change. In one instance, however, which came under my observation, a moderate sized heliazoan (Fig. 17) captured by the tip of its ray one of the youngest individuals (Fig. 16), and while watching to see what would happen to this young one, the ray of a large heliazoan (Fig. 18) came in contact with the larger of the former animals. Out of curiosity merely I watched to see the result of this extraordinary union, and found that the largest heliazoan drew its captured brother to itself and united with it before the smallest individual had touched the body of the one to which it was attached; the smallest heliazoan then appeared to be fastened to a ray of the largest animal, which, however, soon drew it to itself and the two united.

Quite a different process from the one we have been discussing occurs when the heliazoan encounters food consisting of other animals or plants. I have no doubt but that the youngest heliazoan, as well as those of all stages, are able to and generally do develope and reach maturity by the use of no food other than that of other animals and plants; but there is also no doubt that this is a process requiring considerable time as compared with that which occurs when they chance to meet with their own kind, since in the former case the food has to be digested, while in the latter it has not. It was my good fortune to find a large heliazoan which had just captured an infusorium and partially surrounded it. In a few minutes the infusorium was completely enclosed, a clear space remaining around it, however, and gradually it was moved near the center of the animal, where it could be seen slowly moving its cilia in the little water which immediately surrounded it and which separated it from the protoplasm of the heliazoan (Fig. 19, 21). Presently an amoeba came in contact with the heliazoan and appeared to stick to it more or less and to constantly try to move away from it. The heliazoan made several efforts to surround it, but the amoeba in every case moved out before being fairly imbedded, and finally, after several minutes of hard struggling to ascertain which was to be victorious, the amoeba escaped. It was but a short time, however, before another amoeba chanced to touch the heliazoan, and this time with better success to the heliazoan. The amoeba, as soon as it touched the heliazoan, spread out a little on it, and at the same time the protoplasm of the heliazoan began to flow around and to enclose the amoeba, which now made several efforts to escape, but in vain, for within a few minutes a fine film of protoplasm had surrounded it, and the amoeba was within the heliazoan (Fig 19). A quantity of water was also enclosed with the amoeba, and in this it exhibited considerable activity, even after it had been carried nearly to the center of the heliazoan (Fig. 21). It was not long, however, before the amoeba had assumed a globular form and become motionless. I mention this instance in which the heliazoa eat other animals merely to bring out the striking difference between the process and that observed when they eat their own species.

Dr. Joseph Leidy* speaks of having found several globules of granular protoplasm with vacuoles and rays, and alludes to their probable connection with this species of heliazoa. I have reproduced in figure 24 one of his figures of these bodies, and think that there is every reason to believe that they are what he suspected them to be.

Reproduction.—It is not uncommon to find heliazoa in the process of reproduction by fission; in fact, if heliazoa be kept for any considerable length of time they are almost certain to be found in the act of reproducing by this means. I have observed them divide by keeping them in a watch-glass under the microscope, and in one instance I watched uninterruptedly the process, from an oral heliazoan before the constriction began to appear, up to the division and entire separation into two animals. A complete set of drawings was made to illustrate the different steps, and I find by referring to my notes that one of the drawings is almost identical with figure 10, which represents the heliazoan in the process of union.

As regards reproduction in the heliazoa outside of the well-known process of fission, all I can say is from a philosophical stand-point, as no direct observations have been made outside that of the finding of the young. But the presence of young has got to be explained in some way. From Dr. Leidy's "Fresh-water Rhizopods," p. 260, I find that "according to Stein, Carter and other authorities, *A. Eichhornii* contains many nuclei, large individuals having a hundred or more." Whether this has any connection with the heliazoan's having devoured individuals of its own species and thus to have retained their nuclei, and so, by continually adding to the number every time it captured

*"Fresh-water Rhizopods of North America," page 262-3.

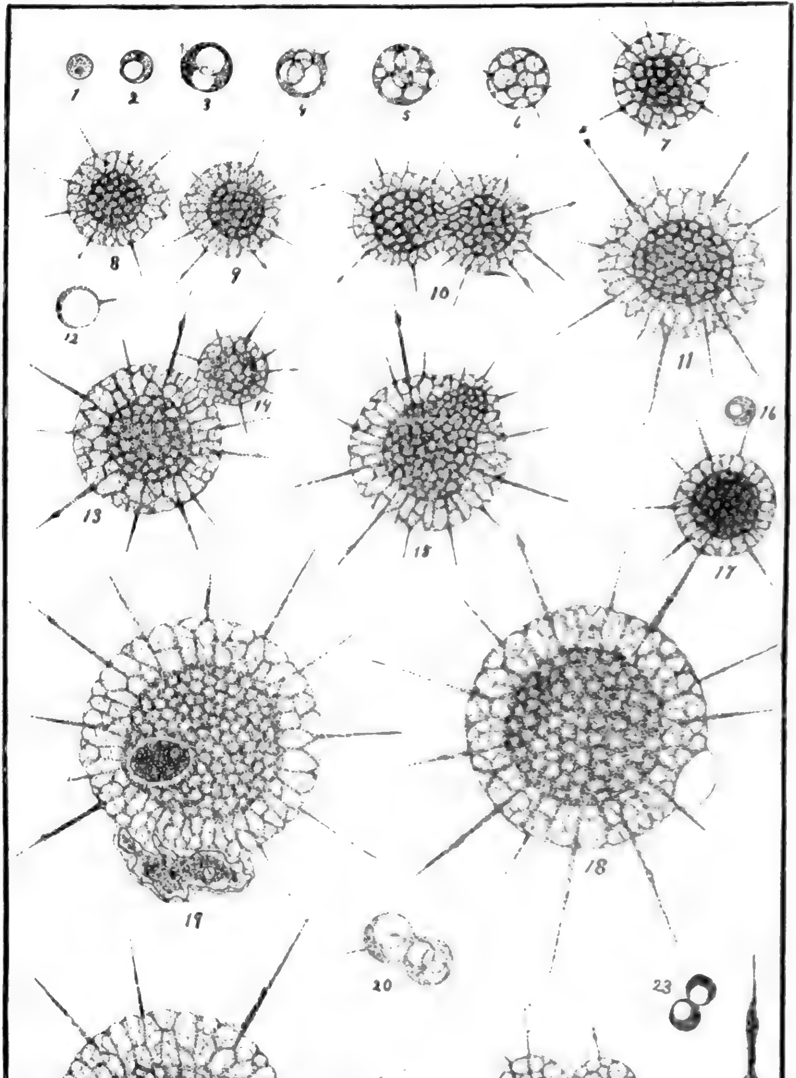
another heliazoan, to have finally attained the number of one hundred, or whether it is connected with the process of reproduction, I cannot say. It seems to me very probable that, in the fall at least, the full-grown heliazoan becomes encysted, and that its protoplasm then divides and subdivides, until it is converted into a mass of minute bodies, which, when the cyst is ruptured, make their escape into the surrounding water, and then appear as naked, spherical masses of granular protoplasm with a nucleus. It may be that the minute bodies acquire a covering before they escape from the mother cyst, and that they then act as spores, and are carried about and developed similar to the spores of infusoria.

Of course this mode of development has never been observed in the heliazoan, but it seems to me to be very probable that it does occur, judging from the observed young individuals, and from the fact that it occurs in certain infusoria.

EXPLANATION OF PLATE.

All the figures were drawn from life except Fig. 24, which is a reproduction of a figure from Dr. Leidy's work on the Rhizopods. Fig. 1, which is a heliazoan, *Actinosphaerium Eichhornii*, of the very youngest stage, is in nature 14.5 *u* in diameter. The other figures are drawn with the same magnification as Fig. 1, and hence they all bear the same relative size in nature as is here represented, excepting Figs. 25 and 26, which are a little too small. I take it to be of much more value to the reader to have the figures drawn so as to preserve their relative size, and then to know the natural size of one of them, than it is to have the figures of various magnifications and know the magnification of each separate figure. I do not wish it understood that the figure taken from Leidy is relatively of the same size as the other figures.

TRINITY COLLEGE, N. C.



J. M. Stedman. Del.

SOME FUNGI OF BLOWING ROCK, N. C.

BY GEORGE F. ATKINSON AND HERMANN SCHRENK.

During the month of August for the summers of 1888 and 1889 it was the good fortune of the senior author of this paper to spend that time in the enjoyment of the invigorating atmosphere and famous scenic beauty of this point in the Western North Carolina mountains.

To the greater number of the readers of this Journal Blowing Rock is not unknown. It may be a matter of interest to others to know that this now fast becoming popular summer resort is found in Watauga county, and is reached by "staging it" twenty miles up the mountain from a point, Lenoir, the northern terminus of the Chester & Lenoir Narrow Gauge Railroad, which connects with the main line of travel from the east and west at Hickory, on the Western North Carolina Railroad.

Even a botanist can cherish commendable curiosity, on his first trip to the place, concerning its "*entitlements.*" Upon reaching the summit near the village one is sped through an unpretentious drive of nearly one mile when the road curves to evade a steep hill. Here is suddenly presented to view the grand panorama of the great John's River valley below and the lofty peaks of the Black Mountains beyond.

When one has become disengaged from travelling paraphernalia, and when rest and refreshments have dispelled fatigue, there comes an irresistible desire to join others in the pilgrimage to the "Rock." Once there the meaning of "Blowing Rock" becomes apparent. The rock juts out upon the west side of the cliff, forming a bold precipice at the north-east of the John's River valley. The currents of air from the farther end of the valley converge as they rise at this point, favored by the cliffs at the north and east, and on an otherwise calm day quite a strong breeze "blows" over the rock. Throw your hat, walking-stick, or whatnot over the precipice and the wind brings them back to you. Legend has it that a despairing lover once leaped from the side of the fair one over the rock and the cruel winds picked him up and brought him back to her feet! It is proper to say, however, that when the writer visited the spot the winds did not seem to be "getting in their work" properly and there was no inclination to jump.

But legends and levity both aside, Blowing Rock is prodigal with flowers and "mushrooms." To one who visits the place in June the profusion of thickets painted with *Rhododendrons* and *Kalmias* are a "joy forever." Later in the season "Black-eyed Susans" wink at you here and there, and various species of interesting *Orchids* are frequently met with. *Eupatoriums* and other vigorous growers vie with each other in their effort to hide the fences which line the roads or cross the fields.

The great prodigality of the fleshy fungi tempted the writer, during portions of two short months, to form the beginning of a closer acquaintance with the *Hymenomycetes* than had been gained from a general study of structure and relationships. Accordingly collections were made of fungi chiefly in this group. Not wishing to be encumbered with books, no efforts were made at the time to identify the specimens. A few notes were taken on the more evanescent characters, the specimens were then dried and preserved for future determination.

The greater number of the *Hymenomycetes* were afterward determined by Mr. A. P. Morgan. Dried agarics are very difficult of determination and it is a matter of some interest that more than half of the *Agaricaceæ* were in a recognizable condition, though some genera like *Cortinarius* were complete failures.

One point of interest in making the collections was the observation that quite circumscribed areas for several days in succession would yield fresh and abundant specimens of the same species. Near Fair View and Sunset Rock *Boletus americanus* was abundant both seasons. A trip down the damp slopes of Glen Burney was almost sure to be rewarded by gorgeous *Thelephoras*. Partly down the John's River valley road, in rather open woods, several species of *Hydnum* would always insist on over loading one's basket. That lovely plant, *Mitremyces lutescens* Schwein., cropped out continually along certain of the shady clay road banks dripping with water. From the same situations where there was less water, clammy *Amanitas* lifted their heads. One point on the Valley Crucis road yielded *Strobilomyces strobilaceus*. Wonder Land produced monster clusters of *Clitocybe illudens*. At one time I could have picked more than a bushel without moving from the spot. This plant is remarkably phosphorescent, the phosphorescence being confined to the hymenium. Sometimes this plant is taken to the hotels, and at night the guests amuse themselves delineating various figures in the dark with the aid of this "fox-fire" mushroom. Another phosphorescent plant, *Panus stipticus*, is common upon dead stumps, etc. Close by the roadside at Wonder Land, also, *Cyclomyces greenii* was found. In an open field east of the Morris pasture the parasol, *Lepiota procera*, grew in abundance, and here and there the Ox-tongue, or beef-steak fungus, *Fistulina hepatica*, offered its juicy meat. *Lactarii* were everywhere and so the dainty *Marasmii*. *Marasmius capillaris* was taken, just a bit of it, from "Flat Top." *Bulgaria inquinans*, *Spathularia velutipes*, *Leotias*, were very common. The *Geoglossums* were rarely seen. *Geoglossum Walteri* was collected by Miss Etta Schaffner down in the John's River valley near the foot of Fair View. Down in the far depths of this valley was a profusion of the maiden's hair fern, *Adiantum capillis-veneris*.

The junior author, Mr. Schrenk, a student in botany in my laboratory, has rendered valuable service in making out the list presented below and in a careful examination of the specimens for the purpose of verification of the identifications, in order to lessen the chances of error. This has occasioned no inconsiderable labor on his part.

In the arrangement of the list the system presented in Saccardo's Sylloge has been mainly followed. No effort has been made at changes in nomenclature, since it did not seem to be called for in a bare list of no more than 254 species.

The *Saccharomyces pyriformis* and *Bacterium vermiforme** were symbiotic organisms composing small amber-colored grains termed "moss seed," "California beer seed," used by some of the mountain people in brewing a beer by placing the grains in water sweetened by molasses. The grains were given me by Dr. Carter, a resident physician.

ORDER HYMENOMYCETEÆ.

FAMILY AGARICACEÆ.

1. *Amanita cæsarea* Scop.
2. *A. muscaria* Linn.
3. *A. pantherina* DC.
4. *A. phalloides* Fr.
5. *A. recutita* Fr.
6. *A. solitaria* Bull.
7. *A. vernis* Fr.
8. *Amanitopsis vaginata* (Bull.) Roz.
9. *A. volvata* (Pk.) Sacc.

*See Ward. The "Ginger-beer plant," and the organisms composing it: a contribution to the study of fermentations—yeasts and bacteria. Proceedings of the Royal Society, Vol. 50, pp. 261, 265.

10. *Lepiota cristata* Alb. et Schwein.
11. *L. procera* Scop.
12. *Armillaria mellea* Vahl.
13. *Tricholoma fulvellum* Fr.
14. *T. portentosum* Fr.
15. *T. saponaceum* Fr.
16. *Clytocybe cyathiformis* Fr.
17. *C. illudens* Schwein.
18. *C. infundibuliformis* Schæff.
19. *C. laccata* Scop.
20. *Collybia confluens* Pers.
21. *C. radicata* Relh.
22. *Mycena corticola* Schum.
23. *M. galericulata* Scop.
24. *M. mucor* Batsch.
25. *M. stipularis* Fr.
26. *Omphalia fibula* Bull.
27. *O. scabriuscula* Pk.
28. *Pleurotus applicatus* Batsch.
29. *Hygrophorus cantherellus* Schwein.
30. *Lactarius albidus* Pk.
31. *L. chrysorrheus* Fr.
32. *L. cilicioides* Fr.
33. *L. cinereus* Pk.
34. *L. corrugis* Pk.
35. *L. fuliginosus* Fr.
36. *L. helvus* Fr.
37. *L. hysginus* Fr.
38. *L. insulsus* Fr.
39. *L. lignyotus* Fr.
40. *L. pergamenus* (Swartz) Fr.
41. *L. piperatus* (Scop.) Fr.
42. *L. pyrogallus* (Bull.) Fr.
43. *L. rufescens* Morg.
44. *L. rufus* (Scop.) Fr.
45. *L. subdulcis* (Bull.) Fr.

46. *L. subtomentosus* B. et Rav.
47. *L. subpurpureus* Pk.
48. *L. theiogalus* (Bull.) Fr.
49. *L. torminosus* (Schæff.) Fr.
50. *L. volemus* Fr.
51. *Russula furcata* (Pers.) Fr.
52. *Cantherellus aurantiacus* Fr.
53. *C. cibarius* Fr.
54. *C. cinereus* Fr.
55. *C. floccosus* Schwein.
56. *C. infundibuliformis* (Scop.) Fr.
57. *C. minor* Pk.
58. *C. princeps* B. et C.
59. *C. wrightii* B. et C.
60. *Marasmius anomalus* Pk.
61. *M. archyropus* (Pers.) Fr.
62. *M. capillaris* Morg.
63. *M. ferrugineus* Berk.
64. *M. melanopus* Morg.
65. *M. plectophyllus* Mont.
66. *M. præacutus* Ellis.
67. *M. rotalis* B. et Br.
68. *M. salignus* Pk.
69. *M. viticola* B. et C.
70. *Lentinus lecomtei* Fr.
71. *L. lepideus* Fr.
72. *L. strigosus* Fr.
73. *Panus stipticus* (Bull.) Fr.
74. *Lenzites betulina* (Linn.) Fr.
75. *L. cookei* Berk.
76. *L. cratægi* Berk. } [illegible] probably but Daedale[illegible] Confragos[illegible]
77. *Pholiota squarrosoides* Pk.
78. *Crepidotus fulvo-tomentosus* Pk.
79. *Paxillus flavidus* Berk.
80. *Agaricus campester* Linn.

FAMILY POLYPORACEÆ.

81. *Boletus americanus* Pk.
82. *B. auriporus* Pk.
83. *B. badius* Fr.
84. *B. castaneus* Bull.
85. *B. chrysenteron* Fr.
86. *B. collinitus* Fr.
87. *B. felleus* Bull.
88. *B. flavidus* Fr.
89. *B. gracilis* Pk.
90. *B. granulatus* Linn.
91. *B. leprosus* Pk.
92. *B. purpureus* Fr.
93. *B. ravenelii* B. et C.
94. *B. retipes* B. et C.
95. *B. speciosus* Frost.
96. *B. subtomentosus* Linn.
97. *B. variegatus* Swartz.
98. *Strobilomyces strobilaceus* (Scop.) Berk.
99. *Boletinus decipiens* (B. et C.) Pk.
100. *Fistulina hepatica* Fr.
101. *Polyporus borealis* (Wahlenb.) Fr.
102. *P. dichrous* Fr.
103. *P. elegans* (Bull.) Fr.
104. *P. elegans* var nummularius (Fr.) Sacc.
105. *P. epileucus* Fr.
106. *P. flavo-virens* B. et Rav.
107. *P. fumosus* (Pers.) Fr.
108. *P. hirsutulus* Schwein.
109. *P. nivosus* Berk.
110. *P. sulphureus* (Bull.) Fr.
111. *Fomes applanatus* (Pers.) Wallr.
112. *F. carneus* Nees.
113. *F. curtisii* Berk.

114. *F. fuliginosus* Fr.
115. *F. salicinus* (Pers.) Fr.
116. *Polystictus abietinus* Fr.
117. *P. circinatus* Fr.
118. *P. decipiens* Schwein.
119. *P. lutescens* Pers.
120. *P. montagnei* Fr.
121. *P. parvulus* Klotzsch.
122. *P. pergamenus* Fr.
123. *P. perennis* (Linn.) Fr.
124. *P. sanguineus* (Linn.) Mey.
125. *P. tomentosus* Fr.
126. *P. versicolor* (Linn.) Fr.
127. *Cyclomyces greenii* Berk.
128. *Favolus canadensis* Klotzsch.
129. *F. tessellatus* Mont.

FAMILY HYDNACEÆ.

130. *Hydnum aurantiacum* Alb. et Schwein.
131. *H. adustum* Schwein.
132. *H. candidum* Schmidt.
133. *H. fragile* Fr.
134. *H. glabrescens* B. et Rav.
135. *H. gracile* Fr.
136. *H. graveolens* Delast.
137. *H. levigatum* Swartz.
138. *H. pulcherrimum* B. et C.
139. *H. repandum* Linn.
140. *H. rufescens* Pers.
141. *H. squamosum* Schæff.
142. *H. zonatum* Batsch.
143. *H. velutinum* Fr.
144. *Tremellodon gelatinosum* (Scop.) Pers.
145. *Radulum pallidum* B. et C.

FAMILY THELEPHOREÆ.

146 *Craterellus cantherellus* (Schwein.) Fr.
147. *C. cornucopioides* (Linn.) Pers.
148. *C. odoratus* Schwein.
149. *Thelephora anthocephala* Fr.
150. *T. cæspitulans* Schwein.
151. *T. cladonia* Schwein.
152. *T. dissecta* Lév.
153. *T. schweinitzii* Pk.
154. *T. sebacea* Pers.
155. *T. spectabilis* Lév.
156. *Stereum frustulosum* (Pers.) Fr.
157. *S. spadiceum* Fr.
158. *S. subpileatum* B. et C.
159. *S. versicolor* (Swartz) Fr.
160. *Hymenochæte rubiginosa* (Schr.) Lév.
161. *H. tabacina* (Sow.) Lév.
162. *H. umbrina* B. et C.
163. *Exobasidium rhododendri* Cramer. On leaves of Rhododendron maximum.

FAMILY CLAVARIACEÆ.

164. *Clavaria abietina* Pers.
165. *C. cinerea* Bull.
166. *C. cristata* Pers.
167. *C. flava* Schæff.
168. *C. fusiformis* Sowerb.
169. *C. gracilis* Pers.
170. *C. gracillima* Pk.
171. *C. grisea* Pers.
172. *C. petersii* B. et C.
173. *C. pinophila* Pk.
174. *C. tetragona* Schwein.
175. *Pterula densissima* B. et C.
176. *Typhula muscicola* (Pers.) Fr.

FAMILY TREMELLACEÆ.

177. *Dacryomyces chrysocoma* (Bull.) Tul.
178. *D. involutus* Schwein.
179. *Guepinia spathularia* (Schwein.) Fr.
180. *Hormomyces fragiformis* Cke.

ORDER GASTEROMYCETEÆ.

FAMILY PHALLACEÆ.

181. *Ithyphallus impudicus* (Linn.) Fr.

FAMILY NIDULARIACEÆ.

182. *Cyathus stercoreus* (Schwein.) De Ton.
183. *C. striatus* (Huds.) Hoffm.
184. *Crucibulum vulgare* Tul.

FAMILY LYCOPERDACEÆ.

185. *Mitremyces lutescens* Schwein.
186. *Bovista pila* B. et C.
187. *Lycoperdon calyptriforme* Berk.
188. *L. echinatum* Pk.
189. *L. gemmatum* Batsch.
190. *L. muscorum* Morg.
191. *L. perlatum* (Pers.) Fr.
192. *L. subincarnatum* Pk.
193. *L. turneri* E. et E.
194. *Scleroderma lycoperdoides* Schwein.
195. *S. verrucosum* (Bull.) Pers.
196. *S. vulgare* Hornem.

ORDER UREDINEÆ.

197. *Puccinia circææ* Pers. On Circæa alpina.
198. *P. menthæ* Pers. On Labiate species.
199. *P. tenuis* Burrill. On Eupatorium.

ORDER PHYCOMYCETEÆ

FAMILY PERONOSPORACEÆ.

200. *Plasmopara viticola* (B. et C.) Berl. et De Ton.

ORDER PYRENOMYCETEÆ.

FAMILY PERISPORIACEÆ.

201. *Microsphæra alni* (DC.) Winter. On Castanea vesca and Corylus americana.

202. *M. grossulariæ* (Wallr.) Lév.=*M. vanbruntiana* Ger. On Sambucus canadensis.

203. *M. vaccinii* C. & P. On Vaccinium.

204. *Podosphæra biuncinata* C. & P. On Hamamelis virginica.

205. *P. oxyacanthæ* (DC.) D. By. On Cratægus punctata.

FAMILY SPHÆRIACEÆ.

206. *Hypoxylon petersii* B. & C.

207. *Daldinia vernicosa* (Schwein.) Ces. et D. Not.

208. *Xylaria carniformis* Fr.

209. *X. cornu-damæ* (Schwein.) Berk.

210. *Ustulina vulgaris* Tul.

FAMILY HYPOCREACEÆ.

211. *Cordyceps militaris* (L.) Link.

212. *C. ophioglossoides* (Ehr.) Link.

213. *Hypomyces banningii* Pk. On Lactarius.

214. *H. lactifluorum* (Schwein.) Tul. On Lactarius piperatus.

215. *H. viridis* (Alb. et Schwein.) Karst. On undetermined agaric.

ORDER DISCOMYCETEÆ.

FAMILY HELVELLEÆ.

216. *Helvella macropus* (Pers.) Karst.

217. *Mitrula lutescens* B. et C.

218. *Geoglossum hirsutum* Pers.
219. *G. Walteri* Berk.
220. *Spathularia velutipes* Cke. et Farlow.

FAMILY PEZIZEÆ.

221. *Geopyxis pallidula* C. et Pk.
222. *Otidea onotica* (Pers.) Fuck.
223. *Lachnea cubensis* B. et C.
224. *L. fusicarpa* Ger.
225. *L. hirta* Schum.
226. *L. theleboloides* Alb. et Schwein.
227. *Helotium citrinum* (Hedw.) Fr.
228. *H. epiphyllum* (Pers.) Fr.
229. *Phialea scutula* (Pers.) Gill.
230. *Chlorosplenium æruginosum* (Œder.) De Not.
231. *C. tortum* (Schwein.) Fr.
232. *Phæopiza scabrosa* (Cke.) Sacc.

FAMILY BULGARIEÆ.

233. *Leotia chlorocephala* Schwein.
234. *L. lubricata* (Scop.) Pers.
235. *Ombrophila clavus* (Alb. et Schwein.) Cke.
236. *Calloria xanthostigma* (Fr.) Phill.
237. *Bulgaria inquinans* (Pers.) Fr.

ORDER MYXOMYCETEÆ.

238. *Arcyria punicea* Pers.
239. *Didymium farinaceum* Schrad.
240. *D. squamulosum* (Alb. et Schwein.) Fr.
241. *Fuligo septica* (Link) Gmel.
242. *Hemiarcyria varneyi* Rex.
243. *Leocarpus fragilis* (Dicks.) Rost.
244. *Stemonitis ferruginea* Ehrh.
245. *S. maxima* Schwein.
246. *Tilmadoche nutans* (Pers.) Rost.
247. *Trichia chrysosperma* (Bull.) DC.

ORDER HYPHOMYCETEÆ.

248. *Isaria farinosa* Fr.
249. *I. tenuipes* Pk.
250. *Zygodesmus fuscus* Corda.

ORDER SPHÆROPSIDEÆ.

251. *Phyllosticta violæ* Desm.

ORDER MELANCONINEÆ.

252 *Pestolozzia funerea* var *multiseta* Desm.

ORDER SACCHAROMYCETACEÆ.

253. *Saccharomyces pyriformis* Ward.

ORDER SCHIZOMYCETACEÆ.

254. *Bacterium vermiforme* Ward.

BOTANICAL DEPARTMENT, CORNELL UNIVERSITY,
March 12, 1893.

RECORD OF MEETINGS.

SEVENTIETH MEETING.

GERRARD HALL, September 13, 1892.

Southern Industrial Progress. Dr. William B. Phillips.

SEVENTY-FIRST MEETING.

PERSON HALL, October 18, 1892.

10. The Work of Science. Charles Baskerville.
11. Early Manufacture of Iron in North Carolina. H. B. C. Nitze.
12. Encystment of Earth-worms. H. V. Wilson.
13. Experiments on Halving Eggs. H. V. Wilson.
14. Effect of the Earth's Rotation on the Deflection of Streams. Collier Cobb.
15. Note on Traps and Sandstone in the Neighborhood of Chapel Hill. Collier Cobb.

SEVENTY-SECOND MEETING.

PERSON HALL, November 15, 1892.

16. A New Secondary Cell. J. W. Gore.

17. Some Curious Products from the Willson Aluminum Works. F. P. Venable.

18. On the Production of an Animal Without Any Maternal Characteristics. H. V. Wilson.

SEVENTY-THIRD MEETING.

PERSON HALL, December 6, 1892.

19. Work of the N. C. Geological Survey. J. A. Holmes.

20. Cerebral Localization. R. H. Whitehead.

The following officers were elected for 1893:

President	PROF. J. A. HOLMES	Chapel Hill.
First Vice-President	PROF. H. L. SMITH	Davidson.
Second Vice-President	PROF. J. W. GORE	Chapel Hill.
Librarian	PROF. COLLIER COBB	Chapel Hill.
Secretary and Treasurer	PROF. F. P. VENABLE	Chapel Hill.

The Secretary reported 1,170 books and pamphlets received during the year, making the total number 9,948.

Two new members were also reported: Prof. Stedman, Trinity College; Prof. Bandy, Trinity College.

REPORT OF TREASURER FOR 1892.

By balance from 1891	$ 40 02	
By fees for 1892	64 50	
By contributions	100 00	
By sales of Journals	1 50	
	$206 02	
To postage		$ 15 65
To engraving		10 82
To express		2 75
To printing		193 00
		$222 22
Deficit		$ 15 80

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY,

VOLUME X—PART FIRST.

JANUARY—JUNE.

1893.

POST-OFFICE:

CHAPEL HILL, N. C.

E. M. UZZELL, STEAM PRINTER AND BINDER,

RALEIGH, N. C.

1893.

OFFICERS.

1893.

PRESIDENT:

JOSEPH A. HOLMES, - - - - - - - - Chapel Hill, N. C.

FIRST VICE-PRESIDENT:

H. L. SMITH, - - - - - - - - - - Davidson, N. C.

SECOND VICE-PRESIDENT:

J. W. GORE, - - - - - - - - - - Chapel Hill, N. C.

LIBRARIAN:

COLLIER COBB, - - - - - - - - - Chapel Hill, N. C.

SECRETARY AND TREASURER:

F. P. VENABLE, - - - - - - - - - Chapel Hill, N. C.

LIBRARY AND PLACE OF MEETING:

CHAPEL HILL, N. C.

3

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

NOTES ON THE FOREST RESOURCES OF NORTH CAROLINA.

BY W. W. ASHE.

BOTANIC DIVISIONS.

North Carolina can be divided topographically into three fairly well-marked divisions:

1. An eastern or coastal plain region, extending inland from the coast a distance of one hundred to one hundred and fifty miles and having an aggregate area approximating 24,000 square miles. Its surface is that of a gently undulating plain of less elevation (ten to twenty feet above sea-level) and a more nearly level surface eastward, and becoming more elevated (three hundred to five hundred feet) and rolling along its western border. Its soil is generally a sandy loam or sand, though in limited areas clay predominates. In the more eastern portion of this region are numerous extensive swamps or marsh areas surrounding small lakes or bordering the streams. In some of these the soil is mainly an admixture of sand and vegetable mold, while in others it is a fertile loam. In this district the normal annual temperature is about 61° F., and the normal annual rain-fall about fifty-five inches.

2. A middle district, which extends westward to the Blue Ridge, two hundred miles beyond the coastal plain, and extends across the State parallel to it, having an area of about 22,000 square miles. In the east it is rolling, but towards the western border is rugged and hilly, and in places even mountainous, being penetrated by mountain spurs from the Blue Ridge. It has an average altitude of eight hundred and fifty to nine hundred feet, but rises at its highest peaks to a little over 3,000 feet, while along its extreme eastern border it is not over four hundred to five hundred feet. On the uplands the soil may be classed in general terms as a loam, which becomes sandy in some places and clayey in others. Along the streams there is usually a rich, dark-colored loam with an admixture of humus. This region has an average temperature of about 58.5° or 59° F., and an annual rain-fall of about fifty inches.

3. The western district is an elevated, mountainous region, with an average altitude of 3,500 feet, but rising (at Mt. Mitchell) to 6,711 feet. This region includes the Blue Ridge, which forms its general eastern boundary, and the Great Smoky Mountains, which border it on the west. Numerous cross ridges, separated by irregular valleys, connect these two mountain ranges. The area of the region is about 6,000 square miles. Though the mountain slopes are often steep, and the valleys quite narrow, the soil is exceedingly fertile, being a loam generally rich in organic matter. The average temperature for the counties of this western district probably approximate 50° F., varying from 57.8° at Hot Springs to an estimated temperature for the top of Mt. Mitchell of less than 38°,* and the normal annual precipitation is about fifty-seven inches.

There are three fairly well-marked botanic divisions coin-

---

*_Climatology of North Carolina_—N. C. Agr. Exp. Sta. Report. Raleigh, 1892; p. 166.

ciding in general with these topographic districts. The lower botanic division, however, extends a few miles west of the sandy coastal plain boundary line, and the third botanic division begins in the damp "coves" and the higher mountain spurs lying just east and south-east of the Blue Ridge.

It must not be inferred from the above statement that these botanic divisions are separated by any sharp lines on the two sides of which radically different conditions of soil and climate and vegetation exist, for while there are certain places where these conditions do change abruptly, generally such is not the case; but, on the contrary, these divisions are separated by what may be called transition zones, in which the conditions of the two adjacent regions commingle to a greater or less degree. Thus in the following counties we find transition conditions between the eastern and middle districts: Northampton, Warren, Vance, Franklin, Durham, Wake, Chatham, Moore, Montgomery, Richmond and Anson. And the tier of counties just east of the Blue Ridge may be regarded as the transition zone between the western and middle botanic districts. Here in the valleys we find physical conditions and plants such as characterize the middle district, and on the slopes of the higher ridges are found a climate and vegetation much like those of the mountain district.

These differences in topography and elevation, with accompanying differences in soil, corresponding in a general way to geological formations, have given this State a wonderful variety of woods, and have placed in juxtaposition trees normally separated by many degrees of latitude. Thus are found in North Carolina eight species of pines out of the thirteen given in the Tenth United States Census Report as occuring in the United States east of the Mississippi River; twenty oaks out of twenty-three; all of the six maples; three elms out of four; all seven magnolias;

five hickories out of eight, and four out of the six species of ash.

Eastern District.—The eastern or lower district, having its climate tempered by the near approach of the gulf-stream, has a decided southern or subtropical flora, as pronounced in the larger forest growth as among minor plants. The trees confined to this district, or but slightly entering the others, are: *Magnolia grandiflora L.** (Magnolia); *M. glauca L.* (Sweet Bay); *Prunus Caroliniana Ait.* (Mock Orange); *Bumelia lycioides Gært.; Gordonia Lasianthus L.* (Bull Bay); *Nyssa aquatica L.* (Black Gum); *N. uniflora Walt.* (Tupelo Gum); *Tilia pubescens Ait.* (Linn.); *Carya aquatica Nutt.; Planera aquatica Gmel.* (Planer Tree); *Quercus laurifolia Michx.* (Laurel Oak); *Q. cinera Michx.* (High Ground Willow Oak); *Q. virens Ait.* (Live Oak); *Q. aquatica Walter* (Water Oak); *Q. Catesbæi Michx.* (Turkey Oak); *Q. macrocarpa Michx.* (Mossy Cup Oak); *Q. lyrata Walt.* (Over Cup Oak); *Q. Michauxii Nutt.* (Swamp White Oak); *Pinus Australis Michx.* (Long-leaved Pine); *P. Taeda Linn.* (Rosemary, Loblolly, or Short-leaved Pine); *P. serotina Michx.* (Pond Pine or Savannah Pine); *Chamæcyparis sphæroidea Spach.* (Juniper or White Cedar); *Taxodium distichum Rich.* (Cypress); *Sabal Palmetto Todd.* (Palmetto).

Middle District.—In the middle section the prevailing growth is the hickories, oaks, elms, and short-leaved pines, common to all the Atlantic States, and these extend into the other sections and enter largely into the composition of their forests. The common trees through this district are *Magnolia umbrella Lam.* (Umbrella Tree); *Asimina triloba Dunal.* (Papaw); *Liriodendron Tulipifera L.* (Yellow Poplar); *Amelanchier Canadensis L.* (Sarvice);

*The names used in this paper are, with few exceptions, those given in Curtis' *Woody Plants of North Carolina;* Raleigh, 1860.

