PROCEEDINGS

OF THE

Delaware County Institute of Science

Carolus M. Broomall, Editor.

PUBLICATION COMMITTEE :

T. Chalkley Palmer, Chairman, Trimble Pratt, M. D.,
Jacob B. Brown, Henry L. Broomall,
Linnæus Fussell, M. D.

Volume I : October, 1905, to July, 1906

MEDIA, PA.

INDEX TO VOLUME I.

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ANNOUNCEMENT.

With the present number the Delaware County Institute of Science begins the publication of its proceedings. Occasional publications under the direction of the Institute during the seventy-two years of its existence and its scientific contributions remaining in manuscript or appearing in print under other auspices, are of a character to warrant the undertaking.

Papers appearing in the PROCEEDINGS may be either technical or popular, consisting of local data and observations, general scientific articles, résumés, and abstracts of lectures before the Institute.

Each number will contain brief notes of Institute affairs.

THE GREAT WALL OF CHINA.

May one be pardoned for beginning with a well-known story? It is a good one, and, perhaps, there are yet those to whom it will be new. The place and the time are put in at random. The spirit of the tale it is that counts; and that is the same of what country soever, or of whomsoever it be told.

A prince of—Sparta, let us say—was visited by a foreign envoy. The envoy noted with surprise that all the towns were open, and he asked the reason. "Come with me to-morrow," said the prince, "and you shall see and hear."

So at the proper time the two attended what in these days would be called a parade. "But how," said the envoy, "has this to do with what I asked last night?"

"These," said the prince, "are the walls of my dominions. Twenty thousand chosen youths, and every one of them a brick."

The Great Wall of China is one of the most stupendous artificial curiosities in the world, and one which for abnormal reasons is among the most interesting monuments which time has spared to this generation.

It was 214 years before the Christian era, somewhere about the time when the great Archimedes lost his useful life at Syracuse in Sicily that a young gentleman of thirteen summers, one Che Wang Te, succeeded to the throne of somebody's ancestors in Peking. He found trouble, sorrow, need, sickness and many other adversities. A short time before, his respected father had been beaten in a great battle with the rebels. The usual 100,000 men had fallen. The usual fire and massacre and famine had been inflicted upon whole regions full of hapless creatures who had no idea what it was all about; and, worse than all, the terrible Tartar was stirring in Mongolia and Manchuria.

The child gave command—or was told to give command—at all events command was given, that a wall should be constructed to guard the whole northern frontier of the Empire from the incursions of the savage horsemen of that region.

Imagination changed fear into necessity, and so, imaginary necessity evolved the wall. A tunnel under the Straits of Dover would, as a mere output of physical force, be child's play beside such a conception as this.

Built it was, however, and that in the course of ten years. It would seem from this that they say true who declare it was but the bringing into one connected whole of a set of isolated fortifications. And it may well be so, for each province would naturally have fortified for itself. And the short time occupied in consummating so enormous a work not only points to some such facilitation, but shows clearly, moreover, that no forced labor was necessary to bring it to pass, that the hearts of the people relied upon a wall to part them from their enemies, and that they worked under a stimulus greater than their fear of a despotic ruler. And it is no more than fair to say that Che Wang Te is described in the annals of the Empire as a good and vigorous prince—as good and vigorous princes go in China.

And there the structure stands to this day, as sound and high and strong as ever. And as useful as it was in the beginning.

But, right or wrong, the fact is that judgment is pronounced upon such things according to the ideas of to-day, at whatever point in the world's history to-day may fall. And judged by to-day, the Great Wall of China has no right to an existence. It serves no purpose useful or sentimental. It called out no genius either in war or in art or in mechanics. If it be a record it is one too vague to be regarded. It is a monument of folly and pusillanimity. It is void of beauty, and it is not even ugly. Any portion of it that the eye can take in without movement of the head is entirely commonplace and unattractive. Extend yonder prison wall out of sight in both directions and have about the same mental impression that the Chinese Wall would give.

It is built of fragile materials, but has lasted 2000 years and more because no one goes near it; and there is so much of it. It is in nobody's way, and the materials have not yet been found worth carrying off. Not yet — for its virtual absorption by the Trans-Siberian Railway is one of the vague but gigantic possibilities of the future.

The Wall is typical and characteristic in the highest degree. As enormous, as useless and as helpless as the bulky Empire of which it used to be the futile hem. Empire and Wall alike are, or are ready to become the prey of the spoiler.

Nothing that is not formidable, nothing that men do not, for some reason, fear, at least a little, is respectable or safe.

The great Gibbon said that "if the Chinese seldom dared to meet their enemies in the field, their passive courage presented an endless succession of cities to storm and of millions to slaughter."

To-day the Flowery Empire is being partitioned among the Powers like a school of herrings. The Wall is garret lumber, given room merely because the room is not yet wanted for something else — allowed to stand because no use has yet been found for what composes it.

The Great Wall as laid down upon the maps extends generally westward from about the 126th meridian to the 100th. Twenty-six degrees of longitude. This on the equator would be, at 70 miles to the degree, 1820 miles. On the 40th parallel it would be 1394 miles. But the line of the wall is so crooked that if fairly straightened out it would be considerably more than this.

On the whole, therefore, its length might after every reasonable adjustment, reach even the 1500 miles that have been claimed for it.

I am not aware that any very accurate surveys have been made, and it sounds well not to mind a hundred miles or so more or less.

However that may be, it runs along the northern frontier of China proper, between this and the great provinces of Mongolia and Manchuria, Mongolia being the westward one of the two. Peking (Pei Ching, North Capital) is in (nearly enough) 40° north latitude, and is 117° east of Greenwich. A point of the Great Wall lies forty miles due north of the city.

As I remember, it was in the latter part of August, 27 years ago. Our ship was anchored at Shan Hai Quan on the Pechelee Gulf, a branch, or rather a bulge of the Yellow Sea, latitude 40° north, longitude 126° east of Greenwich.

A lovely morning. The gig was piped away, and the captain invited such of the officers as were not on duty to go ashore and see the Great Wall, a branch of which reached the water at about a half a mile from where we were lying, while the rest of it stretched and crawled over the hills in a northerly direction, so like the little, old fashioned pictures we used to see so long, so long ago in the geography books that it was absurd.

What we saw on drawing near was a solid wall, ended at one end and endless at the other, thirty-five feet high, twenty-four feet thick, and said to be anywhere from 1200 to 1500 miles long. The part immediately in sight was chiselled over with the names of many men-of-war of many nations.

We landed and saw a few listless Chinamen.

But, coming close beneath that unmatched structure it was seen to be a strong outside of burned bricks, 18 x 10 x 4 inches. Burned bricks of 720 inches in cubical content. This casing was filled in with, I do not know what, but, something said to be a kind of mortar. Whatever it be the erection is as sound and solid as if no twenty centuries had been trying to gently pass it out of existence, but rather as if twenty months or so had set the well cemented joints. And we sought in vain to persuade each himself and so the others, that such feats of clay baking could be exhibited in our own favored land.

A narrow, suitably crooked staircase, of stone, and as solid as the roots of the everlasting mountains, led us, darkling, to the top, and there before us was a path

> "Men might walk on, nor be pressed,
> Twelve abreast,"

somewhat overgrown with bushes, as is usual in such places, stone paved, relieved at certain intervals by a little tower such as we had just passed through to reach the place — a tower, that is, of access, and bordered by a battlemented parapet, strong enough and not too high. Along that path so bordered and so diversified, a man might march for 1200 miles and no 100 yards of what he trod on should differ from another 100 yards. So 't is said.

Up over mountain and down through valley runs that marvellous obstacle. Carried by main force across rivers and over gorges which it thrills a man's imagination only to think of gazing on. Continuous from end to end.

And all to keep at arm's length a lot of whirling, horse-riding, mare-milking, koumyss-swilling, skin-clad Tartars.

When a cloud of these ugly, pig-eyed, flat-nosed, broad-mouthed, tireless, cunning fiends in human shape was seen approaching, the watcher on the wall who first descried them gave alarm at once. Then all defenders of their country's glory rushed along the safe path prepared for them until they reached the threatened point, and then — consulted what to do. If the assailant seemed to be weak, they shot arrows at him and drove him off; if strong, they gave him much money, and he turned away well satisfied.

All for this, and all in vain. For the Tartar rules in China, and the tail which we see cherished with so much stubborn pride has, if history say truly, been worn for 200 years by order of the conquerors.

These Huns, for Huns they were, did not find a wall to stop them until 650 years later; when, under Attila, the "Scourge of God," they were shattered against a living rampart of Gothic Romans under the great Theodoric, at Chalons in Gaul.

I well remember the look of the surrounding country. It was lonely and wind-scourged as if it were a terrible place in the winter time. But that can hardly be, for the latitude is our own latitude and the Pacific Ocean is close at hand to the eastward.

Dreadfully depressed and miserable was the look of the few persons we saw around us. We set out to follow the parallel generally, westward, moving, however, first northwardly, inland along the east or outside of the wall. A poor ragged man advanced and murmured something which was construed as a remonstrance; and, sure enough, it was in due time developed that this dignified and powerful personage was the official in charge of that portion of the Empire. Nothing in our intentions, however, contained any menace to the existence or well-being of the Middle Kingdom. We were, for the time being and so far as that spot of earth was concerned, stronger by a great deal than the whole four hundred and fifty millions that stood behind the Imperial Representative — and we had come a long way on purpose. So we disregarded his feelings and gave him money. His efforts to exclude us were persisted in, but it was so clear that this was a solemn farce "to save his face" that we were no more moved than before.

The children, but for their little tails all over their heads and their wholly scanty costume, were just like any other children — more so, perhaps, for they were excessively well behaved. I gave one small boy a brass anchor button from my jacket, and I do not doubt that it will be treasured in his family to the latest generations.

Perhaps, after all, we might let the Wall stand as a monumental record of the difference between bulk and greatness.

Multiply the Erie Canal by four and then set out to give the striking characteristics of that much under-rated structure. It is all striking together, like the clocks of a great city. Useless to dwell upon a part with the allowanced glance of the bodily eye. The mighty whole must be taken in with the limitless sweep of mental vision. Think of the number of "days" that must, in contractor's parlance, have been "put in" from first to last. They had all the "time" of that kind that there was when this wall was built.

"'T is not so now!"

Be that as it may. The man who does not have a real traveler's sensation when he looks on this Titanic failure to make bricks and mortar take the place and do the work of valor must be tolerably well case hardened. J. B. B.

THE LOCAL WATER SUPPLY.

One of the most important factors in the preservation of the health of a community is the purity of its water supply. The writer has taken considerable interest in the question of the water supply of this locality, and has made a number of analyses in that regard. These figures, aside from establishing the high standard of the Media water supply, will be useful, in addition, for the purpose of detecting any deterioration that may occur in the future. It is particularly with this idea in view that the figures are put on record. In comparing the present figures with those of the older analyses, attention should be called to the fact that in 1899 the Borough of Media installed a very efficient filter plant at its water works on Ridley Creek, which plant has been in constant operation ever since.

Before giving the results of the analyses, a few words of explanation may not be out of place for the benefit of those unfamiliar with the subject. There are two distinct methods of examining a water to determine its usability, one chemical and the other bacteriological. The former measures certain chemical products in the water that indicate the existence of present or past pollution. In the bacteriological method the actual number of bacteria per cubic centimeter is ascertained, including both harmless and harmful bacteria, and the number thus found is taken as an index of the possible danger of using such water. In some cases the particular kind of bacteria is determined. It is only after a judicious combination of both methods that a perfectly fair judgment upon a given water can be given. It is probable, however, that the chemical analysis gives more nearly the true average state of the water, as very much larger quantities are operated upon. In addition, the chemical method gives the actual chemical constitution, and, therefore, its true character as a water. Any permanent change in the chemical composition of the water indicates some change in the environment which may be of extreme importance.

The significance of the results obtained by chemical analysis may be briefly stated as follows:

The Albuminoid Ammonia is a measure of the amount of undecomposed nitrogenous organic matter in the water, this ammonia being produced from the organic matter by artificial decomposition in the laboratory.

The Free Ammonia indicates the presence in the water of nitrogenous organic matter in the actual process of decomposition, the ammonia being the natural product of such decomposition.

Nitrogen as Nitrites shows the presence of nitrogenous organic matter but recently decomposed, being the first step in the oxidation of the ammonia.

Nitrogen as Nitrates shows that the nitrogenous organic matter is still further removed in point of time; in other words, that it is completely oxidized and inert.

Chlorine as Chlorides indicates, as a rule, direct sewage or barnyard contamination. Since all soils, however, contain a certain amount of natural chlorides, allowance must be made for these in considering this item.

Required Oxygen, or Oxygen Consuming Capacity, gives the amount of oxygen necessary to oxidize the organic matter in the water, including both animal and vegetable impurities.

By Total Solids is meant the residue remaining on evaporation to dryness. If this residue is ignited and then reweighed, the difference gives the amount of organic matter present — plus, however, some of the chlorides, which are driven off by the heat.

It is evident that the above chemical impurities, in the amounts ordinarily found, have absolutely no harmful effect of themselves. They are simply the indices of existing or previous organic pollution. The figures do not in any way enable us to ascertain the amount of organic matter that actually existed in the water, because of the complex and variable composition of this matter. The best that can be done is to measure the decomposition products of such impurity, and from experience determine whether we are within safe limits.

In the following table are given the results of the writer's analyses, preceded by such older analyses as could be found. The figures are given in parts per million (milligrams per liter).

TABLE OF WATER ANALYSES:

Sample	Date	Album. Ammonia	Free Ammonia	N as Nitrites	N as Nitrates	Cl as Chlorides	Required Oxygen
Media Tap Water[1]....	2-20-'88	.13	.07	.001	1.93	4.5	2.2
Raw Water, Ridley Cr.[2]	"	.36	.1	.0	1.73	9.5	3.25
H'dcastle Well, Media[3]	-'89	.02	.015	....	25.	47.4	.....
Media Tap Water[4]....	7-9-'89	.215	.045	....	1.2	1.3	.....
" " "[5]....	7-11-'89	.1	.01	....	.9	1.3	.....
" " "[6]....	7-12-'89	.135	.01	....	.7	2.8	.....
" " "[7]....	7-15-'89	.2	.0	....	.2	1.8	.....
" " "[8]....	11-5-'01	.1262	.016	.0	2.1	6.66	3.025
" " "	5-10-'04	.....	.....	....	.....	6.5	.....
" " "	6-2-'04	.071	.085	....	.....	.....	.....
" " "	6-3-'04	.....	.....	....	.....	5.	.....
" " "	6-7-'04	.....	.....	.001	.....	.....	.....
" " "	6-12-'04	.....	.....	....	.59	.....	.....
" " "	6-14-'04	.....	.....	....	.....	5.8	.....
" " "	6-16-'04	.....	.....	.0	.....	.....	.....
" " "	6-29-'04	....	.....	.0	.....	5.8	.....
" " "	7-2-'04	.12	.048	....	.....	.....	.....
" " "	7-3-'04	.....	.....	....	.....	5.5	.....
" " "	7-4-'04	.....	.....	....	.8	.....	.....
" " "	7-8-'04	.....	.....	....	.....	6.2	.....
" " "	7-16-'04	.....	.....	.0	.8	6.2	.....
" " "	7-17-'04	.....	.....	....	.....	.....	.85
" " "	7-30-'04	.....	.116	....	.....	.....	1.05
" " "	8-2-'04	.....	.....	.005	.8	6.1	1.3
" " "	8-9-'04	.....	.....	....	.....	.....	1.3
Broomall's Dam......	8-10-'04	.....	.....	.016	1.43	12.	8.9
Media Tap Water.....	8-10-'04	.....	.....	.0	.....	.....	.....
" " "	8-13-'04	.075	.07	....	.....	.....	.....
Raw Water, Ridley Cr.	9-10-'04	.....	.....	.008	.4	6.	1.55
Set. Basin, W.W., "	9-17-'04	.12	.035	....	.8	4.3	2.45
Filt. Water, " "	9-17-'04	.07	.015	....	.8	4.	1.1
Media Tap Water.....	10-16-'04	.0011	.0003	.0	1.2	4.5	1.55
Filt. W., Media W. W.	11-8-'04	.02	.02	.0	1.5	5.	.9

Total Solids—[1] 58, [2] 98, [3] 342.8, [4] 100, [7] 100, [8] 50.