Cornus florida L. (Dogwood); *Gleditschia triacanthos L.* (Honey Locust); *Acer dasycarpum Ehrh.* (Silver Maple); *A. rubrum L.* (Red or Swamp Maple); *Negundo aceroides Mœnch.* (Box Elder); *Ilex opaca Ait.* (Holly); *Oxydendrum arboreum D. C.* (Sour Wood); *Nyssa multiflora Wang.* (Black Gum); *Diospyrus Virginiana L.* (Persimmon); *Fraxinus Americana L.* (White Ash); *F. pubescens Lam.* (Red Ash); *F. viridis Michx.* (Green Ash); *Sassafras officinalle Nees.* (Sassafras); *Platanus occidentalis L.* (Sycamore); *Ulmus fulva Michx.* (Slippery Elm); *U. Americana L.* (Elm); *U. alata Michx.* (Winged Elm or Wahoo); *Carya alba Nutt.* (Shell-bark Hickory); *C. tomentosa Nutt.* (Hickory); *C. glabra Torr.* (Pig Nut); *C. microcarpa Nutt.; Juglans nigra L.* (Black Walnut); *Quercus phellos L.* (Willow Oak); *Q. nigra L.* (Black Jack); *Q. tinctoria Barr.* (Black Oak); *Q. coccinea Wang.* (Scarlet Oak); *Q. falcata Michx.* (Spanish Oak); *Q. obtusiloba Michx.* (Post Oak); *Q. alba L.* (White Oak); *Fagus ferruginea Ait.* (Beech); *Carpinus Americana Michx.* (Hornbeam); *Ostrya Virginica Willd.* (Iron Wood, Hop Hornbeam or Water Beech); *Betula nigra L.* (Black Birch); *Salix nigra Mars.* (Willow); *Populus angulata Ait.* (Cotton Wood); *P. heterophylla L.*, *P. monilifera Ait.*, *Pinus mitis Michx.* (Short-leaved Pine); *P. rigida Mill.* (Pitch Pine); *Juniperus Virginiana L.* (Red Cedar).

MOUNTAIN DISTRICT.—In this district occur, as characteristic forest trees: *Magnolia acuminata L.* (Cucumber); *M. macrophylla Michx.* (Magnolia); *M. Frazeri Walt.* (Wahoo); *Prunus serotina Ehrh.* (Wild Cherry); *Robinia Pseudacacia L.* (Locust); *R. viscosa Vent.* (Clammy Locust); *Cladrastis tinctoria Raf.* (Yellow Wood); *Ilex monticola Gray; Fraxinus Americana Linn.* (White Ash); *Æsculus flava Ait.* (Buckeye); *Tilia Americana L.* (Linn.); *T. heterophylla Vent.* (Linn.); *Halesia tetraptera L.* (Snow-drop Tree); *Stuartia pentagyna L'Her.; Betula lutea Michx.*

(Yellow Birch); *B. lenta L.* (Sweet Birch); *Quercus imbricaria Michx.* (Water Oak); *Q. rubra L.* (Red Oak); *Q. prinus L.* (Chestnut Oak); *Castanea vesca L.* (Chestnut); *Populus grandidentata Michx.* (Aspen); *Pinus pungens Michx.* (Table Mountain Pine); *P. Strobus L.* (White Pine); *Abies Fraseri Lindl.* (Balsam Fir or She Balsam); *Tsuga Canadensis Carr.* (Hemlock); *T. Caroliniana Engel.* (Hemlock); *Picea nigra Link.* (Black Spruce or He Balsam).

In addition to the above there are to be found in one or more of the botanical divisions of the State over two hundred minor trees, shrubs and vines of more or less value for fruit culture or floriculture, etc. There are four species of grape (*Vitis aestivalis, V. labrusca, V. vulpina, V. cordifolia*), from the first three of which cultivated varieties have sprung. There are also found in these several sections of the State several hundred herbs, various parts of which are extensively used for medicinal purposes, a discussion of the more important of which will appear in a future number of the JOURNAL.

ECONOMIC WOODS.

In the above statement a small number of the trees named as occurring in the different regions have timber of but little value, owing to a lack of strength and durability, and are of such small size as to have little economic value, and there are a few others of such infrequent occurrence as to be commercially unimportant. But in each region there are many valuable forest trees, and the following notes will contain a brief statement of their distribution, abundance, size, and uses:

Magnolia acuminata L. (Cucumber): Two to four feet in diameter, eighty to one hundred and twenty feet high. Frequent in the upper district with Yellow Poplar. Not over 5,000,000 feet standing in the fifteen counties through which its distributiou extends. Has the same use as Yellow Poplar.

M. Fraseri Walt. (Wahoo) is a small tree, one to two feet in diameter. Very common in western district; used medicinally, rarely for lumber; very ornamental.

Liriodendron Tulipifera L. (Yellow Poplar): Four to eight feet in diameter, one hundred to one hundred and twenty feet high. Occurs in all districts; very common in western. Lumber is used in building very extensively, for interior wood-work and cheap furniture. The chief bodies standing are in Watauga, Yancey, Mitchell, Swain, northern Graham, Macon, Jackson, Transylvania, Wilkes and Alleghany. Altogether there is 50,000,000 feet of poplar lumber in these counties. The trees have been removed adjacent to the large rivers and around towns, as it is the building material of this section. Still abundant in the western tier of the midland counties, except along the railroads.

Tilia Americana L. (Linn.): A middle-sized tree, frequent in the higher mountains and mixed with *T. heterophylla Vent.* (Linn.), which is very common throughout the mountains, except around thick settlements, where it has been cut in winter, so cattle could feed upon its buds. Very abundant in Swain, Jackson, Macon, Transylvania, Yancey, Mitchell, Watauga and Ashe. The wood is light, soft and white; rarely sawn for ceiling. It is useful for making paper.

T. pubescens Ait. (Linn.): Very frequent in rich alluvial places along the coast. Same uses and character as the above species, but smaller.

Æsculus flava Ait. (Buckeye): Very abundant as a large tree on damp soil throughout the mountain district. It is not used commercially except around Bryson City, Swain county, where it is manufactured into excelsior.

Acer saccharhinum Wang. (Sugar Maple or Sugar Tree): Very common throughout all mountain counties, where it reaches a height of ninety to one hundred feet and a diameter of three to four feet; and it is found also in the swamps of Pender and Onslow and in low grounds of other eastern counties. It has been cut to a small extent for flooring and furniture, and in the northern counties small quantities of sugar are made from the sap.

A. dasycarpum Ehrh. (White or Silver Maple): A small tree, rarely more than two feet in diameter, sparsely distributed in all portions of the State, usually in moist places; more abundant in the mountain counties.

A. rubrum L. (Red or Swamp Maple): Tree two to three feet through and rarely sawn, and then for ceiling; abundant, especially in moist places, in all portions of the State.

Robinia Pseudacacia L. (Yellow Locust): Once very common through the mountain counties, though it has been very largely used up for posts in thickly settled regions. It is still widely distributed and abundant in Rutherford, Polk and other south-western counties, and occurs sparingly in the middle district. In Haywood and Swain there are factories making from it insulating pins for telegraph poles. The trees are one and one-half to two and one-half feet in diameter; sixty to eighty feet high. The wood is yellow, hard, and resists exposure and decay.

Cladrastis tinctoria Raf. (Yellow Wood): A small tree, one and one-half feet in diameter; forty to sixty feet high, with a deep yellow hard wood; it is mostly confined to rich "coves" of Graham, Macon, Clay and Cherokee counties, but is very frequent through these. It has been used in Cherokee county for making furniture.

Prunus serotina Ehrh. (Wild Cherry): Occurs all over the State, but only in the mountain counties does it reach sufficient size and abundance to become a valuable timber tree. There in rich, cold "coves" it becomes a tree two to four feet in diameter and eighty to one hundred feet high. It is a fine-grained, medium hard, red wood, taking a fine polish; largely used for furniture and interior work of all kinds, and is one of the first trees removed, when easily accessible, on account of its high value. Large quantities of it still remain in certain regions, as in the north-western part of Ashe county and around Grandfather, Beech and Roan mountains. About the head-waters of Caney river there are probably 1,000,000 feet standing; in north Swain, especially on Ocona-Lufty River, about 3,000,000 to 4,000,-000 feet; small quantities are found in other mountain regions; and in the north "coves" of the east slope of the Blue Ridge there is still some cherry timber remaining.

Amelanchier Canadensis L. (Sarvice): Occurs abundantly in the mountains, where it is a small tree, and is used there in turneries in some of the towns.

Hamamelis Virginica L. (Witch Hazel): A shrub or small tree, very common throughout the middle and upper districts. It is use medicinally.

Liquidambar Styracifolia L. (Red or Sweet Gum) is common throughout the middle and lower districts, becoming in the swamps and low grounds of the latter a very large tree, four to five feet in diameter and ninety to one hundred feet high. It forms with cypress and black gum about one-half of the growth of the deeper swamps in many portions of the eastern counties, and has been cut out in only a few places, as around Bladenboro, Wilmington, Newbern, Goldsboro, Hub, and in limited portions of Northampton, Perquimans, Pasquotank and Camden counties. The wood is hard and heavy, fine-grained, red; used for furniture.

Cornus florida L. (Dogwood) is common over the whole State. It is a small tree, with hard, compact, white wood; has been largely removed in many portions of the middle district, around larger towns, for shuttle-blocks, etc.

Nyssa multiflora Wang. (Black Gum): A middle-sized tree, found all over the State, in all soils. Its wood is very compact, with fibers interwoven, and is rarely used, except occasionally for hubs, mallets, etc.

N. aquatica L. (Black Gum) is a very large tree, four to five feet in diameter, common throughout deep swamps of the lower district. The wood and its uses are much the same as *N. multiflora.*

Nyssa uniflora Walt. (Tupelo Gum): A medium-sized tree, common in deep swamps in the section along and south of Neuse river. Its wood is very light, white, but with fibers interwoven as in the other species, and hence is very difficult to split, tasteless; used for wooden-ware of all kinds. Very little has been removed and only in a few counties.

Oxydendrum arboreum D. C. (Sour Wood) is a small tree, very common through mountains and the middle district. Its wood is firm, fine-grained and of reddish color, and is being used for making certain parts of furniture—chair rounds and legs, newel posts, balisters, etc.

Kalmia latifolia L. (Ivy): A large shrub, very common in mountains, growing generally in dense thickets; its matted roots, forming large "stools or burls," are gotten out around Cranberry, Elk Park, Magnetic City, and in several counties south of the French Broad river, and used for making tobacco pipes, handles, etc., and the branches are used for rustic furniture. The wood is hard and fine-grained.

Ilex opaca Ait. (Holly) is a small tree one to two and one-half feet in diameter; common in wet, sandy soils of lower district, but found also in the other districts. The wood is very fine-grained and white; it has been largely removed in the north-east counties, but has not been touched in the south-eastern counties.

Diospyros Virginiana L. (Persimmon): A small tree with very hard, tough wood. It is common through the eastern and middle counties, but has been largely removed from Wilkes, Surry, Caldwell, McDowell, Lincoln, Catawba, Guilford, Forsyth and Union counties, being used in the manufacture of shuttle-blocks.

Fraxinus Americana L. (White Ash) was once common in wet or damp places over the entire State. A large tree two to four feet in diameter and eighty to one hundred feet high. Its wood is white, very elastic, and strong; and in the western counties it is used for making wagons, furniture, and especially the curled wood. In the eastern counties it is used for oars, barrel heads, and lumber. In the middle district it is used for making paper and lumber and furniture. It has largely been removed from the following mountain counties: Ashe, west Yancey, south Madison, Buncombe, Haywood, north Jackson and north Macon, Graham (except along Tuskeegee creek), Cherokee and Henderson. Has been removed in middle district when accessible to railroads and larger streams.

F. platycarpa Michx. (Water Ash) is abundant in many of the larger swamps of lower district, to which it is confined. The counties of Pender, Sampson, Hyde and Pamlico still have very large bodies, but it has been removed where turpentine orchards have been worked.

F. viridis Michx. (Green Ash) and *F. pubescens Lam.* (Red Ash) are middle-sized trees, found only in middle district and used for lumber and making paper. Along lines of transportation they have been largely removed, but in inaccessible places they are still abundant.

Carya alba Nutt. (Shag-bark Hickory) is frequent in the middle and upper districts.

C. amara Nutt. (Bitter-nut Hickory) is common in wet places in the upper districts.

C. glabra Torr. (Pig-nut Hickory) abounds in dry soils in all portions of the State.

C. tomentosa Nutt. (Common Hickory) is very common in dry soils through the lower and middle districts.

All of these hickories have been cut away, more or less, around towns for fire-wood, and for the manufacture of spokes, handles, and wagon material, especially around large towns in the middle district.

Juglans nigra L. (Black Walnut) is largely removed in all mountain counties, except Wilkes and Madison and in a few other counties where it has been especially preserved on limited areas; and in neither of these counties is it very abundant, though there are many trees of large size. It is also found occasionally in many counties of the middle and lower districts, at a distance from means of transportation, but it is there a tree of medium size.

J. cinera L. (Butter Nut) is frequent in most mountain counties and extends but a short distance below the mountains. The curly wood is used for furniture and interior finish.

Quercus alba L. (White Oak) and *Q. obtusiloba Michx.* (Post Oak) are common over the whole State except in the extreme east, although they have been largely removed in middle district for fuel, cross-ties, wagon material, staves and lumber. But large quantities yet remain, and a vigorous second growth of equal density and strength to the original is coming on, so that it appears that there will be an abundance of both at all times over the larger part of the State.

Q. Tinctoria Bartr. (Black Oak), *Q. coccinea Wang.* (Scarlet Oak), and *Q. falcata Michx.* (Spanish Oak) are all most abundant in the middle district on dry soil. They are generally not used where good white oak can be obtained; rarely used for staves and wagon material; more frequently for fence rails, furniture and clap-boards.

Q. macrocarpa Michx. (Mossy-cup Oak), *Q. Lyrata Walt.* (Over-cup Oak), and *Q. Michauxii Nutt.* (Swamp White Oak) all occur in swamps of the eastern section, and where contiguous to large turpentine orchards have been used for staves, and they are also used to some extent for rails, clap-boards, etc.

Q. laurifolia Michx. (Laurel Oak) and *Q. aquatica Cates.* (Water Oak) are trees still very common in lower districts, where they are rarely used, except for rails, the timber being open and porous.

Q. Rubra L. (Red Oak) occurs in the cool, fertile soils of the middle and mountain districts, and sparingly in the eastern counties. It reaches, under favorable conditions, a diameter of four feet and a height of seventy to eighty feet; the wood is reddish, open, and rather coarse grain, but strong, and is used extensively for clap-boards, cooperage, and articles of furniture.

Q. imbricaria Michx. (Water Oak, Laurel Oak or Shingle Oak) is infrequent, occurring only in counties west of the Blue Ridge; a medium size tree, with rather open, porous wood, rarely used, where better material can be obtained, for clap-boards, staves, etc.

Q. Prinus L. (Chestnut Oak) is common on dry ridges through mountain and more elevated parts of the middle section. It is used for furniture, wagon material, and the bark is used for tanning. It has been largely removed around Cranbury, Asheville and Morganton.

Castanea vesca L. (Chestnut) is very abundant through all mountain regions and is found sparingly in some of the Piedmont counties, though the best trees have in many places been removed for rails. It is sawn for lumber at Dillsboro and Asheville, and has been removed largely from Graham, Ashe and Buncombe counties.

Populus grandidentata Michx. (Poplar), *P. heterophylla L.* (Cotton Wood), *P. angulata Ait.* (Cotton Wood), and *P. monilifera L.* (Cotton Wood): All except the first occur frequently in lower or middle districts, though in the neighborhood of turpentine orchards they have been used for making barrel heads. The first named species is confined to the upper part of the middle district.

Of the eight pines occurring in this State five are of the first economic importance. They are *Pinus Strobus L.* (White Pine), *P. australis Michx.* (Long-leaved Pine), *P. Taeda L.* (Short-leaved or Old Field Pine), *P. rigida Mill.* (Black Pine), and *P. mitis Michx.* (Short-leaved or Yellow Pine). *P. serotina Michx.* is very rarely used. *P. pungens* and *P. inops Ait* are practically worthless for timber purposes.

P. Strobus L. (White Pine) extends in a narrow belt along the Blue Ridge from southern Ashe to Macon, also occurs in Graham, north Haywood, and adjacent parts of Madison, and in northern Madison and western Mitchell. It is locally used for shingles. Has been removed only around Marion, in parts of Jackson, Transylvania and Macon counties.

P. australis Michx. (Long-leaved or Turpentine Pine) extends over a large part of the sandy land of the lower district, but occurs only sparingly north of Roanoke river and west of Wake and Richmond counties. It formerly existed as a pure forest over the sandy lands of this area. But the inroads which have been made through it for the past century to supply naval store products, ship timber and building material have removed or destroyed most of the forest adjacent to the railroads and immediately along the larger water courses. The largest bodies still standing are in Montgomery, Sampson, Robeson, Harnett, Cumberland, Johnston and Richmond counties. Large bodies of virgin pine forest are rare except along the extreme western border of the pine belt.

P. Taeda L. (Rosemary, Loblolly, Short-leaved or Old Field Pine) is found over the whole of the eastern district, but growing originally on wet clay lands and often forming considerable clumps in small swamps. When the long-leaved pine is removed this species takes its place on the sandy land and is there called old field pine. In its original growth in swampy places it is decidedly the largest pine in the State, having a height of one hundred to one hundred and twenty feet and a diameter of from three to five feet. Here it has a fine, even grain, heart very large, with but little resin, and a strong, durable wood. The high price paid for large stocks for ship material causes its removal where accessible, even in advance of *P. australis;* but it is still abundant where transportation facilities at present are not suitable for its removal. Its second growth on dry, sandy land is a smaller tree, sappy, with very coarse grain, and little or no heart, the wood decaying rapidly on exposure; but as it makes a beautiful wood for interior finish it is largely sawn around large towns and kiln-dried for that use. The general character of the trees growing on dry, sandy soils is so different from that of those growing about the wet lands that the two trees are usually (though erroneously) believed by lumbermen to belong to different species.

P. serotina Michx. is common over wet lands in the southeast counties and is sometimes sawn with *P. Taeda;* but the lumber is gummy and of poor quality.

P. mitis Michx. (Short-leaved or Yellow Pine), formerly common over the whole area of the middle district and extends through the southern part of the mountain district, being mixed with deciduous trees. It has been largely removed for lumber around the larger towns and thick settlements, and along the lines of the railways; and through Catawba, Lincoln and Gaston counties large quantities of it have been cut and used for making charcoal. Wilkes, Caldwell, Alexander and Rutherford counties contain the finest bodies of this timber to be found in the middle district. This tree frequently reaches two to three feet in diameter and seventy to eighty feet high.

P. rigida Mill. (Black or Pitch Pine) is a tree slightly smaller than the preceding and making inferior lumber, but largely used along with it. Surry, Wilkes, Caldwell, Burke, McDowell and Polk counties contain the larger part of what is known to occur east of the Blue Ridge; but there is also a great deal in the mountain counties south of the French Broad river.

Tsuga Canadensis Carr. (Hemlock) is a large tree; abundant in moist regions through nearly all of the mountain counties. It has only been removed in northern Mitchell, where it has been barked for tanning purposes, and along the Little Tennessee river.

T. Caroliniana Engel. (Hemlock) is frequent on ridges along the Blue Ridge from eastern Ashe to Macon. It has been cut in only a few localities, for frames for houses, etc.

Picea nigra Link. (Black Spruce or He Balsam) forms twenty square miles of virgin forest in Watauga, Mitchell, Yancey, Haywood and Swain counties. Has been cut only in some places about Roan mountain. It is a tree of three feet in diameter and sixty to ninety feet high.

Abies Fraseri Lindl. (Balsam, or She Balsam) covers the summit of the highest mountain peaks.

Chamæcyparis sphæroidea Spach. (Juniper or White Cedar) occurs in many of the large swamps in the eastern district, especially in Harnett, Tyrrell, Gates and most of the other extreme eastern and north-eastern counties. It has been largely removed from Pasquotank, Perquimans and Camden counties, and about the larger eastern towns. It is a medium-sized tree and is very valuable for making pails, tanks, boats, shingles, etc., for which purposes it is largely used.

Taxodium distichum Rich. (Cypress) occurs abundantly in the swamps of the eastern section. It has been worked up around larger towns and in the north-eastern counties of Currituck, Perquimans, Hertford and Camden. It is a very large tree, four to five feet through and from eighty to more than one hundred feet high. Its wood is light, and is used largely for lumber, shingles and boats, and to a small extent for furniture.

Sabal Palmetto Lodd. (Palmetto) occurs somewhat abundantly on Smith's Island, at the mouth of the Cape Fear river. It is a small tree about one foot in diameter and thirty or forty feet high. It has been found to serve an excellent purpose for piling, and this is about the only use to which it has been put.

Juniperus Virginiana L. (Red Cedar) is a common but rather small tree throughout the State, but most abundant in the south-eastern counties. It is used mainly for boxes and posts.

TRANSPORTATION FACILITIES.—Railroads penetrate the State in every direction, there being but few counties which are not touched by them. For marine shipment material from all north-eastern counties goes readily by way of Norfolk. For counties drained by the Tar and Neuse New-bern is the natural shipping point, while for the whole southern and central sections Wilmington is the central point, vessels drawing over twenty feet being able to enter its harbor.

ACCESSIBILITY OF EXISTING FORESTS.—While there is no large body of timber in the State valueless on account of its inaccessibility, there are many so situated that removal is not feasible with the existing means of transportation. But the experience of the past ten years is sufficient to prove that these large bodies of virgin forests to be found in the State will be penetrated by railroads in the near future, as the demand for the timber increases. The hard wood forests in some of the counties west of the Blue Ridge are naturally tributary to Tennessee, and the timber in the form of logs is being removed by floating down the creeks and rivers with the aid of flood dams. Many of these mountain streams are of sufficient size and rapidity to afford ample means for logging. East of the Blue Ridge tracts not adjacent to large streams or railroads are being reached by short timber roads. A number of such roads are now in operation and others are being constructed. In the eastern district, on pine lands where the country is flat, wooden and iron tramways are laid to be operated by horse-power or narrow guage steam engines. In the eastern swamps, to get at the cypress, white cedar and other trees, the plan adopted by larger companies is to dig canals by hand or with dredges parallel to the drainage streams of the swamps. The logs are floated through these canals to some central point and there worked up.

FOREST MANAGEMENT.

Up to within the past few years forest management in North Carolina was deemed quite a useless business, but lately prudent individuals have placed large estates under foresters, one of whom was trained in European schools of forestry. As yet, however, this is little more than an experiment.

During the past two years the North Carolina Geological Survey has made a careful examination of the forests of the State with a view to the inauguration of modern methods of forest management, and the securing of such laws as will best encourage forest protection and improvement.

During the present year (1893) the Survey, recognizing the fact that the long-leaved pine (*P. palustris Miller, or P. australis Michx.*), a most valuable tree in this State, does not, under the existing conditions, extensively reproduce itself, has begun an examination of the causes operating against its increase and means by which it can be planted and economically cultivated, so as to make use of the waste lands formerly entirely occupied by this tree but now barren or covered with the loblolly pine (*Pinus Tadea L.*). Experiments are now under way for the purpose of determining the relative fertility of its seed as compared with those of other pines; causes why other species are so widely disseminated over cleared lands, while the long-leaved pine does not appear to be so; methods of planting, raising and protecting young pines; insects and fungous enemies, and the damage done to the young pines by hogs, cattle, fires, etc.

WOOD-WORKING ESTABLISHMENTS.

A few facts, taken largely from the "Hand-Book" of North Carolina,* concerning wood-working establishments should be stated in this connection. Although little of the lumber sawn in North Carolina, other than for buildings, is worked up in the State, yet the number of wood-working factories is constantly on the increase. The most numerous concerns are manufactories of carriages and buggies. "Of these Alamance county has two, Alexander two, Ashe one, Beaufort one, Bertie three, Caldwell one, Chatham one, Cleveland one, Cumberland two, Davidson two, Durham one, Forsyth six, Gates two, Guilford two, Haywood one, Halifax one, Hertford three, Lenoir two, Lincoln two, Moore two, Pasquotank one, Randolph two, Sampson two, Vance one, Wake one, Warren three, Washington three, Wilkes two, Wilson one, Yadkin four—in all fifty-eight, established in thirty out of the ninety-six counties of the State, and representing every section in it. Among them there is wide range of excellence, defined and governed largely by experience and time. Many of them are new, the product of the new industrial revolution. A few are old and are meritorious, not only for the character of the work done by them, but because of the courage and foresight which gave them existence far in advance of similar enterprises in the State.

"Not less important, and of much wider application, is the manufacture of wagons, carts, etc., conducted by thirty-two different establishments in almost the same number of counties, as follows: Alamance has one, Alexander two, Anson three, Cabarrus one, Caldwell one, Catawba one,

---

**Hand-Book of North Carolina*—Raleigh, 1893, pp. 273–275.

Clay one, Cleveland one, Cumberland two, Pamlico one, Pender one, Rutherford one, Surry one, Stanly one, Wake three, Yadkin one. One of the largest of these is at Waughtown, near Winston-Salem, founded in 1834. Another large one is at Hickory."

"Of furniture factories, there are twenty-five, of which one is in Ashe, three in Buncombe, one in Davie, two in Forsyth, one in Gaston, two in Guilford, one in Henderson, three in Lincoln, one in Macon, one in Martin, one in Mecklenburg, one in Montgomery, one in Moore, two in Rowan, one in Surry, one in Wake, one in Wayne, and one in Yadkin.

"For the making of hubs, spokes, and handles there are six factories, viz.: Bertie has one, Guilford one, Mecklenburg one, Montgomery one, Rowan one, Rutherford one.

"Of sash, door and blind factories there are twenty-four, viz.: Buncombe has two, Burke one, Cabarrus one, Caldwell one, Catawba two, Davidson two, Durham one, Forsyth one, Gaston one, Guilford three, Johnston one, Rowan three, Stanly one, Surry one, Wake two, Wilkes one.

"Of another variety of wood-working factories is that at Newbern for the manufacture of plates and dishes made out of sweet-gum, and also berry baskets.

"At Wilmington a somewhat similar establishment was operated by steam and employed one hundred and twenty-five people. The material chiefly used is gum logs, and the product is butter plates and baskets, berry baskets and crates.

"Of the other simpler and ruder establishments for the conversion of the product of the forest there are, as nearly as can be ascertained, in operation in the State one hundred and fourteen steam saw-mills, eighty turpentine distilleries (undoubtedly below the actual number); and, as largely connected with the products of the forest, a very large number of tanneries, the best and largest equipped of which is the one at Morganton, constructed and conducted on the most advanced scientific application of theory to intelligent practice.

"In connection with paper manufacture it may be said that originally using only the waste of textile fabrics, the immensely increased consumption of paper demanded other raw material, for the supply of which human ingenuity was heavily taxed. The additional material has been found in wood-pulp, mechanically or chemically prepared. The abundance in North Carolina of soft woods suitable for such purposes has led largely to the combination of wood-pulp with cotton, flaxen and hempen fiber; and the factories now in operation in the State are able to supply as good a material for book, printing and wrapping paper as can be made elsewhere. There are three principal paper-mills in North Carolina—that at Salem, in Forsyth county, at Falls of the Neuse, in Wake county, and at Long Shoals, in Lincoln. The product of these mills is bristol-board, writing paper, book and newspaper, and wrapping paper of all kinds."

NOTE.—On page 6, six lines from the bottom, "approximate" should read approximates. And on page 11, eleven lines from the top, "50,000,000" should be 500,000,000.

NOTES ON THE DEFLECTIVE EFFECT OF THE EARTH'S ROTATION AS SHOWN IN STREAMS.

BY COLLIER COBB.

So early as 1837, Poisson produced his general equations for determining the influence of the earth's attraction and rotation on the apparent motion of a projectile, and he applied them to the case of a material point constrained to move on a given curve and attached to the surface of the earth, omitting the effects of friction and the resistance of the air.

In 1859, Ferrel published in *Runkle's Mathematical Monthly* his celebrated paper on the *Motions of Fluids and Solids on the Earth's Surface*, in which he stated that, "In whatsoever direction a body moves on the surface of the earth, there is a force arising from the earth's rotation which deflects it to the right in the northern hemisphere, but to the left in the southern."

Karl E. von Baer, in a paper, *Ueber ein allgemeines Gesetz in der Gestaltung der Flussbetten*, published in the bulletin of the Imperial Academy of Sciences of St. Petersburg, in 1860, showed that the observed changes of position in streams might be explained as a consequence of the earth's rotation; yet the makers of our scientific text-books have not taken the pains to give a correct, or rather, a complete, statement of the true value of this deflective force. Dana states it clearly and correctly in his Manual of Geology;* but Geikie† speaks of it as an *easterly*, a *westerly* deflection, seeming to regard it as a getting left behind, and the same expression is used by Reclus‡ in speaking of the rivers of Gers.

Von Baer's explanation does not account for the fact that

* Third edition, p. 650. † Third edition, 1893, pp. 15, 16. ‡ *La France*, pp. 115, 116.

rivers flowing east or west have their banks worn away in the same manner as those flowing north or south. A body at rest upon the earth, and free to move in any direction upon it, "is maintained in equilibrium by attraction directed towards the earth's center, and centrifugal force directed away from the axis. If the centrifugal force ceased, the body would evidently move towards the nearest pole as down a hill. From the poles to the equator may therefore be regarded as uphill—bodies free to move being prevented from going down towards the poles by centrifugal force. Suppose now a body to move from west to east—that is, in the same direction as the earth revolves; the centrifugal force of the body is increased, and there is a tendency to move uphill towards the equator. If the motion be from east to west, the centrifugal force is diminished and the body tends towards the pole. In each case the tendency is towards the right in the northern hemisphere and towards the left in the southern."*

Admitting the sufficiency of the terrestrial rotation for the deflection of streams, we must look for our examples to those regions where the strata are essentially horizontal and horizontally homogeneous. McGee, in his paper on the geology of the Chesapeake Bay, says: "It may be noted in passing that, throughout its gorge, the Susquehanna River hugs its left shore the more closely, and apropos to the hypothesis of the dextral deflection of rivers by terrestrial rotation (commonly known in Europe as Baer's law), specifically applied by Kerr to the water-ways of the Middle Atlantic slope, and recently discussed in more general terms by Gilbert, Davis, Hendricks, Bains, and others, it may be mentioned that the different water-ways of the Middle Atlantic slope are not only inconsistent in their behavior at and above the fall-line, but in many cases the same stream has not behaved uniformly since the excavation of its gorge was initiated."†

---

*A. C. Bains, in a paper read before the Philosophical Institute of Canterbury, New Zealand, October 4, 1877.

†Seventh annual report of the Director of the United States Geological Survey, p. 554.

McGee's objection is done away with by the fact that the Susquehanna River is not situated in a region of the required horizontal homogeniety, and that if it now shows a preference for its left bank, that preference is probably an inheritance from the time when the favoring conditions did exist, before its superimposition upon the Wiconisco and Tuscarora-Mahanoy synclines, when the course of the river was the reverse of what it is now, and its present left bank was its right bank.*

Turning now to the regions of horizontal homogeniety, we see that their streams all show this right or left deflection, according as they are north or south of the equator. Such a region is that where the phenomenon was first observed, in the middle and lower courses of the Volga. Here all of the conditions are most favorable; the river has a considerable length of course, and the mass of water is powerful enough to clear away any obstacles; "there are enormous floods which periodically increase the force of erosion in the currents, and the cliffs are composed of friable rocks."† Two centuries ago the principal mouth of the Volga flowed directly to the east of Astrakhan; since that time the great current has successively hollowed out for itself fresh beds, tending more and more to the right, and at the present day the branch navigated by vessels turns to the south-south-west. The Volga, up to its near approach to the sea, has a high right bank, and the erosion-valley, which slopes gently on the left, is bounded by rather abrupt cliffs on the right.

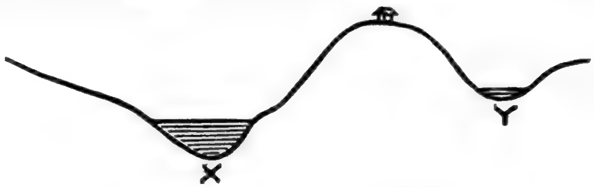


Fig. I.—The Volga and the Rwjaga.

* See Rivers and Valleys of Pennsylvania, W. M. Davis, *National Geographic Magazine*, Vol. I, p. 47, 1889.
† Von Baer.

In the diagram, which is taken from von Baer, we have at X the Volga. Its left bank is flat, or only gently sloping; the right rises irregularly to a considerable height and falls down on the other side, not nearly so far to the river Rwjaga at Y, and then rises slowly again. The Volga is flowing from the observer, and the Rwjaga towards him, and there is barely room for a habitation between them, "where it depends upon the whims of the kitchen maids whether the dish-water which is daily poured out flows immediately into the Volga, or whether it reaches the same destination in a round-about course of four hundred versts. This statement may seem exaggerated, but it is literally true."*

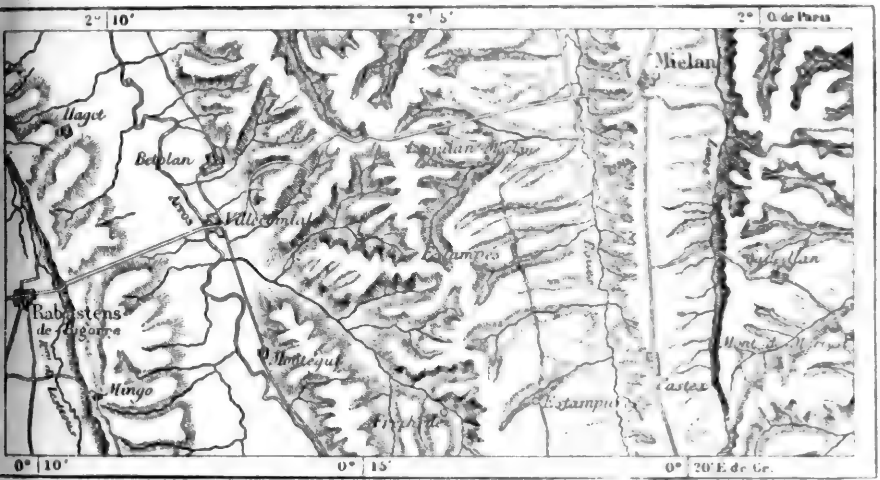


FIG. II.—RIVERS OF GERS. SCALE. 1:150,000.†

In the southern part of France, in the province of Gers, we have a gently sloping plain, an old river delta that has been lifted up, where streams can flow off in every direction down the slope, and take such courses as they may. Here the right-hand tendency is shown to perfection. The streams have their longer tributaries on the left, and their right banks rise in bluffs.

* Von Baer, St. Petersb. Bull. Sci. II., 1860, col. 230.

† From *la Carte d'Etat-Major*, reprinted in Reclus's *Nouvelle Geographie Universelle*, 2.

Turning to the United States and selecting a few places where the necessary horizontal homogeniety is found, we have no trouble in pointing out examples. "The south side of the island of Long Island is a plain of remarkable evenness, descending with gentle inclination from the morainic ridge of the interior to the Atlantic Ocean. It is crossed by a great number of small streams which have excavated shallow valleys in the homogeneous modified drift of the plain. Each of these little valleys is limited on the west or right side by a bluff from ten to twenty feet high, while its general slope on the left side merges imperceptibly with the general plain. The stream in each case follows closely the bluff at the right."*

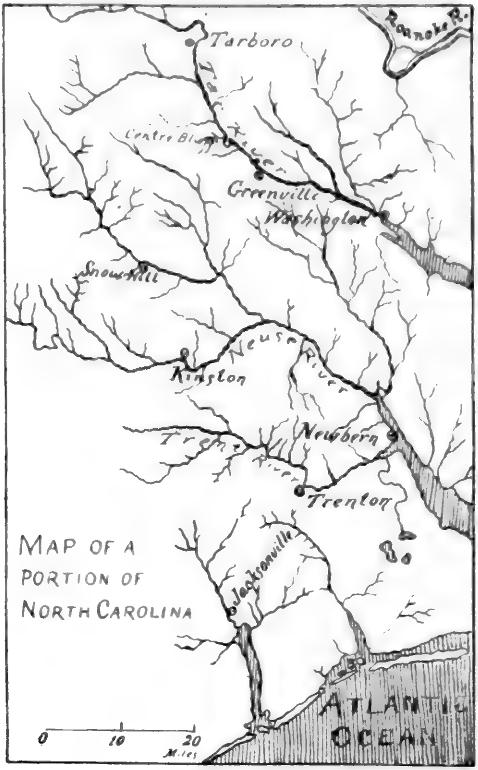


FIG. III.

The peculiar topography of the eastern portion of the Carolinas, where the necessary conditions exist, has been pointed out by Tuomey and by Kerr. Here the streams have cut through the Quaternary and Tertiary formations, and well into the Cretaceous, and in every instance they present the high right bank, with the low sloping country on the left; and, as may be seen by the sketch-map, the tributaries of the Roanoke, the Tar,

* G. K. Gilbert, *Am. Jour. Sci.* 3d xxvii, 431.

the Neuse, and the Cape Fear run well back to the streams lying to the northward. In the case of these streams the dip of the strata is not such as to aid in the making of the right bank higher. Such conditions are represented in Fig-

FIG. IV.

FIG. V.

FIG VI.

ure IV. In Figure V the arrangement of the strata is such as to hinder rather than help the deflective effect of rotation; and yet this is the structure of the Carolina region, as shown in Figure VI, which is taken from Kerr.* But the rocks here are imperfectly lithified, and so friable as to yield readily to the influence.

The Mississippi River does not act consistently throughout its course, but in most instances its right bank is higher except where the prevailing winds are from the north-west. At Burlington, Iowa, the east or left side is low, and the trains of the C., B. & Q. Railroad reach the bridge over embankments and trestle-work, but run directly into the town on the high right bank of the river. At Dubuque just the opposite conditions exist.

Turning to regions south of the equator, we find in the plains of Canterbury, New Zealand, the requisite conditions. The Rakaia River cuts through Quaternary strata and into late Tertiary, and its left bank is its steeper bank. This is also shown in all the rivers entering Tasman Bay through strata of the same age, and there are doubtless many other cases in the same region. I have not at hand the maps and geological report for that region.

* Geology of North Carolina, Vol. I, 1875, p. 10.

Those who are familiar with the map of South America, where the older rocks have been decomposed for great depths *in situ*, and where the younger rocks are but imperfectly lithified over great areas, must recall the fact that nearly all the streams have their longer tributaries on the right, showing a left-hand deflection of the main streams.

The cases cited serve my purpose of showing that wherever the conditions permit the influence of the earth's rotation is perceptible.

THE STONE ARCH.

BY WILLIAM CAIN, C. E.

The theory of the voussoir arch has long exercised the ingenuity of mathematicians, and it may prove interesting, before giving the results of some recent investigations by the writer, to give brief statements of some of the leading theories that have been proposed, from time to time, as indicating the path followed in such original investigations.

As we should naturally expect, the theories proceed from the simplest, where the arch is assimilated in its action to a wedge, to the most complex, where the deformation of each individual stone under stress is considered.

In most of the theories hitherto proposed the arch is regarded as inelastic and the stones infinitely strong, so that the resultant thrust of one part of the arch against another can take place along the very edge of a joint without crushing ensuing.

These simple hypotheses unfortunately do not express the actual conditions, which involve the consideration of the elasticity of all the materials entering into the construction of the arch; the fit of the stones, thickness and degree of hardness of the morter joints (if any), settlement and time of striking of the centers, the manner in which the loads are transmitted to the arch ring, the relative density of the various stones, and finally the dynamic effect of moving loads. The true conditions are thus seen to be so complex as to make the true solution of the stone arch one of the most difficult, if not the most difficult, in all the range of the application of the laws of mechanics to engineering structures.

The latest theory, given further on, includes the most essential of the conditions just outlined, but not all of them; so that it is not proposed as a final and complete solution of the problem, but as one sufficiently near to make the results of decided practical value, approximating to the exact truth, as the hypotheses are more nearly realized in the construction of the arch ring.

Recurring now to earlier theories of the arch, Lahire, at the beginning of the last century, considered that the arch would break along "joints of rupture," half way between the crown and the springing, and he assimilated the action of the upper part to that of a solid wedge, tending to slide downwards along the joints of rupture, which last were considered perfectly smooth, so that the pressure there was directed normally to the point.

This very crude hypothesis was adopted by Eytelwein, who, however, found that joint of rupture for which the pressure exercised against an abutment was a maximum. As a matter of fact, friction can be exercised at any plane joint, which Eytelwein only imperfectly considers; but admitting it, the direction of the thrust at any joint of rupture becomes indeterminate, so that apart from other defects, the theory gives no definite solution.

Coulomb, in 1773, made a great advance by considering that an arch could not only fail by *sliding* along some joint, but also by *rotation* along the edges of certain joints.

He assumed the horizontal thrust at the crown always to pass through either the upper or the lower edge of the joint and found its minimum value, *so that no rotation would occur* about the lower or upper edge of any joint below the crown and such that no sliding could occur along any joint.

It is not necessary to explain the ingenious method by which the true thrust, after his theory, was ascertained. The theory was a marked improvement over the wedge theory, and it has been followed by a host of authors, with various improvements, even up to the present day.

As the thrust either at the crown joint or the lower joints of rupture cannot act along an edge without crushing ensuing, it is evident that the true positions of the thrusts at these critical joints has not been correctly ascertained; further, there is nothing in the theory to raise the indetermination.

The next advance in the theory was made by certain authors who used *a funicular polygon* in studying the resistance at the various points, a method which is still the basis for the analytical treatment of the arch.

It required but an additional step to see that *the curve connecting the centers of pressure* on every joint of the arch ring (to which the proper "funicular polygon" approximates for segmental arches) was a surer test of the stability of an arch ring and that, *in a stable arch*, it must always be possible to draw some "curve of resistance" (as the curve connecting the centers of pressure is called) within the limits of the arch ring, or, for safety, within much narrower limits.

The exact location of this curve, for any arch, loaded in any manner, will completely solve the problem for that arch; but where an infinite number of possible curves of resistance can be drawn within the arch ring (or narrower limits), all varying in the point of application, direction or intensity of the thrust at the crown, it is evident that some additional principle must be introduced to enable us to choose the true one. Mosely introduced for this purpose *the principle of the least resistance*, which at once fixed the true curve as the one corresponding to the minimum horizontal thrust. This caused the results to agree with those of Coulomb, in most cases, though not in all, as the curve so determined does not, for some arches, pass through either edge of the crown joint, as Coulomb's theory requires.

In this and previous theories the arch and load were taken as symmetrical with respect to the vertical through the crown which thus restricts the theory to structures having fixed loads and rendering it of little service in the investigation of the strength and stability of road or railroad arch bridges subjected to a moving load, which produces a maximum distortion when placed over one haunch of the arch; further, the theories demanded incompressible voussoirs of infinite strength, which do not exist.

Scheffler developed very completely the theory of curves of resistance for the least horizontal thrust, for both symmetrical and unsymmetrical arches and loading; but as his theory requires the thrusts at the critical joints to pass through the very edges, it cannot apply to ordinary stones, where crushing would result, as a matter of course. Now, as crushing does not occur at the joints in well-designed arches, it follows (without other considerations) that Scheffler's theory must, at least, be modified. The writer did this in introducing the theory to American readers in 1874, by empirically limiting the curve of resistance to the middle third of the arch ring. With such a restriction, for a joint with mortar, there would be no tension exerted anywhere along the joint, and for a joint without mortar there would be a compression throughout the whole length of the joint, so that no joint would open. Such restrictions had already been suggested by Rankine, Woodbury and others, as leading to safer results in proportioning an arch. The writer, however, called attention to the fact that, as in most well-built arches, the joints did not open, therefore, by experiment on a big scale, it was shown that the true curve of resistance in arches, as generally built, did not leave the middle third; hence, for usual depths of key-stone and usual loads, the true curve of resistance was found somewhere in the middle third. Its position in the middle third of the arch ring could be provisionally found by the principle of least resistance, though it was admitted that its exact position was dependent on the deformation of the arch ring under stress, due to its elasticity, the laws of which were not known at the time.

However, after mathematicians had developed a true theory of the *solid elastic arch*, "fixed at the ends" in position and direction, it seemed possible to apply it to the voussoir arch, and thus locate accurately the true curve of resistance, provided the following conditions were fulfilled:

1. No mortar was to be allowed between the arch stones or voussoirs;

2. The arch stones must be cut so perfectly that they will fit exactly, when not under stress, in place on the "center"—supposed unyielding;

3. Under these circumstances the curve of resistance, determined after the theory of the solid arch for the full sections of the arch ring, must lie in its middle third. If this last condition does not obtain, the solution is still possible, though the full sections cannot be used at certain joints, which involves a tentative method of finding the parts of the joints under stress and the resulting resistance curve, which makes a practical solution of the case much more difficult.

Under the conditions assumed above the deformation of the voussoir arch is exactly that of the solid arch and there can be no question as to the theory applying.

It is admitted, however, that it is difficult to cut the stones with the exactness demanded, and in addition, there will be a slight yielding of the centers, though the stones can easily be cut to bear along the whole length of joint when placed in position on the centers after they have yielded somewhat, as it only requires a close fit of the key-stone after the other stones are in place.

If thin cement mortar joints be used, that are allowed to harden perfectly before the centers are removed, the arch ring is assimilated completely to a solid arch, except that in the theory the successive blocks of cement and arch stones with their different moduli of elasticity must be considered, making the solution very complex. It would seem though that for very thin joints the theory pertaining to a homogeneous arch of stone should approximate sufficiently near to the truth to give results of practical importance.

For thick mortar joints of common mortar or for brick arches the theory proposed may be a rude guide, but it is not pretended that it can be anything but a rough approximation to the truth, so that the depth of key for such arches had better be increased empirically over the depths given by the theory above for a homogeneous solid arch.

The theory of the solid arch supposes immovable abutments and it requires three conditions to be fulfilled when the *arch ring* is under stress from its own weight and the weight of backing, roadway, etc., and any loads that may be placed on it in any position:

1. The end tangents, at the springing, to the center line of the arch ring, must remain fixed in direction;

2. The deflection of one end of the arch ring below the other, due to its deformation under stress, must be zero;

3. There must be no change in span due to the deformation of the arch ring.

Analytical theories of the solid arch have been developed by Winkler, Greene and others, and the graphical solution has been given by Prof. H. T. Eddy, to which the writer has contributed his mite.

In *Van Nostrand's Engineering Magazine* for January and November, 1879, the writer claimed that the theory of the solid arch was the most exact solution of the voussoir arch, and a graphical treatment was given in the last named article. In the same year Castigliano, Winkler and Greene referred the treatment of the voussoir arch to that of the solid arch, and finally, in 1893, the writer, in the second edition of "Theory of Voussoir Arches," has given extended applications of the theory of solid arches to voussoir arches by two distinct methods, one founded on the analytical method in part and the other entirely graphical.

These methods were independently applied to a number of stone arch bridges, whose rise was one-fifth the span, for a loading known as Cooper's "Class Extra Heavy A," so placed as to produce the maximum departure of the resistance curve from the center line of the arch ring, and the results appear to be of such importance as to offer some apology for writing this article.

In the stone arch bridges examined the specific gravity of the voussoirs was assumed at 140 pounds per cubic foot, and the density of the spandrel backing was taken at eight-tenths that of the voussoirs. The weight of this backing and any loads on the bridge was assumed to be transmitted vertically to the arch. It is true that this may not be exactly true; in fact, the spandrel may act as an arch itself to some extent, still such additional security may be supposed to neutralize the *dynamic* effect of moving loads, the *static* effect of the loads being met by designing the arch ring, supposed of constant section throughout, so that for the most unfavorable position of the load, for *any* joint, the line of the centers of pressure on the various joints should be contained within the middle third of the arch ring, and for the joint where the departure was greatest this line should just touch the middle third limit. A slight decrease in the depth of key would thus cause the true resistance curve to pass slightly outside the middle third at some joint or joints.

The proper depth of key to meet this last condition was found tentatively by assuming successive depths of key for the same span until one was found in which the true resistance curve could just be inscribed in the middle third for the most unfavorable position of the live load. Only two trials were needed in any case.

It was found for the arches so designed that no sliding could occur along any joint. The maximum stress, in tons per square foot, at the most compressed edge, varied from nine for the twenty-five foot span to thirty-six for the 150 foot span.

Thus the arch ring possessed the requisite stability for an arch of sandstone or limestone and an excess of stability for granite, whose weight per cubic foot is over the 140 assumed. For material weighing over 140 pounds per cubic foot the depth of key given below can be slightly diminished or a heavier load can be assumed.

The live load assumed is known in Cooper's Specifications as "Class Extra Heavy A."

We give below the distances in feet from the front pilot-wheel to each pair of wheels in turn, and on the same line the weight of the pair of wheels in tons of 2,000 pounds:

Pair of	Pilot-wheels..........	0	feet.........	8	tons.
"	Driver-wheels........	8.1	"........	15	"
"	"	13.83	".........	15	"
"	"	18.33	".........	15	"
"	"	22.83	".........	15	"
"	Tender-wheels........	29.92	".........	9	"
"	"	34.75	".........	9	"
"	"	40.42	".........	9	"
"	"	45.25	".........	9	"
"	Pilot-wheels...........	54.25	".........	8	"

The second locomotive can be located from the last pair of pilot wheels.

For spans of fifteen feet and under, a pair of wheels carrying forty tons was used as producing a more hurtful effect. The above load was placed over one-half of the arch, roughly speaking, the heaviest part being over the center of the haunch. Its exact position, however, was determined very carefully so as to produce the most hurtful effect upon the arch ring.

An approximation to this load was made by omitting the pilot-wheels in some of the computations. Also by the independent partly analytical treatment, used as a check, the load on drivers was supposed uniformly distributed as well as that on the tenders, and for convenience the lengths of each portion were slightly changed to suit the divisions of the arch required in the theory. The pairs of wheels were supposed to bear on cross-ties eight feet in length, so that only one-eighth of this load was supposed to bear on a slice of the arch contained between vertical planes perpendicular to the axis of the arch and one foot apart.

The depths of key so determined for arches of constant section and rise = $\frac{1}{5}$ span are given in the following table, the determinations for the spans 12.5, 25, 50, 75, 100, 125 and 150 having been found directly, the others by interpolation from these values. All dimensions are in feet.

RISE EQUAL ONE-FIFTH THE SPAN.

SPAN.	KEY.	SPAN.	KEY.	SPAN.	KEY.
5	1.96	55	3.7	110	5.80
10	2.12	60	3.9	115	5.95
12.5	2.20	65	4.1	120	6.10
15	2.27	70	4.3	125	6.25
20	2.43	75	4.5	130	6.40
25	2.60	80	4.7	135	6.55
30	2.77	85	4.9	140	6.70
35	2.95	90	5.1	145	6.85
40	3.13	95	5.3	150	7.00
45	3.30	100	5.5	155	7.15
50	3.50	105	5.65	160	7.30

Stone arches of the dimensions given should be perfectly safe against rotation or sliding anywhere for the very heavy rolling load assumed; but the depth of key should not be less than the values given, as the true line of resistance, for certain positions of the moving load, will then pass outside the middle third at certain joints, and although the arch may be stable, the factor of safety is reduced too much and the joints of rupture may open, thus admitting the infiltration of water, which is not desirable; besides, for the larger arches, the maximum intensity of stress at the edges of the joints of rupture may exceed safe limits. In fact, this intensity for the 150-foot span for a 7-foot key is 36 tons per square foot—an admissible value for good solid voussoirs, well laid, though not at all for rubble construction or for brick, except, perhaps, the very best pressed brick. From experience it would seem that an outside limit for this intensity for good granite should be about 46 tons per square foot.

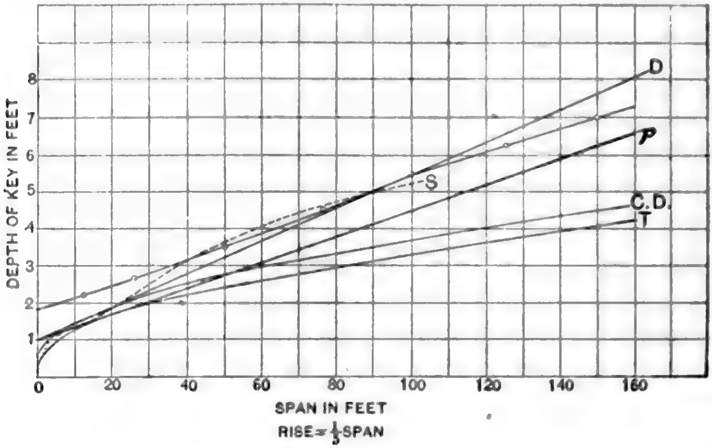
The arch can preferably be built by increasing the radial length of joint as we go from the crown to the springing, as is done in arches of large span, in which case the depth of key-stone can be decreased somewhat below the tabular values with the same security against overturning, sliding or crushing.

In case the abutments or piers yield somewhat at the top from defective foundations the depth of key should be greater than as given in the tables.

The formulas that have been proposed for depth of key by many authorities are not founded on theory, but on the successful practice of the past, particularly for common road bridges and railroad bridges subjected to the lighter loads of several decades ago.

The writer has been convinced for a number of years that the dimensions given by many of these formulas (in current use to-day) are very inadequate for stone arches subjected to the very much heavier rolling loads of to-day, and that arches so proportioned probably are saved from destruction only from the extra resistance afforded by the spandrels. On that account he was led to undertake the very serious labor of computing the depths of key for a number of arches after the theory proposed, and to compare with the results given by some of the empirical formulas.

The results are shown graphically in the figure, the line through the small circles (which is nearly straight) being plotted from the values given in the table above.



The depths of key proposed by the following authors are given by the ordinates to the various lines for the corresponding spans given by the horizontal lines: Trantwine (line T), Croizette-Desnoyers (line C-D), Perouet (line P), Scheffler, by interpolation from his tables (line S, dotted) and Dejardin (line D).

These results refer to materials of only average strength (second-class masonry for the Trantwine line) and vary very greatly; thus for an arch of 160 feet span and thirty-two feet rise Trantwine gives a depth of key of 4.3 feet, whereas Dejardin requires eight feet and then increases the radial length of joint according to the secant of the inclination of the joint to the vertical as we approach the abutment.

The theoretical depths of key agree more nearly with those of Dejardin and Scheffler than with any of the others, though it is in excess for the smaller spans over any of the empirical results, as should naturally be expected.

It is respectfully submitted to constructors that most of the formulas in current use are inadequate to give a proper depth of key for the very heavy rolling loads of to-day, although it is thought that such formulas may still serve the purpose of a rough guide in the design of common road bridges, unless heavy concentrated loads, as steam road-rollers, are to pass over them. In all cases it is best to use the formulas for an assumed key and then by a theoretical treatment determine the proper key by one or two trials.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOLUME X—PART SECOND

JULY—DECEMBER

1893

POST-OFFICE:
CHAPEL HILL, N. C.

ISSUED FROM THE UNIVERSITY PRESSES,
CHAPEL HILL, N. C.
1894.

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

A COMPARISON OF THE METHODS OF SEPARATION AND ESTIMATION OF ZIRCONIUM.

CHAS. BASKERVILLE.

The object of the research, whose results are recorded in this paper, was to compare some of the more prominent methods in use for the determination of zirconium. The directions, as found in the literature of the subject, were as closely followed as possible. At times however they were so indefinite that wide limits were given the analyst. In such cases, several experiments were carried out under varying conditions, so that the accuracy of the method might be fully tested.

It was further desirable in this work to examine any suggestion arising, by which a new method of determination might be devised and its accuracy as well tested. Whenever it seemed necessary the purity of the reagents was carefully proved.

Two solutions were used:

1st. A solution of zirconium chloride purified by crystallization from hydrochloric acid. This contained free acid.

2nd. A solution made by saturating dilute sulphuric acid (4:1) with zirconium hydroxide. This solution was acid to litmus.

The strength of each was determined by evaporating to dryness, igniting the residue and weighing the ZrO_2 obtained. Amounts taken for the experiments were measured from these solutions by means of a calibrated standard burette with a small outlet.

THE DETERMINATION OF ZIRCONIUM.

I. Experiments with Ammonium Hydroxide.

Ammonium hydroxide precipitated the zirconium completely from a cold solution in either a small or large excess. If the solution be hot, however, the excess of ammonium hydroxide must be boiled off, *i. e.*, the precautions taken when aluminium hydroxide is precipitated must be heeded. The precipitate is white and flocculent, settles quickly, is easily filtered and washed with hot water. In most of the experiments carried out this precipitate was washed until the wash water gave no further precipitate, or only a slight cloudiness, with silver nitrate. The precipitate was ignited and heated over the blast lamp until there was no further loss of weight, the residue weighed being taken as pure zirconium dioxide.

The following results were obtained:

Numbers.	*Found.*	*Used*
20	0.1082	0.1083
21	0.1624	0.1626
22	0.e081	0.1083
23	0.1618	0.1626
24	0.1098	0.1083
25	0.1647	0.1626
26	0.1090	0.1083
27	0.2812	0.2808
28	0.2832	0.2815

Nos. 20-26 inclusive were made from the chloride solution and Nos. 27-28 with the sulphate. No. 20 was carried out in the cold with a large excess of ammonium hydroxide. The solution was diluted to about 150 c.c. and the precipitate washed with cold water. No. 21 was also cold, the precipitate being obtained by ammonium hydroxide (sp. gr. 0.97) drop at a time. On addition of the fourth drop the precipitation was complete. No. 22 had also only a slight excess of ammonium hydroxide, but the zirconium was precipitated hot. No. 23 shows the necessity for boiling off the excess of ammonium hydroxide. It was precipitated from a hot solution by a large excess of ammonium hydroxide (10 c.c. sp. gr. 0.97). Nos. 24 and 25 respectively contained a slight and large excess of ammonia, but the boiling was continued for fifteen minutes in each case. No. 26 was diluted to about 100 c.c. (the others were diluted to about 150 c.c.) and 20 c.c. of concentrated ammonia water (sp. gr. 0.92) added and that boiled for fifteen minutes. No. 27 was carried out hot, the slight excess of ammonium hydroxide added being boiled until there was only a faint odor of it left. No. 29 was precipitated by adding 50 c.c. concentrated ammonia water (sp. gr. 0.92). The whole solution in this case amounted to about 100 c.c. This was boiled twenty minutes. Most of the ammonia had disappeared.

Since zirconium is frequently precipitated in a chloride solution when the alkaline chlorides are also present, it seemed advisable to note the effect the presence of these substances had on the determination by means of ammonium hydroxide. Experiments were therefore made with the zirconium chloride dissolved in ten per cent. solutions of ammonium, sodium, and potassium chlorides. These solutions were at first clear, but on boiling 5–15 minutes, at first a slight turbidity was noticed. This increased on boiling until a good precipitate was formed. With potassium chloride this precipitate was curdy and incomplete. Paykull[1] speaks of the formation of double chlorides in the dry way. These precipitates which are very probably similar compounds are now being investigated in this laboratory. It was noted that ammonium chloride did not interfere with the determination, as it was easily volatilized when the crucible was ignited over the blowpipe. The fixed alkalies however interfered, giving high results. These compounds are of interest.

The following determinations were made in the presence of ammonium chloride:

Numbers.	*Found.*	*Used.*
59	0.1106	0.1104
30	0.1070	0.1070
31	0.1077	0.1070

II. With Sodium Thiosulphite.

Sodium thiosulphite, if added as solid crystals to a zirconium chloride solution, previously neutralized with ammonium hydroxide, and then boiled for several minutes, caused complete precipitation. The solid thiosulphite was added up to ten and even twenty per cent. of the solution. The precipitate did not form immediately on addition of the solid thiosulphite, even if the solution was hot, but was rapidly produced after a few moments heating. The precipitate, which settled quickly, was filtered hot and washed with hot water

(1) Ber. VI. 1467.

until the wash water amounted to about twice as much as the original solution. This amount of washing was arbitrarily chosen, as it was found that if it was considerably less the results ran high, showing imperfect washing, due to the presence of sulphite, no doubt. The presence of free acid (one per cent. and less) interfered considerably, preventing complete precipitation (39 and 40–*vid.* below). Moreover the precipitate was finely divided and ran through very close filter paper (S and S, No. 590) along with much free sulphur. The precipitation was made in the cold as well, but in that case, it was found necessary to let the solution remain covered for at least twenty-four hours with occasional stirring. The larger portion of the flocculent precipitate collected well at the bottom of the beaker, but a small portion clung persistently to the stirring rod and sides of the beaker, refusing to come off, even on the most vigorous rubbing with a "policeman."

This reagent will not serve as a precipitant for the zirconium sulphate solution, since the precipitation was found to be incomplete on addition of as much as twenty per cent. of solid sodium thiosulphite to a thoroughly neutralized solution. Preliminary experiments were made with more or less free sulphuric acid present and varying amounts of the thiosulphite (two to twenty per cent.) in solution and solid form, hot and cold.

These determinations were made:

Numbers.	*Found.*	*Used.*
33	0.1102	
34	0.1101	0.1104
35	0.1106	
36	0.1645	0.1635
37	0.1079	0.1104
38	0.1641	0.1635

39	0.0645	0.1104
40	0.1538	0.1635
41	0.1107	0.1104
42	0.1093	0.1104
44	0.1080	0.1083
45	0.1215	0.1296

Nos. 41 and 44 were carried out as first recommended above. Nos. 33 and 34 were in the cold, the former with one per cent., and the latter with three per cent. of sodium thiosulphite. No. 36 had also three per cent., but was boiled. No. 37 shows that a very small amount of sodium thiosulphite will throw down most of the zirconium, as only five drops of a ten per cent. solution were added in the experiment. The precipitation was complete on addition of the thiosulphite up to two per cent. (No. 38,) but the precipitate crept and only a portion settled well. Nos. 39, 40 and 42 show the varying interference of free hydrochloric acid, and No. 45 was a neutralized sulphate solution with twenty per cent. of solid sodium thiosulphite.

III. With Potatassium Sulphate.

The very old method for separation, which Berzelius[3] used for want of a better, and one recommended for use in a great number of text books now, is the precipitation of a zirconium sulphate solution as a basic zirconium potassium sulphate, which according to Paykull[4] may have the formula, $K_2SO_4.2[ZrO_2.Zr(SO_4)_2]+14H_2O$. This would be best brought about by adding an excess of a saturated potassium sulphate solution to a neutralized concentrated solution of zirconium sulphate. The pre-

3. Pogg. Ann. III–208.
4. Ber. VI–1467, and XII–1719.

cipitation however was incomplete even in neutral solutions. The text books vary in regard to the properties of this double sulphate; some[5] state the precipitate to be insoluble or sparingly soluble in either water or hydrochloric acid; another[6] states its solubility in water alone and points out the danger of loss in the necessary washing. Rose[7] referring to Berzelius[8] avoids this loss by washing with dilute ammonium or potassium hydroxide. These contradictory properties were all noted in Watt's Dictionary.

An experiment was carried out to learn the actual deportment of this salt in the presence of water. A fairly concentrated solution of zirconium sulphate, containing ten per cent. of ZrO_2, was completely neutralized with ammonium hydroxide until a permanent precipitate was formed and this dissolved in two or three drops of dilute sulphuric acid. This was done with a boiling solution. To this was added an excess of a saturated potassium sulphate solution. The beaker was placed in cool water. When cold the supernatant liquid, the flocculent precipitate having settled well, was decanted through a tared filter. This filtrate, was tested with more potassium sulphate, boiled and cooled, but no further precipitation occurred. On addition however of some ammonium hydroxide a white precipitate was thrown out, showing either that the potassium sulphate did not precipitate the zirconium completely or the precipitate was soluble in water. The precipitate was washed several times by decantation and the filtrate in each case showed the solubility of the salt.

---

5. Roscoe and Schorl. vol. II, part II–p. 271., and Regnault Chimie II–285, and Wöhler Handbüch Anorg. Anal. p. 117.
6. Pelouse et Fremy Traité de Chimie Générale III–523 2nd Ed.
7. Analyt. Chem. translated by Griffin.
8. Poggendorff's Annalen, IV.–136.

There remained to learn the completeness of the precipitation, Another experiment similar to the above was carried out bearing in mind the suggestion of washing with a solution of ammonium hydroxide, at first with potassium sulphate to be sure that there was an excess of that reagent present and then with ammonium hydroxide. The precipitation had not been complete. After several washings, when the original solution might well be presumed to be removed, or the major portion at least, the wash water (very dilute ammonia water) gave no evidence of the presence of zirconium. Several experiments were carried out, but in only one case was the double salt weighed. It gave about ninety per cent. of the zirconium really present. The filtrates from several were examined and it was léarned that from one to ten per cent. was always lost, the amount depending on the exact conditions of precipitation and the amount of washing succeeding. The objection to using ammonium hydroxide as wash water when it was desirable to separate zirconium from iron, aluminium or titanium, is easily seen.

The conclusion arrived at was, that the precipitation of zirconium as a double sulphate with potassium afforded no quantitative means of determination for that metal, nor of separation from aluminium, iron or titanium.

IV. By Sodium Carbonate.

Sodium carbonate precipitated solutions of zirconium salts completely. A great difficulty arose, however, in the exceeding slowness of filtration and practical impossibility of washing the precipitate free from the alkaline carbonate. A single result, obtained from several analyses, was

	Found.	Used.
ZrO_2	0.1785	0.1723

V. By Ammonium Carbonate.

When a saturated solution of ammonium carbonate was added gradually to a zirconium chloride solution, at first a white flocculent precipitate was thrown down. This seemed to be produced by the free ammonia present, but on a further addition the solution became clear again. If this was boiled, a clear flocculent precipitate came down. The boiling was continued for about fifteen minutes, when the carbon dioxide had ceased to come off. The appearance of this precipitate was exactly that produced by ammonium hydroxide, yet the filtration was very slow, as in the case with the other alkaline carbonate. In some hundred and more precipitations by means of ammonium hydroxide, I have never failed to secure the zirconium hydroxide in such a condition as to filter rapidly. This was very likely a basic carbonate, which required continued heat with the blow pipe for constant weight. Such a precipitate when ignited gave 0.1733 g. ZrO_2 when 0.1723 g. was used.

VI. By Ammonium Oxalate.

L. Svanberg,[9] because oxalic acid failed to give a complete precipitation of zirconium, thought the solution contained a new element, which he called *norium*. Sjögren[10] in his analyses of the mineral catapleiite said: "Eine nicht saure Lösung der Erde aus dem Katapleiite

9. Ofversigt of R. V. Akad. Förhandl. 1845, p. 37.

10. Pogg Ann. 1852, Ergänzung, III. p. 469. J. Prak. Ch. 55, 298.

wird wohl von oxalsaurem Ammoniak gefällt, aber dieser Niederschlag lösst sich nicht nur in einem Uberschusse des Fällungsmittels, sondern auch in einem geringen Zusatz von Oxalsäure." Berlin,[11] however, also said: "* * * dass der durch dieser Salz (ammonium oxalate) in einer Lösung von Zirkonerde bewirkte Niederschlag bei einem Ueberschusse des Fällungsmittels wieder verschwindet. * * * Aus dieser Auflösung schlägt Ammoniak die Zirkonerde vollständig nieder." Hermann[12] repeated all previous experiments, and not only corroborated Berlin's observations, but determined the best conditions for this precipitation. He noted that in an excess of the precipitant (ammonium oxalate), only four-tenths of all the zirconium was precipitated. Such has been the result of my own experiments, save the determination of the rate of precipitation as done by Hermann.

VII. By Potassium Hydrogen Oxalate.

Behrens(13) in his "Contributions to Micro-Chemical Analysis" notes that zirconium can be detected with extreme delicacy (0.0005 m.gr.) by that means. For quantitative purposes, however, potassium hydrogen oxalate could not be used, as the precipitate formed was soluble in an excess of the precipitant, but an incomplete precipitation took place on boiling.

VII. By Hydrogen Peroxide.

(See Separation Zirconium and Titanium.)

IX. By Sulphur Dioxide.

Because of the analogy of the elements, I was led to

11.. J Prak. Ch. 58—145.
12. J. Prak. Ch. 96—332.
(13) Zeit. Anal. Chem. translated in Ch. News, XLIV—124.

try a method commonly used with titanium, viz.: prolonged boiling of a potassium hydrogen sulphate fusion in dilute solution with sulphur dioxide in excess. On application of this method, however, on the prepared sulphate (see above), I failed even after boiling four hours with an excess of sulphur dioxide, to obtain a precipitate, if the solution was acid. If the solution was nearly neutralized with ammonium hydroxide, and then boiled with an excess of sulphur dioxide, after being greatly diluted a precipitate was produced. This precipitation, however, was incomplete, even after boiling six hours or passing steam through the same for two or three hours. The precipitate too was very finely divided, running through the closest filter papers at my command. Therefore this method could not be used.

But on addition of sulphur dioxide to the chloride solution, even in the cold, and if it was acid, a dense white precipitate was immediately noted. On boiling with an excess of sulphur dioxide in a neutralized solution, *i. e.*, the chloride solution, neutralized by ammonium hydroxide until the slight precipitate was no longer dissolved by boiling, and this precipitate then taken up with two or three drops of dilute dydrochloric acid, the separation of the zirconium was complete.

The accuracy of this method is shown by the following results:—

Number.	*Found.*	*Used.*
81	0.1074	0.1077
81	0.1078	
82	0.1043	0.1038
83	0.1070	0.1077
84	0.1047	0.1050

The precipitation took place immediately an addition of sulphur dioxide and after two minutes boiling the precipitate settled quickly and was easily filtered.

This method then is applicable to the chloride only and a sulphate would have to be first changed to chloride by precipitation with ammonium hyhroxide and resolution in hydrochloric acid. This was done and 0.2815 g. ZrO_2 was found when 0.2812 g. was used.

The presence of large amounts of such salts as ammonium chloride did not aid the precipitation of the sulphate. The presence of free hydrochloric acid must be avoided and it is best to use a fresh solution of sulphur dioxide or the gas direct.

SEPARATION OF ZIRCONIUM FROM IRON.