Analysts—[1] [2] Dr. A. R. Leeds, [3] [4] [5] [6] [7] T. C. Palmer, [8] Dr. A. C. Abbott.

Sample	Date	Albumn. Ammonia	Free Ammonia	N as Nitrites	N as Nitrates	Cl as Chlorides	Required Oxygen
Filt. W., Sprin'f'd W.W.	11-8-'04	.025	.03	trace	2.	5.	.7
Media Tap Water......	12-24-'04	.035	.03	.0	1.2	5.	.4
" " "	1-28-'05	.03	.02	.0	trace	5.	1.15
Broomall Homest'd Spr.	2-20-'05	.0	.04	.0	3.8	15.8	.23
Media Tap Water......	2-21-'05	.02	.015	.0	1.3	4.	1.3
Carr Spr., west of Media	3-2-'05	....	.....	.....	.8	3.4	.4
Broomall Homest'd Spr.	3-3-'05	....	.....	.....	2.52	17.4	.55
Raw W., Media W. W.[1]	3-11-'05	.192	.081	trace	.8	3.4	3.75
Filt. W., " "[2]	"	.131	.102	.0	.8	3.4	2.3
Media Tap Water......	4-22-'05	.045	.007	.0	.96	5.	.55
Raw Water, Ridley Cr.	5-27-'05	.265	.045	.002	1.2	5.7	.95
" " Crum Cr..	"	.145	.045	.0025	1.	5.4	.6
Hardcastle Well, Media	6-5-'05	....	.....	.0006	.....	59.5	.5
" " "[3]	6-9-'05	....	.....	.....	33.	59.8	....

Total Solids—[1] 140, [2] 80, [3] 400.

A few points of interest may be drawn from the table. First, and of prime importance to the residents of Media, is the very satisfactory showing of the Media tap water for the year as compared with Dr. A. R. Leeds' standard for American rivers :

	Average Media Tap Water	Leeds' Standard
Albuminoid Ammonia...............	.0496	.10 to .28
Free Ammonia......................	.0434	.01 to .12
Nitrogen as Nitrites..................	.0006	.003
Nitrogen as Nitrates..................	.8490	1.11 to 3.89
Chlorine as Chlorides.................	5.43	3. to 10.
Oxygen Consuming Capacity........	1.05	5. to 7.

It is also of interest to compare the analyses of the Broomall Homestead Spring, located on the edge of the Borough, with the analysis of the Carr Spring, situated some half a mile from the town, and far removed from human habitation.

As regards the efficiency of our filtration plant, the analyses of September 17, 1904, and March 11, 1905, give valuable data. In the latter two analyses there is shown an increase of free ammonia. This may be due to the fact that the analyses are not actually of identical portions of the water, since the samples, being drawn at the same time both outside and inside the filter, differ in age by the time required for the water to pass through the settling basin and filter. Or, the increase of free ammonia may be due to the fact that an actual decomposition of organic matter had taken place in passing through the filter.

The analyses of May 27, 1905, give a comparison of the raw waters of Ridley and Crum Creeks. This shows Crum Creek slightly the better, although the analyses of the filtered waters, November 8, 1904, shows the Media water a trifle better. If this were the permanent state of affairs, it would indicate that the Media filtration plant was acting more efficiently than that of the Springfield Water Company. It is more probable, however, that we are merely dealing with the natural variations of the streams. It seems fair to assume that the two creeks are about on a par, since they are practically the same size, run through the same kind of territory, and apparently have about equal chances of pollution.

Another point of interest that may be mentioned is the increase of chlorides and nitrates in the Hardcastle Well. This well is situated on the edge of the town, and in a fairly well built-up section. Having but one old analysis, however, with which to make comparison, it is impossible to tell whether the water has really deteriorated. The low required oxygen and the high nitrates and chlorides in the water apparently indicate a considerable previous pollution by sewage, subsequently, however, almost entirely oxidized before reaching the well. The well is 50 feet deep, the lower 42 feet being through rotten rock, which probably acts as a very efficient filter. There are a number of cess-pools in the neighborhood, the nearest being about 35 feet distant. The water is quite hard, containing considerable calcium.

C. M. BROOMALL.

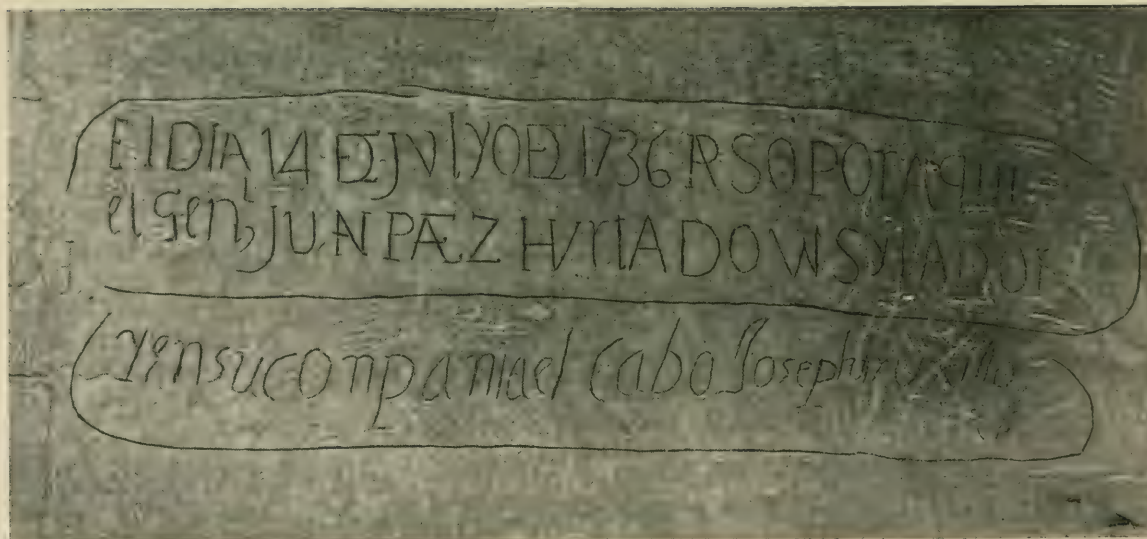

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PLATE I.

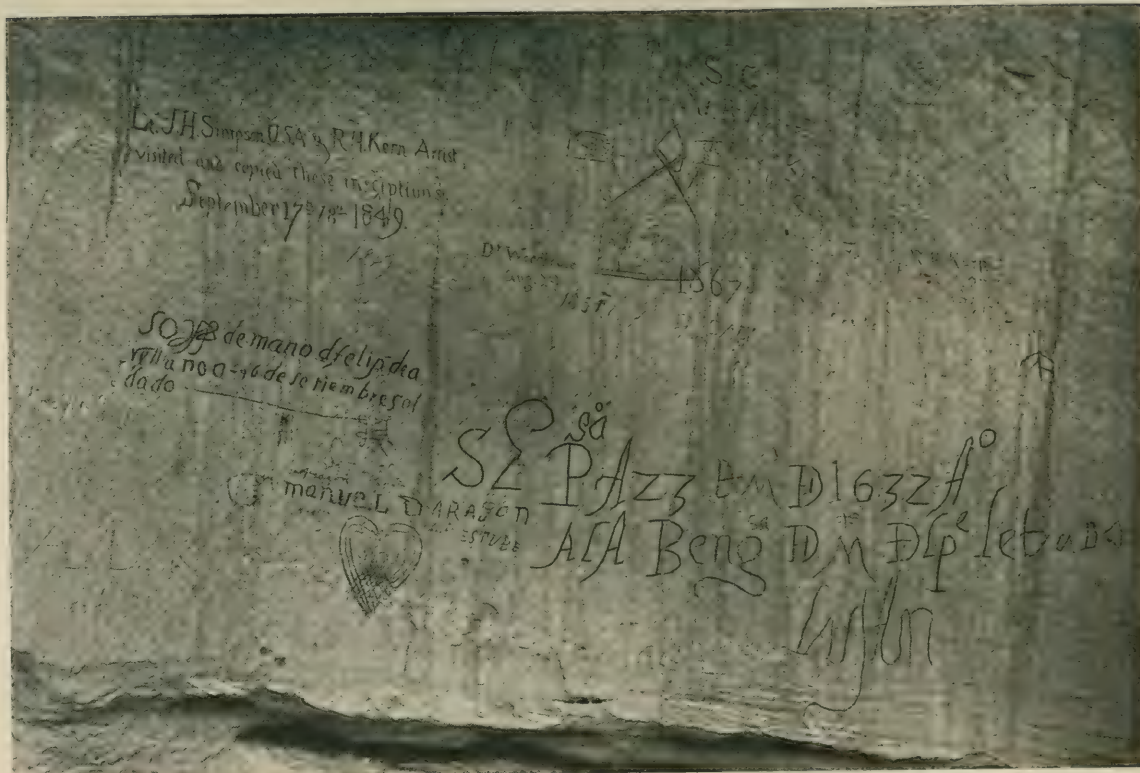

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PLATE II.

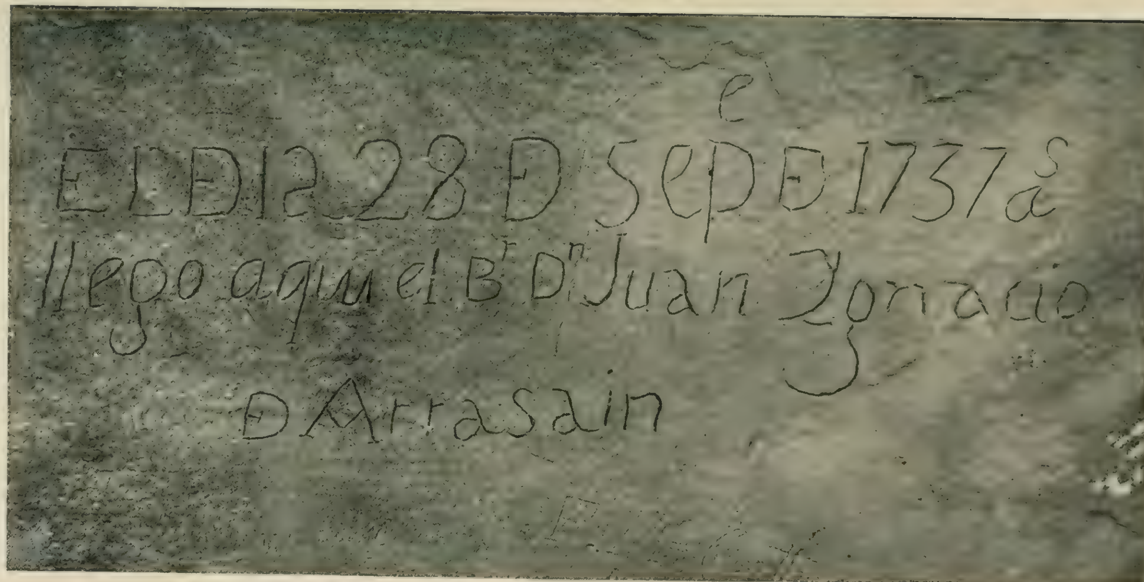

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PLATE III.

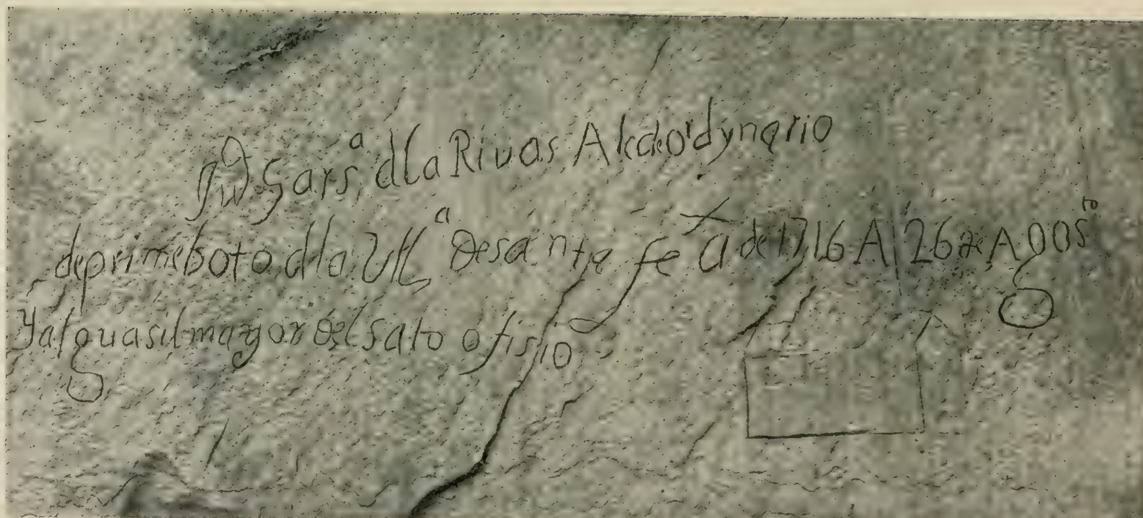

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PLATE IV.

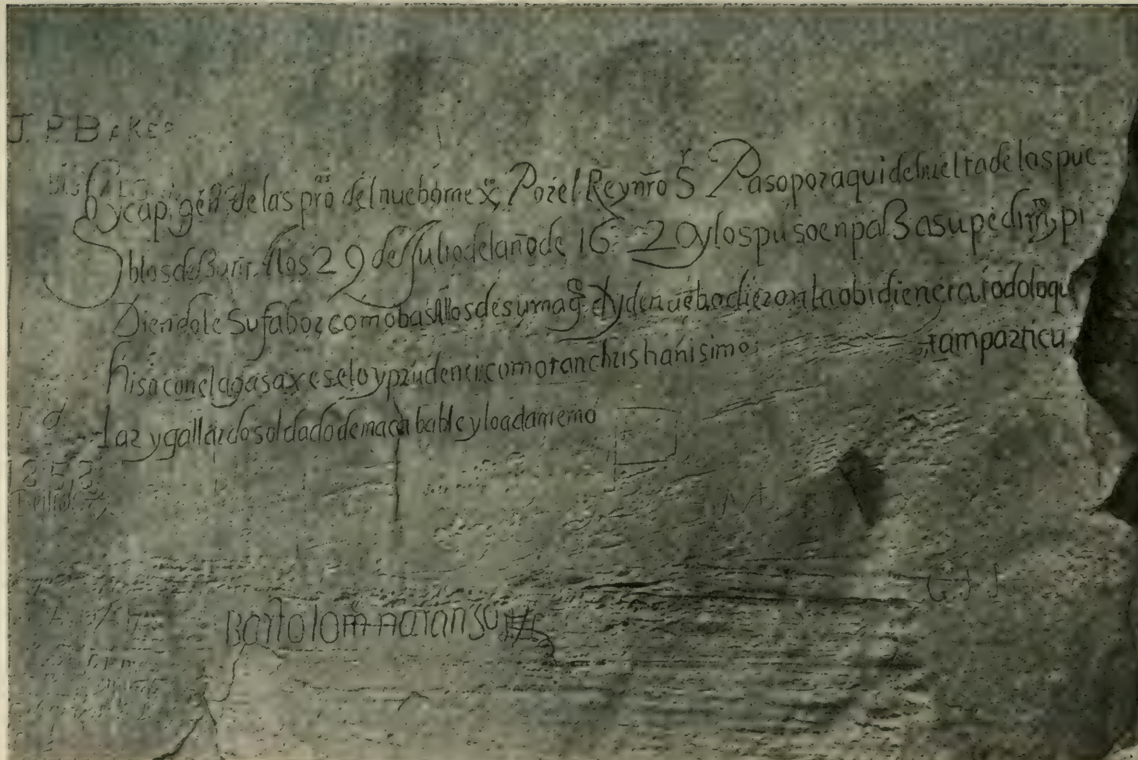

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PLATE V.

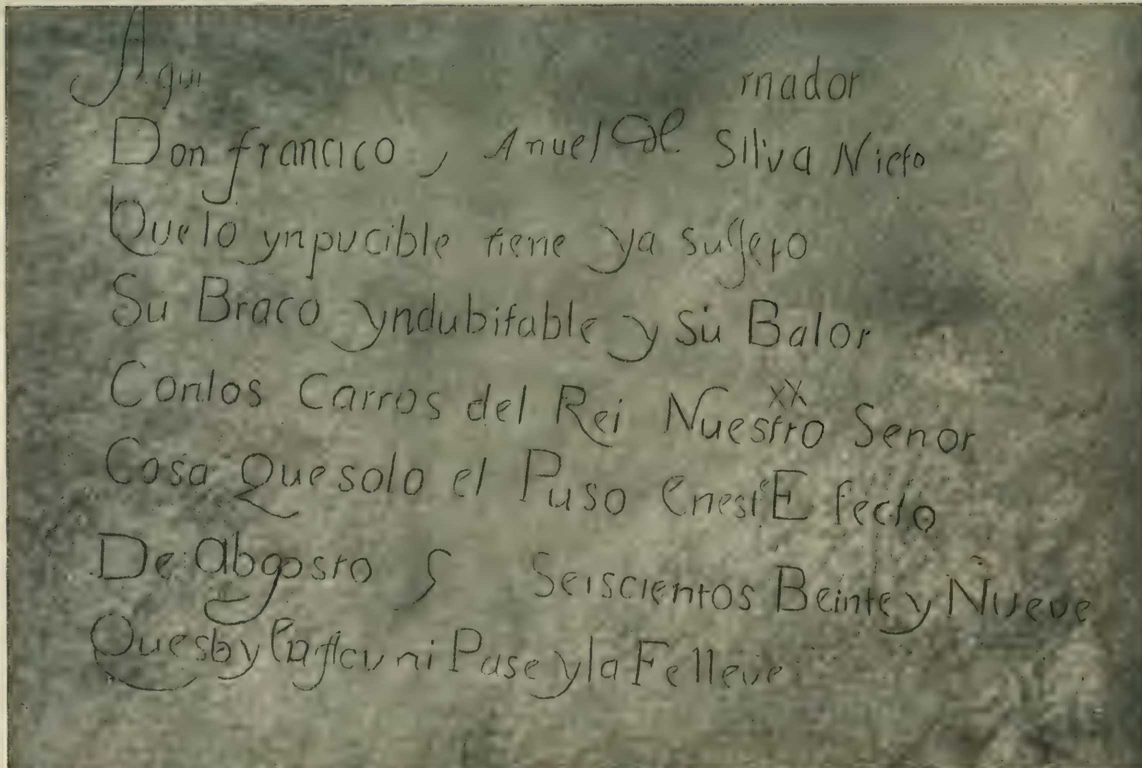

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PLATE VI.

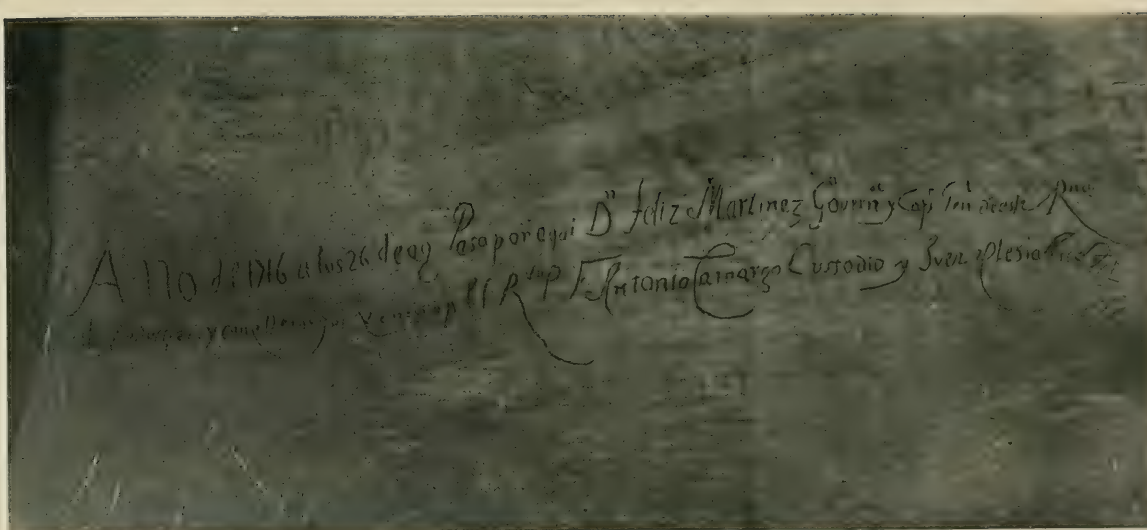

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PLATE VII.

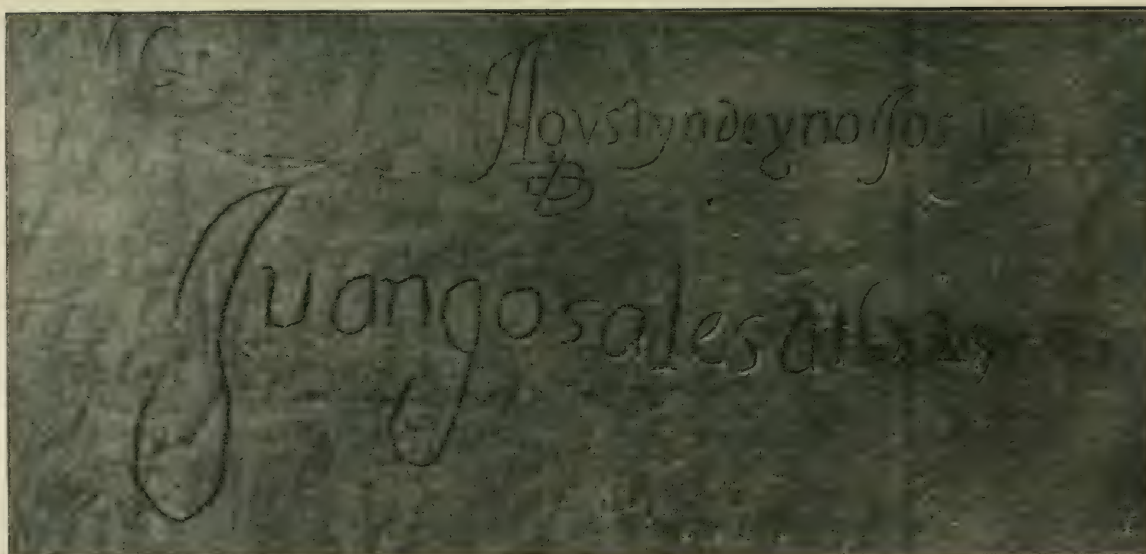

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PLATE VIII.

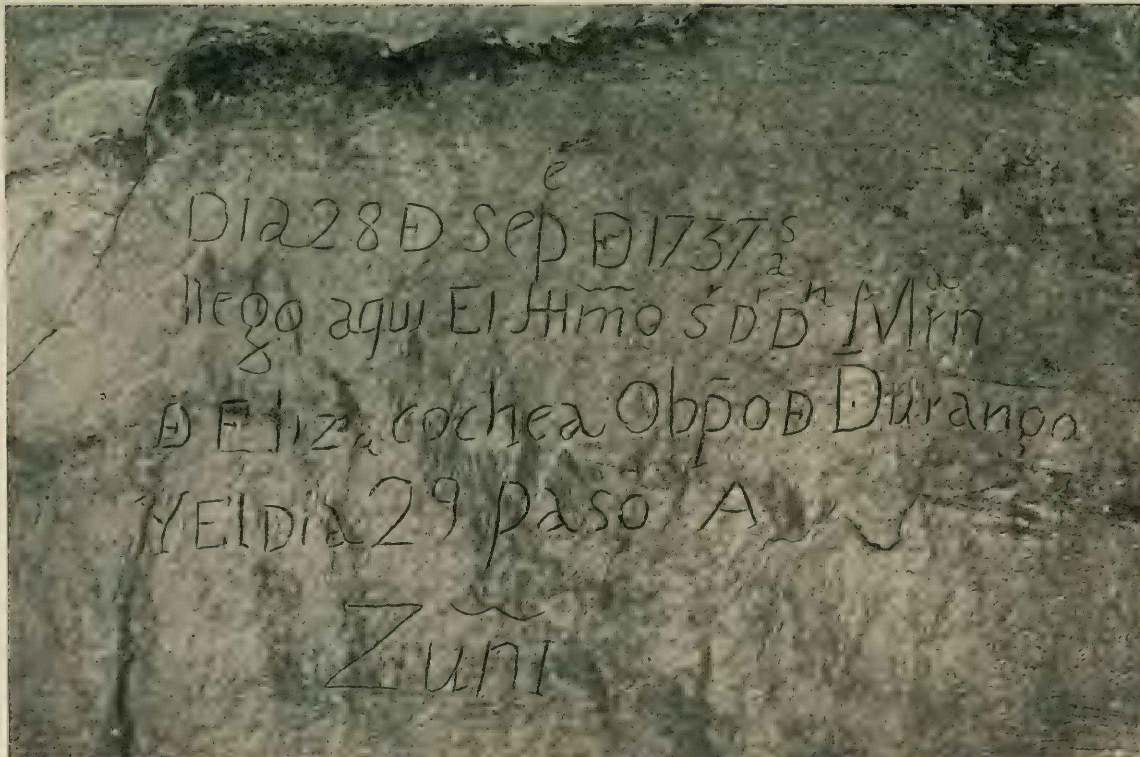

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PLATE IX.

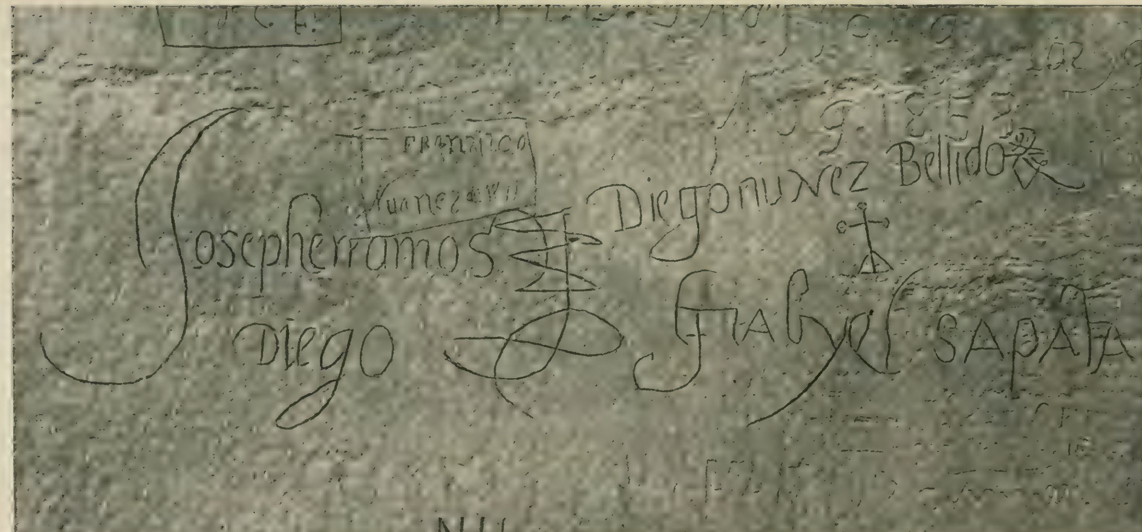

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PLATE X.

PHOTOGRAPHS OF SOME OF THE INSCRIPTIONS ON EL MORRO, NEW MEXICO,

BY HOMER E. HOOPES,

WITH TRANSLATIONS AND NOTES,

BY HENRY L. BROOMALL.

In western New Mexico, fifty miles southwest of Grant's Station and about forty southeast of Gallup Station on the Atchison, Topeka & Santa Fé Railroad, and about thirty miles east of Zuñi, stands a sandstone mesa known to the Spanish pioneers as El Morro and to their Anglo-American successors as Inscription Rock. Its physical appearance, suggestive of tower and battlement, is the source of its Spanish name, equivalent to "the castle." Its prosaic English name refers to the inscriptions carved on its available face in the days of the Spanish régime.

This rock lies on an ancient route between New and Old Mexico. Its position on the way from Zuñi to the Rio Grande, and the water, wood and shelter which its surroundings then gave, made it a usual halting place. The vertical plane of the north face of the rock and of the south face at a re-entering angle of the eastern side afforded a smooth, fine-grained surface at about a man's height from the base and protected from rapid weathering by the overhanging cliff. Here the soldiers and padres of the Spanish expeditions of the 17th and 18th Centuries inscribed their names, titles, dates and deeds.

The first published study of these inscriptions was made under the direction of Lieutenant J. H. Simpson, of the Corps of Topographical Engineers, United States Army, in 1849. His report is contained in "Reports of the Secretary of War, Ex. Doc. No. 64, 1st Session, 31st Congress," published in 1850, and consists of lithographic plates from drawings of the inscriptions made by himself and R. H. Kern and translations made by "the conjoint assistance of Chief Justice J. Houghton, Señor Donaciano Vigil, secretary of the province, and Mr. Samuel Ellison, the official translator" in the State Department. This is the only publication purporting to give a complete transcript of the rock, and, notwithstanding the defects of both plates and linguistic work, it remains to-day the authority for what was written on the rock.

An able student of the subject is Charles F. Lummis. It is to be regretted that his work — at least, as published — is only partial. It consists of a chapter entitled "The Stone Autograph Album," in his book, "Some Strange Corners of Our Country," New York, 1898, and its value is enhanced by the historical setting in which Mr. Lummis' knowledge of the Southwest enables him to place the rock and its memorials. But the representations and translations of such of the inscriptions as he gives, while far better than Simpson's, are not as accurate as they might be.

A. F. Bandelier visited the rock about 1889 and copied the inscriptions. He describes the locality and gives historical data and translations of a few of the inscriptions in his "Final Report of Investigations among the Indians of the Southwestern United States, Part II," in "Papers of the Archæological Institute of America, American Series, IV," Cambridge, 1892, pages 329-332.