I. By Ammonium Sulphide in an Ammoniacal Tartrate Solution of their Salts.

Rose[14] knew the property tartaric acid possesses of rendering solutions of a number of metallic oxides incapable of precipitation by alkalies. However he made use of just such a solution, by adding to it an excess of ammonium sulphide, to separate iron from zirconium. He said, "If to the solution of these two bases a *sufficient* quantity of tartaric acid has been added, the addition of an excess of ammonia produces no precipitate. "I found five times as much tartaric acid as iron present was a "sufficient quantity," but an excess, five per cent. of the whole solution, had no ill effect, although such a large excess is not necessary. If the iron was present in the same amount as the zirconium, the separation was found to be incomplete, if only one precipitation of

14. Analyt. Chem. translated by Griffin, p. 58.

the iron was made. The zirconium dioxide could not be obtained perfectly white, but possessed from a yellow to a brown color due to the iron present. However, if the amount of iron be small, five per cent. and less, as it occurs in the mineral zircon, the separation was thorough and the ignited zirconium dioxide obtained was snow white and iron free.

Two analyses are given :—

	Found.	*Used.*
ZrO_2—	0.1119	0,1118
	0.2815	0.2818

The process was as follows : To the solution of the salts, tartaric acid, best solid, to five times the amount of iron present, was added, and this neutralized by an excess of ammonium hydroxide, and then ammonium sulphide in excess. This was warmed slightly, covered, and set aside to settle. The supernatant liquid must acquire a yellow color before filtration. To avoid this delay, one experiment was carried out by boiling and direct filtration. Time was thereby saved. The precipitated iron sulphide was washed quickly with a dilute ammonium sulphide solution. The filtrate was evaporated in a porcelain dish on a water bath until it became of small bulk, when it was transferred to the crucible, in which the final residue was to be weighed. Sometimes it was noticed that there was a further separation of iron sulphide during this evaporation. This was filtered off before the concentration became too great without causing any error in the final result. The crucible when apparently dry was heated for several hours in an air bath at 100 °C. and then ignited, top on. After the volatile portion of this residue was driven off, the lid was removed and all the carbon burned away.

The crucible was then heated with the blow pipe until the weight was constant. This required at least an hour if a porcelain crucible was used.

The method was carried out by the writer as given above and accurate results, as noted, obtained, when the iron was no more than five per cent of the two metals present. The iron was not determined. The great amount of time required was the only objection to be noted.

II. By Ammonium Hydroxide, Ammonium Sulphide and Sulphurous Acid.

Berthier[15] said that if a mixture of the salts of iron and zirconium in solution be precipitated by an excess of ammonium hydroxide and then an excess of ammonium sulphide be added, that the ferrous sulphide formed could be dissolved out with a sulphurous acid solution. Several experiments were carried out. The solution was precipitated by an excess of ammonium hydroxide, —in one the excess was boiled away—then an excess of freshly made ammonium sulphide was added and the whole allowed to settle. (Experiments were made with both the colorless and yellow ammonium sulphide). The supernatant liquid was drawn off, or the whole filtered, and the precipitate boiled with a strong sulphurous acid solution. Most of the black sulphide became immediately decolorized. After a five or ten minutes boiling, the solution was filtered and washed with hot water and a weak sulphur dioxide solution. The precipitate remained brown however, strongly colored by the iron which had not been dissolved. In one experiment this impure precipitate was redissolved

15. Booth's Encycl. Chem.

in dilute hydrochloric acid and the process repeated. There was only a slight diminution in the amount of iron left. If the hydrochloric acid solution of this precipitate was neutralized by ammonium hydroxide and then an excess of sulphurous acid added, the zirconium separated out perfectly white and free from iron.

	Found.	*Used.*
ZrO_2	—0.1070	0.1070

The method of Berthier as I carried it out did not give satisfactory results.

III. By Sodium Thiosulphite.

With proper precautions zirconium was completely separated from iron by means of sodium thiosulphite. The directions given for this method were not always specific.[16] It was noted (by the writer) that unless the solution be neutralized, the precipitation would be incomplete; also if it be neutral and the boiling long continued, the precipitate might be very finely divided and hard to catch on the filter paper; also if all or the greater part of the sulphur dioxide be boiled away the oxide of iron separated immediately on access of the air after the removal of the clock glass used to cover the beaker. No accurate separation was obtained if the solution was rendered neutral with ammonium hydroxide or the precipitation was made when the solution was hot.

But the method of Chancel[17] and Stromeyer[18] gave accurate results. By this method the solution was rendered neutral with sodium carbonate, the beaker

16. Rosc. and Schorl. II—sI—271., and Miller's Chem. II—p. 643.
17. Ann. Ch. Pharm. CVIII 237.
18. *Ibid*, CXIII–127.

placed in cold water, and when the solution was cooled, an excess of sodium thiosulphite was added. After the solution became decolorized, it was boiled, and the white precipitate (zirconium hydroxide according to Stromeyer) settled out well. This precipitate was easily filtered, washed with hot water, burned and ignited to constant weight.

These results are reported :—

Numbers.	*Found.*	*Used.*
140	0.1315	0.1333
141	0.0552	0.0565
143	0.1640 }	0.1614
145	0.1613 }	

Nos. 140 and 141 were in solutions in which there was present free acid—No. 140 hydrochloric—and No. 141 sulphuric. No. 143 was not properly neutralized and on addition of the sodium thiosulphite, a heavy flocculent flesh-colored precipitate settled out. This on warming became white, but when the precipitate was burned showed the presence of some iron. No. 145 was carried out exactly according to the directions given above.

IV. By Ammonium Sulphite.

As I carried out the experiments, I failed to succeed in perfectly separating iron and zirconium by this method, which is also recommended by Berthier.[19] Solutions of the chlorides of these two metals were made with equal and varying amounts of each, then an excess of freshly prepared ammonium sulphite was added. The zirconium sulphite precipitated was soluble in an

19. Booth's Encycl. Chem. 1850.

excess of the precipitant, but zirconium hydroxide was thrown down on boiling. If the boiling was kept up until no more sulphur dioxide came off, immediately on permitting the liquid to come into contact with the air, a scum of oxide of iron formed. Next, the boiling was not continued so long—the precipitate when burned, however, still contained some iron. Besides the results obtained were low, as may be seen by these analyses:—

Number.	*Found.*	*Used.*
150	0.0463	0.0535
152	0.0871	0.1070
156	0.0453	0.0535

The hydroxide is, doubtless, partly soluble in an excess of the sulphite, even after boiling.

V. By Sulphur Dioxide.

The method of precipitation of zirconium from a chloride solution on addition of sulphurous acid in excess affords an excellent means of separating zirconium from iron. The zirconia precipitated by sulphur dioxide in large excess and boiled two to three minutes, was, after filtration, washed four or five times with hot water. The further necessary precautions have been given above. The iron was titrated in the filtrate. The experiments gave these results.

Number.		*Found.*	*Used.*
160	ZrO_2	0.1047	0.1043
	Fe	0.0830	0.08225
161	ZrO_2	0.1074	0.1070
	Fe	0.08248	0.08225
162	ZrO_2	0.1078	0.1070
	Fe	0.0820	0.08225

163	ZrO_2	0.1043	0.1043
	Fe	0.04389	0.04225
166	ZrO_2	0.0537	0.0535
	Fe	0.04334	0.04225

SEPARATION OF ZIRCONIUM FROM ALUMINIUM.

I. By Sodium Hydrogen Carbonate.

Having noted the property of zirconium of being re-precipitated from a solution (at first precipitated but soluble in an excess of sodium hydrogen carbonate) on boiling with ammonium chloride, Pelouse and Frémy[20] proposed it as a method of separation of that metal from aluminium. Severale xperiments were carried out by the author of this paper, but the conclusion arrived at was that it was a qualitative separation, which could not be used for quantitative purposes.

II. By Sodium Iodate.

Davis[21] gives a neat and accurate method for the separation of zirconium and aluminium. The directions, as given by him, for the process must be most carefully followed in order to obtain accurate results. Moreover the process is inapplicable when iron, be it in a ferrous or ferric condition, is present. The method therefore offers but little of practical value in ordinary analysis.

"Their[22] (aluminium and zirconium) solution in hydrochloric acid is treated with sodium carbonate until a permanent precipitate is formed. This precipitate is

20. Traité de Chimie Générale, III–523, 1854 Edition.
21. Am. Ch. J., XI–26.
22. *Ibid.* p. 29.

dissolved in the smallest possible quantity of dilute hydrochloric acid and sodium iodate ($NaIO_3$) added in excess. The solution is heated for about fifteen minutes. It is then allowed to stand twelve hours filtered, washed down with boiling water, dissolved in hydrochloric acid and finally precipitated with ammonia, ignited and weighed." I found in an analysis 0.0515 g. ZrO_2 when I had used 0.0520 g.

Analyses were made also according to his recommendation of the use of from five to ten per cent. of sodium chloride. The results obtained were high, doubtless due to imperfect washing. An example:

	Found.	*Used.*
ZrO_2	0.0596	0.0520

The numerous experiments made served merely to confirm Davis' work. It was necessary to avoid a too far neutralization with sodium carbonate as the separated zirconium was contaminated with varying amounts of aluminium. The permanent precipitate formed by the sodium carbonate was difficult at times to redissolve in a small amount of dilute hydrochloric acid. Yet an excess of acid must be avoided, for it was learned by experiments, as Davis had noted, that the presence of even 0.1 per cent. by weight of hydrochloric acid would cause low results. Four hours was a sufficient time for complete separation however. An experiment with the sulphate solution showed no action whatever. Even the small amount of sulphuric acid in an aluminium sulphate solution was found to interfere, hence the necessity of having a hydrochloric acid solution, free from sulphuric acid, was apparent. Davis evidently noted this as he was particular in having a pure solution of aluminium chloride in his experiments.

III. By Sulphur Dioxide.

Sulphurous acid may be used for the separation of zirconium and aluminium as well. The process is essentially the same as for the separation of iron and zirconium (see above).

The analyses proving this are al.o given.

Number.		*Found.*	*Used.*
201	ZrO_2	0.1042	0.1043
	Al_2O	0.0608	0.0610
207	ZrO	0.1070	0.1070
	Al_2O	0.0316	0.0305

SEPARATION OF ZIRCONIUM AND TITANIUM.

As is well known, titanium and zirconium are metals possessing many properties in common. Their deportment with reagents is very similar, varying only in degree, as a rule. This fact, and that of the properties of each being further altered by the presence of the other in the same solution,[23] renders their separation extremely difficult. An example of this alteration of properties was noted on boiling a solution of sulphates of these metals. On long continued boiling titanium sulphate, when in solution alone, is completely precipitated. Zirconium sulphate, under the same conditions. produces no precipitate, whereas a mixture of these permits of only a partial precipitation of the titanium, the larger portion remaining undissolved (Berzelius[24]).

I. By Potassium Sulphate.

It was not found possible to use the precipitation of

23 Rose Analyt. Chem, p. 172.

24. Pogg. Ann. VI., 232.

the zirconium as the basic potassium sulphate, for the reasons above noted. For want of a better method, however, this was for a long time used.

II. By Boiling an Acetic Acid Solution.

Franz and Streit claimed complete separation if the solution, neutralized by ammonium hydroxide, were rendered strongly acid with acetic acid and boiled sometime. The usual preliminary qualitative experiments were carried out by the writer, and he obtained a precipitate in both cases. The titanium was precipitated directly and in large amounts, whilst the zirconium was also precipitated, but in small amounts. Of course solutions of approximately known strength were used in these experiments. When this was noted the completeness of the titanium precipitation was not tested. This method, therefore could not be recommended.

III. By Ammonium Oxalate and Ammonium Carbonate.

The experiments of Hermann[25] were very carefully repeated. The zirconium chloride solution was diluted to contain one part in one hundred parts of water, and to this was added double the weight (of zirconium) of ammonium oxalate. I did observe, as he says,[26] "Dabeienstand anfänglieh eine Trübung, nachdem aber die ganze Quantität des Oxalats zugesetzt worden war, klärte sich die Flüssigkeit wieder vollständig auf. Man

25. J. Prak. Ch. 97—338.
26. *Ibid*, 337:

gass jetzt diese Lösung von oxalsaurer Ammoniak-Zirkonerde in eine concentrirte Lösung von kohlensaurem Ammoniumoxyd." But I did *not* observe, "Dabei blieb die Flüssigkeit ganz klar und setzte auch nach längerem Stehen keine Spur eines Niederschlags ab."

A chloride solution of titanium, treated in the same manner as above, gave a heavy precipitate, when the double oxalate formed an addition of the ammonium oxalate, was poured into a saturated solution of ammonium carbonate. As noted above a precipitate was obtained with the zirconium chloride solution as well; nevertheless an analysis was made and 0.0327 g. titanium was found when 0.0302 g. had been used. This proved to the writer that advantage could not be taken of this for a *complete* separation of zirconium from titanium. Hermann[27] noted this incompleteness in his further remarks concerning an experiment he performed: "Die geringe Differenz von 0.18 Theilen Zirkonerde zu wenig und 0.18 Theilen (used 6, found 6.18) Titansäure zu viel kam daher, dass die Titansäure beim Fällen durch kohlensaures Ammoniumoxyd ein geringe Menge Zirkonerde mit niedergerissen hatte."

IV. By Hydrogen Peroxide.

So no good and accurate method was known until Bailey[28] noted the effect of adding hydrogen dioxide to a zirconium solution. This is the only thoroughly accurate method yet proposed. Its neatness and rapidity in application are to be especially noted. At the same time consideration must be given to the difficulty in obtaining perfectly pure hydrogen dioxide.

---

27. *Ibid*, 439.

28. J. London Ch. Soc. Trans. 1886, p. 149.

He proceeded[29] by adding an excess of hydrogen dioxide to a moderately acid solution of a mixture of iron, zirconium and titanium. After twenty-four hours standing in a stoppered flask, the precipitated oxide (Zr_2O_5) was caught and filtered, washed and ignited. In carrying out this method the writer noted the necessity of having an acid, yet not too acid, solution. If the solution was first neutralized with ammonium hydroxide or sodium carbonate, the precipitated zirconium oxide was highly contaminated with iron, which could not be washed out.

Analyses gave these results:

Numbers.	*Found.*	*Used*
ZrO_2	0.1111	0.1118
Fe	0.0135	0.0138
TiO	0.0302	0.0302
ZrO_2	0.2425	0.2424

The precipitation was found to be complete on boiling the solution two or three minutes to avoid the twenty-four hours delay by standing cold. After filtering from the zirconium oxide, the filtrate was rendered alkaline with ammonia water, filtered and the precipitate dissolved in dilute hydrochloric acid. The excess of acid was neutralized and the titanium determined by precipitation on boiling with sulphur dioxide.[30] The iron was determined from the filtrate from this.

The hydrogen dioxide obtained from the manufacturer[31] was found to contain a large amount of silicic acid in solution along with the other ordinary impuri-

29. *Ibid* p. 482.
30. The author J. Am. Ch. S.
31. Dr. Merchand, 28 Prince st., New York.

ties. The strength of this solution was 72 volumes, being brought to this strength according to Thénard's method[32] (Marchand). I further purified and concentrated this to 111 volumes by distilling in partial vacuum, according to Talbot and Moody.[33] I found the potassium sulphate present interfered very much with the reaction by the formation of the more or less soluble basic zirconium potassium sulphate. So nothing definite could be learned from my experiments, which were many, with either the 111 or 72 volume hydrogen peroxide.

To avoid the formation of the compound with potassium sulphate, hydrochloric acid[34] was used. By this method was obtained a solution of the dioxide practically free from silicic and sulphuric acids, but one weaker, being only 55 volumes. It was with this solution the analyses above reported were made.

This method of using hydrogen dioxide is the only accurate method given for the separation of zirconium and titanium. It is direct and rapid, delicate and elegant, but expensive and by no means always convenient.

I cannot close this summation without expressing my great indebtedness to Dr. F. P. Venable, for his ever ready sympathy with and kindness to me in this work. I wish also to express my thanks to Dr. Chas. Marchand, 28 Prince st., New York, for six pounds of 72 volume hydrogen peroxide, with which he kindly presented me.

---

33. Mass. Inst. Technology Quarterly, V-123.
34. *Ibid*, 131.
32. Anneles de Chemie de Physique, [2] 10-114, 335, 11-85.

PRIMITIVE STREAK AND BLASTOPORE OF THE BIRD EMBRYO.

BY H. V. WILSON.

Embryologists, with but few exceptions, recognize in the bird embryo a gastrula stage. There is, however, a very considerable diversity of opinion as to just what constitutes the gastrula. Leaving aside certain interpretations for which at present there seems no good ground, we find there are two very different views held regarding the nature of this embryonic stage.

According to the older view, advanced by Balfour and Rauber, the essential difference between the bird gastrula and the fish gastrula is that a part of the original edge of the blastoderm, is in the bird turned in to form the primitive streak. Thus while in the fish the blastopore is represented by the blastoderm edge, in the bird it is represented by the primitive streak plus the blastoderm edge. This theoretical view receives the support of the well known researches of Duval on the germ layers of birds[1]. Duval finds that the very young blastoderm of the bird is similar to that of fishes. In both, the ectoderm and entoderm are continuous round the edge, which therefore corresponds to the blastopore. But this precise similarity is only transient, for in the bird the primitive streak soon makes its appearance. The manner in which the primitive streak is formed proves conclusively that it is only a modified part of the blastoderm edge. The young blastoderm (fish-like stage) grows centrifugally at all

1. De la formation du blastoderme dans l'oeuf d'oiseau. Annales des Sciences Nat. Zoologie. T. XVIII., 1884.

points except at that which corresponds to the future tail end of the embryo. By this means a certain portion of the blastoderm edge becomes turned in on each side of the median line in the posterior region, the two portions running forwards side by side to the point already mentioned, where no centrifugal growth occurs. These two portions fuse and form the primitive streak, which thus at first extends to the very edge of the blastoderm. Now, however, centrifugal growth begins at the posterior pole of the blastoderm, and the primitive streak gradually takes up its well known position at a distance from the edge.

In opposition to this view Oscar Hertwig, Rabl, and others claim that the blastoderm edge is not a part of the gastrula mouth, but is a peculiarity of certain mesoblastic ova, and that the blastopore is represented exclusively by a structure known as the *sickle* plus the primitive streak. This doctrine is based on the belief that an ingrowth or invagination of cells takes place only in the region of the sickle and streak, and not round the edge of the blastoderm. In a paper on the development of teleost fish I have already attempted a criticism of this view[2], and will only add that it is to my own mind in direct contradiction with the admirable account given by Duval of the formation of the primitive streak. On the other hand it receives support from the discoveries of Kupffer on the reptilian embryo, and from Koller's description of the way the streak is formed in the bird embryo.

According to Koller's account[3], which is adopted by

---

2. The Embryology of the Sea Bass. Bulletin U. S. Fish Commission. Washington. 1891, pp. 268–271.

3. Beiträge zur Kenntniss des Hühnerkeims in Beginne der Bebrütung. SB. der König. Akad. d. Wiss Wien. 1879.—Untersuchungen über die Blätterbildung in Hühnerei. Archiv für Mikros, Anat. Bd. XX. 1881.

Hertwig in his text book, there very early developes a sickle-shaped thickening which lies between the area pellucida and the area opaca, in the posterior region of the blastoderm. A groove, the sickle groove, is present in this thickening, and in the median line there is a short anterior projection called the *sichel-knopf*. The primitive streak is produced by the continuous growth in the median line, of the *sichel-knopf*, and is therefore an outgrowth of the sickle. Since neither the sickle nor the primitive streak is at any time connected with the blastoderm edge, the latter structure cannot be regarded as a part of the blastopore, which is represented exclusively by the two former structures.

The contradiction between Duval's and Koller's account concerns a fundamental feature of the process of gastrulation, and more facts on the early history of the bird blastoderm are much to be desired. Duval himself, in his criticism of Koller's papers (l. c.), states it as his opinion that the sickle is an inconstant feature, of no morphological importance, belonging in the same category as other local thickenings of the blastoderm. I may mention that I have myself looked through very young blastoderms, in which the primitive streak was from one-half to two-thirds the length of the area pellucida, without discovering in the majority of them any trace of the sickle. I am aware that Koller describes the sickle as becoming much less conspicuous with the continued growth of the streak, but his figures of blastoderms[4] corresponding in age to mine, show an evident remnant of the sickle, while I can find no trace of such a structure in the majority of my embryos.

Koller, it will be remembered, kept his eggs at a

4. SB. d. König. Akad. d. Wiss. 1879. Beiträg. &c., figs. IV.a. IV.b. V.

temperature below the normal temperature of incubation, in order to lessen the rapidity of development. A certain percentage of abnormalities was to have been expected from the use of the temperature below the normal, and I have satisfied myself that at 35° various kinds of abnormalities do occur. Out of a considerable number of young blastoderms, incubated at 35°, while the majority showed no trace of the sickle, in a few cases the primitive streak exhibited abnormalities suggesting more or less strongly the sickle. Surface views of two of these blastoderms are given in Figs. 1 and 2. In the primitive streak of Fig. 2, I could not make out the primitive groove, but the groove was very evident in the sickle at the posterior end of the streak. (Kupffer and Benecke[5] give a wood-cut figure of a chick blastoderm, quite like my figure 2, except that the primitive groove is shown. While they incline to the belief that the sickle in such a blastoderm is of morphological importance, they admit that it was only rarely that such blastoderms were found.) In the blastoderm shown in Fig. 1, the groove was conspicuous, both in the streak and in the transverse outgrowths of the streak. This blastoderm was sectioned longitudinally. A median section through the streak is shown in Fig. 3. The transverse groove is deep; the hypoblast is differentiated as a distinct layer; the epiblast and mesoblast are indistinguishably fused. In Fig. 4 is represented a section lying in the plane *x-y* of Fig 1. In this region the transverse groove is as deep as in the median section, but the three layers are separate.

My failure to find the sickle in blastoderms where, according to Koller it should be present, and the obser-

5. Die ersten Entwicklungs vorgänge am Ei der Reptilien. Königsberg. 1878. p. 11.

72

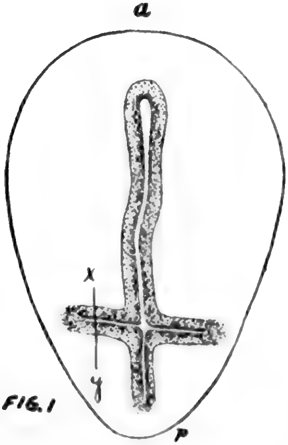


FIG. 1

FIG. 2

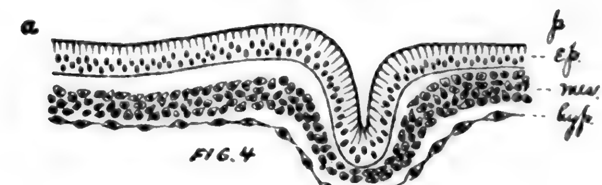


FIG. 3

FIG. 4

vation of abnormalities resembling in a measure the sickle, incline me to accept Duval's view of this structure, and with him to regard it as an inconstant feature of no morphological importance.

Hertwig, in his paper on "*Urmundrand Spina bifida,*" (1892), touches on the question of meroblastic gastrulation, and it would seem that he no longer believes in the existence of Koller's sickle. For in his brief sketch of the manner in which the primitive streak is formed, he follows Duval, and represents the streak as arising by the coalescence the blastoderm edges. He therefore comes to regard the edge of the young blastoderm as the blastopore.

Hertwig does not look on the entire edge of the young blastoderm as the blastopore, but for some reason unknown to me divides it into a blastoporic part and a part designated as the *Umwachsungsrand*, by which name he formerly (text-book) meant the entire blastoderm edge. The edge of the teleost blastoderm is likewise divided into blastopore and *umwachsungsrand.* This division is surprising, for round the entire edge of the teleost blastoderm there is an ingrowth of cells, just as there is round the blastopore lip of the amphibian embryo. And the existense of such an ingrowth is undoubtedly a very strong argument for regarding the whole edge as the blastopore· It would be interesting to learn the facts that have induced Professor Hertwig to divide the edge of the teleost blastoderm in this manner.

But if Hertwig has come to regard the edge of the blastoderm, or any part of it, as representing the *urmundrand* in the bird embryo, it would seem that he must have abandoned his former views on gastrulation in the Sauropsida, and have taken a long step towards the position of Balfour and Rouber.

CHAPEL HILL, NORTH CAROLINA.

Explanation of the figures illustrating Mr. Wilson's paper on "Primitive Streak and Blastopore of the Bird Embryo":

Fig. 1. Surface view of abnormal chick blastoderm. + 16.

Fig. 2. " " + 16.

Fig. 3. Median longitudinal section through the primitive streak of Fig. 1. × 90.

Fig. 4. Longitudinal section through line x-y of Fig. 1. × 90.

a.—anterior.
p.—posterior.
ep.—epiblast
mes.—mesoblast.
hyp.—hypoblast.
Pr. str.—primitive streak.

ADDITIONS TO THE ERYSIPHEÆ OF ALABAMA.

BY GEO. F. ATKINSON.

In Vol. VII, II, of this Journal was published a list of the Erysipheæ, collected by the writer, from the Carolinas and Alabama. During the following year several more species were collected in Alabama by the writer and one of his students. The former list was accompanied with quite full notes of a descriptive character. In the present list only such notes are added as seem necessary in addition to the characterizations found in descriptive works:

Spærotheca castagnei Lev.

On Erectites hieracifolia, Nov. 5, 91; and Bidens frondosa, Nov. 3, 91, B. M. Duggar, collector.

S. lanestris Hark.

On Quercus alba, Dec. 91, G. F. A. The conidial stage only was found.

Erisiphe cichoracearum D C.

On Helianthus annuus, Oct. 19. 91, B. M. D. Aster tradescantia, Nov. 31; A. diffusus, Nov. 30; Mikania scandens, Oct. 26. and Solanum carolinense, Nov. 10, 91, G. F. A.

E. galeopsidis D C.

On Verbena urticifolia, Oct. 23, 91, B. M. D.

E. liriodendri Schwein.

On Liriodendron tulipifera, Oct. 28, 91, B. M. D.

Phyllactinia suffulta (Reb.) Sacc,

On Cornus florida, Nov. 3; Cornus sp. undtd, Oct. .18.

Podospæra biuncinata C. & P.

On Hamamelis virginiana, Oct 28, 91, B. M. D.

P. oxacanthæ (DC).

Prunus americanus var. mollis, Oct. 31, 91, B. M. D; Cratægus, Nov. 9, D. H. Benton.

Microsphæra semitosta B. & C.

Tecoma radicans, Oct. 19, 91, G. F. A. This species has heretofore been reported only on Cephalanthus occidentalis. The perithecia are a little larger than those I have observed on Cephalanthus, measuring 90 to 115. The appendages in well matured specimens are very characteristic.

M. euphorbiæ B. & C.

On Euphorbia preslii, Oct. 21, 91, B. M. D.

M. ravenelii B.

On Gleditschia tricanthos, Oct. 13, 91, G. F. A.

M. vaccinii C. & P.

On Vaccinium, Oct. 18, 91, B. M. D.

M. grossulariæ (Wallr.).

On Sambucus canadensis, Oct. 13, 91, G. F. A. In the previous list this occurred as was given as M. vanbruntiana Ger.

The measurements are given in terms of the micro-millimeter.

BOTANICAL DEPARTMENT, CORNELL UNIVERSITY.

SOME SEPTORIÆ FROM ALABAMA.

BY GEO. F. ATKINSON.

The species of Septoria enumerated in this list were collected during my connection with the Alabama Polytechnic Institute at Auburn, Ala. The list is not large, perhaps from the fact that no especial effort was made to collect the members of the genus. Where no name is given as collector they were collected by myself. Where no locality is given Auburn should be understood.

Septoria brunellæ E. & H.

On Prunella vulgaris, July 16, 90, Shorters. The specific name of this plant was given from a mistaken spelling of the genus Prunella which has crept into many American botanical works. See Coville, Bot. Death Valley Expedition, p. 176.

S. cerastii Rob. et Desm.

On Cerastium arvense, Mar. 25, 91. Perithecia not very black, probably because they are not very old. The spores are a little stouter than the description calls for, and are faintly 1 – 5 septate. The spores in the specimen in Roumg. Fung. Gall. Exs. 2485, are also faintly 1 – 5 septate; the perithecia are very black but agree with the Alabama specimens in being rather angular in outline.

S. rubi West.

On cultivated Rubus, Aug. 8, 90.

S. rubi var alba Peck.

On Rubus trivialis, Apr. 91, Mobile, Zimmer Bros. The leaves are also affected with Cercospora rubi West. and Caeoma nitens.

S. virgauræ Desm?

On Solidago seratina. There is some doubt about the correct determination of this plant. It seems near this species, but the spores measure 30 – 40 and are faintly 3 – 5 septate. Perithecia small 50 – 75. Spots small, whitish, depressed, dark bordered.

S. erechtites E. & E.

On Erechtites hieracifolia, Sept 10, 91, B. M. Duggar.

S. œnothera West.

On Œnothera biennis,

S. dianthi West.

On Dianthus barbatus,

S. speculariæ B. & C.

On Specularia perfoliata, Mar 28, 90.

S. jussiææ E. & K.

On Jussiæa leptocarpa, July 24, 91, Duggar and Newman.

S. sambucina Pk.

On Sambucus canadensis, Aug 24, 91, B. M. D.

S. sonchina Thüm.

On Sonchus oleraceus, Feb. 25, 91, B. M. D.

S violæ West.

Viola primulæfolia, July 16, 90, Shorters.

S. xanthii Desm.

On Xanthium, July 11, '90, Uniontown.

S. graminum Desm.

On Panicum sanguinale, Aug. 19, '91, B. M. D. Spots brown, elongate, irregular or involving the larger part of the terminal portion of the leaf. Perithecia amphigenous, more abundantly epiphyllous black, frequently depressed when dry, 80 - 90. Spores hyalines, slender, larger at base, soon tapering into a long, very slender, strongly curved flagellum, 2 10 septate. Very young ones are narrowly obclavate with the smaller end little curved and 1 2 septate, 1 1½ in diameter at base, 30 - 70 long.

S. alabamensis n. sp.

On Nepeta glechoma, Jan. 29, and Feb. 27, '91. Spots indefinite, occupying irregular portions of the leaf. Perithecia 80 - 90. Spores 20 - 30 x 1 or less, sometimes faintly 1 - 3 septate, staight or slightly curved or flexuous.

The measurements are given in terms of the micromillimeter.

BOTANICAL DEPARTMENT, CORNELL UNIVERSITY.

ADDITIONAL NOTE ON THE FUNGI OF BLOWING ROCK, N. C.

In making out the list of fungi from Blowing Rock, which was published in Part 2, Vol. IX, of this Journal, two species were overlooked. They are as follows:

Cordyceps acicularis Rav.

On larva of elaterid beetle.

Cnomoniella coryli (Batsch.) Sacc.

On leaves of Corylus.

GEO. F. ATKINSON.

AN EXAMINATION OF THE CHLORIDES OF ZIRCONIUM.

BY F. P. VENABLE.

A chloride of zirconium of definite composition would prove a valuable compound for determining the atomic weight of the element. There are several difficulties in the way of securing such a result:

1. The tendency to form basic chlorides.
2. The ease with which hydrochloric acid is lost through the action of heat and of dehydrating agents.
3. The presence of free hydrochloric acid.
4. The deliquescent nature of the chlorides.

It is particularly desirable that the conditions under which a definite chloride can be formed should be discovered, as zirconium seems to yield no very satisfactory compounds for the determination of the atomic weight. There have been many efforts at finding out these exact conditions.

Most text-books state that anhydrous, pure zirconium tetra-chloride can be prepared by passing dry chlorine over a mixture of charcoal and zirconia heated to a high temperature. Hermann used this sublimed zirconium chloride for the determination of the atomic weight. As Clarke says, however, little confidence can be placed in his results. Bailey* has recorded that even with great care to avoid the presence of moisture, he was unable to prevent the formation of oxychlorides. He also says that in no case was it found possible to prepare the chloride free from iron and silica. The

*Chem. News. LX.. 17.

necessity for the presence of these in the materials used or in the resulting compound is not very apparent. I have as yet had no opportunity of repeating his experiments.

The chlorides most commonly worked with have been those formed by the solution of the hydroxide in hydrochloric acid, followed by precipitation or crystallization from concentrated hydrochloric acid.

Berzelius attempted to remove the excess of hydrochloric acid by heating the salt to 60° C. but was not able to obtain a definite compound. Two analyses gave:

ZrO_2	0.332	0.485
AgCl	0.661	1.076

The silver chloride should be about two and one-third times as much as the oxide.

Paykull dried the salt between filter paper and found the composition of the crystals to be $ZrOCl_2 . 8H_2O$, the amorphous form precipitated by hydrochloric acid being $2ZrOCl_2 . 13H_3O$.

Endemann has described basic or oxychlorides $Zr_3O\,Cl_4$; ZrOClOH, and $Zr_8O_8Cl_7(OH)_9$; Troost and Hautefeuille have described others, $Zr_2O_3Cl_2$ and Zr_2OCl_6. In fact water is so easily taken up and hydrochloric acid lost that a large number of such indefinite compounds might be prepared by slightly varying the conditions.

Nylander* mäde a series of attempts at dehydrating the chloride. He prepared the chloride by dissolving the hydroxide in hydrochloric acid and evaporating to crystallization. The salt formed white needles, easily

*Bidrag till kännedomen om Zirkonjord. Inaug. Diss. Lund 1864.

soluble in water. They were washed with alcohol and for analyses I. and II. were pressed between filter paper. III. and IV. were dried over sulphuric acid. The results were as follows:

Zr	27.56	95.69	30.11	31.78
Cl	21.58	21.58	23.06	23.80
Loss (H_2O)	50.86	52.78	46.83	44.12

or calculated on a dry basis:

Zr	56.08	54.41	56.63	57.18
Cl	43.02	45.59	43.37	42.82

Again preparations were made as before. I. was dried between filter paper, II. over sulphuric acid, III. was pressed between filter paper and then dried over sulphuric acid, IV. was dried a long time over sulphuric acid. The analyses gave the following:

Zr	28.52	34.91	37.78	35.69
Cl	21.93	26.09	25.87	21.74
Loss	49.55	39.10	36.35	42.57

or calculated on a dry basis:

Zr	56.93	57.23	59.34	62.14
Cl	43.07	42.77	40.66	37.86

Lastly he allowed a solution of the chloride to evaporate over sulphuric acid, washed the crystals obtained with alcohol and pressed them between filter paper. Analyses gave:

	I.	II.
Zr	27.94	28.74
Cl	27.32	26.67
Loss	44.74	42.62

or, calculated on a dry basis:

Zr	50.36	50.04	Zr	38.50
Cl	49.44	49.96	Cl_4	61.50

The above results show that his preparations were indefinite oxychlorides or mixtures, in varying proportions of zirconium tetrachloride and oxychloride.

Bailey repeatedly crystallized the chloride from hydrochloric acid, washed it with hydrochloric acid and then removed the free acid.

1. By washing with a mixture of one part alcohol and ten parts of ether.
2. By gently heating the salt.
3. By exposing the finely divided salt at ordinary temperatures in a vacuous dessicator over potash, until no hydrochloric acid appeared when air passed over it.

The analysis was performed by dissolving the salt in water and precipitating the zirconia with ammonia, then acidulating with nitric acid and precipitating the chlorine by means of silver nitrate. By method 2 a constant and progressive diminution of chlorine was observed. Therefore no analyses were made. For the other methods he gives the results of the analyses by a statement of the ratio of ZrO_2 to AgCl:

	ZrO_2	: AgCl
Berzeliu's determination	1	: 1.991
	1	: 2.260
Bailey's method 1:	1	: 2.206
	1	: 2.179
	1	: 2.226
	1	: 2.260
Method 2:	1	: 2.264
Method 2 without washing:	1	: 2.245
	1	: 2.309
	1	: 2.285
$ZrOCl_2$	1	: 2.350

These preparations are evidently mixtures also.

Hermann* states that the hydrated chloride, gotten in crystals on evaporating its aqueous solution, becomes opaque at 50° C., giving off part of the water and half of the hydrochloric acid, and leaving a basic chloride or oxychloride, $ZrCl_4.ZrO_2.18H_2O$ or $ZrOCl_2.9H_2O$. The same compound is obtained in stellate groups of white silky prisms on evaporating a solution of the chloride. These crystals, when heated, become white and turbid and are converted into the anhydrous dioxychloride $ZrCl_4.2ZrO_2$.

The conditions here are inexact, and though Hermann may have obtained these compounds, he would find it difficult to prepare them again. While it is perfectly true that an oxychloride is formed on the evaporation of an aqueous solution of the chloride, I have been unable to obtain the compounds he mentions. Linnemann† maintains that crystallization from hyhrochloric acid (sp. gr. 1.17) and treatment with alcohol and ether gives a fine, crystalline, snow white, silky body, leaving 50 per cent. of its weight on ignition, and therefore very nearly pure $ZrCl_4$ which should leave 52.5 per cent. He claims that this is "chiefly a neutral, not a basic compound."

My own experiments on the dehydration of this salt have extended over the past two years, as opportunity was afforded. Several series of experiments were undertaken; some along the lines attempted by others, and others by methods not tried before. In all the purified chloride, obtained by repeated crystallization from hydrochloric acid was used, the salt being still wet with

*Watts Dict. V. p. 180.

†Chem. News. LII. 224.

the excess of the acid. There was no attempt at drying this between filter paper. The method of preparing this salt has been fully described in a previous paper in the *Journal of Analytical and Applied Chemistry*, 5, 551.

In the first experiment this chloride was washed once with water and then put in a dessicator and dried over calcium chloride (porous dessicated). It remained in the dessicator about seven months. Even after this lapse of time it still continued to show a slight loss in weight. It yielded, on analysis, 48.84 per cent. ZrO_2.

Another portion was placed in a jar over solid lumps of sodium hydroxide. After six weeks the loss was very slight. Careful ignition left a residue of ZrO_2, equivalent to 42.99 per cent. of the original weight. There was found to be 24.44 per cent. of chlorine present.

Again a portion was placed over calcium chloride and dry air was drawn over it at the rate of about fifty litres in the twenty-four hours for six months. After the first two months it was examined weekly by the interposition of a flask containing silver nitrate to see whether hydrochloric acid was still coming off. Even after the lapse of so long a time as this it was found that the loss of hydrochloric acid continued, although it was slight. On analysis this gave ZrO_2 42.28 per cent. and Cl. 24.35. Although the results in this, and the experiments immediately preceding, correspond fairly well they are unsatisfactory, as they point either to a mixture of chlorides or an oxychloride of very complicated formula, and hence unsuited for the ultimate aim of the research.

Lastly a portion was placed over concentrated sulphuric acid and the atmosphere above it exhausted occasionally. This was kept up during two months of summer weather. The loss in the last fifteen days was about .02 per cent. of the whole. The mass was powdery, with a slightly discolored crust. It was all soluble in water, however, and yielded a clear colorless solution. It contained 53.30 per cent of ZrO_2. This corresponds very nearly to the formula $ZrCl_4$ and is altogether at variance with the results obtained by Nylander and with the assertion made by Hermann, that half of the hydrochloric acid was lost over sulphuric acid.

This last experiment showed the possibility of securing pure zirconium chloride, provided the excess of hydrochloric acid could be removed. It was thought that this might be done by heating in an atmosphere of hydrochloric acid. A weighed flask was so arranged that it could be kept at a definite temperature while a stream of dry hydrogen chloride was passing through it. The temperature ranged from 100° to 110° C. and the chloride placed in the flask melted, solidifying again after the loss of the water and excess of hydrochloric acid. If the drying was done slowly enough fine crystals of zirconium chloride were gotten which lost no further weight on being kept at 100° C. A more rapid drying left a hard white mass which was quite hygroscopic. Heating this mass for several days did not cause any diminution in weight, provided the flask was kept full of hydrogen chloride. If the mass was heated even a short time in the absence of hydrogen chloride then further heating caused a continuous loss of weight even in the presence of a rapid stream of hydrogen chloride. After this it was impossible to secure a constant weight.

This method of drying has been tried repeatedly on various preparations, and I regard them as showing conclusively that a neutral chloride of zirconium can be prepared and dried.

Analyses of this chloride gave the following percentages of ZrO_2:

52.70 52.78 52.63

Experiments have already been begun with a view of utilizing this body in a series of experiments looking to a revision of the atomic weight of zirconium.

In connection with this subject it may be well to mention some improvements in the method of purifying zirconium chloride. (See *Journal of Analytical and Applied Chemistry*, 5, 551).

In the first place the separation from silica by evaporation to dryness is not complete. It is impossible to heat this chloride to the necessary temperature without such a decomposition as will render the zirconium chloride also insoluble. It is best then to make this preparation as thorough as possible by heating, then to change the chloride into oxide by ignition, and to treat this several times with hydrofluoric acid until the trace of silica is all driven off. This silica is too small in amount to interfere with ordinary uses but would have to be removed where perfect purity was demanded.

Again, where the hydroxide is dissolved in dilute hydrochloric acid, or contained so much water that the acid was greatly diluted by it, it will be found that more or less of a white insoluble powder will form on evaporation as recommended on a water-bath and on subsequent treatment with boiling strong hydrochloric acid. By a careful arrangement of glass wool in a hot water funnel the dissolved chloride can be filtered away from this soluble mass. It seems to be quite insoluble in hydrochloric acid though easily dissolved by water. Analysis shows that this mass is $ZrOCl_2$ and with it was found as an impurity whatever silica the separation by heating failed to remove.

Lastly, my assistant, Dr. Baskerville. has shown that much time and hydrochloric acid will be saved if in the solution containing much iron the zirconium hydroxide be first precipitated out by means of sulphur dioxide. This precipitate can then be dissolved in acid and purified by crystallization as already recommended.

Of course it need scarcely be mentioned that if silica has been removed by ignition and treatment with hydrofluoric acid, it will be necessary to fuse once more with caustic alkali and repeat the ordinary purification.

UNIVERSITY OF NORTH CAROLINA.

SOME ATTEMPTS AT THE FORMATION OF ETHYL GLUCOSIDE.

J. R. HARRIS.

Glucosides are substances ocurring in nature in plants and are supposed to be ethereal derivatives of the glucoses. Under the action of dilute acids or ferments they break up into glucose and other bodies. A number of these ethereal derivatives of glucose can be prepared synthetically in the laboratory.

A. Michael[1] obtained them by the action of alcoholic solution of acetochlorhydrose upon the alkali salts of phenol.

1. Compt. rend. 89, 355.

The formation of Helicin according to the following equation would be an example of this method: $C_6H_7ClO_5(C\ H_3O)_4 + C_7H_3O_2K + 4C_2H_6O = C_{13}H_{16}O_7 + KCl + 4C_2H_5C_2H_3O_2$.

Emil Fischer[2] has recently discovered a new method of forming these derivatives. and has prepared compounds of methyl, ethyl, propyl, amyl, isopropyl, allyl and benzoyl glucose. Also analogous compounds of arabinose, methyl-arabinoside.

These do not reduce Fehling's solution; they break up into glucose and the corresponding alcohol on treatment with dilute acids or ferments, and behave in every way similarly to the natural glucosides.

I proposed to form them by the action of alkyl iodide upon the sodium glucosate according to the following equation:

$$C_6H_{11}NaO_6 + C_2H_5I = C_6H_{11}O_6.C_2H_5 + NaI.$$

For this experiment, the ethyl glucoside was chosen, as the materials for its preparation were already on hand, and because in all probability the method would work as well for this one as any other member of the series.

The insolubility of sodium glucosate in all neutral anhydrous mediums on hand, was recognized at the outset of this work to be a great obstacle in the way of the successful operation of the method.

As a preliminary test, 15 grs. of anhydrous glucose was taken and gently boiled for some time with 150 c. c. of about 97 per cent. alcohol. This solution, when saturated, was poured off into a large flask in which the precipitation was to be made, and kept warm by standing in a water bath, in order to prevent the glucose from crystallizing.

---

2. Ber. 26, 2400.

Another portion of 150 c. c. of alcohol was poured upon the residue and gently boiled as before. When the hot alcohol seemed no longer to have any solvent action upon the residue, it was carefully decanted off into the precipitating flask.

About half the amount of glucose taken went in solution by this treatment.

The alcoholic solution was then precipitated with an excess of sodium alcoholate, and allowed to stand over night. An amount of ethyl iodide equivalent to the sodium alcoholate used was then added direct to the alcoholic solution containing the suspended precipitate of sodium glucosate. The mixture was now gradually warmed up on a water bath, with a reflux condenser attached to prevent loss of ethyl iodide.

At about 75° C. the mixture began to deposit a reddish brown substance upon the bottom of the flask, and the solution to change to yellow color. At about 80° C. the mixture boiled, and the deposition on the bottom of the flask was more rapid, it being complete in about twenty minutes, leaving a dark brown supernatant liquid. A portion of the liquid was taken out and allowed to stand for some time over freshly ignited potassium carbonate, but no absorption of iodine was noticed.

This, and the remaining portion in the flask, was then filtered through animal charcoal. A liquid of a pale brown color was obtained, which reduced Fehling's solution.

It was not thought that the change would be complete, so it was impossible to tell by this means whether or not the glucoside had been formed. It was then evaporated in a water bath to a syrupy consistence, and the syrup extracted several times with acetic ether.

The acetic ether extract was evaporated in a dessicator over sulphuric acid.

By this means beautiful crystals were obtained, however, colored somewhat by the brownish syrup.

These crystals were tested by the flame test for sodium, and starch paste for iodine. They were clearly shown to be sodium iodide.

The glucose used in this experiment was thought to be impure, and besides it was probable that another test, under somewhat different conditions, would give more satisfactory results.

In his work on glucosides, Fischer[3] dissolves the glucose in a little water, and besides, water is formed in the reaction which he made use of, hence I concluded that it was not absolutely essential for the materials used to be water free. I accordingly started another experiment, using pure anhydrous glucose[4] of my own preparation dissolved in a little water.

Fifteen grams of glucose was dissolved in 5 c. c. of hot water and the solution added to 300 c. c. of 98 per cent. alcohol. This solution was precipitated by an equivalent amount of sodium alcoholate. The precipitate was rapidly filtered off by means of a pump, exposed to air as little as possible, washed with 98 per cent alcohol and transferred to the precipitating flask.

The precipitate was now suspended in 300 c. c. 98 per cent alcohol and an amount of ethyl iodide added equivalent to the sodium ethylate. The mixture was now carefully heated up on a water-bath, with frequent shaking.

---

3 Ber. 26, 2400.

4. Made by the method of Soxhlet J. pr. ch. 21, 245, as given in Emil Fischer's book on Organic Preparations, and purified by recrystallization from strong alcohol.

It was noticed that the change began to take place as before, at about 70° C., by the brownish deposit at the bottom and sides of the flask, as the flask was this time immersed in hot water, taking care that the mixture should not come to boiling.

The greater portion collected on the bottom as a dark brown semi-syrup at that temperature, and the supernatant liquid was straw colored.

The change was complete on heating for 30 minutes just below the boiling point of the mixture. The liquid in the flask now had a strong smell of ethyl iodide, and reduced Fehling's solution.

About half was poured into a smaller flask provided with a reflux condenser and gently boiled in a water bath for three hours. At the end of this time the smell of the ethyl iodide did not seem to have diminished, and it still reduced Fehling's solution.

It was then evaporated on a water bath to a syrupy consistency, and the syrup extracted with a mixture of equal parts alcohol and ether, benzen, petroleum ether and acetic ether. No crystal of sodium iodide could be obtained, and only a thick syrup which powerfully reduced Fehling's solution.

The other portion of the liquid was then transferred to a distilling flask and fractioned. A few c. c. came over between 74° and 78° C. and was mainly C_2H_5OH. Most of the alcohol comes over between 78° and 82° C., leaving a dark brown syrup behind in the flask. The dark brown substance obtained as a deposit in the operation was set aside for examination. Meanwhile another experiment was started, varying the conditions somewhat.

Fifteen grams of anhydrous glucose was dissolved in 400 c. c. boiling absolute alcohol. The solution cooled somewhat, and an equivalent amount of sodium ethylate added, and rapidly cooled to the same temperature. The precipitate was filtered off by means of pump and washed with absolute alcohol, avoiding all exposure to the air possible. It was then transferred to the precipitating flask and an equivalent amount of ethyl iodide added.

The mixture in the flask provided with a reflux condenser, was gradually warmed up to boiling. The changes first noted were the formation of a dark brown deposit on the bottom of the flask at about 70° C., a coloring of the liquid, and at the same time a diminution of the precipitate. Finally, at the boiling point of the mixture, the precipitate appeared to become sticky, and to collect into one mass, instead of being flocculent, and to gradually get smaller and smaller, both going into solution and coloring it a dark brown and melting down to a semi-syrup on the bottom of the flask.

The, time, in this test, for the change was one hour; much longer than in the former experiments. The liquid in the flask was divided into two portions, one of which was boiled in a flask with a reflux condenser for several hours, and no change was observed.

It reduced Fehling's solution and had a strong smell of ethyl iodide. The portions were now combined and submitted to fractional distillation.

About half of the amount of ethyl iodide used was recovered in the fraction coming over between 74° and 78° C.

The alcoholic fraction emitted still a strong smell of the iodide. Hence it seemed that the ethyl iodide had played no part in the change undergone by the sodium glucosate. The residue left in the flask from the experiment was treated with benzen, ether, petroleum ether and chloroform, but none of these had any appreciable solvent action. It was then dissolved in water, a portion of the solution evaporated to dryness in a platinum dish, dried to constant weight, and then ignited at a low red heat.

Weight of dish and substance, - -	24.9115 gr.
Weight of dish, - - - - - - - - -	23.8732
Weight of substance taken, - -	1.0383
Weight of ash and dish, - -	24.1276 gr.
Weight of dish, - - . -	23.8732
Weight of ash, - - - -	2644

To ash, 34.50 per cent.

This was recognized as sodium carbonate, and is equivalent to 10.63 per cent sodium.

The percentage of sodium calculated for sodium glucosate is 11.37 per cent.; found in this syrup 10.63 per cent. Hence it must be a modification of glucosate.

In conclusion it is hardly necessary to say that the negative results of the above experiments do not prove the impractibility of the reaction proposed. It remains, however, to find some neutral anhydrous medium in which sodium glucosate is soluble and by which it is not decomposed, as in most chemical reactions of this character the reacting bodies must be either liquid or in solution.

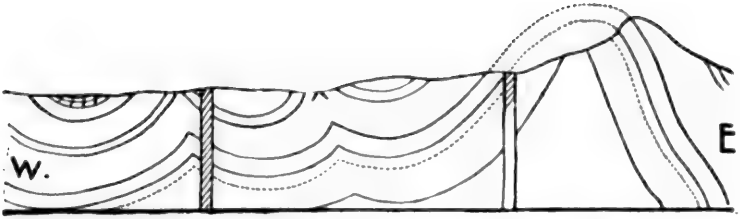
ON THE GEOLOGICAL HISTORY OF CERTAIN TOPOGRAPHICAL FEATURES EAST OF THE BLUE RIDGE.

COLLIER COBB.

The peculiar forms of the topographic outliers of the Blue Ridge, extending across North Carolina from King's Mountain on the south to Pilot Mountain on the north, attracted my attention when a boy, and in May, 1892, I visited the region and began a study of the King's Mountain district under the direetion of Professor N. S. Shaler. The entire summer was spent on the field, as well as the larger portion of the following summer and two of my winter vacations.

The precipitous faces of the mountains, lying at two well-marked levels, suggested to me wave action, and I began my work upon the hypothesis that these outliers had been islands in a sea of no great depth, at a date comparatively late, when the age of the rocks composing the mountains is taken into consideration. The accompanying geological section, from what was formerly known as Bird's Quarry, in the present village of King's Mountain, westward across the mountain, I have adapted from Lieber, putting in the quartzite which forms the crest of the mountain, lying above Lieber's "mica slate." The order of succession of these rocks is, beginning with the newest, limestone, talc-schist, a white sandstone passing into a slightly flexible variety, micaceous shale, diorite-schist, talc-schist, quartzite, and micaceous shale, the last resting on a granitic rock which outcrops on Crowder's creek at the eastern foot of the mountain.

94



SECTION EAST AND WEST THROUGH KING'S MOUNTAIN.

[There is a marked unconformity between the limestones and the schists not shown in Lieber's section.]

King's Mountain, Crowder's Mountain, and the hills to the north on the old Lincolnton road, are the western members of a southward plunging syncline while the hills to the east of High Shoals, Dallas and Gastonia, are the eastern members, the same hard crest making the crest of them all. On the eastern side of the syncline the dip to the west is not great, averaging not more than fifteen degrees; while the eastward dip on the King's Mountain side is usually between thirty degrees and forty-five degrees. The eastern hills are low, rising very little above the surrounding country, which varies little from nine hundred feet above tide, and they show none of the topographic features so prominent on the western side, where King's Mountain rises to a height of 1692 feet, and Crowder's Mountain 1606 feet. The level of nine hundred feet is a base-level of erosion, clearly marked, and extending entirely across the State, from north to south, and just above "the fall-line" to the base of the Blue Ridge mountains.

The evidences of wave action upon and at the base of these cliffs is clear and unmistakable. They consist of sea-caves, pinnacled rocks—many of the Devil's Pulpit type—washed-out dykes, crevices of the spouting horn sort, below which may even yet be made out the old beaches which lay below the cliffs. These wave-markings are shown in the photographs of various portions of King's and Crowder's mountains. These features are nearly all on the west side, the side away from the dip. The best marked of these old sea-benches varies little from 1400 feet above sea-level. The next one that can be made out distinctly at all points is about 1000 feet above sea.

I then made a search for the fragmental material that had accumulated during the island existence of these mountains. There is a good talus all around, rather more on the eastern side, where it is shingly, than on the west. A search for the stratified deposits immediately around the mountains was not at first so successful; but in the cut of the Charleston, Cincinnati and Chicago railroad, at Blacksburg, S. C., just back of the Cherokee Inn, is a very good exposure showing two or three feet of quartzite pebbles covered with about the same thickness of mottled clay closely resembling the Miocene clays of eastern North Carolina. Later, I found the same strata of quartzite pebbles and clays in the old cutting at the Catawba Gold Mine, about one mile from the mountain, and also pebbles, clays and regular stratified sands in a basin like region on the road from All Healing Springs to Gastonia, two miles southwest from Gastonia. The general absence of these deposits, however, is to be explained by their looseness, and the ease with which they could be washed away by the currents. The taluses have in every case, I think, been formed since the sea departed from the region, as the materials composing them are angular fragments, and never the round pebbles to be found in the deposits mentioned above. Not only have the deposits of this time been largely washed away, but the older crystallines, which are here decayed to great depths, have yielded readily to the rains wherever the land has been deforested. The accompanying photograph, taken on the Gastonia road two and a half miles from All Healing Spring, shows a gully twenty to thirty feet deep made by the rains since the Civil War when the field was abandoned. It may be noted that the trees which have come upon the field since its abandonment are none of them more than thirty years old, as shown by their rings of annual growth.

I could find in the King's Mountain region no means of determining the approximate age of these deposits, but when I extend my observations across the State to the Dan River and Pilot Mountain regions, I found there the same pebbles of quartz and quartzite resting unconformably upon the brown sandstones of the Newark system, while above the pebble-beds, and conformable with them, were the same mottled clays that I had found in the King's mountain region. This established their date as certainly post-Triassic, and I should have been inclined to call them Cretaceous, had not an examination of the border of the Cretaceous in Harnett, Cumberland and Moore counties, convinced me by the coarseness of the materials there that there was the western border of the Cretaceous, and that the beds of that age could not have extended as far westward as the region under consideration. It led me to the belief, however, that the base-levelling of the piedmont region must have been accomplished while the shore-line lay near the present western border of the Cretaceous rocks, or in Cretaceous time. And, while I am as yet unable to determine the exact age of these deposits, I have at least found out that the peculiar shaping of these topographic outliers was the work of waves, and that it was accomplished in post-Cretaceous time.

DO SNAKES CHARM BIRDS?

COLLIER COBB.

On the 15th of May I happened upon an interesting thing which throws some light on the alleged power of snakes to charm birds. A few days before this, a snake, a garter, (*Eutænia*), about the size of a man's finger and little over eighteen inches in length, had been killed in the walk leading from the New East Building to the eastern side of the University campus, at Chapel Hill. The head of the snake had been pushed into the hole made by the end of the cane with which it was killed, and the snake was in this position with its head pressed down in the hole, when I came upon it, surrounded by seven quails (*Ortyx virginiana*). The quails were gazing upon the snake, very much as "charmed" chickens will gaze upon the chalk line or the crack in barn floor, taking no notice whatever of my presence until I lifted the snake up with a stick. They remained in the position in which I found them long enough for a boy to run from the Episcopal church to the walk, which must have taken two or three minutes. This observation is valuable as showing that, in this instance at least, the "charming" is in the bird itself, and is not a power possessed by the snake.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOLUME XI—PART FIRST

JANUARY--JULY

1894

POST-OFFICE:
CHAPEL HILL, N. C.

ISSUED FROM THE UNIVERSITY PRESSES,
CHAPEL HILL, N. C.
1894.

TABLE OF CONTENTS.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

THE LONG LEAF PINE AND ITS STRUGGLE FOR EXISTENCE.

BY W. W. ASHE.

As a country increases in population the relative area of its woodland and forests, from which both timber and a large part of its fuel must be drawn, decreases in like or even greater proportion. The care and propagation of timber trees *en masse* becomes a feature of economic administration; and in all cases the inauguration of the policy of forest cultivation has emanated from the government. The cause of this dependence on the government for the initiation is patent. Although individuals may see, as forest materials become scarcer, that some definite plan, in regard to forest management, should be followed, they are, as a body, unable to put on foot a general line of action which will in any measure tend to increase the supply.

This inaction of individuals is due to two causes: (1) A disregard for the future, since the benefit of any reform, or at least the realization of increased income from any reform which may be made in the management of forests will be derived only after many years; broadly speaking will be of advantage only after the passing of a generation. For this same reason there is an increasing tendency to cut all marketable trees, even of the smallest size, that returns may be had at once.

(2) Even when some desire is evinced to so care for woodland that the return therefrom may be regular and the condition of the woodland may not deteriorate, either in respect to average size or choice of trees, there is great ignorance shown of all requirements for tree growth and of the action demanded to secure desired results.

The larger and more thickly settled European governments, recognizing these facts, have many years ago undertaken to place all their own forest lands under systematic management and at the same time supply, by means of their schools of forestry, the knowledge of these methods to private land-holders or to trained officers who may serve them. In many of these schools series of experiments, analogous to those made upon grains, etc., in the Agricultural Experiment Stations of the United States, have been carried on upon forest trees, to determine the conditions of light, soil, moisture and density of tree growth which they require for their best development, and the age they should be allowed to reach before cutting, the diseases, fungous and other, to which they are subject, their destructive insects, and the trees, naturally and those most advantageously, associated together in forests.

What has been done by these governments for their forests will have to be repeated in modified forms by the federal and various state governments for their respective forests as soon as the great bodies of standing timber which have required the uninterrupted efforts of centuries to accumulate, are destroyed or thinned out. Conditions will be presented analogous to those experienced in Europe and these must be treated along the same lines and finally resolved by the application of similar methods and by considering the general effects upon our trees of their environments, the soils, atmospheric changes and the various forms of plant and animal life. It will be understood from this how necessary it is that the pathological characteristics of trees worthy of extensive culture for their timber, should be known.

As yet we are in the dark about the demands of even our more common trees. As a people it has scarcely become known to us that our forests are exhaustable, much less that there are large waste areas, now entirely unproductive of commercial timbers and that these areas less than fifty years ago were wooded, in some instances heavily wooded, with valuable trees. There are such tracts of waste land in North Carolina in what are known as the "pine barrens" of the eastern counties. In the course of an examination of the timber lands of eastern North Carolina undertaken last year (1893) by the North Carolina Geological Survey some inquiry and research was made into the extent of these waste areas and a more extended discussion of the results of this examination will be found in Bulletin 3, of the North Carolina Geological Survey, now being published. These areas were found to include considerably over 400,000 acres and to be increasing so rapidly that the causes leading to them were sought for. This entailed an analysis of the life histor y of the long leaf pine and of the other pines with which, in this region of North Carolina, it is most intimately associated. While these observations are by no means either exhaustive, or even full, they will show in a general way with what difficulties a tree has to struggle, under the changed condition of civilization, in order to grow up and reach maturity. They also show the pressing need for a more efficient, or at least common sense, method of dealing with our forest lands if there are in the future to be any forests.

A brief statement of the facts noted in regard to these pine lands, summarized from the same bulletin, will serve to show the deplorable condition of these lands at the present time and how they were when covered with virgin forests.

There are four pines found in the eastern section of North Carolina. Only two of these are, however, generally enough distributed to be of economic importance. These are *Pinus palustris* (Miller) the long leaf pine and *Pinus taeda* (Linné) the loblolly pine, called in eastern North Carolina short leaf or old field pine. The loblolly pine has numerous close allies in eastern America and Europe, though it is a very distinct tree from any of these. Its growth in the virgin forest is confined to the wet margins of the swamps, to "hammocks" in the swamps and to the moister lands with sand or loamy soils, even when sometimes immersed.

The long leaf pine has in North Carolina reached the farthest northerly extension of any pine in its subsection of the genus Pinus. Taking the sum of like morphological characters as expressing the greatest relationship and starting with the white pines, which are the most northerly distributed pines of America, it will be found that the sub-section of the genus Pinus, to which the long leaf pine belongs, is farthest from the white pines, *i. e*, has fewer like characters in common, and at the same time has the most southerly extension of any pines of America. The congenitor of the long leaf pine is the Cuban pine, *Pinus cubensis* (Goert) which is found in Florida, Georgia, and the West Indies, while other nearly allied species are found in Mexico and the tropics.

Byrd, Lawson,* and the other early historians and eulogizers of eastern North Carolina unanimously assert that the long leaf pine extended over all the higher sandy land from Nansemond county, Virginia, southward. It was abundant in Hertford, Perquimans and Gates counties, where a tree of this species is rarely ever seen now, and through Bertie county which was then called the "Pine Forest" and which is now covered with a heavy growth of loblolly pine. Long leaf pines must have been common in the Pamlico peninsular as tar kiln mounds, now covered with large trees of other species, are frequently seen as one rides along the road. Within the last fifty years the upland forests of Wilson, Edgecombe and the northern section of Wayne counties were composed almost entirely of long leaf pine, while at the present time the loblolly pine has gotten possession of this land wherever the soil was sufficiently moist to support the growth. South of the Neuse river over the rolling dry sandy soil of the "pine barrens" the long leaf pine held undisputed possession. These lands are two poor and dry for the loblolly pine to grow upon until the soil has been cultivated and fertilized. The only tree which disputed the control of these lands, with the long leaf pine, was a small oak, the sand black jack oak, *Quercus catesbæi* (Michx) which is worthless for all timber purposes. As the long leaf pine after having been worked for turpentine was burnt off of these tracts or was cut for

* Byrd writing in 1728, Lawson in 1701.

lumber, the only tree which replaces it was this sand black jack oak.

These waste tracts, either naked or covered with the sand black jack oak, lie south of the Neuse river and are to be found in every county from New Hanover westward to Richmond and Moore. It was with a view to ascertain the feasibility of restocking these lands with a valuable tree and preventing the enlargement of these waste acres that this examination was made of the habits, characteristics and relative adaptability to existing conditions, both natural and artificial, of these two pines, *Pinus taeda* and *P. palustris.*

THE CAUSE OF THESE WASTE LANDS.

From the preceding it appears that there is a large amount of waste land lying in the southeastern part of this State. There are now over 400,000 acres of such land, and the amount of it, from various causes, is constantly increasing. This land consists of high rolling or hilly sand barrens, formerly covered with extensive forests of long leaf pine. These forests yielded turpentine abundantly, but on account of the larger amount of sapwood and the coarser grain of the wood of trees growing on these poorer sandy lands the lumber, though of good quality, was of a grade inferior to that from trees grown on fertile soils. Now, however, owing to the grossest neglect, large portions of these forests have either been destroyed entirely or reduced to such a condition that there is neither mill nor turpentine timber on them. and no regrowth of the long leaf pine has been allowed to take the place of the older trees as the latter were being gradually exterminated. The soils of the barrens on account of their sandiness and poor quality will produce very few kinds of trees which have any economic importance. No valuable broad leaved trees (oaks, etc.) thrive on these lands, and among the conifers (pines, etc.) the long leaf pine is the only one growing naturally on them. The short leaf pine, where the loam sub-soil lies near the surface, is rarely found, and it is only after the ground has been cultivated and enriched and the moister layers of earth have been brought to the surface that the loblolly pine will grow there. So it seems that the long leaf pine is the only native tree of much value which flourishes on these barren sandy lands. There are very few, if any other, forests in the eastern United States so peculiarly limited as to the variety of valuable tree growth as the long leaf pine forest, particularly when it grows on the sand barrens, and there are no other forests which demand such care to obtain a regrowth of the original dominant species. Many kinds of trees after being lumbered or burnt out are succeeded by smaller and less valued species, but the original growth in time again takes possession of the land. This is the case with the spruce forests of western North Carolina, and the white cedar (juniper) in the eastern section of the State. However it may have been primarily in the long leaf pine forests, this is not the result under the present management of these pineries. After the removal of the pine the land quickly becomes waste land, and passes from a growth of sand black jack to utter barrenness. No where is there any general sign of either the long leaf or any other pine again forming a prominent part of the growth on these sand hills.

Unless there is some radical change in their management, these lands may even cease to produce the few sand black jack oaks which now flourish on them. There is even a possibility and in fact it can be said a great likelihood that this valuable tree, the long leaf pine, will become extinct in North Carolina unless some steps are taken to secure its more general propagation. It has already become extinct over large tracts lying to the north of the Neuse river which were formerly occupied either exclusively by this pine or by mixed forests of it and hard woods and loblolly pine.

THE REASON WHY LONG LEAF PINE FORESTS ARE NOT SELF PROPAGATING.

The causes which have operated to prevent the long leaf pine from propagating itself are several, and all of them are important and act uniformly throughout this sandy area. A brief statement of some of the peculiarities of this tree may enable us to see more clearly why it needs more special protection than must necessarily be accorded other trees to enable the forests to reproduce themselves. The chief causes which have influenced and tended to retard the general regrowth of this tree at the present time arise from a highly specialized form of seed and plant structure and a decidedly unique manner of growth when compared with the other pines of this same region. These characteristic peculiarities lie chiefly in the young pine seedling, in the seed, and the structure of the leaf buds.

THE SEEDING OF THE LONG LEAF PINE.

Although the writer has not yet carried on systematic observations, on (1) the frequency of seeding of the long leaf, (2) the relative abundance of its seed as compared with those of other pines, and (3) the fertility of boxed and unboxed trees of the same species, long enough to have obtained accurate results, yet the observations of different persons, thoroughly familiar, for many years, with the pine of the barrens, will, he thinks, for most of these cases be found sufficiently accurate, their results being supplemented by his conclusions drawn from a personal investigation extending over several years. Although there were certain years in a virgin long leaf pine forest, just as there are with all other trees, when there was no seed borne, yet these were rare and the yield of seed was usually abundant. Wm. Byrd, writing in 1728, says:* the mast of this tree is very much esteemed for fattening hogs through all of Albemarle County, (North Eastern North Carolina) on account of its greater abundance and the greater certainty of its occurrence (than that of the oaks). The forests of which he was speaking were largely virgin at that date. There are to be found frequent statements mentioning the same fact by other historians, of both an earlier and later date.

So far as could be ascertained the masts (as the seeds of this pine are called) have not been as abundant for the past fifty years as they formerly were. There seems to have been only three large long leaf pine masts since 1845. One of these occurred just about that time, the next one was in 1872 and there was one in 1892, which was not as large, however, as either of the preceding. There is a fairly abundant mast about every four or five years, and on intermediate years the production is small and localized. In North Carolina most of the trees which now bear seed are boxed and have been in this condition for from 50 to 100 years.

* History of the dividing line between Virginia and North Carolina, p. 29.

and the opinion prevails throughout the pine barrens that pine masts are less frequent and less abundant now than before the pines were so largely boxed and thinned out. The removal of a great part of the trees may explain, in part or wholly, why masts are less abundant. It would naturally be inferred that there would be a large decrease in the productiveness of boxed trees, whose vitality, measured by the rate of accretion between them and unboxed trees, has been greatly impaired by the practiced manner of boxing. However, from a tabulated record of observations carried on during several years, there as yet appears no marked difference between the productiveness of boxed and unboxed trees, similarly situated.

There are several important differences between the reproductive capacities of the loblolly and long leaf pines, all of them to the advantage of the loblolly pine.

The fertility of the long leaf pine is much less than that of the loblolly pine, its most frequent associate. The loblolly pine bears cones at an earlier age, and usually produces more seed, both perfect and imperfect ones, and the great variety of soil, on which the loblolly pines grow, causes a slight difference in the time of flowering of different trees, making this pine less liable to have the entire prospect of a seed yield dstroyed by frosts or by heavy rains during polination. While this may possibly explain why the loblolly pine has come up as a regrowth over so much of the moister loam land, it has affected the growth of the pine barrens very little.

The seed of the long leaf pine are very large, $\frac{1}{3}$ to $\frac{1}{2}$ an inch long, independent of the wing, while no other pine of this region has seed over $\frac{1}{4}$ an inch long, but there is a smaller proportion of abortive and otherwise imperfect seed in a long leaf pine cone than in the cone of the loblolly pine. This would be decidedly to the advantage of the long leaf pine in seeding old fields, etc., were its seed not too heavy to be carried far by the wind. They usually fall within fifty feet of the parent tree, while the light winged seed of the loblolly have been known to scatter thickly over fields from trees over a quarter of a mile distant; and single seed are reported to have been blown several miles. Furthermore, as described more fully beyond, the seed of the long leaf pine are much more extensively destroyed by hogs, fowls, squirrels, rats, etc. Another reason for the exclusively loblolly growth in fields may be that even when the seed of the two pines fall on the same land the loblolly pine by its rapid growth during the first few years overshadows and effectually crowds out the more slowly growing long leaf pine; and the latter, during this early slow growth are easily destroyed by fires and by live stock. The two are, however, rarely seen associated together in second growth woods. The seed ripening in October, fall to the ground rapidly and if there is a warm moist season sprout immediately. In the event of a long warm rain just after the seed are matured, they will frequently sprout in the cones and the entire yield will be thus destroyed.

THE YOUNG PLANT.