In the work of Elliott Coues entitled "On the Trail of a Spanish Pioneer: the Diary and Itinerary of Francisco Garcés, etc., 1775-1776," New York, 1900, Vol. II, p. 374-380, appear representations of two of the inscriptions upon three well-executed plates, of which two are reproductions from Simpson and the third is from a photograph taken by Mr. Lummis. Notes, one accompanying the plates and the other on pages 478-479, give historical data and translations, mainly from Bandelier, Bancroft, Lummis and F. W. Hodge.

The foregoing seem to be all the published plates and literature on the inscriptions of El Morro.

The plates herewith presented are from photographs taken in August, 1904. They are faithful reproductions of nine of the inscriptions and a few isolated names on the north face of the rock. It is hoped they may add something to the accuracy of memorials likely to be soon destroyed.

Some of the translations by the authors above cited are left uncertain or incomplete. Solutions of some of these difficulties are suggested in the following transliterations and translations.

PLATE I.

El dia 14 de Jvlyo de 1736 paso por aqui
el gen(era)l Juan Paez Hvrtado visytador
y en su conpania el cabo Joseph Truxillo

The day 14 of July of 1736 passed by here
the general Juan Paez Hurtado, inspector,
and in his company the corporal Joseph Truxillo.

Represented by Simpson on his plate No. 67 and translated on page 124. Represented and translated by Lummis, page 176.

Simpson erroneously renders "Truxillo" as "Armenta," and adds eight other names to this inscription. These names are at various distances to the right of it, and, even if contemporaneous, the circumscribing lines distinctly exclude them.

Juan Paez Hurtado was lieutenant governor in 1704 and 1705, governor and captain-general in 1712, and inspector-general in 1716.* This inscription makes him inspector-general also in 1736.

PLATE II.

Soy de mano d(e) Felip de A
rellano a 16 de Setiembre sol
dado

I am from (the) hand of Philip de A-
rellano on 16 of September Sol-
dier.

This inscription is not given by Simpson, his plate of the nearest other inscription not covering the location of this.

*W. W. H. Davis, "The Spanish Conquest of New Mexico," Doylestown, Pa., 1869, page 421.

Lummis transliterates and translates it at page 173. It is represented on Lummis' plate in Coues, page 377.

Arellano "was one of the Spanish 'garrison' of three men left to guard far-off Zuñi, and slain by the Indians in 1700."*

> Se p(a) sa(ron) a 23 de M(arz) o de 1632 a(ñ) o
> a la beng(an) sa de m(uer) te del p(adr) e Letrado
> Lujan
>
> They passed on 23 of March of 1632 year
> to the avenging of (the) death of the father Letrado.
> Lujan.

Represented by Simpson on plate No. 68. His attempted translation at page 124 is a failure. Lummis, on page 180, reproduces, transliterates and translates it, accrediting its interpretation to "a great student of ancient writings" whom he does not name. Coues, page 377, repeats Lummis' translation and reproduces a photograph of the inscription taken by him.

Father Francisco Letrado was sent to Zuñi upon the founding of the mission there in 1629. He was killed by the Indians in 1630 or 1632. Lujan, the writer of this inscription, was a soldier of the expedition sent in 1632 to avenge the death of Letrado.†

PLATE III.

> El dia 28 de Sep(tiembr) e de 1737 a(ñ) os
> llego aqui el B(achille) r D(o) n Juan Ygnacio
> de Arrasain
>
> The day 28 of September of 1737 years
> arrived here the Bachelor Don Juan Ignacio
> de Arrasain.

Represented by Simpson on plate No. 66 and translated on page 123. Mentioned by Lummis on page 179.

Don Juan Ignacio de Arrasain probably accompanied the Bishop of Durango, whose arrival on the same day is recorded on Plate IX.

*Lummis, loc. cit. †Lummis, loc. cit., pages 180-81. Coues, loc. cit., Vol. II, pages 375-7.

PLATE IV.

Ju( ) Gars(i)a d(e) la Rivas Alc(al)de Ordynario
de prime boto d(e) la V(i)lla de Santa Fe a(ño) de 1716 a 26 de Agosto
y alguasil mayor del sa(n)to ofisio

Ju García de la Rivas, Alcalde-Ordinary
by first choice of the Villa of Santa Fé, year of 1716 on 26 of August,
and chief alguacil of the Holy Office.

On his plate No. 67 Simpson gives the first two lines of this inscription and a third line of different content and style of writing, which probably belongs elsewhere on the rock. It certainly is not in this position, as the present photograph clearly shows the third line transcribed above, according in context and handwriting with the preceding lines. At page 124 Simpson translates: "Juan Garica de la Revâs, Chief Alcalde, and the first elected of the town of Santa Fe, in the year 1716, on the 26th of August. By the hand of Bartolo Fernandez Antonio Fernandez Moro." Besides the omission of the actual and insertion of the erroneous last line, this translation misreads the name and the title in the first line and mistakes the significance of "de prime boto de la Villa." The alcalde-ordinary, or inferior alcalde, was chosen by the corporation of magistrates, and the phrase "de prime voto" refers not to the time of election, as if this officer were the first of a series, but to him as the first choice over other possible or actual candidates. "Villa" is a town having certain privileges distinguishing it from the ordinary town or aldea; * but the word may also be applied to the corporation of magistrates governing a villa or pueblo.† The word as here used may therefore be translated with either shade of meaning — "by first choice of the town of Santa Fé," or "by first choice of the magistracy of Santa Fé."

* La poblacion que tiene algunos privilegios con que se distingue de la aldea, como vecindad y jurisdiccion separada de la ciudad: Dictionary of the Spanish Academy, sub voce.

† El cuerpo de los regidores y justicias que gobiernan la villa ó pueblo: ibid.

The other authors cited neither reproduce nor translate this inscription. The only reference to it seems to be by Hubert H. Bancroft.* When writing of an expedition of Governor Martinez, he says in a foot-note: "On this trip Gov. M. left his name inscribed on El Morro, Aug. 26th, with a record that he was on the way to reduce the Moquis with the custodio, P. Camargo, and Juan Garcia de Rivas, alcalde of Sta Fé. Simpson's Jour., 104-5, pl. 65, 67." This statement is evidently condensed from the two contemporaneous inscriptions reproduced on this plate and Plate VII of the present list. None of the authorities accessible to the writer mentions Juan Garcia de Rivas or, as Simpson renders it, Juan Garica de la Revâs. The form of the name as given by Bancroft may be due to other sources of information or to a better reading of Simpson's plate itself.

Without other data by which to fix the name "Juan," the deliberately formed upward stroke and circle would suggest "Julio."

PLATE V.

Soy cap(itan) gen(eral) de las pro(vinci)as del Nuebo Mex(i)co por el rey n(uest)ro s(eño)r Paso por aqui de buelta de los pue
blos de Zuñi a los 29 de Julio del año 1629 y los puso en paz a su pedim(en)to pi
diendole su fabor como basallos de su mag(esta)d y de nuebo dieron la obidiencia todo lo qu(e)
hiso con el agasaxe selo y prudencia como tan Christianisimo............ [obliteration]............tam particu
lar y gallardo soldado de inacabable y loada memo(ria)

I am captain-general of the provinces of (the) New Mexico for the king our lord. (He) passed by here on return from the
towns of Zuñi on the 29 of July of the year 1629 and he put them in peace upon their petition, ask-
ing him his favor as vassals of his majesty, and anew they gave the (their) obedience: all the which
he did with the clemency, zeal and prudence as (like) such (a) most Christian...... [obliteration]......most disting-
uished and gallant soldier of unending and praised (exalted) memory...

* The Works of Hubert H. Bancroft, Volume XVII, History of Arizona and New Mexico, 1530-1888, San Francisco, 1889, page 235.

This inscription is reproduced by Simpson, plate 67, and Lummis, page 178. It is incompletely translated by Simpson, page 124, Lummis, page 178, and Bandelier, pages 330-331.

On the rock, some distance below this inscription, appears the name "Bartolome Naranjo." Simpson, in contradiction to his own plate, transfers this to the beginning of the first line and then translates it as "Bartolome Narrso, Governor and Captain General," etc. His plate shows nothing preceding the letters "soy" of the present reproduction and transliteration. Lummis, however, figures some vaguely formed letters at this same place, which he transliterates "El Illustrisimo Señor" and then translates the beginning of the first line as "The most illustrious sir and captain-general," etc. The accompanying photograph agrees with Simpson's plate and affords no foundation for his or Lummis' insertion of name or title before or instead of "soy." Bandelier ignores the difficulty by beginning the inscription "El capn genl," etc.

In support of the present transliteration it may first be noted that it preserves the marginal line of the whole inscription and begins it with an appropriately ornamented letter. The form of this letter, or, more properly, compounded letter, is characteristic of an initial. If so, it is plainly a combined "so" which the following "y" completes into "soy." This style of beginning an inscription is quite common, and in fact occurs again on the same rock in an inscription reproduced on Plate II of the present list. The grammatical person changes in the "pasó" following the introductory words. The first clause is annunciatory: the second is narrative. A similar grammatical change is made in the inscription on Plate VI, where several third-person forms are followed by first-person forms of verbs referring to the same subject.

The perversions of meaning in Simpson's translation need no comment here, since they have been corrected by Lummis and Bandelier. But it is curious that both the latter authors should leave "loada" untranslated, and the more so because Simpson had already rendered it quite fairly as "famed," although his faulty grammar led him to construe it as qualifying "soldado," which its gender does not admit of. The word is the regularly formed feminine past participle of "loar," from Latin "laudare," to praise, whence also English "laud."

As a mere matter of epigraphy, the year in this inscription may be read either 1620 or 1629. Bancroft says: "Among the inscriptions copied by Simpson from El Moro (sic) is one to the effect that the governor passed that way on July 29, 1620, returning from a successful tour of pacification to Zuñi," and adds in a foot-note the names of "Bartolome Naranjo or Narrso," and others, "one of which may be that of the governor." He says further that Naranjo has been named as governor by one author and Narrso by another, apparently on the authority of this inscription.* But the name Narrso is Simpson's erroneous rendering of Naranjo, and the name of Bartolome Naranjo, by reason of its different style of writing and position, does not necessarily belong to the inscription, and should not be read into it as the name referred to by the title given in the first line, unless the connection were otherwise historically supported. There seems to be no record of the officials of 1620 and thereabouts.

Bandelier and Lummis, however, render the date as 1629 and attribute the inscription to the then governor of New Mexico, Francisco Manuel de Silva Nieto,† mentioned by name on Plate VI.

PLATE VI.

Aqui...... [obliteration]......rnador
Don Francico Manuel de Silva Nieto
Que lo ynpucible tiene ya sujeto
Su braco yndubitable y su balor
Con los carros del rei neustro señor
Cosa que solo el puso en este efecto
De Abgosto 9 seiscientos beinte y nueve
Que se oyera a Cuñi pase y la fe lleve

* Bancroft, loc. cit., page 159.
† Lummis, page 178. Bandelier, page 330.

Here...... [passed] ......Governor
Don Francisco Manuel de Silva Nieto
Whose indubitable arm and valor
Has now overcome the impossible
With the wagons of the king our lord.
(A) thing that he alone put into (this) effect
9 of August six (teen) hundred twenty and nine.—
That it might be heard, I passed to Zuñi and carried the Faith.

This interesting inscription is represented by Simpson on plate 66 and by Lummis on page 177. It is incompletely translated by Simpson, page 124, Lummis, page 177, and Bandelier, page 330.

It is first to be noted that this inscription is a sonnet, rhyming respectively in the first, fourth and fifth, in the second, third and sixth, and in the seventh and eighth lines. The metrical form causes some inversions of construction, such as "de Abgosto 9," which is "of August the ninth"—not "on August 9," as Lummis seems to take it. He also construes the words "braco" and "balor" in the fourth line as if they were in an oblique case and the verb in the third line passive instead of active, requiring him to supply the preposition "by" and the participle "been" to make sense. In fact, "braço" and "valor" form the subject of the verb "tiene sujeto," the verb being in the singular in accordance with the sense, a grammatical license very common when the verb, as here, precedes its subject. These details are mentioned to vindicate the scribe's knowledge of his own tongue.

"Six hundred" for "sixteen hundred" is not an error. It is a common locution according to Spanish or Italian usage even down to our times, much as we might say '99 for 1899.

The spelling of "Cuñi" for "Zuñi" is consistent with "braco" for "brazo." In print or manuscript there would have been a cedilla under the "ç" to indicate its soft sound before "a," "o" or "u," an orthographic device still maintained in French, but replaced by "z" in modern Spanish.

The present translation of the first part of the last line is new. The following comparisons are adduced in confirmation of it. "Quesb" being a succession of letters seldom if ever occurring in Spanish, the apparent "b" with its stroke inside the loop suggests that it may be in fact some other letter or combination of letters. The upright stroke is shorter than that of the other "b's" in this inscription and is quite like the ornamental upright on the "q" of "que" at the beginning of the third line. If it is ornamental also in this case, the remainder of the letter is plainly a combined "e" and "o." For the transliteration of "era" in "oyera," compare the form of "en" in the sixth line. "Que se oyera," thus obtained, completes the sense of the remainder of the line according to grammatical requirements and the spirit of the expression. "What is meant by Governor Nieto's carrying the faith (that is, Christianity) is that on this expedition he took along the heroic priests who established the mission of Zuñi."*

The historians we have cited add nothing to the information we get about this officer from the inscriptions on Plates V and VI.†

PLATE VII.

Ano de 1716 a los 26 de Ag(osto) paso por aqui D(o)n Feliz Martinez Govern(ad)or y Cap(ita)n Gen(era)l de este r(ei)no
a la reduczion y conq(uista) de Moqui y en su co(m)p(añia) el R(everen)do Padre F(ray) Antonio Camargo custodio y juez eclesiastico

Year of 1716 on the 26 of August passed by here Don Feliz Martinez, Governor and Captain General of this realm,
to the reduction and conquest of Moqui, and in his company the Reverend Father Friar Antonio Camargo, custodian and ecclesiastical judge.

Represented by Simpson, plate 65. Imperfectly translated by him on page 123 and fully translated by Lummis, page 179.

Don Feliz Martinez was governor and captain-general in 1715 and 1716. His official career was unfortunate and ended in his recall to Mexico. The enterprise, recorded in the above inscription so confidently in advance, was a failure.‡

*Lummis, loc. cit., page 177. †Bancroft, loc. cit., pages 153, 161, notes. Bandelier, loc. cit., page 331, note. ‡Davis, page 422; Lummis, page 179; Bancroft, pages 233-235; loc. cit.

The inscription on Plate IV is of the same date, and presumably refers to the same expedition.

PLATE VIII.

Agustyn de Ynojos	Juan Go(n)sales a(ño) 1629
Augustin de Inojos	Juan Gonsales, year 1629

Augustin de Inojos, according to another inscription on the rock, given by Lummis, loc. cit., page 172, was alferez (ensign) and "passed by here" with Captain Juan de Arechuleta and Lieutenant Diego Martin Barba in 1636. The expedition was sent by Governor Francisco Martinez de Baeza "to arrange the troubles in Zuñi."*

Of Juan Gonsales nothing seems to be known but this autograph and date. A man of the same name accompanied Oñate's expedition of 1598-9.†

PLATE IX.