The young long leaf pine seems to be specially adapted by the form of its root system for growing on a sandy soil. By the end of its first year's growth, its root system, which has grown rapidly, consists of a large tap-root which extends 6 to 10 inches deep in the sand from the bottom of it branch out the smaller roots which draw nourishment from the soil. It is this deep seated root system, sent thus early far down into the soil, which enables this pine to grow on the sand barrens, and it is doubtless because the roots of the loblolly are small and divide for the first year or two into a great many small divisions, lying near the surface, that it does not get sufficient moisture and nourishment from the dry surface sand to enable it to thrive on the sand barrens before this land has been cultivated. This long tap root of the long leaf pine frequently goes through the sand into the loam soil and secures for the tree a firm anchorage against storms and enables it to draw its nourishment from a more fertile soil. The stem parts of the long leaf pine are as peculiarly adapted for growing on a sand soil as the root system is. Instead of the stem branching or growing the first year, it only puts out a great number of very long thick leaves, exceedingly close to the ground. These leaves soon spread out and help to shade the ground close to the plant and keep it moist. At the end of the first season's growth the single (terminal) bud is not over an inch and a half above the earth and the bud itself is nearly an inch long, so that it can be said that the stem of the seedling does not grow any in height during the first year, all the energy of the plant being diverted to increasing the root and producing the great tuft of long deep green leaves which spread out immediately below the bud and make the plant resemble more a tuft of some marvellous kind of grass than a young tree. Some of the lowest leaves usually die during the first year ; most of them remain on for two seasons.

The second and third year growth of the stem in height is slight, though it increases in thickness, but after that, at least in a forest, its growth is wonderful. Frequently in a thick wood where young trees have been allowed to grow, they will in eight or nine years after height growth has begun, have reached a height of 18 or 20 feet and a diameter of no more than three or four inches, and will have grown each year from only one bud, the terminal one, at the end of the woody axis, there being no branches and no sign of any having been formed. For leaves there will be only a single broom like bunch terminating the slender stem. The rapidity with which this stem is raised and the fewness of its branches until the natural height of the tree is reached makes one of the fiine qualities of the timber. It gives long stocks which have no knots in them, even small ones, to produce any uniformity of quality or to make weak places on the interior of an apparently perfect piece of timber. This feature which is the cause of so fine a quality of wood is a great drawback to the development of the young trees. This single terminal bud is a very large and complicated structure, and when once destroyed in any way no other bud is usually ly formed by which the growth of the young seedling can be continued. It is true of most conifers (*i. e.* pines, firs, cypress and cedars) that they do not form buds readily and that they rarely sprout from the stump and are very difficult to reproduce from cuttings, etc., but with the long leaf such buds are formed and sprouts developed even more rarely than with most other conifers.

ENEMIES OF THE LONG LEAF PINE.

The long leaf pine has a severer struggle for existence than any other of our forest trees, for the reason that in all stages of its reproduction and growth it is more severely and continuously attacked by a greater variety of enemies than any other. Besides the natural drawbacks to its development from the peculiar manner of forming several of its parts, and the fact that these parts when destroyed are not replaced, its large and sweet seed are eaten in large quantities by fowls of various kinds, rats, squirrels, and by swine, which prefer them to all other kinds of mast, and when there is enough long leaf pine mast become very fat on it. If the destruction caused by swine ceased here there would doubtless still be sufficient seed left to reproduce some parts of the forests as the mature trees are gradually thinned out, for one year old seedlings are common 12 months after heavy masts. No sooner, however, has the young pine gotten a foot high and its root an inch in diameter than the hog attacks it, this time eating the roots, which until two inches in diameter, are very tender, juicy, pleasantly flavored and free of resinous matter. In the loose sandy soil the piny woods hog or "rooter" finds little difficulty in following and devouring these tender roots to their smallest ends. Many small trees are destroyed in this way; and cattle, furthermore, are said to frequently bite off the tops of the small plants, and with it the terminal bud, in the early spring. This is doubtless done while grazing, more accidentally than otherwise.

Fires often destroy all the young pines that escape the hogs. They kill the small pines by burning the highly inflammable bracts around the bud and so stop its growth, or in high grass frequently burn all the leaves. Larger trees, even until they are three or four inches through, are easily killed in spring, when the sap is rising and the outer layer of wood is growing rapidly, by a hot fire which will burn the thin exfoliated layers of bark all over the trunk. The loblolly pine is less injured by fire because its bark is thicker and so offers more protection to the growing wood,—the bark, too, lying closer to the wood in firmly appressed layers, does not so easily take fire.

So far as has been observed, young long leaf pines are attacked by no injurious beetles or bark borers or by any fungi sufficiently to injure them. The mature pines, however, have in the past years several times been attacked by bark beetles in such numbers as to destroy the pines over large areas. A few trees which have been killed from their attacks can be seen at any time around the edges of districts when lumbering is in progress, or about districts which have been recently lumbered.

The chief agencies, then, which prevent a regrowth of the long leaf pine on the high sandy lands, are the hogs and the fires; and the attacks of the hogs are directed against parts which seem to have been developed to meet requirements of a plant growing on a dry barren soil of loose sand. These peculiarly developed parts are the seed, large for a pine, which contain abundant nutriment for the young plant to enable the root to push itself rapidly into the sand ; and then the long succulent root which grows for a considerable distance straight down without branching. Since the first settlement of these sandy lands the "ranging" of swine has been allowed in the forests, and while there were enough pines standing, and frequent masts, they fed a large number of hogs.

The practice of firing the barrens, has been adopted in many cases with a view to improve the pasturage ; while in many other cases, after the trees were boxed, the leaves and trash pulled away from around them, the forests were burned over to prevent, in a dry season, a chance conflagration getting from under control and burning the faces of the turpentine boxes and the timber. That this policy of burning the barrens is a very bad one and calculated to do far greater damage than that immediately apparent has perhaps been made evident. That sooner or later the present management or lack of management which has characterized all dealings with the barrens for the past 140 years, must be changed if the long leaf pine forests are to be made self-propagating, no one who has ever seen their condition, or fully realizes what it is, can possibly doubt. The logical result of these burnings in the past has been the destruction of millions of feet of standing pine and the prevention of the growth of young trees; which, had they started even 50 years ago, would now be large enough for small timber and turpentine trees; while the burnings of the present and future, if not soon discontinued, will mean the final extinction of the long leaf pine in this State.

NITRIFICATION.

J. R. HARRIS.

The changes which nitrogenous organic matter, or any form of nitrogen, undergo in nature in being converted to nitric acid, or nitrates, is called nitrification. Nitrogen is one of the most abundant, and at the same time most important, elements in nature. More than three-fourths of the atmosphere around us consists of nitrogen, and it enters as an essential constituent into all forms of animal and plant life. The complex nitrogenous organic compounds found in nature are not assimilated as such, but are in some way formed within the plant from simpler nitrogen compounds taken in through the roots.

When these complex compounds are exposed to the decomposing agencies of the air and soil they readily return to the simpler and most stable forms which can exist in nature. The nitrates, as the last and highest state of oxidation of nitrogen, are known to be the most stable compounds. As an evidence of this, vast deposits of sodium nitrate have been stored up and preserved in the rainless regions of Chili, Peru and other countries, Minute amounts of nitrates are almost universally present in soils and waters. They have been found by many experiments and practical field tests to be the form of nitrogen most acceptable as a plant food and to an application of which they most readily respond. Nitrates would seem to have been indicated by nature as the most convenient starting point for the formation of all nitrogen compounds

A knowledge of their wide-spread existence in nature and the very important relation which they bear to agriculture has long been known. Chemists have performed many experiments and advanced numerous theories as to the manner of their formation. This natural phenomenon was evidently a process of oxidation brought about by means of atmospheric and soil agencies. Simple oxidation was not sufficient to explain the notable nitrate formation in compost heaps and nitre beds. The process was known to be much more active and to take place near the earth's surface. Calcium carbonate or wood ashes were absolutely necessary and, contrary to all oxidation processes, a limited supply of air gave the best results. Carbonates evidently aided in some way, probably in decomposing the organic matter, but rapid decay hindered the process, and in combustion, which is more rapid oxidation, the production of nitrates was indeed very small. So that chemists puzzled over this apparently inexplicable question for a long time before a true suggestion was offered.

It is only within the past twenty years that a satisfactory theory has been advanced and only within the past three or four years, after the most careful and painstaking experiments by some of the most eminent physiological chemists has the theory been accepted.

A. Muller (Landw. Versuchs-Stat, 16, 273. Jour. Chem. Soc. 1873, 1267) observing the rapidity with which the ammonia of sewerage and certain waters changed to nitrates and that pure solutions of urea and ammonium compounds were not susceptible to this change, suggested that it was due to the action of ferments. The truth of Muller's suggestion was first shown by the labors of Schloesing and Muntz (Compt. Rend. 85, 1018). They studied the action of heat upon the process and soon found that varying temperatures exerted a remarkable influence. A temperature of 100°C. for one hour was sufficient to destroy the nitrifiable power of certain soils and vegetable moulds in which nitrification was known to be most actively taking place. The addition of a little unheated mould however, served to again start the process. This was very strong evidence that nitrification was in some way connected with organized life. A powerful microscope revealed to them the existence of numerous organisms of the most varied kinds, being most abundant in vegetable mould.

Nitrification could be started or stopped at pleasure and was clearly seen to be due to the life action of these micro-organisms. The observations of Schloesing and Muntz were soon followed by the publication of the experiments carried out in the Rothamsted laboratory by R. Warington (J. Chem. Soc. 1878, 44). In addition to confirming the previous experiments of Schloesing and Muntz, Warington added many proofs establishing the ferment theory and showing its relation to nitrification. The results of his experiments extending over a period of about fifteen years (J, Chem. Soc. 1878, 1884, 1885, 1889, 1891) are published with all the minute details. And it is to the labors of Warington more than to any one else that we owe our present knowledge of the nature and results of the life action of these microscopic organisms. The fact that they were really lower forms of life was not generally accepted, though the chain of evidence establishing this theory now seems to be complete. They possess all the attributes of organized life requiring a suitable temperature for their development and suitable food for their existence. The most favorable temperature is about 100° F; above 120° or below 40° they are rendered inactive, and are destroyed at 212°. The presence of organic matter and phosphates are essential. They are destroyed by the action of disinfectants, insecticides, and the presence of any considerable amount of alkalinity is detrimental to their growth, Just as calcium carbonate or wood ashes were required in nitre heaps so it, too, is necessary for the growth.

These organisms are found much more abundant in the surface layers of the soil, a fact which confirms observations, long known to be true, that production of nitrates was mainly confined to the surface. Even in warm countries where the natives collect the nitrates accumulated as an incrustation on the soil, they are aware of the fact that the efficiency of the bed depends on removing only the upper crust. Warington found the following amounts of Nitrogen as nitrate in two fallow soils at Rothamsted:

In the first nine inches	25.5,	40.1	lbs.
" " second " "	5. 0,	14.3	"
" " third " "	——	5.5.	"

Portions taken at different depths were added to diluted, sterilized solutions of urine containing a little calcium carbonate and gypsum. The formation of nitrates was accepted as evidence of the presence of the organisms. In this way Warington succeeded in detecting their presence at depths of six feet from the surface, below this he was unable to find them. It is especially note-worthy that there was always a period of inactivity followed by a period of activity after the introduction of the soil portions. This he regarded as due to incubation, and the time required was much less in the case of surface portions. We would naturally expect to find any forms of life near the surface, and especially so, since the conditions most essential for their growth exist in greater abundace in surface soils. While Warington's cultures were made in solutions, in which the conditions were not the same as those of the soil, he was better able to control them, and to make the experiments of any desirable composition. But little is known of the way in which they act, only certain products are obtained as a result of the organisms' existence. When a suitable nitrifiable solution is seeded with either a portion of a nitrified solution or of a soil or soil infusion, nitrates are usually produced as the final result. In some cases notable quantities of nitrites were formed and they were noticed always to precede the formation of nitrates. This led Warington to suspect the presence of two different organisms. And various attempts were made to isolate them.

The Franklands (P. F. and Grace C.; Chem. News, March 21, 1890) were unable to isolate them by gelatin cultures. The organisms either did not grow on gelatin or, when so grown, lost the power of producing nitrates. They finally succeeded in getting an attenuation, one millionth of the original solution, by means of the dilution method, which produced nitrates in suitable solutions and had the microscopic appearance of bacilli. Warington (J. Chem. Soc. 1891, 484) finally succeeded in isolating the two organisms, the presence of which was indicated by his previous experiments. They are very similar in appearance and belong to the same family. The nitrous organism, isolated through successive cultures in ammoniacal solutions made permanently alkaline with sodium carbonate, and containing phosphates, oxidized ammonia to nitrous acid only; it produced nitrous acid in solution of milk, urine and asparagine, and could apparently assimilate carbon from acid carbonates. The nitric ferment did not produce either nitrites or nitrates from ammoniacal solutions, in fact ammonia hinders its action. It rapidly changes nitrites to nitrates.

Previous experiments of Warington (J. Chem. Soc. 1884, 637) had shown that in all experiments in which nitrogenous organic compounds were used, the formation of ammonia preceded that of nitrites and nitrates.

Warington believed that ammonia was the only nitrifiable substance, and only such substances as were capable of forming ammonia through the action of soil organisms could form nitrates. More recent investigation has shown that the process takes place in at least three different stages, and is probably due to the action of different organisms. Emile Marchal (Bul. Acad. Belgique 1893 (3) 25, 727 abs. Chem. Cent. Blatt. 1894 2, 97) isolated some of the most prevalent soil organisms and studied their action upon organic matter. He was enabled to isolate by means of alkaline gelatin and peptone some thirty different species, all of which changed organic nitrogen into ammonia. Fifteen of the number were energetic in effecting this change. The Bacillus Nycoides, one of the most abundant in nature, produced ammonia from egg albumen, legumen and gluten. A temperature of about thirty degrees C. and a slight alkalinity was most favorable to its development. Messrs. A. Muntz and H. Coudon (Ann. Agron. 19, 1893 No. 5 page 209) found that Bacilli, Bacteria, Micro-cocci, and yeasts produced ammonia in sterilized soils from nitrogenous fertilizers. The production of ammonia then is not due to the action of any one species, but a great number of organisms have the power effecting this change. Ammonia once formed passes very rapidly into nitrates. This is shown by the facts that although these organisms are continually producing ammonia, yet only minute amounts of its compounds can be detected in soils. It is also formed in numerous other processes of putrefaction and decay, the greater portion of which escapes into the air to be again brought to the soil by snow, rain and dew. It is, however, generally admitted that plants may absorb some ammonia through the leaves, but the amounts obtained in this way are believed to be very small. When any considerable time has elapsed after a heavy application of ammonium compounds to the soil, only traces are found, whereas nitrates can be detected in fairly large amounts. Nitrates are continually formed according to Berthelot and Andre (Storer, Vol. 1, pp. 307-8) in certain parts of plants. Here the plant cells promote oxidation in a manner analogous to that of the micro-organism. They prove this by inserting portions of the stems of the amaranth. plant into washed and sterilized soil. After a time a notable nitrate formation had taken place in the soil containing the plant stems, while none was found in other soils similarly treated but containing none of the amaranth. Small amounts of nitrates are formed from the action of electricity upon the nitrogen and oxygen of the air. Rain water collected immediately after a thunder storm invariably contains a greater percentage of nitrates than at other times. There are also various oxidation processes continually producing small quantities of nitrates. They can usually be detected in certain metallic oxides as ferric-oxide and manganese dioxide, though it has not yet been explained in what way these substances aid in the formation. The action of all these agencies is necessarily slow, and some nitrogen is lost to the soil, being given off in the free state. In other changes, too numerous to mention, great quantities of nitrogen yearly return to the air.

There must exist somewhere in nature a means of supplying this deficiency or the visible supply of available nitrogen would annually become less and less. The experiments of Lawes and Gilbert and Pugh in England and Boussingault in France, in which combined nitrogen was excluded by a series of wash bottles, were long ago accepted as proving that a plant could not utilize free nitrogen of the air. Recent investigations show that this is not true of leguminous plants when aided by the action of certain soil organisms. It is believed by some that the equilibrium between free and available nitrogen is in part preserved in this way. When leguminous plants are grown under normal conditions there are formed upon the roots small nodular or wart like protuberances varying in size from that of a pin head to a pea. They are generally called tubercles. Microbes are found associated with all tubercles, and are plainly the cause of their formation. Leguminous plants, when grown in sterilized soil, have no tubercles and require nitrogenous food for their growth. If soil infusions are added to the cultures in sterilized soil, tubercles are formed and the plants thrive without the addition of nitrogenous manures. It is then clearly not an inherent power of the plant, but depends upon the presence of the tubercles, which are caused by the soil organisms. Atwater and Woods (Conn. Station Ann. Report, 1889), found in a series of eighty nine experiments that, in all cases, where there was tubercular formations there was also an increased gain of nitrogen, being the greatest where there was the greatest number of tubercles. So far as our present knowledge extends root tubercles are confined to the Leguminosæ. They are readily produced on the roots of any member of this family, either by inoculation, the addition of small portions of crushed tubercles, or soil infusions containing the organisms. The concurrent opinion of all the investigators of this subject is that the formation of tubercles is caused by the soil microbes, and upon their formation depends the power of the plants to assimilate free nitrogen of the air. Here the agreement ceases. There are about as many different opinions in regard to the way in which this nitrogen accumulation takes place as there have been investigators of the subject. However it may be, it is evidently a step in the process of nitrification, in that nitrogen is fixed in a form available to the plant. If, indeed, nitrates are neither produced by the organisms before this absorption takes place, nor within the plant by the action of the cells, it is certainly converted into a nitrifiable compound. It is only from a study of the results of the life action of these micro-organisms that the important role which they play in the many changes taking place in nature has been discovered.

THE EXHAUSTION OF THE COAL SUPPLY.

F. P. VENABLE.

Bodies of scientific men, as the British Association for the Advancement of Science, and various public prints have for some time been discussing the problem of the earth's coal supply and its probable exhaustion. There is a growing uneasiness on the part of the public that the end of our supply of coal is in sight and that we are in danger of running short of fuel. If the agitation of the question would correct the present enormous waste of fuel and lead to proper economy in its use, the gain would be great, The vast waste in coke ovens, the loss in crude furnaces, in imperfect engines and wretched heating appliances is enough to make any thoughtful man stand aghast. For instance, a high authority tells us that the loss in our heating stoves, grates etc., is 80 or 90 per cent, that is, one ton of coal should last us nine or ten times as long as it does now or do that much more work. A family now using ten tons of coal for heating purposes during the winter could get along very nicely with one ton if the heating arrangements were perfected. Any one who has watched, on a still day, the long lines of smoke left by passing trains or the black trails stretching for miles behind ocean steamers can realize our prodigal waste of nature's generous gift. Still I do not think there is much reason for the dread that we are hastening to a time when the coal question will lead to a new struggle for existence, a painful illustration of the principle styled "the survival of the fittest." Many estimates of the coal supply and its probable rate of exhaustion have been given. These are based on very imperfect data and vary greatly but they all agree in giving us a respite of from one to two centuries. Taking these estimates as approximately correct and agreeing to the assumption that the use will increase at the rapid rate of the past quarter of a century, does not a greater danger threaten than the comparatively slight one of being forced to eat our food raw and winter in the tropics?

Geologists tell us that these coal deposits were laid away at a time when the proportion of carbon dioxide in the air was much greater than it is now. These masses of coal represent carbon dioxide decomposed and so made available by plant life and then stored away. We dig it up and burn it back to the original form, restoring the carbon dioxide to the air. These processes of decomposition and reoxidation go on side by side at present and Saussure has supposed a sort of equilibrium between the forces removing the carbon dioxide from the atmosphere, such as the growth of plants, the washing of rain etc., and those restoring it, as the breathing of animals, combustion of organic matter and decay. That such an equilibrium exists is not above question. The changes in the amount of carbon dioxide would be so slight from year to year, however, and accurate analytical methods are so recent an acquisition that there is no experimental proof to settle the question. Still, it is clear that if the present proportion of carbon dioxide in the atmosphere is dependent upon a sort of equilibrium between, in the main, the formation of carbon dioxide by combustion and its removal by the growth of plants, this balance cannot be kept up if we enormously increase combustion, at the same time cutting down our forests and so limiting plant growth. The removal of this prejudicial body from the air by the formation of earthy carbonates is too slow to materially affect the result. This means then that the total amount of carbon dioxide in the air must increase and of course its ratio to the oxygen also. It is well known that this ratio does not bear much increase before the danger line is reached.

One of the calculations of the present total amount of carbon doxide in the air, or carbonic acid, as it is commonly called, places it at some four billion tons. Now taking one of the estimates (Mr. Wister's) of the consumption of coal for one hundred years, namely, 840,000,000,000 tons. we find this is equivalent to about 3,000 billion tons of carbon dioxide. This would give 30 billion tons a year, or seven and a half times the present estimate of the total amount in the air. This amount added to that breathed out by the increasing population of the earth makes it manifest that, before the huudred years are out, we will be in the serious danger of asphyxiation.

Though the above estimates may be somewhat beyond the mark, and, of course, they are offered as approximations only, one cannot help thinking that two of the great problems of the immediate future will be, devising less wasteful methods for using our fuel and freeing the air from the impurities we so recklessly pour into it.

As to the question of our supply of fuel, the great strides in the knowledge and use of electricity leave little doubt that it will furnish the light, heat and motive power of the future. We will not have to rely upon the etherific force of Keely or others. Every torrent, every waterfall, the motion of the tides, the quiet flow of the rivers, reservoirs of pent-up rainfall, all will be called into requisition to generate for us this force, so beneficent when tamed. Who would have believed a few years ago that it would so soon have attained its present position as motive and lighting power? It is already usurping the place of fuel in extracting the metals from their ores and we have scarcely entered upon the era of its use in the manufactures.

If, however, we must have fuel we need not seek very far for inventions which might supply our needs. It is not conceivable that we shall go on for another hundred years with the inconvenient and wasteful use of fuel in the solid form, any more than we would now be willing to return to the torch and tallow dip of our fathers as a source of light. Gaseous fuel will be the only form marketable in the next century and the sooner we come to this the better. The advantages in the use of gas for heating and industrial purposes have already been experienced by those dwelling in the natural gas region and they are loath to give it up.

The gaseous fuel of the future will consist mainly of hydrogen and carbon monoxide. The first we can easily obtain by decomposing water by means of electricity and it is only a question of cost that interferes with its present use. The second constituent, carbon monoxide, can be prepared by the same agency from the carbon dioxide or carbonic acid, of which we have been speaking and, if the demand justified it, the methods of production for both of these substances could doubtless be so improved and cheapened as to become entirely practicable.

We must bear in mind that there is no destruction of matter possible on the face of the globe, and our use of the coal means only that we change it into some not immediately useful form from which, as we have just seen, it is possible to recover it, thus bringing it into use again. In this we would be but imitating nature in her cycle of changes. Man dies, his body decays and its constituent materials come into general circulation once more and are ready to be utilized in the building up of a new man. Men burn a plant, some living growing plant somewhere gathers together the materials thus once used and scattered, and gets them into a shape in which man can use them again.

We have not taken into account the possibility, as shown by repeated experiments, of utilizing the sun's heat and the immense amount of energy scattered by it over the earth's surface. We are told that the total amount of this energy poured out every year upon each acre of the earth's surface is some 800,000 horse-power. As Crookes says, what a waste is here! A flourishing crop grown upon that acre utilizes only some 3,200 horse-power and consequently 786,800 horse-power is lost.

Even a small part of this caught, concentrated, set to work, changed into electricity or stored up against a rainy day when clouds come between us and our source of energy, would suffice for all man's present needs.

Of course, the coming of a time when water-power and sunshine will be the force-giving, and hence wealth producing conditions, will work many changes among the nations and the advice given by some to such countries as England, which can hope for but little under these new conditions, to pay off their national debts and so relieve posterity from all possible burdens, is not without just foundation.

The outlook is, therefore, not so bad as it seems at first sight and we may get along very comfortably, long after our supplies of natural gas, petroleum, and coal have been exhausted. Still economy should be insisted upon and these grand gifts of nature not squandered.

SULPHUR FROM PYRITE IN NATURE'S LABORATORY.

COLLIER COBB.

An interesting occurrence of native sulphur in York county, South Carolina, came to my notice in connection with the work of the University Summer School of Geology, at King's Mountain, in the summer of 1893, and having visited the place again with the class and made a careful examination in 1894, I deem the occurrence well worthy of note and record. Sulphur crystals have been described by G. H. Williams* from the

*Johns Hopkins Univ. Circular, No. 87, April, 1891.

Mountain View mine, Carroll county, Md., and Weed and Pirsson† have described the occurrence and form of crystals from the Yellowstone National Park; but so far as I am able to learn this peculiar occurrence is unique.

On the Greene place, opposite the home of Mr. E. B. McSwain, near the north-east corner of York county, and about two miles from the King's Mountain battle-field, South Carolina, is a well-marked vein consisting of two bands of iron pyrite about one inch in thickness, with a band of calcareous quartz, from one to three inches in thickness, lying between them. This is the condition of things in the unchanged portion of the vein. Following the vein to the northward and downward, we find the quartz honeycomed by the leeching out of the calcite, and later the interstices are filled with native sulphur, that portion of the pyrite lying next the quartz having been changed to iron oxide. I was unable to find any dikes in the immediate neighborhood, and though the vein was in a portion of its course folded with the schists composing the country-rock, the folded portions were in most instances entirely unchanged.

---

†Am. Jour. Sci., xlii, 401, 1871.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOLUME XI—PART SECOND

JULY--DECEMBER

1894

POST OFFICE:
CHAPEL HILL, N. C.

ISSUED FROM THE UNIVERSITY PRESSES.
CHAPEL HILL, N. C.
1894.

TABLE OF CONTENTS.


ME
NEW YORK
DELAWARE B
VA
CAPE HATTERAS
CAMBRIAN LAND
GA
FLA
CANAVERAL
CAMBRIAN SHORE
CRETACEOUS
TERTIARY
QUATERNARY

33

JOURNAL

OF THE

Elisha Mitchell Scientific Society

HISTORY OF THE ATLANTIC SHORE LINE.*

HUNTER L. HARRIS.

The history of a shore line consists in an exposition of the changes which have taken place in it; these changes consisting chiefly in its migration across the land surface on which the body of water rests. If this body of water be an ocean or in direct and open communication with an ocean these changes of position may be effected in two possible ways: (1) By an actual depression or elevation of the water surface. (2) By depession or elevation of the land mass along which the shore line occurs.

Without discussing the reasons for such a conclusion we may say that in the great majority of cases the first of these two causes need not be considered as a factor. Usually it is the oscillation of the crust about

---

* This paper is a thesis prepared in the second course in Geology at Harvard College, and has been furnishrd me by Mr. J. B. Woodworth, the instructor under whose direction the work was lone. It is an admirable compilation, and serves as an introduction to the more extended work upon which Mr. Harris had entered at the time of his death.—C. C.

the margin of the ocean that causes the migration. If this be in the nature of an uplift the sea will recede, the shore line successively occupying positions further and further out upon what was formerly sea-bottom. If on the other hand a subsidence of the land surface takes place, the sea will transgress the land and the shore line will successively occupy higher and higher parts of the land slope, that is, further and further inward from its former position.

Slight changes in the position of a coast line may take place in other ways than by bodily movements of the land mass, namely by the deposition of material on the margin of the sea-bottom, thus causing the shore line to recede from the land and by removal of material from the shore, thus causing the sea to transgress the land. These causes are however productive only of comparatively small migrations when acting alone. Evidently we must look upon oscillations of the land mass as the chief cause of change in the position of shore lines.

In order to get at the history of such a shore line as that of the Atlantic of North America, we must know how to read the evidence of its former presence in places other than that now occupied by it. What are these evidences? Probably the most direct, as well as the most exact, evidence is furnished by the actual and characteristic marks left in the form of raised beaches or bench marks. Another evidence is furnished by the position and character of sedimentary deposits,—though the absence of evidence of either kind does not necessarily mean that shore conditions were never present there. While the presence of beach marks furnishes more exact evidence of shore line position in certain cases, the application is not of so wide extent as the more general evidence of sedimentary deposits, on account of the greater ease with which the former are effaced. The burden of the evidence then lies in the sedimentary deposits of the Atlantic slope, or, more accurately, of that part of North America whose sedimentary deposits can not be referred to some other ocean or water body.

To decide what should be taken as evidence of proximity to shore line we must be familiar with the principles governing the deposition of sediment. Running water is the principal carrier of fragmental materials such as go to make up secondary deposits. These materials vary greatly in coarseness and in composition. Far the greater part, however, is mineral matter, resulting from the decay and disintegration of the rocks of the land, and the fragments which compose it vary from an impalpable powder to the greatest size which can be swept along by water in motion—this latter depending upon the velocity and volume of the current. It is by means of this principle of the carrying power of water that we explain the sorting of those fragments which find their way into moving water. A current of high velocity will transport comparatively large pieces of rock material, until, by decrease of slope or by entrance into some other body of water, its velocity is lessened; then the materials will be deposited, the coarsest first and others in turn as the stream continues to lose velocity. The finest may be deposited a great way out in the ocean, sea or lake, which receives the transporting current.

Since the ocean serves as a receptacle for all the drainage of the land, there is being deposited, within its minor depths and out to a distance of perhaps a hundred miles from the land, all the solid materials brought into it by streams. And since the ocean provides the gradual retardation of currents which make their way into it, we have a perfect fulfillment of the conditions of water sorting, and, hence, we may declare the general rule that the coarser materials are deposited near the shore and the finer out. Indeed, where we find undoubted marine deposits including fragments of large size such as grit or pebbles, we may reckon with certainty upon the proximity of the sea shore during the time when they were deposited.

So then the presence in any region of such fragmental deposits as may be judged from their nature to be *marine* declare unmistakably the presence there of the ocean at such a date in geological history as our study of these deposits may refer them to. For instance, if we were to find in Western New Jersey marine deposits of Cretaceous age, dipping gently eastward, we should conclude that during the Cretaceous period the Atlantic shore line lay west of that point. How far west it may have stood we must determine by other means, perhaps by actual shore marks, such as a wave cut bench, or a series of beach gravels or sand dunes. Or else from from the coarseness of the sediments near their inner border we may conclude that they mark the actual shore line of that period.

Other processes of reasoning are often brought to bear which cannot be dwelt upon within the narrow limits of this paper. We should remember always that such evidences as have been mentioned do not necessarily indicate the greatest amount of encroachment of the sea within any given period, for deposits made further inland may have been removed by the general erosion of the surface: so also shore marks are comparatively seldom left as enduring monuments, and their absence may be no evidence of the absence of shore conditions.

Of the relative position of land and water (and consequently of the shore-lines) of pre-Cambrian times we know almost nothing. Those changes, which we call metamorphism, have progressed so far, by virtue of the great age of these sediments and their position at the bottom of the stratified series, that it is extremely difficult to read in them the conditions under which they were deposited. We are quite sure that there existed, at the beginning of Cambrian times, a land area, made up of pre-Cambrian sediments, lying somewhere along the Atlantic coast region of North America. A series of very old, highly altered and disturbed sediments now exist as a land area forming an almost continuous belt between the Appalachian mountain system and the present Atlantic border from Canada southward to Georgia. This area, which is in the main supposed to be pre-Cambrian in age, is plainly shown by its structure to have been once involved in a series of complicated mountain building movements, and was in fact part of a great mountain system. Where this land once rose to mountain heights it is now a low, gently sloping and undulating surface made up of hills of gently rounded outline, all rising to about the same height and having in the distance the appearance of a flat country. That is to say it has so long been subjected to the forces of denudation that the mountain ridges which once existed have washed away and finally disappeared, leaving a land surface of low relief and weak topography. What then became of all the material thus removed? It found its way into the borders of the adjoining ocean and was laid down as sediments, and so to the east, south and west of this pre-Cambrian area lie now upon its edges where they were deposited, the later sediments of the stratified series.

Having found out something of the position of the land of the Atlantic coast region at the initiation of the Cambrian period, we may begin to formulate our knowledge of the shore-line history from that date.

First let us observe that the evidence of former shore-lines given by actual marks of the shore itself is of such a transitory nature that we must not expect to find such evidence in the older rocks. While they may retain a perfectly characteristic form through the Quaternary period or even longer, the chances of their preservation from earlier times becomes less and less as we go back into the geological past. In the Cambrian then we are forced to reason almost entirely from the nature of the sediments, that is, their texture, and composition, and their position with respect to the source of the materials forming them.

There are very few undoubted Cambrian rocks in North America which can with any degree of certainty be ascribed to the Atlantic field of deposition. In the Cambrian Correlation Papers of C. D. Walcott, a series of rocks of Cambrian age, including slates, quartzites, conglomerates and limestones, are located and briefly described under the general name of the Atlantic coast province. These areas are rather small and discontinuous, and extend in a general southwesterly direction from the southern coast of Labrador, across Newfoundland, Nova Scotia, and ending in eastern Massachusetts. The age of each district has been determined by fossils which occur, however, only in restricted zones within the formation. The other members are often classed as Cambrian only on conjecture: hence arises considerable difficulty in interpreting the conditions of deposition. This difficulty is increased by the removal of the greater part of these rocks by erosion, leaving widely separated patches which can scarcely be placed in any reasonable relation with each other. Usually, however, the series lie upon the eroded surfaces of pre-Cambrian rocks, Laurentian and Algonkian, and often show basal conglomorates formed from those rocks. In such cases the materials seem to have been brought from the west or northwest, and from no great distance. These areas lying about the Gulf of St. Lawrence seem to show by the gradual change in the character of the sediment from basal conglomerate to limestones formed at a moderate depth, that the sea transgressed the Algonkian land westward, allowing the accumulation thereon of the Cambrian deposits, first in shallow bays and afterward in gradually deepening water.

Regarding the Cambrian slates and quartzites of eastern Massachusetts, Prof. W. O. Crosby says; "In general the quartzite is more and the slate less abundant northwestward, indicating that the ancient shore line along which these slates were deposited lay in that direction, and originally the Primordial strata were probably spread continuously over all the region to the southwest of that line." Also, "It is very clear that the quartzite, north and west of the Boston basin, is the source of the quartzite pebbles which play such a prominent part in the composition of the conglomerate, especially in the central and northwestern sections of the basin."

Of the Cambrian section of Bristol county, Massachusetts, Prof. N. S. Shaler says: "The frequent return of conglomerate layers and the coarseness of the pebbles show that during most of the time when the beds were accumulating the region was near shore;

so too the large amount of sandy matter even in the slates affords a presumption that the region was not remote from the coast line. The rocks from which the pebbles were taken were mainly identifiable in the western portion of the field above described."

The general inference is then that during a large part of Cambrian time the shore line was in a general way coincident with the present shore-line from Massachusetts northward; that a gradual subsidence of parts of the coast region ensued by which the ocean transgressed the land, accumulating, as it moved inward, a sheet of coarse deposits which were in turn covered by fine argillacious and calcareous sediments forming slate and limestone. These seem to have been formed in a sheltered sea, hence the opinion is that the land barriers existed somewhere to the *east*. During this inward march of the shore-line there must have been many partial returns to its former position but the general result was an inward extension, amounting in some places to fifty, and in other places to one hundred miles, from its present position.

When we attempt to reckon upon the southward extension of the Cambrian shore-line we are entirely at a loss, for, in the first place, we have no known Cambrian deposits south of New England which can be clearly ascribed to the Atlantic field of deposition. Apparently the Cambrian, as well as the whole of the Paleozoic rocks are entirely missing from the southern Atlantic province. This has led to the belief, which is supported only by negative evidence, however, that during the whole of the Paleozoic era the eastern extension of the continent was much greater than it is now. There is really little doubt that this was the case, and the evidence of land barriers lying to the east of the New England section during Cambrian times, leads to a conjecture which may here be stated.