Dia 28 de Sep(tiembr)e de 1737 a(ño)s
llego aqui el ill(ustrisi)mo S(eño)r D(octo)r D(o)n Mar(ti)n
de Elizeacochea Ob(is)po de Durango
y el dia 29 paso a
Zuñi

Day 28 of December of 1737 years
arrived here the most illustrious Señor Doctor Don Martin
de Elizeacochea, Bishop of Durango,
and the day 29 passed to
Zuñi.

Represented by Simpson, plate 66, and translated on page 124. Transliterated and translated by Lummis on page 179.

This inscription, according to Lummis,‡ records the first visit to Zuñi of a Bishop of Durango. New Mexico was included in his bishopric.

Plate III records probably a member of the Bishop's company.

*Lummis, loc. cit., page 172. †Bancroft, loc. cit., page 125.
‡Lummis, loc. cit., page 179.

PLATE X.

Joseph Erramos Diego Nuñez Bellido Gabryel Sapata

These autographs are reproduced by Simpson on plate 67 and the latter two by Lummis at page 162. Simpson renders the first and last as "Joseph Ramos" and "Friar Zapata."

MINUTES OF MEETINGS.

JUNE 1, 1905.—Regular monthly meeting. The Committee on Publication reported in favor of issuing quarterly numbers of the proceedings of the Institute. The recommendation was adopted and seven members were appointed to have present charge of the matter. C. M. Broomall presented a specimen of the Luna moth, and Sanford Omensetter exhibited a piece of wood bored by a species of bee and remarked upon the habits of boring bees. Charles Potts spoke on the peculiarities of a tent making caterpillar, describing especially the concerted spasmodic movement of all the individuals of a colony when disturbed. Additions to the Library: Census Report of 1903; Annuaire Astronomique pour 1906, Bruxelles; Annales de l'Observatoire Royal de Belgique, two volumes.

JULY 6, 1905.—Regular monthly meeting. Homer E. Hoopes, on behalf of the committee appointed to investigate the threatened destruction of Castle Rocks, presented to the Institute a fine photograph of the north face of the exposure. The committee having reported the great probability that the rocks would soon be a thing of the past, was directed to prepare resolutions of protest against this impending vandalism. The By-Law providing for the publication of the proceedings was adopted on final reading and the Committee on Publication was elected. Mrs. Mary M. Needles presented to the Library volumes of "The Portfolio" for 1812, 1813 and 1814. T. C. Palmer spoke of the botanical symposium at Ohio Pyle, exhibited specimens of plants collected there and outlined the geological features of the region. He also spoke of the abundance of the larger fungi at and near Ohio Pyle and stated that fresh water algæ, including diatoms, were scarce, the collections of these forms yielding only about twenty species in all.

AUGUST 3, 1905. — Regular monthly meeting. The Committee on Castle Rocks reported resolutions of protest, which were adopted and ordered spread upon the minutes. Lewis Kirk read from a recent publication the suggestion that the English language might prove the better instrument for the education of the Filipinos than the Spanish language. Henry L. Broomall, dissenting, gave several linguistic reasons for the opinion that this idea was without foundation. Sanford Omensetter presented a nest of the Scarlet Tanager. This nest was built in an Osage orange hedge along a frequented street in our borough and but twenty-five feet from habitations. During the time the nest was occupied by the young, a cat captured the female, but the male bird continued to care for the brood and carried it along successfully to maturity. Additions to the Library: Two quarterly numbers of Smithsonian Miscellaneous Collections; Britton's Manual, second edition.

INSTITUTE NOTES.

Last year's course of regular and adjourned meetings was eminently successful. The following lectures and papers were delivered before the Institute: The Sun Dial, Jacob B. Brown; Borax, Sanford Omensetter; The Structure of the Crystalline Rocks, F. J. Keeley; The Local Serpentines, T. Chalkley Palmer; Vacuum Tubes, C. M. Broomall; The Calculation of Easter, J. B. Brown; The Pueblo Indians and the Enchanted Mesa, Homer E. Hoopes; The Materials of Language, two lectures, Henry L. Broomall; Russia, Jacob B. Brown; A Cruise on the Chesapeake, T. Chalkley Palmer; Hibernation, Sanford Omensetter; Bermuda, Rev. S. H. Leeper; Yosemite Valley and Lower California, Homer E. Hoopes; The "Burnt Mills," Howard Lungren; Volcanoes, H. Clay Borden; Japan, Jacob B. Brown; The Origin of Language, Henry L. Broomall; Snap Shots of Foreign Lands, Col. Joseph W. Hawley; The Hopi Indians and the Snake Dance, Homer E. Hoopes; The Scientific Significance of Errors of Speech, Henry L. Broomall.

The destruction of Castle Rocks, now seemingly inevitable, is cause for the expression of just indignation. The historic and legendary associations of the spot are many, and these should have been sufficient to preserve it from such violation. The rocks composing the group are without rival in southeastern Pennsylvania as an example of the rare mineral enstatite on a grand scale. As such they have been visited by geologists from many sections and have served most admirably for the elucidation of certain geological and petrological problems. That considerations of this order should be outweighed by petty financial interests is lamentable enough.

A number of members of the Institute have been much interested in silk worms of late. They report that when spinning time came one of the worms, after several unsuccessful attempts to spin, went into the pupa state without making a cocoon and in about two weeks came out a fully developed moth. The steps in the process were watched with much interest. It is rather remarkable that although this worm had made no cocoon, nevertheless toward the end of the pupa period it secreted a yellow liquid, apparently the same as is used by the normal moths to soften the silk in order to escape from the cocoon.

The plates in this issue of the PROCEEDINGS were made by the Photo-Chromotype Engraving Company and printed by Harris & Partridge, all of Philadelphia. They certainly deserve credit for the work.

"Whatever is, is right,"—a saying that would be all very well did it not carry with it the inevitable implication that nothing that ever was, was wrong.—J. B. B.

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Vol. I, No. 2 January, 1906

PROCEEDINGS

OF THE

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PROCEEDINGS

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VOL. I, No. 2 JANUARY, 1906

LIST OF WINTER BIRDS.

BY LINNÆUS FUSSELL, M. D., AND SANFORD OMENSETTER.

The following list of winter birds found near Media, the result of some years' observations in the field, has been filed in the archives of the Institute. It was thought wise to class as winter birds those seen between the first days of November and March. By the former date most south-bound species have departed for a warmer clime, while early March is yet too cold for those which pass the season of snow and ice in lower latitudes.

For the benefit of readers at a distance we may state that Media, a country town of some 3000 population, lies fourteen miles southwest of Philadelphia, in about latitude 39° 54′ north, longitude 75° 23′ west of Greenwich. The river Delaware, at Chester, is over a mile wide and five miles away. The watercourses nearer Media are unimportant in comparison, thus accounting for the absence of any number of aquatic species. The character of the country is rolling agricultural, dotted here and there by wooded areas, while in winter northwest winds prevail. The town is flanked on the east and west by deep valleys, through which flow the waters of Crum and Ridley creeks.

The names are those of the American Ornithologists' Union.

289 Bob White, Colinus virginianus
316 Mourning Dove, Zenaidura macroura
325 Turkey Vulture, Cathartes aura

331 Marsh Hawk, Circus hudsonius
332 Sharp-shinned Hawk, Accipiter velox
333 Cooper's Hawk, Accipiter cooperii
337 Red-tailed Hawk, Buteo borealis
339 Red-shouldered Hawk, Buteo lineatus
360 American Sparrow Hawk, Falco sparverius
365 American Barn Owl, Strix pratincola
373 Screech Owl, Megascops asio
375 Great Horned Owl, Bubo virginianus
390 Belted Kingfisher, Ceryle alcyon
393 Hairy Woodpecker, Dryobates villosus
394c Northern Downy Woodpecker, Dryobates pubescens medianus
402 Yellow-bellied Sapsucker, Sphyrapicus varius
412a Northern Flicker, Colaptes auratus luteus
477 Blue Jay, Cyanocitta cristata
488 American Crow, Corvus americanus
501 Meadow Lark, Sturnella magna
511 Purple Grackle, Quiscalus quiscula
517 Purple Finch, Carpodacus purpureus
529 American Goldfinch, Astragalinus tristis
534 Snowflake, Passerina nivalis
554 White-crowned Sparrow, Zonotrichia leucophrys
558 White-throated Sparrow, Zonotrichia albicollis
559 Tree Sparrow, Spizella monticola
567 Slate-colored Junco, Junco hyemalis
581 Song Sparrow, Melospiza cinerea melodia
584 Swamp Sparrow, Melospiza georgiana
English Sparrow, Passer domesticus
593 Cardinal, Cardinalis cardinalis
619 Cedar Waxwing, Ampelis cedrorum
655 Myrtle Warbler, Dendroica coronata
704 Catbird, Galeoscoptes carolinensis
718 Carolina Wren, Thryothorus ludovicianus
722 Winter Wren, Olbiorchilus hiemalis
726 Brown Creeper, Certhia familiaris americana
727 White-breasted Nutnatch, Sitta carolinensis
731 Tufted Titmouse, Bæolophus bicolor
735 Chickadee, Parus atricapillus
748 Golden-crowned Kinglet, Regulus satrapa
749 Ruby-crowned Kinglet, Regulus calendula
759b Hermit Thrush, Hylocichla guttata pallasii
761 American Robin, Merula migratoria
766 Bluebird, Sialia sialis

EASTER SUNDAY AND THE DOMINICAL LETTER.

BY JACOB B. BROWN.

The matter to be taken in hand is in all strictness astronomy, though it may not seem so. We are, namely, to compare the records, true and conventional, respectively, of the sun and moon.

The good prelates of the Council of Nice in the year of our Lord 325 saw fit to make the festival of Easter a movable one; that is, to make it dependent upon the moon as well as upon the sun, instead of giving it a straightforward solar date, like that of Christmas or Ascension Day. They may have had in mind that from the sixth hour on the day of the Crucifixion "there was darkness over all the land unto the ninth hour," a darkness not occasioned by eclipse, because the moon was at the full. And they desired, moreover, not to run the risk of coincidence with the Jewish festival of the Passover.

They therefore enacted that the first Sunday after the first full moon which falls on or next after the 21st of March should be Easter Sunday.

The determination of Easter thus involves the difficult problem of reconciling three periods which have no common measure — the week, the lunar month and the solar year.

In order to show how this is accomplished some preliminary statement is necessary.

The Vernal Equinox in the Ecclesiastical Calendar is fixed invariably for the 21st of March, though this date does not always or even usually agree with the fact.

The full moon for the purposes of the rules and calculations to follow is the fourteenth day of a lunar month reckoned according to an ancient ecclesiastical computation, and not the astronomical full moon, from which it may differ as much as two days.

The Paschal moon is that of which the fourteenth day falls on or next follows the Vernal Equinox. The Paschal full moon cannot happen before the 21st of March, and Easter therefore cannot be earlier than the 22nd of March.

Should the full moon happen on the 20th of March, then the following would be the Paschal moon, but the full of this moon falls 29 days after the 20th of March, or on the 18th of April. Now if the 18th be a Sunday, then Easter is the following Sunday, 25th April, which is the latest date on which Easter can fall.

How many days, then, after the 21st of March will Easter occur?

First, there will elapse a number of days from the 21st of March to the 15th of the Paschal moon, which is the first day on which Easter can fall.

Next there will elapse between the 15th of the Paschal moon and Easter Sunday a number of days which is either 0 or less than seven. Add this number to the above and get the number of days from 21st of March to Easter.

This last is called the Number of Direction ; and a step in advance has been made, for it is now perfectly evident that we must know how old the moon was on the 21st March in order to get any farther.

If there were means of knowing how old the moon was on any given date, say the 1st of January, her age on the 21st of March could at once be determined.

A long step toward this determination was made in the year 432 B. C. The great Greek astronomer Meton then discovered that, given the relative position of the moon and the earth and the sun on any day, that same relative position would recur nineteen years (nearly) later. In fact 235 complete lunations occupy nineteen years within about 90 minutes.

This group of years is of course called the Metonic Cycle.

The discovery has been in full use ever since it was made ; and one of the periods began with the first year before the Christian Era. That is to say, the moon was new on the 1st of January of the year which is sometimes called the year "0." If then we add unity to any date of the Christian Era and divide the sum by 19 we shall have as quotient the number of cycles from the beginning of the Christian Era and a remainder which denotes the place in the cycle of the year in question.

For example add one to 1904, get 1905. Divide by 19. Quotient concerns us not; remainder 5. This is the place in the cycle of the year 1904, and this number of the place is called the Golden Number of the year. Golden, for some good and sufficient reason, probably because being very important it was red or gilt in the Calendar.

It must at once be evident that two given years though widely separated by time will see the same phases of the moon if they have the same Golden Number. And it must now furthermore be clear that if we could know the age of the moon at the beginning of the cycle and the change that takes place year by year we should have all that is necessary to fix the moon's age on any day of the year.

The Golden Number, then, denotes the place in the Metonic Cycle of the year in question, and is the remainder after throwing out the nineteens from the sum of the given date and unity.

Now to know the age of the moon at the beginning of the cycle and the change that takes place year by year.

If we remember that all necessary corrections are made at the proper time and that no fraction of a second is in the end gained or lost, it is for the present purpose quite near enough to the fact to say that the solar year is 365 days long and the lunar year 354 days long. Here is a difference of 11 days, and that is the difference in the moon's age at the end of the lunar year and at the beginning of the solar year. The difference is of course cumulative, and as at the beginning of the cycle it is 30 days, or 0, which is the same, and at the beginning of the second year 11 days, so it is 22 days when the next year comes round. The fourth year it is 33 days; but as the Julian lunation, which is used, is called 30 days, the 30 is thrown out and the difference is 3 days. So on round and round the Metonic Cycle. It is clear that multiplying 11 by the Golden Number of the year, less one (that is, less the age of the moon at the beginning of the year 1), and throwing out the thirties we shall have the moon's age at the beginning of that year.

There are limitations to this rule of which due account is taken.

The difference between the moon's age at the end of the lunar year and at the beginning of the solar year is called the Epact.

The same idea is conveyed by the ordinary definition, "The moon's age on the first of January of the year in question."

The age of the moon on the first of March, called the March Epact, is the same as on the first of January, as will be evident on counting days and finding two complete Julian lunations.

And so another step is taken, for we have now the moon's age on the 21st of March, and we can infer at once whether the moon in question be the Paschal moon or not. If its age be 14 days on the 21st of March, or if it be not 14 days old until after the 21st of March, then the moon is the Paschal moon according to the definition. If it be more than 14 days old, or over the full on the 21st, then the next moon is the Paschal moon and Easter is "late." There is a "long carnival," since Ash Wednesday depends upon Easter.

We have now reached the number of days between the 21st of March and the 15th of the Paschal moon, and in order to have the Number of Direction, or the number of days between the Paschal full moon and Easter Sunday it only remains to fix the day of the week on which the 21st of March must fall.

This is provided for by a device called the Dominical Letter, or letter that stands for Sunday.

The Dominical Letter is to be duly discussed within, and may be taken for granted for the present.

By its means the day of the week belonging to any date of the Christian Era may be determined.

There has thus been sketched, as it were, the mathematical machinery by which Easter Sunday according to the decree of the Council of Nice may be computed for any year of the Christian Era.

Let us see if our machinery will work, however clumsily, by calculating Easter for 1905; remembering that while the astronomical lunation, in fact twenty-nine and a half days (nearly) is called for convenience alternately 30 days and 29 days, the ecclesiastical is 28 days, and that the Julian Epact, which requires adjustment as the years go on, calls the lunation 30 days.

We compute the Epact as 25. That is to say, we lessen the Golden Number, which is 6, by unity, multiply 11 by the remainder 5; and from the resulting 55 take the Julian lunation of 30, leaving 25. The moon, then, is 25 days old on the 1st of March; 30 days old, that is to say new, on the 6th of March; full on the 20th of March. This throws the Paschal full moon over 28 days later to the 48th of March, or 17th April, which is a Monday. And the 23rd of April, the Sunday next after, is Easter Sunday.

That the astronomical facts are at variance with the above matters not. The Epact is 24, not 25; and the moon is full on the 19th April, not the 18th. The irregularity is constantly occurring, and is referred to above when speaking of the possible discrepancy between the ecclesiastical full moon and the real or astronomical full moon. It is adjusted by the Dominical Letter.

The Dominical Letter is an immutable landmark, allowing margin in fixing upon the Epact and the Paschal full moon.

And this is the place for its discussion.

The matter is one of which many educated persons are apt to know no more than of the Book of Jasher. They have heard the one and the other mentioned, no more.

The apology for setting it forth at some length is that it is one of those cases in which knowledge is clear gain; though the lack of it may be little loss.

The common year is recorded as being 365 days long; that is, 52 weeks or cycles of seven, and one day over. The first of January is therefore in each common year one day later in the week than the year previous. But in the leap year there are recorded 366 days or fifty-two cycles of seven and two days over. In such a year, therefore, the 31st of December does not fall as usual on the same day of the week as the first of January, but one day after; so that the next following New Year's Day is two days later in the week than the one immediately previous. Everybody knows this, but to have it fresh in mind will throw more light upon what follows.

The Dominical, Lord's Day or Sunday Letter, then, is one of the first seven letters of the alphabet, to be fixed upon by computation. It is used to determine Easter Day, to find the day of the week corresponding to any date given, and for other important purposes.

1	2	3	4	5	6	7
A	B	C	D	E	F	G
sa	S	mo	tu	we	th	fr

Set down the first seven significant figures in consecutive row. Under these respectively the first seven letters of the alphabet in their order. Then under 1 the day of the week on which falls the first of January, say Saturday; under 2 the next following day of the week, and so on to the end of the week. The letter under which Sunday falls will be the Dominical Letter for the year; for after the first Sunday every next following seventh day will be a Sunday, which must necessarily fall together with the next following seventh letter, which will be the same as in the first instance. And the other days of the week have, each, its letter which will take value accordingly.

In the little Table, B is the Dominical Letter.

If the year be a leap year a change must be made. It is no longer true that after the first Sunday every seventh day is a Sunday; for a day has been interpolated, the 29th of February. The Sunday next following is moved one day farther from the 1st of January and after the so-called Intercalary Date it is as if the year had begun one day later still in the week. The whole line of days is shifted, as it were, one to the left; and each day comes under the letter preceding the one beneath which it had stood before — Sunday with the rest.

1	2	3	4	5	6	7
A	B	C	D	E	F	G
S	mo	tu	we	th	fr	sa

It follows that Sunday, and with it of course the other days of the week have for the rest of the year new letters, the ones next preceding those which they had previous to the Intercalary Day. A, therefore, as appears by the second little Table, for Sunday.

There are two Dominical Letters for each leap year, and the intercalation throws the letter one place back.

If, then, we know the Dominical Letter or Letters for any year, the framing of the "Block and Rhyme Device," set forth later on in this paper, is a simple matter.

The Dominical Letter for any year within reasonable limits can be discovered by counting back or forward from any known date.

As the year goes forward the letter goes back, one place for every common year, two for every leap year, the circle round. As the year goes back the letter goes forward, one place for every common year, two for every leap year, the circle round.

But the Sunday Letter can be computed at once for any year of the Gregorian Era by an arbitrary rule, and even denoted by a general formula.

I shall make an effort to set forth the results of that patient thought which men, dead long ago, have in their time applied to such a rule.

As to the formula, though it is entirely within the scope of simple algebra, I shall not trouble you with it.

In order to compute a letter it must be given a value in numbers. In the present case A is the first letter, B the second letter, and so on to G, the seventh letter. The letters are made quantity by taking their ordinals. A = 1, B = 2, and so on in regular course. We thus start with A and from G. And the calculation will bring out one of the first seven natural numbers, being devised to do so.

With a view to the starting point it is natural to go back to the beginning of the Christian Era.

The year 1 of our era was historically the 753rd after the foundation of Rome. It began on Saturday, January 1st. Its Sunday Letter was therefore B, and that of the year previous was C. On this Basis (with a capital B) a computation can be founded, and it is not difficult to remember that the year in which the Birth (capital B) of our Lord is generally, but by no means universally, regarded as having taken place had for its letter, B.

The letter backs one for every common year — two for every leap year. Leap years are every fourth year, beginning with the year One. It follows that if we add to the given date as many whole fours as there are in the given date we shall have a number of years in each of which the letter will back one. Dividing now by seven, we shall have a number of cycles which do not affect the result, and a remainder either of 0, in which case the letter is C, or else of some number less than 7, in which case we back from C as many places as there are units in the remainder.

The letter found for leap year is for that part after the 29th of February. The intercalary is regarded as already in its place. The letter backs as the years advance, the former part of the leap year is first reached and the latter part is crowded, as it were, under a fresh letter one place farther back.

The rule is general in the mathematical sense of the word ;

that is to say, whatever date be taken. For example, year 0, by which is meant the year preceding the year One. (There is no year 0 in chronology.) To nothing add one-quarter of nothing, which is nothing. Contains seven no times and nothing over. Back nothing from C and get C for the letter of the year 0.

Again, the year One. To one add a quarter of one in whole numbers. This is a contradiction of terms according to our Arabic system of notation. There is nothing to add to one, and one contains seven no times and one over. Back one from C and reach B.

And so of other cases.

This method of proceeding would be good from the year One to the end of time but for irregularities. In 1582 the Julian Calendar was corrected by Pope Gregory XIII. Ten days were dropped. Friday, 5th October, was called Friday, 15th October. By the rule C was the Dominical Letter. But the change carried Friday, and in like manner of course, Sunday, forward ten letters, once round the cycle and three over.

Friday landed upon A and Sunday upon C.

This three must be provided for in the computation.

Moreover, as previously remarked, we start from C. We wish to start from G. This gives us another three to be provided for.

Furthermore, three leap years in four hundred years were suppressed in order to correct the over-correction of leap year.

There are various ways of dealing with these irregularities. Two will be given, entirely independent each of the other, and models, both, of elegant ingenuity.

It will be noticed that 1600, the year before the beginning of a new century, has A for its Post Intercalary Letter. Accordingly a method of computation has been devised, starting with A, instead of from G, and covering as will be seen the Gregorian Era, which began in 1582.

In the prefatory part of the Protestant Episcopal Prayer Book a little Table will be found like this :

TABLE I.

6	5	4	3	2	1	0
B	C	D	E	F	G	A
				1600	1700	1800
1900 2000	2100	2200	2300 2400	2500	2600	2700 2800
2900	3000	3100 3200	3300	3400	3500 3600	3700
3800	3900 4000	4100	4200	4300 4400	&c	&c

And near it the rule for its use, as follows :

"To find the Dominical or Sunday Letter for any year of our Lord add to the year its fourth part, omitting fractions, and also the number which in Table I standeth at the top of the column wherein the number of hundreds contained in the given year is found ; divide the sum by seven, and if there be no remainder then A is the Sunday Letter, but if any number remain then the letter which standeth under that number at the top of the Table is the Sunday Letter.

Note : that in all bissextile or Leap years the letter found as above will be the Sunday Letter from the 1st day of March, inclusive, to the end of the year."

We back at the reformation of the calendar two places, from C to A. This has precisely the effect that would be produced by adding two to the sum of the given year and a quarter of the same before dividing by seven. Add two, as per table and rule, in the sixteen hundreds, proceed as set forth, and with the remainder begin with A and back. The table is so devised that this gives the same result as looking for the remainder in the top line and taking the letter that stands beneath.

In the seventeen hundreds one letter or step back is cancelled because 1700 is not a leap year. Add one, therefore, not two, throw out the sevens and count back beginning with A.

In the eighteen hundreds one more is cancelled — 1800 being a common year. Nothing, therefore, is to be added to the year.

In the nineteen hundreds still another year is cancelled. This is subtracting one from the sum to be divided by seven, and this, again, is the same as adding six, for the quotient does not concern us. Add six, therefore, as being more convenient.

The year 2000 being a leap year all remains as in the nineteen hundreds, because no step back is cancelled.

In the twenty-one hundreds one step back is cancelled, because 2100 is a common year. Accordingly, instead of adding six as in the year before, add but five.

In the twenty-two hundreds, add four; in the twenty-three hundreds, three, and in the twenty-four hundreds three, again, for the reasons given above.

The twenty-four hundreds bring us round to the addition of two, as in the sixteen hundreds. And so the process goes on, "in sæcula sæculorum." The Prayer Book rule is thus justified and the table proved correct.

It will be noticed that the columns go down by periods of 900 years. This is arithmetical necessity, the periods being seven, and the included leap years, which cause no difference, being two.

The years between 1582 and 1600 come under the 1600 column for the reason that in them we back to A as starting letter, which is in fact increasing by two the sum of the years to be divided into cycles of seven.

For the years from the beginning of the era down to 1582 add one-quarter of the date to the date, omitting fractions. Divide the sum by seven and with the remainder back from C, as set forth previously.

These two rules provide for any year in the Christian Era, whether before or after the reformation of the calendar. As will be fully set forth, and in a more suitable place, farther on.

The Prayer Book rule is cumbersome. The memory cannot easily carry so many data. And there is a better rule, which requires knowledge of the date only.

In Sir Richard Phillips' "Million of Facts" there is in the Chronology Chapter a curt "Rule for finding the Dominical Letter."

It says, giving no reason or explanation whatever: —

1. Divide the centuries by four.
2. Take twice the remainder from 6.
3. To this remainder add the odd years and a quarter of the same, neglecting fractions.
4. Divide the sum by seven.
5. Subtract the remainder from seven and this last remainder will be the number of the required Dominical Letter.

For example, 1904.

Nineteen contains 4 four times and three over. And six less twice three is nought.

Four and a quarter of four is five, which contains seven no times and five over. The five subtracted from seven leaves two, which is the ordinal of the letter of 1904. B, therefore. But 1904 is a leap year, and the ordinal found is for the portion subsequent to February 29th.

For the previous portion of the year C is the letter.

The letter backs in the Julian Calendar five in every four years, and five hundred in every four hundred years. Now five hundred contains a number of cycles of seven and three over. And were it not for this "three over" we should come round to the place of beginning. The difference is, however, provided for by the suppression in the Gregorian Calendar of three leap years in 400 years. A fact which may be taken for granted. We thus do not go as far back by three places as we should otherwise do in that space of time, and in fact do come exactly round to the place of beginning. Coincidence is restored, the same day of week, day of month and letter falling together once more, and the same order recurring. The period is called the Dominical Cycle, and as the secular suppressions are not made in the Julian Calendar this is a new condition introduced by the Gregorian reformation, and the rule gives for the years previous to 1582 results which must be modified to fit the facts. It is now clear that we shall in dividing any date by 400 get certain Dominical Cycles which do not concern us and a remainder of centuries which is to be dealt with.

So then, suppress the last two figures of the date and divide by four. This will give the same result as dividing the entire date by 400, and be more convenient. The result is a quotient of Dominical Cycles and a remainder either of 0 or of certain centuries the final years of which are not leap years. In each of these remainder centuries then (if any) there are twenty-four leap years instead of twenty-five, which gives virtually 124 common years in each of which the letter backs one. Then, dividing by seven, get a quotient of sevens and a remainder of five backward places. But to back five is the same as to advance two. We choose the latter course, double our remainder from dividing the centuries by four and subtract from six.

The reason for subtracting from six has been hinted above.

The six is used merely to reach a base or bench mark, and has nothing to do with the change of letter occasioned by change of year. We have, namely, not yet fixed upon a starting point for the calculation. To this end it is matter of course to go back to the beginning of the Christian Era and set out from the historical fact, already mentioned, that our year One began on Saturday, January first. This makes B the letter of the year, and C the letter of the year preceding. We have thus advanced three letters from G before beginning to count years. Moreover, on reaching 1582 we are ten letters short of where we ought to be if our calculation of hitherto is to be adjusted to our calculation of hereafter. In 1582, namely, in order to square the record with the fact, Friday, October 5th, with letter E, was called Friday, October 15th, with letter A. An advance of ten letters, or, leaving out the seven, which does not influence the result, of three letters. When we reach 1582, then, we have gone forward six letters, three from G to C of the year "o" and three more on account of the change at the calendar reformation. Now our problem sets out to show how many letters the years of a given date will carry us back from our base or bench mark, G. So we go back six letters to G as a first step in the solution. We have seen that the remainder centuries (if any) after the Dominical Cycles are thrown out, carry us forward each two letters. So we double and subtract from the backward six just mentioned, leaving always a backward remainder of 6 or 4 or 2 or 0.

The odd years and a quarter of the same, neglecting fractions, carry us back each one letter. To these add the backward remainder from just above and divide the sum by seven. The remainder shows how many places back from G the years of our date have carried us, and subtracting this remainder from seven shows how many letters forward from G. The letter reached being the same in both cases.

In other words, the last subtraction gives the numeral of the required Dominical Letter.

The rule and the reasons might now take this shape: —

1. Divide the centuries by 4.

   Because that throws out the Dominical Cycles which do not affect the result.

2. Multiply the remainder by 2.

   Because each remainder century gives us two places forward.

3. Subtract the product from 6 and set down the remainder.

   Because we have moved back six places in order to start from G once more, having gone forward three for the year "o" and three more at the calendar reformation. A backward remainder of 0 or of an even number less than seven will always be left.

4. Set down the years and a quarter of the same, neglecting fractions.

    Because this gives the number of years in each of which we back one. There are, namely, as many leap years as there are whole fours in the number of years.

5. Add up.

    Because all the above is backward movement, and the above is all the backward movement from G which the years of the given date occasion.

6. Divide by seven.

    To throw out the sevens which do not affect the result.

7. Subtract the remainder from seven.

    Because the remainder is the number of places backward from G, and the difference between the same and seven is the number of places forward from G.

The English did not move into line until 1752, and we might inquire what would become of our rule had the Gregorian system dated from that year instead of 1582.

The delayed calendar reformation allowed another centurial year, the year 1700, to go through as a leap year, thus anticipating by one day the record (not the fact) of the vernal equinox. Eleven days were to be dropped instead of ten. So to square the record with the fact Thursday, September 3rd, with letter A, was called Thursday, September 14th, with letter E, thus advancing through eleven letters, or four, which is the same in result, and modifying the rule in form but not in principle.

Three places which we advance for C in the year "o," together with the four places due to the calendar reformation, make seven places, which leave us at G, where we were. The Dominical Cycles are thrown out, and the remainder centuries give each five back or two forward. We choose the former way because it is more convenient, multiply our remainder centuries by five and set down the product. The odd years are dealt with precisely as before and for the same reasons. They give a certain number of places backward, and these are added to those caused by the centuries. We throw out the sevens, subtract the remainder from seven, and may, perhaps, be a little puzzled to divine why our result is wrong, by one, every time until we recollect that the year 1700, and that year alone of all the century remainders, is a leap year. It throws the letter back two places instead of one, and affects every result after 1700 by making a permanent addition of one to the sum out of which the sevens are to be cast. To provide for this irregularity one is subtracted from the backward places already obtained ; or, what is the same in result and more convenient, six added to them. The sevens are now thrown out, the remainder subtracted from seven as before — and the rule works.