A persistent and connected series of Cambrian outcrops lies along the Appalachian mountain system from Alabama to the river St. Lawrence. These are known to have been deposited in the great continental sea which covered the central portion of North America during the whole of Paleozoic time and even later. These Cambrian rocks with the other Paleozoic sediments were involved in the orographic movement which gave rise to the Appalachian mountains. Their present outcrop, however, is adjudged to mark in a general way the eastern border of the continental sea in which they were deposited. To furnish this enormons thickness of Paleozoic sediments a much larger land area must have existed toward the east than now remains. The fact that the denuded surface of much folded pre-Cambrian rocks is seen now to disappear eastward under the present continental shelf, in some measure bears out this idea.

The conjecture now follows, that the Cambrian rocks of New England heretofore described as belonging to the Atlantic coast province form really a part of the Appalachian province; that is, that they were deposited not in the Atlantic, but, along with the not far distant Cambrian rocks of eastern New York in the continental sea. This satisfies the conditions which have been predicated of them, namely, that they were deposited, not in the open ocean, but in a more or less sheltered sea. The elevation of a part of this area in the process of Appalachian mountain building and the subsequent denudation of the whole of New England, reducing it almost to base-level, would account for the existence of the Cambrian rocks only in isolated patches, while the disturbance of their original stratigraphic position would make it impossible to read any of their history by the stratigraphy.

If this conjecture be true, the "land barriers lying to the east" of New England would be but a part of the broad pre-Cambrian land strip which extended from some part of the North Atlantic in a southwesterly direction almost to the present shores of the Gulf of Mexico. In such case all ideas of the Atlantic shore line previous to the Triassic period are involved in the statement that it existed *at some distance east of its present position.*

Taking up the thread of the history at the beginning of Mesozoic time we find a series of elongated basin deposits of Triassic (Rhaetic?) date consisting chiefly of red sandstones and conglomerates. These rocks form a long train of detached areas stretching from central Massachusetts southwestward to South Carolina. They lie unconformably upon the denuded surface of the pre-Cambrian crystallines, and appear to have accumulated either in shallow inland seas or in sheltered embayments of the ocean. All of them are separated from the present ocean by older rocks, except that of Connecticut, which itself communicates with it only by a narrow neck.

We have, then, in Triassic times very little evidence of the position of the Atlantic shore-line itself. If the Triassic rocks of Connecticut and New Jersey were, as has been thought, deposited in embayed portions of the ocean waters, or fronting the open sea, then we must have had a coming in of the shore-line by submergence of the greater part of the pre-Cambrian land area, by which the Triassic sediments accumulated even upon the edges of the Paleozoic rocks of the continental province. Such a submergence must have brought the ocean to the very foot of the Appalachian mountains which had received their initial uplift just before the beginning of Triassic time. But, if on the other hand, the deposits were made in lagoon-like baisins of inland waters, the ocean shore-line may still have stood as far out as at present, or farther. The evidence is that those areas south of the New Jersey area at least, were accumulated in inland seas. If such was the case — and it is the most probable theory — the Triassic ocean extended inland in a great bay with its center somewhere near the mouth of the Hudson River and its shore-line reaching to the base of the Appalachians in western New Jersey and eastern Pennsylvania whence it swung gradually southward to somewhere near the position of the present shore-line.

The conditions of depositions of these sediments have, however, always been difficult to reconstruct. No solution has ever been offered which proved generally satisfactory. The Connecticut basin seems to represent the estuarine phase of a river which was the ancestor of the Connecticut. From analogy, I would offer as an explanation of the elongated similar basins to the southwest that they also represent drowned portions of consequent rivers which may be reasonably supposed to have existed at so short a time after the folding of the crust which formed the Appalachian system. The character of the deposits would accord well with this supposition.

Following the Triassic period of deposition came an emergence causing a retreat of that part of the shoreline south of New England, by which it assumed a position coinciding with the present shore in Long

Island Sound, but gradually departing therefrom toward the south. In Maryland the departure amounts to one hundred miles inland from the present coast and it continues at about that distance to Georgia, where it swings rapidly westward and northward forming the Mississippi embayment of the Cretacous ocean.

The extensive denudation, which had been long going on over the permanent land area, now extended over those Triassic rocks which were above sea level, and, by the beginning of Cretaceous time, this area was reduced to surface of low relief, much as it appears today, but somewhat nearer base-level. Of the conditions existing during Jurassic time we know nothing since we have no distinctly Jurassic rocks in this province. But of Cretaceous deposition we have a good record in at least two formations whose inland extension is marked by the Cretaceous shore-line already described.

A study of the earlier of these two formations by W. J. McGee shows that, after the base-levelling of the ancient land area, which was achieved just before Cretaceous times, a shoreward tilting of the area took place by which the streams were revived to such a degree that they rapidly sank into deep narrow valleys. A submergence then caused the sea to invade these estuaries, the coast assuming in general the position which marks probably the greatest transgression during Cretaceous time. Then followed the accumulation of the Potomac sediments which, with their equivalents, extend from New Jersey southward, certainly as far as North Carolina, and probably as far as the Mississippi embayment. A period of emergences and retreat of shore-line then intervened before the deposition of the glauconite beds of later Cretaceous which are seen to overlie the Potomac. During *later* Cretaceous then the shore line returned nearly to its former position. Close study of the different members of each of these formations would probably reveal signs of shore migrations of comparatively small magnitude besides the sweeping changes herein mentioned. Moreover it is not definitely made out that the inner border of existing Cretaceous deposits is the limit of encroachments of the sea in Cretaceous time. Great denudation, going on in Tertiary time, caused a second base-level to spread over a considerable part of the ancient land area which had been uplifted at the close of the Triassic; and it is to be supposed that much of the denudation took place in the relatively soft Cretaceous beds, by which large areas may have been entirely removed.

Coming now to the Tertiary, we find that while there were undoubtedly many oscillations of level during this period, the principal Tertiary shore-line corresponds closely to that of the Cretaceous from their most northerly occurrence (off Cape Cod) as for south as Virginia. Between these points the two border lines are never more than twenty miles apart. In Southern Virginia, North Carolina, South Carolina, and part of Georgia, the Tertiary border overlays that of the Cretaceous; but from Georgia northwestward into the Mississippi embayment, the Tertiary lies further out, allowing an exposure of the Cretaceous beds in a strip perhaps fifty miles wide.

In the Tertiary of the Atlantic coast province, Eocene, Miocene, and probably Pliocene, sediments occur, though in the case of one or more formations it is difficult to discriminate between Miocene and Pliocene. Hence the term Neocene is often used to describe the Lafayette (Appomattox, Orange Sand) formation of the middle and southern Atlantic, which has been carefully studied by Mr. McGee. There is usually more or less unconformity between the three or more formations of Tertiary, and often they are not continuous over the whole Tertiary field, but thin out and disappear from some portions while they reach great height and thickness elsewhere. It is difficult to say more than there were at least three migrations of the Tertiary coast-line caused by uplift and subsidence which took place rather unevenly but never causing any considerable transgression over the border line already described.

It is reasonable to expect that the characteristic forms caused by the persistence of shore conditions at certain levels would furnish evidence in the case of such recent deposits as the Tertiary, and doubtless they would if sufficient study had been made even of these terraces, shore cliffs and raised beaches which are known to exist. Such shore marks would enter very prominently into the investigation of the Quarternary shore-line to which our attention must now be directed.

It should be remembered that there has been a successive addition of essential land surface along the Atlantic slope from Cape Cod southward through all the geological time from Triassic down to Quaternary, and a consequeut recession of the shore-line eastward. From Cape Cod northward, however, the reverse has to some measure been true, that is, there has been an excess of subsidence over the constructive processes by which all the deposits from the beginning of the Mesozoic to the Quarternary, if formed at all, are now buried beneath the sea.

The most marked feature of Quarternary time was the great ice invasion. A prodigious accumulation of ice in the northern half of the continent was accompanied by a spreading out of its mass on all sides so that it extended southward far into temperate lattitudes, reaching at its greatest extension the middle courses of the Mississippi River. On the Atlantic coast of New England the glacial covering spread into the sea and probably floated off as icebergs. As a result of the abrasion and transport of rock material by the ice, the glacial field is covered with deposits of irregular distribution and possessing the peculiar characters by which they are readily distinguished from ordinary aqueous sediments. During the formation of some of these glacial heaps, the land along the North Atlantic coast must have stood somewhat higher than at present. Some of these deposits, which were evidently made upon the land, now lie as small wasting islands off the present shores. Indeed it has been claimed that the central part of the glacial field must have stood much higher at the beginning of the glacial period than now, the difference amounting to thousands of feet in the region just south of Hudson's bay, which was supposed to have been the glacial centre. This has been supposed a necessary condition to account for the accumulations of snow and ice in such enormous quantities, and its descent into lower latitudes. There is evidence of such a condition in Europe in the fiorded Scandinavian coast, as has been pointed out by Dana, and the submerged valleys extending out from the Hudson and other rivers may be cited as an American evidence of a similar sort. But we have much clearer evidence of *submergence* during a later part of the glacial period, which amounted to only a few feet at New York City but increased northward, — reaching 200 to 225 feet off the coast of Maine, 500 to 600 feet at Montreal and 1000 feet on the coast of Labrador.

These approximate figures are taken from careful measurements by various observers of the heights of certain shore cliffs and marine deposits shown to be of Quarternary age. I have omitted measurements of various points between, and have given in the place of exact figures a sort of general average of the observations of several persons, arranged in such a way as to show the gradual increase in the amount of submergence going northward.

It is difficult to reconcile the views held by various geologists of the amount of subsidence which took place at several points along the New England coast and northward. The differences depend on different criteria used in the discrimination of shore-lines, difference in opportunity for and general incompleteness of observation, etc. The consensus of opinion, however, as regards the Atlantic shore-line is about as I have represented it. The result of such a subsidence must have been the submergence of parts of the Maine coast, parts of Nova Scotia, Newfoundland and Labrador, and of a large area extending up the St. Lawrence River to the Great Lakes.

Of the middle and southern Atlantic coast little has been done in discriminating and tracing the many shore-line terraces of Quarternary age which undoubtedly exist as distinct features. Some mapping of the Quarternary deposits has however been made. Of these, one formation has been studied by McGee and named the "Columbia" loam. It belongs especially to the middle Atlantic slope and is older than the moraine deposits of the glacial epoch. It is both fluviatile and marine and is scarcely observed southward from North Carolina, where its inner border approaches the present coast. It represents a brief glacial submergence amounting to 400 feet in the northern part of the field (New Jersey) and almost nothing at its southern limit.

Other Quarternary formations occur in the southern field, of which the shore-line limit lies 10 to 50 miles inland, from South Carolina to Florida. Here the Quarternary forms one third of the peninsula (the southern end) and thence the division line swings along the Gulf coast where it marks off a border formation almost equal in width to the similar strip along the Atlantic states.

Far the largest area of land surface which has been added to the Atlantic border is seen to to be of Tertiary age. On the inner border of this a narrow strip of Cretaceous and on the outer edge a thin layer of Quarternary sediments, make up, taken with the Tertiary, practically all that the continent has gained; and the area represents the final amount of recession of the Atlantic shore-line during recorded geological time. North of Cape Cod the result of oscillation so far has been on the other side, and the coast-line now probably stands farther in upon the land than at the beginning of recorded time. Here we have lost rather than gained continental area.

The subjoined map attempts to represent the Atlantic shore-line history in the order in which I have attempted to compile it in this paper. The study has necessarily been crude and incomplete in its nature and is offered as an introduction to a more critical and extended study which may be undertaken later on.

REFERENCES:

LeConte.— *Elements of Geology*. 3d edition.

Walcott, C. D. — *Cambrian Correlation Papers*; Bulletin 81, U. S. Geol. Survey, (Atlantic coast Province).

Shaler, N. S. — *On the Geology of the Cambrian District of Bristol Co., Mass.* Bull. Mus. Comp. Zool. XVI., pp. 24-26.

Davis, W. M. — *The Geological Dates of Origin of Certain Topographic Forms of the Atlantic Slope of the U. S.* Bull. Geol. Soc. America, II., pp. 548–581.

Shaler, N. S. — *Geology of Mount Desert Island.* 8th An. Rept., U. S. Geological Survey.

McGee, W. J. — *Three Formations of the Middle Atlantic Slope.* Am. Jour. Sci. XXXV.

DeGeer, Baron Gerard. — *On Pleistocene Changes of Level in Eastern North America.* Proc. Bost. Soc. Nat. Hist., XXV., 454-477.

AN EXAMINATION INTO THE NATURE OF PALÆOTROCHIS

CHARLES HENRY WHITE.

While Professor Ebenezer Emmons was "Geologist to North Carolina," he discovered a singular form in Montgomery county which he believed to be a fossil. He announced the discovery in 1856, and owing to the low horizon in which he found it, regarded it as the oldest representative of the animal kingdom on the globe, and gave it the name *palæotrochis;* old messenger. At this time he wrote a letter to one of the editors of the American Journal of Science in which he said: "It is evident that the fossil is a coral," and described it as follows: "Form lenticular and circular and similar to a double cone applied base to base; surfaces grooved, grooves somewhat irregular but extended from the apices to the base or edge."[1]

In his Report of the Midland Counties of North

1. American Journal of Science, Vol. XXII, 2nd Series, p 390.

Carolina, on plate 14 opposite page xx., he gives a section of the region in which the palæotrochis is found, which is reproduced in Fig. 1. On page 61 of the same is the following descriptive section, enumerated in the ascending order:

1. Talcose slates, passing into silicious slates, and which are often obscurely brecciated. Thickness undetermined.

2. Brecciated conglomerates, 300–400 feet thick, and sometimes porphyrized.

3. Slaty Breccia, associated with hornstone.

4. Granular quartz, sometimes vitreous, and filled with fossils and silicious concretions of the size of almonds; 200–300 feet thick.

5. Slaty quartzite, with a very few fossils, about 50 feet thick.

6. Slate without fossils, 40 feet thick.

7. White quartz, more or less vetrified, filled with fossils and concretions; 700–800 feet thick.

8. Jointed granular quartz, with only a few fossils.

9. Vitrified quartz, without fossils; 30 feet thick.

10. Granular quartz, no fossils, and thickness very great, but not determined.

He says that some of the rock beds in which these forms occur consist almost entirely of them, and are intermixed with almond shaped silicious concretions "which frequently contain the fossil." He speaks of their occurrence from the size of a small pea to two inches in diameter, but by far the greater number belong to one or the other of two sizes; the smaller size represented by Figs. 2—4, and the larger by Figs. 8 and 9. The smaller he calls palæotrochis minor, and in addition to the characters given above, "the apex of the inferior size is excavated, or provided with a small roundish cavity, with a smooth inside, or sometimes marked by light ridges, which may be accidental; the opposite side is supplied with a rounded knob, from the base of which the radiating groves begin."[1] In the larger, or palæotrochis major the rounded knob and opposite cavity are absent.

"This fossil is a silicious coralline, and not silicious from petrification. It seems never to have had a calcareous skeleton like most corallines: but, during its existence, to have been entirely composed of the former substance. The animal was gemmiferous—the germs being sometimes cast off, in which case new and independent individuals were produced; on others, the germs adhered to the parent. These start from the circular edge at the base of the cones; their growth produced a change of form which is illusrtated in Figs. 2 and 4.[2]"

"The palæotrochis is found at Troy, Montgomery county, at Zion about twelve miles south-west of Troy, where the fossil occurs in the greatest profusion. It has also been noticed on the road from Troy to Birney's bridge."[3]

Shortly after the description of the palæotrochis was published, Professor James Hall, in a letter to Professor Dana,[4] suggested that these forms were merely concretions. In 1868, Professor O. C. Marsh in an article on this subject in the American Journal of Science says that he suspected that they were inorganic and an examination of the interior clearly indica-

---

1. Geological Report of the Midland Counties of North Carolina E. Emmons. p.62.
2. *Ibid* page 63.
3. *Ibid* page 64.
4. American Journal of Science Vol. XLV. p. 218.

ted that they were not corals, and as soon as microscopical sections could be prepared, they were more carefully examined, but no trace of organic structure could be detected, the entire mass being evidently a finely grained quartz. It follows therefore, he says, that this name should in the future be dropped from the genera of fossils. He says further: "Admitting the inorganic nature of these remarkable forms, their origin becomes an interesting question and it is certainly not easy to give a satisfactory explanation of it," but, that it seems to have some analogy with cone-in-cone structure which is probably due to the action of pressure on concretionary structure when forming. In some respects the two are quite distinct, but evidence of pressure is clearly to be seen in both. [1]

With this the matter seems to have been dropped except a general unrest among scientists, into whose hands the specimens came, that the results obtained should not be final.

The late Professor W. C. Kerr, State Geologist, made a collection of these specimens with a view to making an examination of them but did not live to do the work. That the subject might be further investigated, Professor J. A. Holmes, State Geologist, visited the region and collected a large number of specimens. For the same reason, Professor Collier Cobb, at whose suggestion and under whose direction I make this examination, obtained an original specimen collected by Professor Emmons, from the Massachusetts Institute of Technology.

With this brief history of the palæotrochis, let us examine its character, mode of occurrence, etc.

---

1. American Journal of Science, Vol. XLV. p. 219.

The specimens I have used are those collected by Professor Emmons and Professor Holmes, referred to above.

The rock mass in which the specimens occur is granular quartz of a dark color and splits roughly along apparent planes of bedding. The weathered surface of the rock is very rough, consisting of the protruding fossil-like forms and cavities out of which they have weathered, interspersed with more or less even patches of weathering concretions.

These protruding forms are composed of quartz of a light gray color, sometimes brown from oxides of iron. Around each of these forms there is a ring of softer grayish white material, which in many cases has weathered below the general surface of the rock, leaving the forms standing up apparently in little cups. The concretions in weathering are also grayish white and are circular in section, showing concentric structure about very small neuclei. The fossil-like forms of the palæotrochis are larger than the concretions. I counted in an average specimen, twenty of the palæotrochis exposed in an area of nine square inches, which averaged about three-eights of an inch in diameter, never varying much from that size. The concretions were somewhat more numerous and considerably smaller. The palæotrochis is not distributed evenly through the rock nor does it occur in definite planes of stratification. The individuals are turned in no definite position with respect to each other, but with very rare exceptions one apex or the other of the double cones rests on bedding planes or on planes parallel to these—not with the axis perpendicular to the plane but inclined at a varyingangle depending upon the flatness of the form. Inother words, their general position is that which they would assume if left under the influence of gravity to collect under water. Figure 10 is a section at right angles to the bedding planes showing their mode of occurrence.

The rock mass clearly shows evidence of considerable pressure at right angles to the bedding planes. This is not only shown by the mass, but often by individual specimens as shown in Fig. 11, which, lying in the position it would naturally assume, received the pressure from above, giving it its present form with the vertical plane of fracture which has since been filled. Owing to the shape and position of the specimen, the pressure would be unequally distributed, fracturing it in the direction shown for the obvious reason that the greatest stress was in that plane. Lines of fracture are also found in microscopic sections of specimens which do not show it externally, Fig. 12.

In form, isolated specimens and those exposed on the weathered surface of the rock, answer to the description of Emmons, given above (pages 50, 51, and 52; also see figures 2-7). But when the weathered surface is broken away and a fresh surface is exposed, these forms are enveloped in a gray, translucent, radial fibrous mineral, which under the microscope proves to be an impure chalcedony. This, as we would expect, weathers gray-white on exposure [1] and is washed away faster than the surrounding rock. The interior, or palæotrochis proper, I find is graunlar quartz as did Marsh. The small concretions prove to be chalcedony throughout. There is a definite line of separation between the chalcedonic formation and both the surrounding rock on the outside and the enclosed palæotrochis.

1. See page 54; also Text Book of Geology. A. Geike—Third Edition. 1893. p. 69.

The concretions are also distinct from the rock mass. Figure 13, taken from a microscopic section, roughly illustrates these points.

Having the general characters of palæotrochis before us, let us now compare it with the forms that it has been thought to resemble and examine more carefully the more minute details.

(1) Is it a concretion? "There is a general tendency in matter, when solidifying to concrete around centres. These centres may be determined (1) by foreign substances which act as nuclei, or (2) by the circumstances of solidification, which according to a general law, favor a commencement of the process at certain points in the mass, assumed at the time. As the solidifying condition is just being reached, instead of the whole simultaneously concreting, the process generally begins at points through the mass; and these points are the centres of concretions into which the mass solidifies.

"The concretions in the same mass are usually nearly of equal size; hence the points at which solidification in any special case begins are usually nearly equidistant.

"In a concretionary mass, the drying of the exterior, by absorption around, may lead to its concreting first. It then forms a shell with a wet unsolidified interior. The interior may then dry, contract, and become cracked; or, it may undergo no solidification, and remain as loose earth; or, it may solidify by the concreting process, forming a ball within a shell, with loose earth between."[1]

If the forms we are considering were even spherical,

---

1. Dana's Manual of Geology, page 628.

the most general concretionary form, we should still have no difficulty in deciding that they do not belong to the last class, since the interior is a compact mass of semi-crystalline quartz, often showing the layers in which it was laid down by the ordinary process of deposition. (Fig. 14.) From what has been said of their distribution (p. 54), they could not belong to the second class. The chalcedonic envelope is distinctly concretionary, and regarding the palæotrochis as a nucleus, they *can* belong to the first class. But the palæotrochis itself is no ordinary concretion, which Marsh admits and tries to find some analogy between it and cone-in-cone structure.

(2) Is it stylolites or cone-in-cone? "Stylolites are cylindrical or columnar bodies varying in length up to more than four, and in diameter up to two or more inches. The sides are longitudinally striated or grooved. Each column usually with a conical or rounded cap of clay, beneath which a shell or other organism may frequently be detected, is placed at right angles to the bedding of the limestones, or calcareous shales through which it passes, and consists of the same material. This structure has been referred by Professor Marsh to the difference between the resistence offered by the column under the shell, and by the surrounding matrix to superincumbent pressure. The striated surface in this view is a case of 'slickenslides.' "[1]

It is true that the palæotrochis shows signs of pressure, but, as already pointed out (p.55), the pressure had a tendency to deform the structure and obliterate the grooves or striae instead of forming or constructing them, while the layers of deposit of which the forms

1. Text Book of Geology. A Geikie. 3d. Edition, 1893, p. 316.

are composed, show that there was no pressure when forming. (p. 56, also Fig.14.) Neither are they in the slightest degree similar in form.

"Undoubtedly few of the structures classed under the general head of concretions are more curious than cone-in-cone. The name is descriptive, the structure consisting of corrugated or crenulated conical layers, one within another, and in the more complex specimens it is seen that thin layers of the rock, a calcareous and sideritic clay, is composed of the closely crowded nests of cones, the axes of the cones being transverse to the bedding planes. The height of the cones measures the thickness of the layers, which is commonly one to four inches. It seems necessary to suppose that during the compression of the layers of clay by vertical pressure it is divided by an indefinite series of conical gliding surfaces, which are corrugated by the intermittent character of the movement."[1]

"Clay iron stones sometimes exhibit the regular structure known as cone-in-cone, in which case the seam has a tendency to divide into cones, the bases of which are towards the top and bottom of the bed, while their apices are directed towards the center."[2]

By comparing the character and mode of occurrence of palæotrochis with cone-in-cone, it is seen that there is no similarity between them, but the quotations are given in full to show that no inorganic form has yet been described which explains the origin of palæotrochis.

The palæotrochis is not two cones applied base to base, that simply roughly suggests the general form, and its failure to conform, even approximately, to a

1. Dynamical and Structural Geol., W. O. Crosby, p. 278.
2. Ore deposits, J. A. Philips. p. 165.

geometric figure and its freedom from rigidity in its appearance, either in form or markings, suggests that it is not of inorganic origin. And yet the persistence in conforming to a general outline, in the radial groovings, and the rounded knob at one apex with the smooth cavity at the other makes the conclusion irresistable that it is not "accidental," that they were all formed under like conditions and in accordance with certain laws, and no mode of crystallization or wholly inorganic arrangement can be conceived that will supply the conditions or suggest the laws capable of imitating these forms. The rounded knob and the cavity opposite are very striking. I have examined many isolated specimens and without exception the knob and cavity are present. Those exposed on the surface of the rock, as has been pointed out, generally show one of the apices, and of those I have examined—upwards of 300 in all—not one failed to present either a knob or a cavity,[1] with the exception of not more than four whose apices had been so crushed by pressure that these characters had been destroyed, or the knob simply broken off as in figure 11. I have never yet found one that had a knob at each apex or a cavity at each apex. These two markings seem to be as persistent and as characteristic as the two valves of a brachiopod. The cavity has the exact appearance of the socket of a ball and socket joint. The inner surface appears perfectly smooth under a magnifying glass and vividly suggests that it has been the seat of an organ or of an organism.

(3) It has been shown so far that the palæotrochis

1. This statement applies only to these which present an apex and not to those rare exceptions that do not present either apex.

is not similar to any concretion or class of concretions heretofore described and that it has no anology to cone-in-cone or stylolites. Let us now examine the evidence by which Professor Marsh came to the conclusion that it is not a coral and see if he was justified in that conclusion.

His conclusion, given on page 52 of this paper, is not drawn from the form or external markings, but when he examined the interior with a microscope and found no organic structure he deemed the evidence sufficient and concluded that in the future this name should be dropped from the genera of fossils. If he had found organic structure of course the proof would have been direct and positive, but the absence of organic structure is by no means a proof that it is of inorganic origin, for Nicholson and Lydekker say, in speaking of replacement by silica, the following: "In a large number of cases of silicification, the minute *structure* of the fossil which has been subjected to this change is found to have been more or less injuriously affected, and may be altogether destroyed even though the *form* of the fossil be perfectly preserved. This is the rule where the silicification has been secondary, and has taken place at some period long posterior to the original entombment of the fossil in the enveloping rock."[1]

Therefore it appears that Marsh's determination can not be relied upon.

(4) Was Professor Emmons justified in his statement that it is a coral? It is true the general form, the radiate striae, or grooves, and what he took to be

1. Manual of Palæontology—Nicholson and Lydkekker. Vol. 1. p. 7.

the method of reproduction as described above (p. 52) might have seemed to him more suggestive of the coral than of any known form, organic or inorganic, yet the proof is not positive and I can find no just ground for his position.[1]

Admitting the organic origin of palæotrochis, how could it have been preserved? Considering its distribution through the rock mass and the position assumed by the individuals, with the material in which they are imbedded, the explanation is possible by different methods. The first that occurs to me, and which is offered merely as a suggestion is this: The indviduals dropped to the sea floor and were imbedded in ooze. This ooze being largely calcareous but containing a considerable amount of silica on beginning to solidify would have formed in it, silicious concretions, just as they are found in the chalk beds of England. Their origin is explained as follows by LeConte: "Nodular concretions seem to occur whenever any substance is diffused in small quantities through a mass of entirely different material. Flint nodules in chalk. Carbonate of lime modules in sandstone, &c."[2]

As concretions start around nuclei which are generally of a different material from the concreting substance, and are particularly favored by decaying organic matter, it is quite natural to expect these bodies of organic matter to be encased with silica at the same

---

1. I have found several specimens that answer to Professor Emmons's description of the process by which they are reproduced, and at apparently different stages of the process. One of the best, which was not in Emmons's collection, I have shown in Fig. 15. This answers better to his description than his own figures, 2 and 4.

2. LeConte's Elements of Geology, p. 188.

time the small spherical concretions are being formed about minute nuclei. Chalcedony often encloses organic forms and so perfectly that the colors of the plants thus encased are preserved.[1] After a great lapse of time let all the calcareous matter of the deposit be replaced by silica, and then follow a period of pressure and uplift and you have the form as it occurs to-day.

That solutions pass through chalcedonic envelopes is shown in water geodes and in geodes containing bitumen.[2] In this view we would expect the cast of silica in the shell of chalcedony to be purer than that which surrounds these forms. This is observed to be the case with palæotrochis. (p. 54). And from the rule of replacement by silica (pp, 60, 61) we would be surprised to find internal organic structure.

It is not the purpose of this paper to assign these forms to any class or order, not even to show whether they are animal or vegetable. But in passing we may note certain classes of organisms, to one of which it may be referred at some future time.

(1) It might have been a calcareous sponge whose spicules were destroyed by replacement. Though as no spicules have yet been found, it can not be put down as a sponge.

Figure 16 represents a sponge similar in form to the palæotrochis.[3]

(2) It may belong to the class hydrozoa.

---

1. Transactions of the Geological Society, Vol. II. First Series. p. 510.

2. Dynamical and Structural Geology, W. O. Crosby, p. 275.

3. Ward's Catalogue. p. 205. For description see Transactions of the Geological Society. Vol. 1. p. 337.

(3) It may be an organ of some animal. The form represented in figure 17 is a "cast of what Nathorst considers to be the radial canals of a species of a craspedot Medusa, belonging to the family Æquordae." [1]

(4) They may prove to be of vegetable origin; another variation of the many and striking forms assumed by sea plants.

From the peculiar nature of the knob and cavity, I offer as a bare suggestion that in their original growth they were probably joined togther as in Fig. 18.

These are mere suggestions to show that the palæotrochis is not wholly unlike all organic forms, though it can not yet be assigned a definite place among organisms.

The purpose of this examination has been to call attention to the work done on the palæotrochis, to investigate the methods by which the results were obtained, and to see if the conclusions reached would stand the test of an examination made in the light of more recent discoveries and by more modern methods.

I claim (1) that neither Emmons, Hall, nor Marsh made that careful and scientific investigation of these forms necessary to justify the conclusions reached, and that these conclusions should not be accepted. And I claim (2) that the weight of evidence in the present state of knowledge indicates that the palæotrochis is of organic origin. The reasons briefly summed up are:

(1) Its distribution in the rock. (p. 54)

---

1. 10th Annual Report, U. S. Geological Survey, 1888-'89. Plate op. p. 676.

(2) Positions assumed by the individuals. (pp. 54, 55).

(3) Their conformity in shape to a general type as persistently as that of any class of organisms. (pp. 51–58).

(4) The failure to conceive of any inorganic process by which such forms could be produced. (p. 59).

(5) That they attract concreting material and are the nuclei of concretions. (pp. 54, 56).

(6) Their general resemblance to determined organic forms. (pp. 62, 63).

(7) An apparent method of reproduction, (pp. 52, 61).

It may take years of patient examination to find direct and positive evidence by which the palæotrochis may be referred to its proper place among organisms, and such evidence may never be found, yet I believe the importance of the subject justifies a much more extended and careful examination than it has yet received.

EXPLANATION OF PLATES.

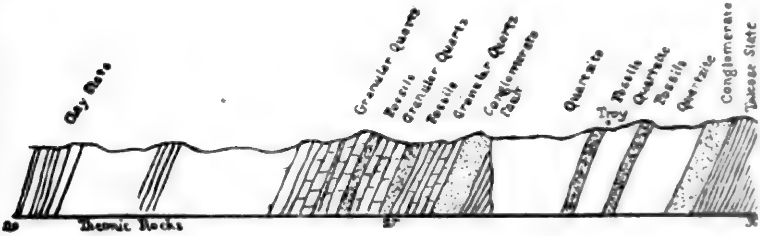


Fig. 1. Section through region of Palæotrochis Beds. After Emmons.

Figs. 2, 3 and 4. *Palæotrochis minor*. After Emmons.

Figs. 5, 6, 7. Specimen found by Emmons, in possession of Prof. Collier Cobb.

Figs. 8 and 9. *Palæotrochis major*. After Emmons.

Fig. 10. Showing position of fossils in bed.

Fig. 11. *Palæotrochis* deformed and fractured by pressure.

Fig. 12. Microscopic section showing fracture.

Fig. 13. Microscopic section showing chalcedonic envelope.

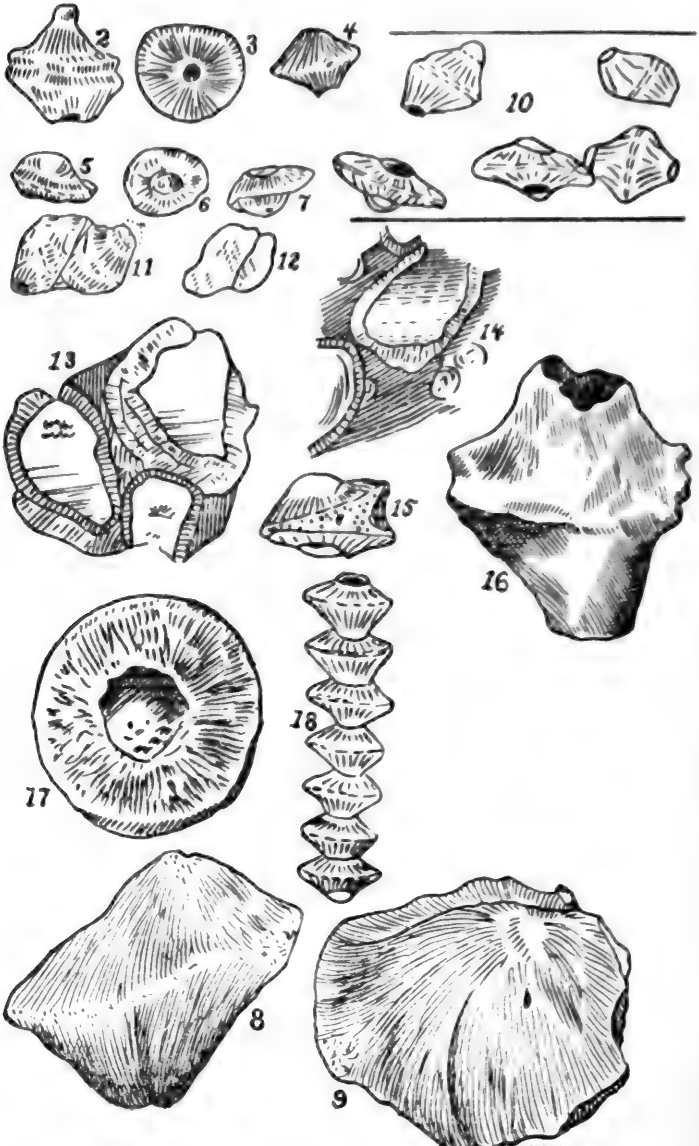
Fig. 14. Polished surface of rock showing layers of deposition in specimen.

Fig. 15. *Palæotrochis* showing what Emmons described as budding.

Fig. 16. Sponge.

Fig. 17. An organ of medusa.

Fig. 18. Suggestion as to possible arrangement of *palæotrochis*.


2
3
4
10
5
6
7
11
12
14
13
15
16
17
18
8
9
T.C.H.

THE ATOMIC WEIGHTS AND THEIR NATURAL ARRANGEMENT.

F. P. VENABLE.

It is proposed in the following paper to emphasize the necessity for the acceptance of oxygen as the standard for the atomic weights, to point out the fact that their absolute determination is not within the bounds of reasonable hope; to show the folly of speculations as to the primal elements in the present state of our knowledge; and to suggest certain changes in the Periodic Arrangement of the elements as given by Mendelejeff.

THE OXYGEN STANDARD.