The rule and the reasons might now take this shape : —

1. Divide the centuries by four.

   To cast out the Dominical Cycles.

2. Multiply the remainder by five.

   Because each remainder century gives five places back.

3. Set down the odd years and a quarter of the same, neglecting fractions.

   Because this gives the number of years in each of which we back one.

4. Add six.

   Because of the exceptional year 1700.

5. Add up and divide by seven.

   To throw out the cycles of seven.

6. Subtract the remainder from seven.

   To get the number of places forward instead of backward from G.

The rule is unsuitable and useless. It is framed and introduced here by way of illustration merely.

THE RHYME DEVICE.

This is an expedient for making practical, every day use of the Dominical Letter. It is known to many, but not to all.

Take this senseless old rhyme :

At Dover Dwells George Brown, Esquire,
Good Christopher Finch And David Frier.

Its use is to be learned by heart, and to fix in the memory the letters which stand permanently for the first of each month.

The couplet consists of twelve words, and the initial letters are, each, one of the first seven letters of the alphabet — these and no more. It must be so to serve our purpose.

A,	used twice,	At, And
B,	used once,	Brown
C,	used once,	Christopher
D,	used thrice,	Dover, Dwells, David
E,	used once,	Esquire
F,	used twice,	Finch, Frier
G,	used twice,	George, Good

Set these initial letters in vertical column in order of the rhyme.

Fill out the horizontal lines in alphabetical order.

Put the months in order due from top to bottom at the left (say), the days of the months in order due, at the top, and in lines of seven horizontally.

	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31				
January	a	b	c	d	e	f	g
February	d	e	f	g	a	b	c
March -	d	e	f	g	a	b	c
April -	g	a	b	c	d	e	f
May - -	b	c	d	e	f	g	a
June - -	e	f	g	a	b	c	d
July - -	g	a	b	c	d	e	f
August	c	d	e	f	g	a	b
September	f	g	a	b	c	d	e
October	a	b	c	d	e	f	g
November	d	e	f	g	a	b	c
December	f	g	a	b	c	d	e

It cannot fail to strike any one who looks at this block that here is the foreshadowing of a calendar. Lines of seven, as in the days of the week, horizontally ; columns of twelve, as in the months, vertically.

It will be seen at once that, taking any letter and counting back or forward from it seven, we shall come round to the same letter.

It will be seen that taking any letter that falls under a number which is the ordinal of the last day of the month it is, with one exception, the letter next following alphabetically which will stand under the number 1 above and represent the first of the next following month.

The exception is D when it stands for the 29th of February. In this case D becomes the letter for the first of March also, because the Sunday Letter changes at this point for the last of the year. The letter backs one and shoves, as it were, D, as first of March, over into the place occupied by the 29th of February, so that there is a lap at the first of March which takes up the excess. The block is permanent in its present form and will serve for any year whatever of the Christian Era.

In order to a full understanding of the matter some discussion of the years previous to 1582 is desirable.

The Julian Calendar Reformation, 46 B. C., fixed 365 days and a quarter as the length of the civil year, and one day in every four years was interpolated to use up the excess.

But a quarter of a day corrects too much. The civil year is in fact

365 days, 5 hours, 48 minutes, 46.48 seconds, or
365.2422 days long, and not
365 days, 6 hours, or
365.25 days long.

When the sun enters the first point of Aries, four years after the last leap year, the earth has made, not 365.25×4 turns $= 1461$, but $365.2422 \times 4 = 1460.9688$ turns. The fourth yearly revolution is complete before the last diurnal turn is finished, 0.0312 of a turn being yet due. The Vernal Equinox is reached not at the same recorded hour and minute as the year previous, but earlier; and finds itself with each completed circuit farther back by record. The date of the fact is anticipated and comes nearer and nearer to the first of January last past. The difference of time is 11 minutes, 14.5 seconds per year. At every leap year nearly three-quarters of an hour too much has been intercalated and the record is thrown back by that amount. One might say there is too much leap year, and the remedy is to leave out some of it.

At the time of the Council of Nice in the year 325 of the Christian Era the real Vernal Equinox fell on the recorded 21st of March instead of on the 25th of March, the date fixed by Julius Cæsar, and from that time on the date kept drawing nearer and nearer to the first of January, until the Gregorian Calendar Reformation in 1582, when it fell upon March 11th.

Pope Gregory XIII chose that the recorded date of the Vernal Equinox should be the date of the Council of Nice — 21st of March — instead of Cæsar's date, 25th of March. His correction of 11 minutes, 14.5 seconds per year was applied to 1582 — 325 = 1257 years, instead of 1582 years. Twelve hundred and fifty-seven years at eleven minutes and twenty-four hundredths of a minute give nine days and eight-tenths of a day, called without sensible error ten days, and to throw these out Friday, October 5th, with letter E, was called Friday, October 15th, with letter A. And the Sunday Letter of 1582 became C. It will be noticed that the days have really elapsed in unbroken line, each with its letter. The record of number only was wrong, and was corrected.

Let us now take a date previous to 1582. The discovery of America by Columbus in 1492 — historically October 12th, O. S., October 22nd, N. S. In either case Friday. For the rule given for the "previous" portion of the era gives G as Dominical Letter, making Friday, E, 12th. And it is ninety years from 1492 to 1582. In these ninety years there are precisely 16 cycles of seven letters. So that the N. S. letter of

1582 being C, N. S. Friday has letter A. And the same will be the case with 1492. Accordingly we find A under 22nd October, as is right and proper.

Take one more instance.

George Washington was born in 1732, February 11th-22nd. The O. S. Sunday Letter of 1732 was A, and as the letter of February 1st is always D, we have :

D E F G A B C

G, Saturday, February 11th.

The N. S. Sunday Letter of 1732 was E, and D, Saturday, was February 22nd.

The letter shifts eleven places, or four, which is the same.

Now from 1582 to 1732 is 150 years. Add to this one-quarter, or 37, and get 187, or 26 cycles of seven and five over. This would shift the letter five places. But 1700 is not a leap year, and shifts the letter but one place. Therefore, 26 cycles of seven and four over, which justifies the other computation.

The subject is not exhausted by any means, but enough has been presented to put any one that feels so disposed in the way of going farther.

The whole matter may now be summed up.

The letter backs one for every common year and two for every leap year.

Leap year is every fourth year beginning with the year One. And the letter of the year One was B.

So that dividing any date by four and adding the whole part of the quotient to the date gives the number of times the letter has backed one place from C. This with exceptions by special enactment.

Take the year 1904.

1904 + 476 = 2380. Throw out the sevens, and find that 2380 is measured by seven. We back nothing from C.

But the rule gives the Sunday Letter of 1904 as B, six places farther on.

There is something yet to be taken into account.

In fact, as stated, the years 1700, 1800 and 1900 are by special enactment not leap years, so that three years must be subtracted from 2380 as not operative to back the letter, leaving 2377. Throw out the sevens and find that we must back four places from C, landing on F, which is still wrong. But furthermore, the rule which gives B starts from G, and we from C, three places in advance. We make ourselves solid with the rule — we pay these three places back by a farther subtraction to that amount from 2377, leaving 2374. Throw the sevens out and get a remainder of one. We then back one from C to B, which is correct.

Again, 1899 and a quarter thereof is 2373, which is measured by seven. We do not move from C. But, as before, the arbitrary rule has moved the letter forward three places before beginning to back. And 1700 and 1900 are inoperative.

Subtract 5, therefore, from 2373. Get 2368, throw out the sevens, get remainder of 2 and back from C to A, which is correct.

In the seventeen hundreds there is four to subtract from sum of date and a quarter thereof; namely, the one century year, 1700, and the same three as before.

And so of the other centuries.

The summary presupposes knowledge of certain specific facts.

The rule of Phillips brings out the same results mechanically and generally, requiring knowledge of nothing but the date.

What follows will probably rather edify than entertain.

RULE FOR FINDING EASTER.

In that previously mentioned "Million of Facts," by Sir Richard Phillips, will be found a curt rule for computing Easter.

This is a rule without any reasons subjoined, and one which rather disregards astronomical facts. It is based upon the principle of a thirty days lunation and upon the coincidence that the age of the moon is the same on the first of March as on the first of January. It is a kind of arithmetical puzzle or trick which, however, always works correctly.

(Verbatim, literatim.) "Easter is the first Sunday after the first full moon that occurs after the 21st of March; to find it add 6 to the Epact and subtract from 50 or if the sum is above 30 subtract the remainder and the difference is the day of the full moon counting from after March 1; this is called the Easter limit, and Easter is the following Sunday. To fix the day of the month add 4 to the number of the Dominical Letter for the year and subtract the sum from the Easter limit; then take this remainder from any multiple of seven greater than said remainder, add the new remainder to the Easter limit and the sum will be the day on which Easter Sunday falls; in March if less than 31 or in April if more than 31."

We have seen that the latest possible Paschal full moon is on the 16th of April. But on the arbitrary basis of a thirty days lunation it is on the 18th of April. For when a full falls on the 20th of March the next is the Paschal moon, and its full is just 29 days later, or the 49th of March, 18th of April, which is the extreme limit of the Paschal full moon. Moreover, when the epact is zero the moon is full in a lunation and a half or on the 45th day, the 14th of April. And it is clear that subtracting the March epact from a lunation and a half must give the number of days between the first of March and the Paschal full moon.

But a lunation and a half brings us to the 46th day, which is 44 days after the first of March, and is reached by subtracting 6 from 50, the extreme limit.

Add, therefore, 6 to the epact and subtract the sum from 50 to get the number of days to the Paschal full moon, counting from after the first of March.

The Easter limit reaches from first of March to Paschal full moon day, inclusive.

The object of the second clause of the rule is to find the numeral of Easter counting from March 1st. The numeral of the Paschal full moon is the next natural number to the Easter limit.

Now as the letter of every first of March is D, to find the letter of any date thereafter subtract 4 (the numeral of D) from the date and throw out the sevens. The number of letters to count on from this to the Dominical Letter of the year will be the number of days to add to the Paschal full moon; in fact, the Number of Direction. And this is why 4 is added to the numeral of the Dominical Letter.

In the year 1904 Easter by the Almanac, which makes no mistakes, was on the 3rd of April.

The letter of 1904 is B. The Golden Number is 5. From Golden Number subtract one, and multiply by 11; product, 44. Subtract a lunation, 30, and have 14 as Epact of 1904.

To 14 add 6, making 20; subtract from 50, leaving 30 the Easter limit or number of days from March 1st to Paschal full moon.

Second Clause: To 2, numeral of Dominical Letter, add 4, making 6, which subtract from 30, the Easter limit, bringing us to the 34th of March, or 3rd of April, as the date of Easter.

In point of fact the Epact is 13 and not 14, for reasons which we shall save ourselves a vast deal of useless trouble by taking for granted. This throws the calculation out by making the Easter limit 31 instead of 30. But when we subtract the 6 from 31 we leave 25 instead of 24, and finally add but three to 31 instead of 4 to 30, obtaining the same result, 34th March or 3rd of April. If the rule make the Easter limit less by one, it is because the Epact is greater by one.

The arbitrary rule for Epact is therefore neither scientific nor exact, and can only then be trusted to evolve a correct result when "checked" by a more trustworthy standard.

The change of Epact is, as stated, not exactly eleven days, and the discrepancy is cumulative. In fact, the institution of Epact is entirely analagous to that of leap year, in that the account is purposely kept wrong for convenience sake, and adjusted from time to time to fit the facts. But the periodical discrepancy is smaller in the matter of the Epact, and the adjustment takes place at such long intervals that it attracts no notice. In short, the Epact, which is computed by a rather complicated formula, concerns calendar makers only; and is here mentioned with its slow changes for no other purpose than to set forth the use of the Dominical Letter as an immutable landmark which allows much margin in the other items of the account and yet yields a correct result.

The WEEK seems to antedate every other human institution.

What I have laid before you makes no pretence to originality. It was evolved by the men of old time and set in order by your reader.

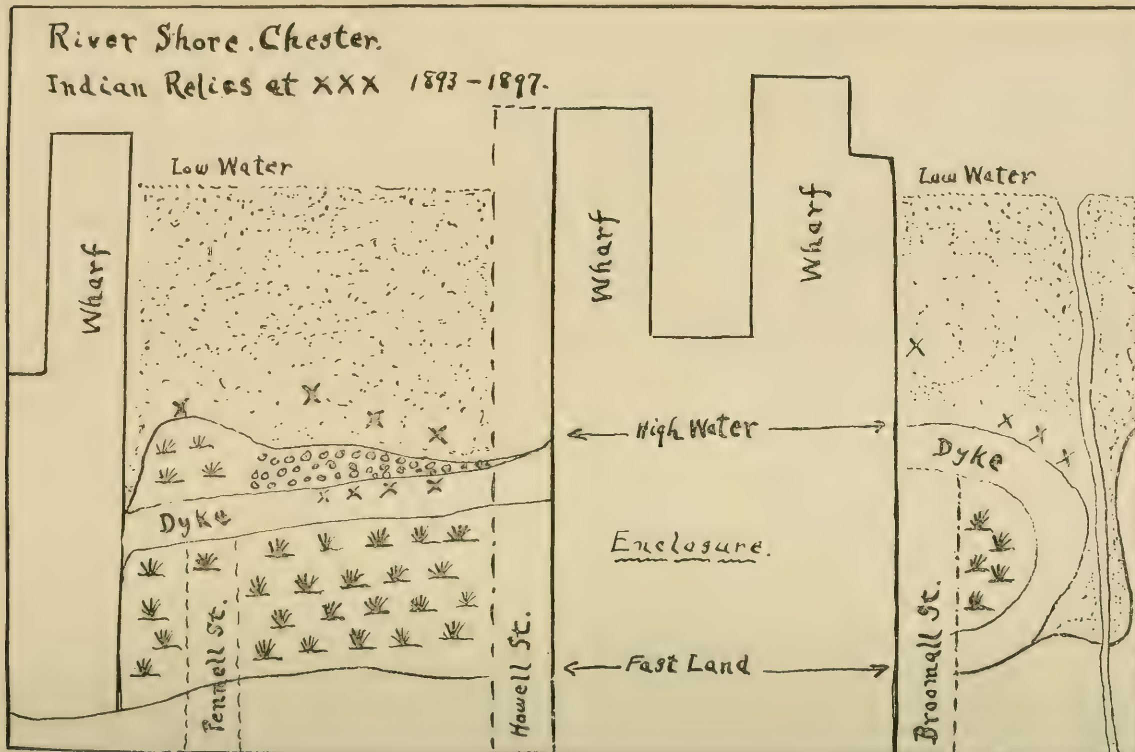
INDIAN IMPLEMENTS,

Collected on the River Shore at Chester, 1893 to 1897.

BY T. CHALKLEY PALMER.

The stone implements and clippings presented to the museum with this paper were all collected near high water mark on the shores of the Delaware in the vicinity of the continuations of Pennell, Howell and Broomall streets, in the city of Chester. As is shown in the accompanying rough sketch, this high water mark runs along the edge of a dyke. This dyke, now in many places obliterated, is probably very old, and may easily be a part of the rather extensive system of banks thrown up by the early European settlers along the river, other examples of which are still extant. Back of the dyke lies a marsh some three hundred feet wide, and back of the marsh is the fast land. This marsh is being filled up rather rapidly, and within a few years it will have disappeared altogether.