In 1888 the writer of this paper published in the JOURNAL OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, (Vol. V. 98.) a plea for the adoption of Oxygen as the standard for atomic weights—a return to the very wise and scientific usage of Berzelius. A reprint of this paper was sent to the *London Chemical News* and must have been in the hands of the editor of that journal when there appeared in its pages a paper by Dr. Bohuslav Brauner, of Prag, upon the same subject. The reprint mentioned was published in the *Chemical News* a week or so later. The same standpoint was taken in the two papers and largely the same arguments used. Indeed it seemed almost incredible that the two could have been written entirely independently of one another. These facts were adverted to by Dr. Brauner in a subsequent paper in the Berliner Berichte (Ber. deutsch. chem. Ges. XXII. 1175.) when the question was being discussed between Meyer and Seubert, Ostwald and himself.

This was six years ago. The matter has not been much discussed in the mean time. Still the desired result has been partially attained. Many chemists seem to have adopted the oxygen standard and it is made use of in most recent work in this line. Some have spoken of this as only a temporary abandonment of the hydrogen standard. This can be true only in case the chief argument for the oxygen standard ceases to be valid. This argument is, that, in the majority of cases the atomic weight determinations involve combinations with oxygen and hence the use of its atomic weight in calculations. This weight should by all means be fixed and not dependent upon determinations of the ratio to hydrogen or any thing else, to be upset every few years by new and "more accurate" determinations. Only in two cases can hydrogen replace oxygen as the standard. First, in case suitable compounds of the various elements and hydrogen can be obtained. This does not seem very probable. The second case is where absolute accuracy of determination is conceded as impossible and the final atomic weights can be settled upon by some methods of mathematical calculation. Such methods have been suggested but their adoption does not seem probable. It is scarcely necessary to point out that the use of O as 16 or O as 15.96 would make a very marked difference in the cases of elements of high atomic weights—several integers for uranium for instance. Oxygen as 16 must remain the standard for the present and it will be so considered in the remaining portion of this paper and uniformity in this regard is very earnestly to be pressed upon all who desire the advancement of the science.

HOW FAR IS ACCURATE KNOWLEDGE OF THE ATOMIC WEIGHTS ATTAINABLE?

The atomic weights are generally considered the most important constants in chemistry and yet so imperfectly are they known and so varying the numbers assigned them that it has not been possible so far to settle finally whether they really are constants or variables within narrow limits. The probability, however, is so greatly against this latter view that there are few who are inclined to accept it. As more than three quarters of a century of work has been expended upon them, work engaging the utmost efforts of the masters of the science, as Berzelius, Dumas, Marignac, Stas and many others, it may with perfect justice be asked whether absolute accuracy is attainable.

Some have hoped that the more perfect knowledge of the chemists of the present, the better methods of separation, purification and general manipulation, and the fine balances, would enable them to attain to the desired accuracy. There have been, of course, many improvements but any one who will carefully examine the determinations of Berzelius will find many of them in marvellous agreement with the finest work of late times and when he goes over the list and sees for how many of these atomic weights the work of Berzelius is still relied upon as the best, he will be less boastful of the progress and less hopeful of results from it.

Certainly, if accuracy is to be attained, then the usual method of those who re-calculate these weights, and in fact the only allowable method at present, namely, that of taking the work of different authors, and critically averaging it, must be rejected, for this would never secure concordant results as they would have to depend upon the judgment of the critic and calculator. All of this back work must be wiped out of existence, except for historical use, and we must begin anew with every conceivable refinement of method and apparatus, perhaps devoting, as has been suggested, some central endowed laboratory to that work and that alone.

Calculations of "probable errors" have given a seeming accuracy to many atomic weight determinations. In this chemists have followed the lead of Stas. It seems to me that this is very misleading, these calculations often being made upon small series in which the possible error, as shown by the variation in individual experiments, is ten times that shown by the calculation. In the proposed new determinations this method of calculation should only be allowed in the case of several hundred closely agreeing determinations.

Of course, it might as well be confessed that absolute accuracy is not to be even hoped for. The best methods and appliances which can be devised or manufactured will always be imperfect and there is besides the personal error of the observer to be allowed for. To what extent shall we demand accuracy, then? Where shall the line be drawn? Is it to be at the first decimal place or the second? It seems useless or hopeless to speak of the third. There can scarcely be said to be an atomic weight at present known correctly to the first decimal place. Take the numerous determinations for oxygen, exceedingly modern and excellently well carried out, and see how they vary between 16.0, 15.9 and 15.8 and look at the original series from which these results were calculated and see how they are but the means of series with decidingly varying figures—a balancing of errors perhaps. One is induced to think that for many years, at any rate, the highest attainment to be hoped for will be a correct first decimal.

These being the facts, it is but false pedantry in the present state of our knowledge to write these figures beyond the integer in most cases unless the decimal is a large one. In a few cases the first decimal might be used. In no case is the second justifiable. What would be gained by a knowledge of the absolute atomic weight beyond the satisfaction of having secured that much knowledge of the truth? Do these costly labors promise results sufficiently valuable to justify them or are the energies of many of the most skilled chemists misdirected and wasted? Of course no true labor is wasted, but an energy which would accomplish grander results in some other direction is wasted if turned into trivial channels. All will acknowledge that no good to practical chemistry would result from weights known to the second decimal place. If known approximately to the first every requirement of the analytical chemist would be satisfied.

Two things may be gained for science however by such knowledge. First, the question of constancy of weight would be settled, beyond all reasonable doubt, and secondly, data would be obtained for the discovery or confirmation of underlying laws.

Some dim presentiments of such laws were seen when these weights were in their most chaotic state. The vision of them was obscured by the confusion of standards and the disagreement in determinations. As these difficulties were partially removed the way became clearer for the discovery of the inter-relation of the elements and the dependence of their properties upon their atomic weights. It must be remembered that for several of the elements the atomic weights are unknown and for others are very poorly determined. It is extremely important that these be correctly determined, and work spent upon them is far from wasted, but I must confess that I can not but feel that further efforts to discover the ratio between hydrogen and oxygen are of little value to science and that chemists generally would be more grateful were the same labor devoted to such elements as thorium, cerium, or nickel, and many others.

The question of the variation of the elements in their atomic weights is a very elusive one and scarcely capable of being finally settled by even the most accurate work of the chemist. The supporters of the hypothesis have always a loop-hole of escape in the limits within which these numbers may be supposed to vary. This variation is now narrowed down to the decimal places. As the determinations become more accurate, it is easy for the limit to be moved from one decimal to another and so defy pursuit. Nothing but absolute accuracy, an accuracy shown in every experiment, with all sorts of varied proportions, and not an averaged result, could finally end the discussion. But with a settled standard and the atomic weights known to the first decimal place, the way would be clear for laws dependent upon their inter-relation.

APPROXIMATION TO WHOLE NUMBERS.

Speculations upon the numerical relations existing between the atomic weights began almost with the first imperfect list of these weights. These took two directions. First the ratios to some common standard or unit as hydrogen, and secondly the relations between the weights of elements of the same group or family. The first subject was looked into simultaneously in the year 1815 by Prout in England and Meinecke in Germany. The second was naturally taken up some years later, the first to suggest numerical regularities being Döbereiner in 1817 and he has been followed by a number of others.

Prout's hypothesis has always attracted the most attention. It may well be divided into two parts: first, an assumption that the atomic weights are all whole multiples of hydrogen. This was afterwards modified so as to read that they were all integral multiples of the half atom of hydrogen. This half atom, or rather body having half the atomic weight, was called pantogen. The second was a deduction from the first assumption. If they were multiples of hydrogen, then they must be composed of hydrogen or of pantogen. Why this should be the case or was at all a necessary deduction no one seems to have attempted to show.

The first assumption has been examined and worked over bv many investigators with a view to proving its truth or falsity. If proved true, it would be interesting and useful, but it could never justly be claimed as showing that the elements were formed of hydrogen or the hypothetical pantogen. If we take the list of atomic weights as calculated by Ostwald and select those in regard to which we can feel sure that the weight is approximately correct and if we disregard variations of less than one tenth from the unit, then we find that twenty-three out of thirty-five are integral multiples of hydrogen. Clarke claims forty-one out of sixty-six but includes such as niobium, didymium, gallium, tungsten, thorium, &c. A little critical examination of his list will easily cut the whole number down to little more than half of the forty claimed. The best that can be said is that about two in three are whole numbers and the remainder run the full range of decimals from .1 to .9 and no halving of the atomic weight can possibly hit upon them. When it is considered that about as many of the elements are whole numbers when hydrogen is taken as 1.0025 as when it is equal to unity, it will be seen how little bearing upon hydrogen as the primal element the facts of integral atomic weights would have.

THE IMPROBABILITY OF HYDROGEN BEING THE PRIMAL ELEMENT.

I hesitate to discuss this question because I scarcely think it is seriously urged but a few thoughts may not be amiss. The supposition of a primal element having as its atomic weight half or any other fraction of the weight of hydrogen is based simply upon the increased number of coincidences of the atomic weights with whole multiples and can have little weight. Such an hypothetical pantogen escapes all serious argument. But against the supposition that hydrogen is the primal element many things may be urged.

In its favor there is little beyond the fact that some two-thirds of the different atoms, so far accurately determined, have approximately integral weights and that, in the table of elements, hydrogen occupies a most anomalous position and refuses to be satisfactorily arranged in any of the groups or periods. If, however, we are to judge of this matter by ordinary rules, it seems highly improbable that an element of such definite, postively marked characteristics can by any kind of condensation or combination be changed into such markedly opposite bodies as as fluorine and sodium or chlorine and potassium. We are coming more and more to regard an element as representing an assemblage of properties. Thus chlorine stands for a form of matter, gaseous and most energetically negative whilst a slight increase of weight brings us to potassium a solid metal and most energetically positive and it is quite unlikely that this should be due merely to a small additional condensation of such a body as hydrogen. It is contrary to the gradual change of properties observed in cases of polymerism or even homology in organic chemistry.

The supposition of two or more primal elements, condensed in varying proportions, is in accord with phenomena known to us but of course is so far without experimental or other basis if we exclude the mathematico-spectroscopic work of Grünwald. Take for instance, the widely different results obtained by varying the ratio between nitrogen and hydrogen in their compounds. Thus 3N and H give a well characterized acid and N and 3H give an equally definite base. This complete reversal of properties can no more be attributed to the hydrogen alone than to the nitrogen. The primal elements might act in this way in their condensation into the common elements.

There is no basis for the formation of any hypothesis as to the primal elements and speculations on this score are as idle as the dreams of the early Greek philosphers. The future may bring such knowledge as will afford the needed data. Certainly we are a long step nearer to it in the recognition of the fact that the properties of the elements are dependent upon and determined by the atomic weights.

THE PERIODIC LAW.

A quarter of a century has passed since the first announcement of the Natural Law and the publication of Mendelejeff's table. The truth of the law in a general way seemed to be accepted very readily by chemists. It was incorporated in text-books and there explained, but comparatively little use has been made of it in teaching the science. Even Mendelejeff himself, in his *Principles of Chemistry*, has not made the fullest use of it. Victor Meyer, in his lecture before the German Chemical Society more than a year ago, showed how it might be used and how he used it himself, and probably, this will do much toward popularizing its use.

There must be some reason why so great a help to scientific study is not made more use of. Does it lie in a lingering distrust of the law itself or failure to accept it or is it because of the imperfections in the arrangements of the elements offered by Mendelejeff and others? It is most probably due to the latter and this paper is presented with the hope of clearing up some of these difficulties.

The modern chemical world has recognized in the discovery of Mendelejeff the greatest step forward since the announcement of the atomic theory. It is too much to expect that so great a discovery should spring full-panoplied from the head of its author. It has been accepted by chemists in all lands and is the basis of present chemical thought. Doubtless many have observed the imperfections of the law's original form or rather the table as first brought out. Probably some have ventured to comment upon it. Such criticisms have escaped me with one or two exceptions.

It is with much hesitation that I venture to point out what seem to me to be imperfections and blemishes in so great a work. Few may agree with me in calling them imperfections. I do not purpose to detract one particle from the greatness and importance of the essential truths contained in this discovery. Mendelejeff's table, as we have it at present, is a great advance upon the first one published by him in 1869 which must be pronounced tentative only and decidedly unsatisfactory. The table of Victor Meyer is far behind it in presenting the facts of the periodic law. There have been many attemps at devising a graphic representation of this law. I know of none which can be called real aids to the student or which do not introduce new ideas which, to say the least, have no basis in the facts as known to us at present. None of them can be regarded as a safe substitute for the simple table of Mendelejeff.

Taking that table I would venture to point out some obstacles to its present full acceptance. These have been in part revealed to me by the effort at an honest presentation of this great truth of nature to honest-minded, clear-sighted young men. Before mentioning these difficulties which lie here in the path of a teacher, I must preface that my criticisms are aimed at what I may be allowed to call the unessentials of the law. Mendelejeff's great feat was in seeing clearly and announcing intelligently that the properties of the elements were dependent upon and determined by the atomic weights. This is the essential of the periodic law and is in accord with our fullest knowledge. The second part of the law as usually stated, that these properties are periodic functions, attempts in a measure to define the dependence. It may also be true but it is not fully proved and is open to objections. It seems to me that this hypothetical portion could well be left in abeyance until fuller knowledge gave it a stronger footing, meanwhile substituting something less open to criticism and which cannot weaken the central truth.

Take this table and examine it. First we find two kinds of periods made use of—periods containing seven elements and those containing seventeen. If it had only been possible to arrange all of the elements in sevens as Newlands attempted to do, the periodic idea would have been most convincing and the law of octaves running through nature would have seemed most wonderful. But these elements do not admit of being arranged in this way and the use of periods of different lengths is to fresh young minds, unacquainted with mathematical expedients, somewhat forced.

Secondly, there is a very anomalous position assigned to the triads or, as sometimes written, the tetrads, Fe, Co, Ni, (Cu,) etc. They have been set off to themselves, clearly so as to make the other elements fall even approximately into their places and into the proper sevens. I say approximately, for the student soon sees that although there is a similarity there is also a wide difference between the elements of the first and of the last seven in any period of seventeen.

Thirdly, in the lower periods, in order to get elements to fall into their places a great many unknown elements have to be interposed. Thus between cerium and ytterbium, the next element in the list, there are blank places for sixteen elements. The third large period of seventeen has only four known elements in it and the fifth has only two. Of the five periods only one is completely filled out. To say the least, this shows a very imperfect knowledge of the elements, or a great deal of guess work. In the table there are sixty-four known elements and thirty-five blanks for elements yet to be discovered. I hardly think it possible that the majority of chemists believe that after all of our diligent search for the past century less than two-thirds of the elements have been discovered. Where are the others in hiding? Will they be discovered by the spectroscope in the rare earths? There is certainly hope of finding some but the number to be found is appalling. The average student thinks, in all honesty, that the coincidences of the first part of the table will scarcely justify such forcing and wholesale interpolation. If our knowledge of the elements is as imperfect as that, we have no right to force them into periods. Some of them seem little inclined to fall into these periods of their own accord. How do we know that the remaining two-thirds may not upset the entire calculation? Certainly we are venturing a good deal upon a very imperfect knowledge of the remainder. Let us see how the matter stands. The periodic idea may be true but we do not know enough about these elements yet to be able to give this idea a very prominent place in the natural law, and we ought to avoid the assumption of so many unknown elements unless absolutely necessary.

As I do not intend to tear down without some effort at re-building, I would, with much real diffidence, for I realize that I may be looked upon as one who would rush in where only the great masters of the science can safely tread, offer the following table as a substitute:

						MH_4		MH_3		MH_2		MH				
M_2O		MO		M_2O_3		MO_2		M_2O_5		MO_3		M_2O_7				
Li — 2 —		Be — 2 —		B — 1 —		C — 2 —		N — 2 —		O — 3 —		F				
16		15		16		16		17		16		16				
Na		Mg		Al		Si		P		S		Cl				
16	40	16	41	17	43	20	44	20	44	20	47	20	45			
K	Cu	Ca	Zn	Sc	Ga	Ti	Ge	V	As	Cr	Se	Mn	Br	Fe	Co	Ni
46	45	47	47	45	43	42	45	43	45	44	47		47	46	47	47
Rb	Ag	Sr	Cd	Y	In	Zr	Sn	Nb	Sb	Mo	Te		I	Ru	Rh	Pd
48	89	50	88	50	91	50	89	88	90	88				87	88	88
Cs	Au	Ba	Hg	La	Tl	Ce	Pb	Ta	Bi	W				Os	Ir	Pt
						90				54						
						Th				Ur						

My first suggestion is that the wording of the Natural Law be so changed as to read: "The properties of the elements are dependent upon and determined by the atomic weights." The somewhat difficult idea of function is simplified and periodicity is subordinated. Then I would substitute the following table for that ordinarily given. It is not greatly changed, and not much originality is claimed for it, but however slight the changes I would insist upon their value, because they do away with the dependence upon periods, and they certainly make the table an easier, more intelligible, and more useful one to the student. There is no forced effort at rounding off any period or group. There is room for additional elements when discovered, but the table is not dependent upon them.

Lastly, the inter-relation is more clearly brought out. I do not maintain that this table could ever have been discovered without the idea of periods, though I think it might. The periods still underlie it, but they are out of sight for the present and are not necessary. The table is not dependent upon them.

There are seven group elements having a mean increment of two in their atomic weights. It is by no means essential that there should be just seven of these. At present we do not know more, but I think there is possibly a place for one more having the atomic weight 21, differing widely from the others as it occupies a singular position.

These group elements are also to be called bridge elements as they show marked gradation of properties from one to the other and so serve to bridge over the groups and connect one with the other. Linked to them by an increment of sixteen are seven typical elements. These show the distinctive properties of the groups to which they belong and a wider divergence from the next group to them. From them can be deduced the properties for the remaining elements of the group. Thus in group I Li is the bridge or group element and Na the type. From this type two lines of elements diverge, averaging three to the line. These triads would of course be changed into tetrads or pentads by the discovery of more elements. No importance is attached to the fact that at present they are in threes. There is a distinct increment for each line of elements. These can be averaged thus; Fig. 1 representing the arrangement and increments for the first three groups, and fig. 2 the arrangement in the last four groups, the increments varying slightly. These increments could be averaged in all except one case, and the agreements with known atomic weights would be close enough to admit of the easy arrangement of the elements in the prescribed order. Naming the triads Right Triad and Left Triad respectively we find that these averaged increments would be as follows: the increment from group to type element is sixteen; from the type to the first element in the Left Triad (L. T.) is 18; to second element L. T. is 63; to the third is 112;—to the first element to the Right Triad (R. T.) is 44; to the second R. T. is 88; to the third is 177.

Fig. 1.

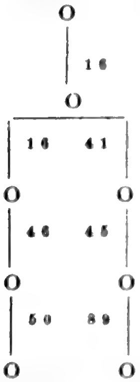
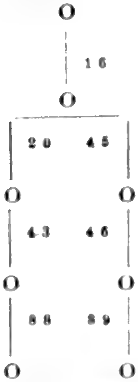


Fig. 2.

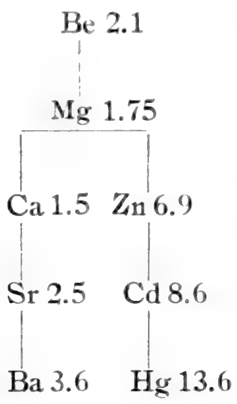


The one exception is in the increment from Type to III L. T. from group IV to VII. Instead of being 112 this is 141.

To the right of Group VII we have three triads which have nearly the regular increments belonging to the Right Triads, namely, 47 and 88. They are without any type element, it seems most likely that they belong to one group. The Group element would have an atomic weight of 21 and the Type one of 37.

The arrangement in the table then is partly one based upon regular increments in the atomic weights, and since these are so poorly known, partly upon our knowledge of the chemical properties of the elements. When it is recalled that about one half of the atomic weights are imperfectly known it will be evident that these averaged increments are approximations only. It is impossible to bring out such perfect symmetry as obtains in the homologous series in organic chemistry. And yet these groups should be something of the same kind. Following the analogy to the organic hydrocarbons a little further, may not the existence of an element in two different conditions as to valence, &c., as, for instance, copper or mercury or iron be looked upon as a species of isomerism. Such speculations are of little use, however, and quite apart from our present purpose.

I have found this table very useful in teaching elementary chemistry and it can most profitably be made the basis of the entire course. Thus in the first four groups the left triad contains the elements most closely resembling the Types. In the last three they are to be found in the right triads. As to natural occurrence of the elements, in the first four groups those in the left triads occur in the same compounds and generally in connection with the type; those in the right triads occur as the type or as sulphides or are free. In the last three groups this is reversed. The right triad elements occur as the types and the left triad as the type or as oxides. So too the properties of the elements show this relation to the types. Take as an example the specific gravities in Group II.



It is not necessary to pursue this part of it at greater length. The careful teacher will easily work out all these comparisons for himself and will find that chemistry taught by the table is shorter (so much repetition being saved) and is easier for the pupil and its symmetry and beauty is much more easily brought out. There is no special claim for originality made here. The germs of such a table or arrangement can be found in several text-books but I do not know of any in which the idea is fully developed or such a table as this is given.* I offer the whole as a suggestion. Perhaps some may find it useful who have met the same difficulties which I have encountered. Others may have overcome these difficulties in a still better way than this, and yet others may see no difficulty at all in the present table. I think, at least, all will agree with me that there are difficulties and very genuine ones also in the use of Mendelejeff's or Meyer's tables as given by the respective authors.

IMPROVEMENT IN THE METHOD OF PREPARING PURE ZIRCONIUM CHLORIDES.

CHAS. BASKERVILLE.

The preparation of pure zirconium chlorides from zircon is a rather long and tedious process. Linneman's method, [*Sitz. Ber. Kais. Akad. d. Wissen-Schaft.* Vol. II, 1885, translated in Chemical News LII, 233 and 240. on "Treatment and Qualitative Composition of Zircon."] which is very long, was much shortened and simplified by Venable [*Journ. Anal. and*

---

* The arrangements of Bayley, Hinrichs, and Wendt are some what similar but the ideas which I would make prominent, are obscured by other considerations and speculations.

Applied Chem. Vol. V p. 551]. Bailey's method [*Journ. London Chem. Trans. 1886, p. 149*] of precipitation by means of hydregen peroxide is very expensive, aside from the difficulties one encounters in preparing the reagent pure.

Having learned that zirconium could be precipitated completely, freed from iron and aluminium, [Baskerville *J. Am. Chem. Soc. XVI, p.* 475.] by means of sulphurous acid, when working with the small amounts usually employed in analysis, I proposed to apply the same treatment to quantities in bulk for the purpose of obtaining a pure salt of zirconium.

The powdered zircon, washed with hydrochloric acid, (100 grams) was fused and treated according to the directions given by Venable [*loc. cit.*] up to the point where the impure zirconium chloride had been freed from silicic acid and was in a dilute hydrochloric acid solution.

This solution was nearly neutralized with ammonium hydroxide. A strong stream of washed sulphur dioxide gas was then led into the cold solution to thorough saturation. This required about fifteen minutes. Partial precipitation occurred in the cold, but other experiments had shown that the precipitation would be more complete if this solution saturated with sulphur dioxide was diluted largely and boiled. Five to ten times as much distilled water was accordingly added and the whole boiled half an hour in large evaporating dishes. The zirconium precipitated out and settled nicely. No bumping occurred during the cooking—while hot, the liquid was rapidly gotten away by means of an unglazed porcelain suction filter. The precipitate was washed two or three times with hot water, then boiled in water and again washed after filtering. This precipitate was then dissolved in dilute hydrochloric acid and boiled to expel most of the sulphur dioxide. The solution was re-precipitated with ammonium hydroxide. The precipitated hydrates were washed free from ammonium salts and then dissolved in concentrated hot hydrochloric acid. Five crystallizations from the strong acid were found to be sufficient to remove the small amount of iron remaining.

Investigations are now in progress concerning the composition and nature of the precipitate produced by the sulphur dioxide.

A NEW POST OAK AND HYBRID OAKS.

BY W. W. ASHE.

During the past two years, 1893 and 1894, I have observed during several trips through the eastern sections of Virginia, North and South Carolina, a large number of oaks morphologically different from any described species, and in most of the cases, where mature fruiting specimens have been secured, the characters have required that they be referred to the already large list of oak hybrids. One of them, however, is a new form of the post oak, distinct enough to merit varietal place, and so described. The other forms, which I have examined, from which late fall leaves, winter buds and fruit were secured, have proved to be hitherto undescribed hybrids; while a large number are hybrids previously observed by others in different parts of the United States and to the elucidation of which my meagre notes can add but little. I do not think the following hybrids have been previously reported from North Carolina: *Quercus Rudkinii*, *Q. sinuata*, *Q. aquatica* x *Q. Catesbæi*, *Q. minor* x *Q. alba*. The last one I find in the middle section of both North and South Carolina. In Mecklenburg county I found a fine specimen of *Q. coccinea* x *Q. phellos*, but its characters do not agree at all with the *Q. heterophylla* as described by Michaux in the Sylva or by Mr. Martindale. I have a large number of other forms from these and other states which I have not yet looked over or from which I have not yet succeeded in obtaining fruit or flowers.

To several of these hybrids, which are most constant in form, distinct in character and which are not intermediate in form between the parents, I have ventured to apply specific designation.

The following are the forms in my herbarium which I have looked over, with a few brief notes describing them:

Q. cinerea x *Q. Catesbæi.—Form 1.*—The sessile leaves, 3 to 5 inches in length, are narrowly oval to oblong, rarely oval in outline, with three short bristle-tipped lobes at the summit; or oval and entire. They are either rounded or acute at base. Above they are smooth and shining; below, whitened with the close white stellate pubescence of cinerea. The veins are straight and prominent while those of cinerea are obscure. The twigs and buds are coarse and large like those of Catesbæi; but the bark and general appearance of the trees is that of cinerea. The persistent leaves turn, in the fall, first a yellow and then by December a dull brown, at which date the foliage of Catesbæi is scarlet or partly green. The fruit, however, is that of Catesbæi, frequently, with a tumid base to the cup, or the wall of the cup rolled inward around the margin. These trees are frequent. Ten or twelve were seen, which were essentially alike in foilage; and those which had fruit agreed in that.

Form 2.—The leaves are longer than in the above, 4 to 6 inches long; mostly oblong in outline; always three lobes at the summit, usually with long falcate lobes; either dentate or lobed on the margins. There are some scattering white pubescence of cinerea over the lower surface and tufts of coarse hairs in the axils of the veins. The bark is rough and black. The trees usually fork and have the general appearance of Catesbæi. The leaves turn scarlet in the fall like those of Catesbæi. The acorns vary a good deal but are more generally like those of cinerea. Several of these trees were seen.

Q. *cinerea* x Q. *laurifolia.*—Leaves oval or oblong, 1.5 to 2 inches long, acute at each end; deep green and shining above, below lighter and covered, especially on young shoots, with a scattering appressed tomentum. The leaves of young shoots are variously lobed, especially towards the summit. The midrib is very prominent, and also one or two pairs of lateral veins. No tufts of hairs are in the axils of the leaves. Twigs are covered when young with a thick white pubescence. The trees are small, 15 to 25 feet high, with broad, spreading, globose crowns, rather resembling laurifolia. Leaves remain bright green, or partly turn yellowish by December 6. Nut is brown, smooth, obscurely ribbed, subglobose; cup deep, covering from one-third to one-half of the nut; scales smooth, firmly appressed. Acorns are almost intermediate in character between those of the parents, except in pubescence. The fertile embryos are largely atrophied. Several trees were found in different places, but always near the coast.

Q. *cinerea* x Q. *aquatica.*—The leaves 2.5 to 3 inches long, 1.5 to 2 inches broad, are broadly spatulate; rounded or three lobed at the summit; rarely rounded at base. Above they are smooth; below varying from the thick, white pubescence of cinerea to nearly smooth, with small tufts of coarse pubescence in the axils of the veins. The venation is mostly obscure. They are small trees, 20 to 25 feet in height, with drooping branches and rather smooth gray bark. The twigs are pubescent save where the pubescence has worn off. On December 2 the trees are nearly naked of leaves, the leaves still persistent being yellow, while type trees of aquatica are green. The nut is globose, brown, not ribbed, tomentose, as are the scales of the shallow or deep cup; cups persistent on the twigs as those of aquatica frequently are. Several specimens of this hybrid were seen, all near the coast.

Q. *petiolaris.*—Q. *cinerea* x Q. *tinctoria?*—The leaves are oblong or elliptical, 4 to 6 inches long and 1.5 to 2 inches broad; sinuate or crenate on the margins; mostly three lobed and dilated at the summit; truncate or subcordate at base. The lobes at the summit are usually bristle-tipped. Leaves are smooth above or with glandular, septate hairs along the midrib; the under surface covered with a close, brownish tomentum, wearing away with age; tufts of coarse pubescence in the axils of the primary veins. The venation is that of the black oaks (tinctoria and coccinea) with 4 to 6 pairs of prominent, impressed primary veins. The petiole is one-half inch long. The long buds, .3 inch, are lanceolate. The slender twigs are covered with the brownish tomentum of cinerea. Five or six such forms were seen; all small trees with the bark and general aspect of cinerea. By December 1 the leaves have turned a light brown and are mostly persistent. The deep, nearly sessile cup, enclosing nearly one half of the nut, is top shaped and acute at base. The large, obtuse, pubescent scales are appressed or usually so. The cup is strongly spreading just below the margin. The nut is about one third larger than that of cinerea, oval, pubescent; the persistent base of the style is prominent. Only one tree was found in fruit and its nuts were mostly imperfect.

The character of the pubescence on leaves, twigs and fruit, the oval and entire form of a few of the leaves and the general appearance of the tree indicate cinerea as one parent. The other parent is one of the long-petioled leaved black oaks. Rubra, which probably does not occur, or rarely, where this was found, would be excluded by the deep cup. The shape of the leaf points to cuneata, but neither nut, cup or bud agrees in any particular. The forms of nut and cup are clearly toward those of tinctoria or coccinea, and especially does the thick wall of the cup and the angle made by the outer surface just below the margin indicate one of these species. I am inclined to say tinctoria.

Q. *cinerea* x Q. *nigra*.—The leaves are 3 to 4 inches long, 2 to 3 inches broad, usually broadest at the upper end. In shape they vary from elliptical to ovate, rarely slightly three lobed at the summit. The oval leaves are acute at base and usually acute at the summit. The others vary from rounded to cordate at base. Old leaves are smooth above except on the midrib which is covered with the close septate, stellate, brownish-gray pubescence of cinerea; below they are covered with a down of the same color. There is a distinct petiole one-eighth of an inch long. The venation shows the dichotomous forking so characteristic of nigra. The upper bud scales are pubescent. The leaves are thick and stiff. In the fall they first turn yellow and then dull brown and persist. They are small trees, 6 to 10 feet in height, with drooping branches and rough bark. Only a few nuts could be found, only a few trees fruiting. These were oval and black ribbed, somewhat larger than the nuts of cinerea, and had disproportionately enlarged hemispherical cups, covered with coarse pubescent scales. The trees in November have the general appearance of nigra after the leaves have turned. Perhaps ten such trees were seen, all in the neighborhood of the coast.

Q. *aquatica* x Q. *nigra*.—The leaves are 2 to 4 inches long, 1.5 to 3 inches broad; broadly ovate or deltoid in outline, broadest above the middle. They are scolloped or slightly 3 (rarely 5) lobed and short bristle tipped; sessile and usually acute at the base. Above they are glabrous and also below, except in the axils of the principle veins where there are tufts of coarse hair. The leaves are thick and firm, and on November 24, were mostly green or the lemon yellow which withering leaves of aquatica turn. The venation is that of nigra. The buds are small but hairy at the summit as are those of nigra. The twigs are slender and warty. The pubescent—scaled cup is hemispherical, and encloses one-half of the ovate, obscurely ribbed nut. The nuts are imperfect, often with the fertile embryos but slightly more developed than the abortive ones. The branches are drooping; the bark is slightly gray. Only a single tree was seen, about 20 feet in height and with a broad spreading crown. Imperfect nuts and cups were abundant, the latter usually remaining on the tree.

Q. *dubia.*—Q. *phellos?* x Q.———. Leaves are entire, 3 to 7 inches long, and 1.5 to 3 inches broad. They vary in shape from lanceolate and linear lanceolate to broadly ovate or elliptical. The lanceolate leaves are shaped like those of phellos, broadest at the lower third; the larger ones are obtuse at each end and symmetrical. All are tipped with a single bristle. Above they are smooth; below there is some scattered pubescence over the entire surface and a line of coarse hairs along both sides of the midrib, as is the case usually in phellos. There are many pairs of prominent straight lateral veins. The venation is something like that of tinctoria. The stout petiole is nearly one-fourth of an inch long. The slender buds, .15 inch long, are pubescent, but the twigs are smooth. The distinctly peduncled cup is top-shaped or hemispherical, with involute margin; scales small, bright brown, closely appressed, almost smooth. The cup is .6 to .9 inch broad, .4 to .5 inch deep, and encloses one-half of the nearly globose, black and brown striped, hoary nut. It fruited abundantly.

Only a single tree of this remarkable form was seen. This was in the open, and was about 25 feet tall, with a spherical crown and spreading branches. The trunk, 10 feet long, had a rough, dark bark. The leaves were partially green and yellowish on November 20. They all turn a dark brown and drop. When green it resembles the evergreen magnolia. Although the shape of the leaves does not bear me out, I think this tree will prove to be a hybrid between phellos and tinctoria or coccinea. The texture of the leaves, however, is firmer than in any of those trees. There is no physiological debarment, that I know, which might prevent a third species from entering this combination.

That is, a hybrid phellos x tinctoria might in turn be fertilized by cinerea or nigra, and this tree be the result.

Q. *falcata*. Q. *phellos* x Q. *cuneata*.—The leaves are 3 to 5 inches long, and 1 to 2 inches broad; oval or oblong to lanceolate in outline. The smaller leaves are entire, oval in outline, and acute at each end and have a very short petiole; while the largest are lanceolate with several shallow lobes towards the base and a long terminal, frequently falcate lobe, tipped with a single bristle. The petioles are from one-fourth to one-half an inch long. The nearly sessile cup is saucer-shaped, .5 to .6 inch in diameter and .2 inch deep with the closely appressed scales tubercled at base. The cup encloses only the base of the globose or sub globose nut which has the light brown color, in dead specimens, and wartiness peculiar to cuneata. Nuts are mostly imperfect and many, only half-formed. A large tree 60 to 65 feet in height with a large and spreading crown; bole 18 inches in diameter, with a rough dark bark resembling that of phellos. The foliage was a light green on November 20; dead leaves turn at once a dull brown.

Quercus minor var. Margaretta.—The leaves are 2.5 to 3 inches long, and 1.5 to 2 inches broad. They are oval in outline; entire, wavy-margined or with three spreading lobes at the summit. They are mostly acute at base, rarely obtuse or truncate. Above they are smooth, below they are soft downy. The slender petiole is from one-fourth to one-half inch long. The twigs are slender and smooth. The buds are acute and bright red, sharply 5 angled and large, .15 to .2 inch long. The cup is top shaped, rarely rounded at base, sessile or nearly so. The cup is .4 to .55 inch deep,

.45 to .5 inch broad and covers one-half or more of the slender brown nut which has a length of from .7 to .8 inch and a breadth of form .4 to .5 inch. The nut is silky canescent at the summit and is persistently beaked with the long and slender base of the style. This tree fruited abundantly in 1994, and was the only high ground white oak in eastern North Carolina that did do so. They are small trees 20 to 30 feet in height, growing in the high pine barrens of eastern North Carolina. When trees are killed by fire the roots usually sucker freely. The bark is similar to that of the type.