The implements were mostly found along the outer edge of the dyke, but some of them lay in the inter-tidal tract among



River Shore. Chester.
Indian Relics at XXX 1893 - 1897.
Wharf
Low Water
Dyke
Pennell St.
Howell St.
Wharf
Wharf
High Water
Enclosure.
Fast Land
Low Water
Dyke
Broomall St.

the shingle — notably the largest axe and the rough maul. The arrow heads and clippings mainly came from a gravelly portion of the dyke itself, and were uncovered, a few at a time, by heavy rains and storm tides.

The relics arrange themselves into the following classes : —

About 110 arrow heads of varying size and shape, all reasonably perfect.

A number of broken pieces of arrow heads, all apparently parts of finished implements.

Many worked stones, plainly rejections and failures. In some cases it is easy to see the cause of failure to produce the perfect dart.

Several water-worn and weathered arrow heads and spear heads. These are of argyllite, a material less resistant to water and weather than quartz and jasper.

A quantity of clippings or flakes, all exhibiting marks of Indian workmanship. Many of these are of material not native to the region.

Several fragments of pottery, some with decorative markings and some showing evidences of continued use, such as a greasy stratum within and a fire reddened surface without.

A piece of a gorget, made of chlorite slate or similar rock, broken through one of the holes. These holes have been drilled inward from both surfaces with a conical drill, so that each hole is smaller at a point midway between the two flat surfaces. The gorget was originally a rough crescent.

A scraper or flesher of jasper, of a size to be grasped in one hand. It has a rounded, definitely bevelled edge.

A pounding stone or hammer. This is in two fragments, and has split along a plane of schistosity.

Two axes and a kind of maul which would seem admirably adapted to the beating out of brains.

Beyond what is above described, other persons have found in the same place several axes and about sixty arrow heads.

There is nothing very remarkable about these relics as relics. In shape and substance they afford nothing new.

There is a good variety of color, texture and shape among the arrow heads. A large number are of white quartz of varying degrees of transparency and coarseness of grain. The material for the making of these was easily found in the scattered blocks of "white flint" so common along the Delaware. The black flint of which others are made is not so easily traced. While arrow heads of this material are to be found scattered widely over Delaware county, they are scarce compared with those made from white quartz and jasper. The black arrow heads, in fact, have sometimes the dull opacity of black jasper, and at others the conchoidal fracture and the semi-translucent, thin edges of the chalk flints and the gun flints of our ancestors. The jasper, whether red or yellow, possibly came in part from the serpentine belts, where it is still found sparingly, and some of it may have been taken from the aboriginal quarry discovered some years ago in New Jersey.

If these implements are not especially noteworthy from a collector's viewpoint, their occurrence in such variety in one place would seem at least worthy of record. Here, evidently, once stood an Indian village. Two or three centuries ago, if we are to accept contemporary ideas as to the slow and continuous subsidence of this shore, the high water mark was about four feet, vertically, lower than at present. The swamp back of the dyke was less prominent. The wigwams were probably close to the water, in the angle between the river and Lamokin Run. The topography, possibly, was more nearly like that of the river shore at present near Claymont, where the fast land joins on to a shingly beach pitched at a considerable angle with the horizontal.

What with subsidence and encroachment of the tidal waters, covering over with the rejections of neighboring industrial establishments, building of bulkheads and piers and opening of streets, the site of this aboriginal village, known only to us from these stone implements, bids fair to be altogether unknown to our children. Hence this account and the accompanying sketch.

THE SIGNIFICANCE OF ERRORS IN SPEECH.

(Abstract of Lecture before the Institute.)

BY HENRY L. BROOMALL.

To vary from the standard pronunciation or grammatical forms of our tongue is to "murder the King's English." The strength of the expression shows our absolute reliance upon the existence of a correct standard of language. Social and educational notions alike inculcate a horror of the error of speech. It stamps the speaker as now or originally of a social status assumed to be beneath those who conform to the authoritative dictionary and grammar-book. It is held to be a vicious or at least careless variation from what is right — an individual fault, a personal reproach.

To enforce this regard for the standard form of language is sound pedagogy. Speech, as an intellectual and social art, must have its accepted canons to ensure accurate thought and exchange of thought among the members of society. But the science of language has none of the practical limitations of the art of speech. The art may condemn and avoid the error, but the science must recognize it as a fact to be accounted for. It exists in all tongues and it must have a cause that will explain its universality and regularity. The perversity of the individual speaker may be cause enough for the pedagogue, but it will not explain the fact that the error is never unique in kind and that it always has or had its analogue in a standard form.

Hence the present inquiry into the scientific significance of errors in speech. It pretends to nothing more than an unusual illustration of the life of language.

The personal observation of the individual is so limited in time that he is led to regard linguistic change as only historical, as only a past growth leading up to the present and apparently mature state of his language. His fundamental notions of things are embodied in the forms of speech as they now are. His tongue responds to all his intellectual wants and he sees no room for further growth. He recognizes the new words he acquires as mere accessions to his vocabulary: he does not see or hear them grow. His language is so thoroughly himself that its psychical motives and energies do not easily become an object of his observation. It is only as a student, instead of a speaker, that he appreciates the living language as the contemporaneous expression of thinking — of thought in the making and never finished. Any comprehensive view of our subject, therefore, must begin with the process of thinking.

Thinking becomes language when and because, with each element and part of the thinking, rises to consciousness an associated sound. This association of sound and meaning is made and maintained by imitation of the speakers around us. The imitative faculty alone is exerted by the individual in acquiring his language. As his powers of thinking develop, he finds ready at hand in his community the appropriate sounds for expression. These he imitates until by repetition the association of sound and sense is immediate, the thought with its corresponding sound or the sound with its corresponding thought coming to mind as one. If this imitation and repetition were always perfect, language would not change. The necessity for mutual intelligibility and the natural tendency of the individual to conform to established canons of thought and expression ensure approximate accuracy in this imitative process.

In fact, however, this process of imitation and repetition and resulting association of sound and sense is subject to unstable conditions which produce variation. These conditions are mental and physical. On its mental side, language expresses thinking, and thinking is a thing of life — it grows or decays. The knowledge, experience, wants and ideals of the individual and of the community are continually changing, becoming greater or less, higher or lower. The higher thinking needs distinctive expression for its originality. The lower thinking fails to use the full powers of the language it imitates. Here, then, we have a mental energy, or lack of energy, as the case may be, ever varying, and ever interfering with the accurate perpetuation of the language as it comes to us. It modifies the imitation. This motive toward variation in language we may call Increasing Significance, because under it language becomes more truly significant of the changed thinking by becoming less accurately imitative.

The physical instability is more apparent because it directly affects the sound rather than the meaning. It takes far more time to articulate a word, phrase or sentence than it does to think it and recall mentally the associated sounds. Thus the course of a communication, as it runs from the mind of the speaker to the mind of the hearer, is slowed up when it comes to the point of actual vocal utterance in order that the articulating organs may have time to enunciate each particular phonetic element — to disintegrate, as it were, the words and phrases as thought in the mind into a succession of meaningless sounds — meaningless until regrouped into words and phrases by the hearer. There is therefore a continual pressure upon the articulating apparatus to keep up with the mental process. Here, in the actual process of speaking, the two elements of speech, the mental and the physical, have inherently different rates of speed. As the salient points of a sentence must be within reasonable time of one another, so that the continuity of the thought may not be lost, there results at intervals a re-adjustment for which the thought is restrained and the articulation is hurried. Under this condition, sounds not absolutely necessary for intelligibility tend to be omitted and others slurred, weakened or jammed together. Distinctness is sacrificed for rapidity. This consequent failure of perfect imitation may be termed Decreasing Effort, because whatever phonetic change here results is due to insufficient effort at the particular point of articulation where the loss or corruption of the sound occurs.

To these specific causes of variation should be added the general cause arising from the inequalities of the individuals of the community both in mental equipment and physical conformation of the vocal organs. The same word never means absolutely the same to different individuals nor is it pronounced the same. Practically, these differences are negligible. But they constitute an unstable condition in the operation of speaking and hearing, giving play to the motives that tend to vary the forms of language.

The evolution of language, then, is Imitation modified by Increasing Significance and Decreasing Effort.

The unstable conditions are not uniform throughout the forms of the language or amongst all the people speaking it. The Imitation may be maintained here and modified there. In every community there are localities, occupations and social grades where the imitation continues pure, or nearly so, long after it has been modified in the intellectual or more active centres of population. Hence, the provincialism and the archaism. When the Irishman says *mischaiv'ous* and our grandparents *mischiev'ous*, they maintain the Imitation, while the word has been modified in the standard to *mis'chievous*. *Mischaiv'ous*, *mischiev'ous* and *mis'chievous* are three successive stages in the development of the word. Each was or is correct in its time. The two older forms have become errors, not because those who use them mispronounce, but because other speakers mispronounced them and their modification has now become legitimate. Such errors are not careless variations of correct speech : they are simply instances of Imitation maintained too long. The progress of the language has left them behind. The same process accounts for *contra'ry* and *blasphe'mous*. Indeed, to many of us now, "a con'trary person" is decidedly not so much so as "a contra'ry person," and the jingle of "Mary, Mary, quite contra'ry" can hardly be forgotten.

The Irish brogue is largely of this character. Its *mate* for *meat*, *tay* for *tea*, *obleege* for *oblige*, *belave* for *believe*, are the old pronunciations maintained in English Ireland, while the imitation has been modified in the more progressive centres of English-speaking people. So, too, the farmer's cattle call *coo* is old English *cu*, while the standard *cow* is the modified pronunciation of *cu*, just as *mus*, *ut* and *hus* have become *mouse*, *out* and *house*. In *vandue* and *anvelope*, for *vendue* and *envelope*, there is still left an imitation of the French nasal sound of *en* belonging to the words when adopted by English.

Errors of grammar arising under the same process are innumerable. One of the commonest is the use of the double negative without the forms neutralizing one another and leaving the phrase affirmative. In the Anglo-Saxon Gospels of about 995 is written: "Ne geseah naéfre nán man God," literally "Not saw never none man God," now worded (John i-18) "No man hath seen God at any time." The negative idea is here attached to each negatived word in the phrase, just as, for illustration, the grammatical gender of a French noun appears also in its accompanying article and adjective, "le bon homme" and "la bonne femme." Our present vulgar double negative is the survival of this old mode of negation, becoming an error now because the standard has developed a new method. The forms *her'n*, *our'n*, *his'n*, are modern instances of the use of the old English adjectival suffix *n*. It is still represented among correct forms by *mine* and *thine* as contrasted with the abbreviated *my* and *thy*. So, too, *them horses* preserves the same grammatical suffix *m* that the standard still holds proper in *him* and *whom*.

Just as the foregoing errors arise from maintaining the Imitation too long or too well, so, conversely, all other kinds of errors result from modifying the Imitation too much or too soon. This erroneous modification, however, is always along lines or directions of development already operating among standard forms. Just as the former errors are Survivals of past correct forms, so these are Anticipants of future correct forms.

Anticipant errors are modifications. In order that we may consider them comprehensively, we may generalize the process of language as primarily —

Imitation which is	Maintained until	Decreasing Effort	Mechanically
			Voluntarily
	Modified by	Increasing Significance	Differentiatively
			Analogically

The process of Decreasing Effort, operating mechanically, is familiar under the term "phonetic decay." It is exemplified by the loss of gutturals and aspirates in English where the spelling attests their former sound, as *k* in *know* and *knee* and *gh* in *light* and *might*. So also, where the spelling does not suggest it, *h* has been dropped from *loaf*, Anglo-Saxon *hlaf*, and from *lean*, A.-S. *hlaenan*. The same cause produces the modern error of omitting the aspirate in *what*, *when*, *why*, *which*, *where* and *whether*. This omission of the aspirate, which is characteristic of English, is an error when extended to the latter words, but is sanctioned in the former.

Where a sonant, such as *v* or *z*, is brought immediately before a surd, as *t*, such as would occur in the compound *five-ten*, the difficulty in changing the tension of the vocal chords between two consonants uttered together is relieved by doing so between the preceding vowel and the consonants, where it is naturally easy to do : *ivt* and *izt* become *ift* and *ist*. Hence, *five*, in combination with a suffix beginning with *t*, appears as *fifteen* and *fifty*, *drive* as *drift*, *bereave* as *bereft*. The same cause produces colloquially, "we haf to," "he has to," and *jewsharp* (the *s* losing its *z* sound). So, conversely, we give the same pronunciation to *past* and *passed* to avoid the effort of making *d* sonant after the surd *ss*. Another such combination is *dy* or *ty* before a vowel. Here the position of the vocal organs for the production of *y* is difficult to assume quickly after that required for *d* or *t*. Effort is saved by accommodating tongue and ear to intermediate or compromised positions and sounds. Thus, *ty* becomes *ch* and *dy* becomes *j*. We still try to say *natyure* and *literatyure*, where the *u* is really *yu* long, but *picture* and *future* with the *ch* sound are now admissible. Spanish legitimated this change by spelling phonetically, as in *derecho* from Latin *directum*, *hecho* from *factum* and *leche* from *lacte*. Hence the vulgar *Chuesday* for *Tuesday* and "gechour hat" for "get your hat." Just as Latin *diurnalis* becomes our *journal*, so we hear *individual* as *indivijual*, *immediately* as *immejately*, *tedious* as *tejous*, *duke* as *juke*, *Indian* as *Injun*, and *did you* as *dijou*. Our unphonetic use of the alphabet prejudices us against conforming the spelling to these changes of sound, although the best speakers unconsciously make them at times and we always understand the speaker who makes them wherever these combinations of sounds occur. The Sanskrit writer, who used his alphabet phonetically and consistently, recognized this phonetic law, and, were the words his, would have written *dijou* and not *did you*. To say *literachure* is to follow both linguistic law and precedent: to say *literatyure* is to imitate a Latin spelling.

Consonantal *r* easily becomes vocal *r* and then coalesces with a neighboring vowel. Thus, in the standard use of English, *barse* has become *bass* and *sprecan speak*. Among many speakers *farther* and *father* not only sound the same, but also lose their final *r*. Not without respectable example, then, are such vulgarisms as *catridge* for *cartridge*, *mash* for *marsh*, *hoss* for *horse*, *cuss* for *curse* and *bust* for *burst*.

The voluntary lessening of effort is illustrated by the clipping of one or more syllables or letters from a word when they have no separate or individual significance. In this case there are no intermediate forms such as occur in the gradual change under the mechanical process. Thus, by voluntary omission, *mobile* became *mob*, *cabriolet cab* and *omnibus bus*. The corresponding error is *pants* for *pantaloons* and *gent* for *gentleman*. These shock our linguistic taste, but *mob*, *cab* and *bus* must have been at first just as abhorrent to the cultivated ear. An interesting example of this process is the use of *phone* for *telephone*. Perhaps, to most of us, it has already lost vulgarity. Such cases of change are less frequent than those produced under the mechanical process. The variation, when attempted, is usually too great to contend against the accustomed imitativeness of language, and therefore few of such forms survive. They are striking examples, however, of the effect of the purposeful mind in language, and lead us directly to the lines of development where the change of the meanings of words and forms is due to mental action.

The expression of new developed meanings, be they higher or lower, is attained by gradually adapting old meanings to new ideas in the same words, building compounds, appealing to the mimetic value of certain sounds, appropriating variations of form produced by decreased effort and transferring forms from one meaning to another under some analogy in character. These are mental acts. They form the controlling element in linguistic development, although, owing to the fact that the phonetic form is physical and representable in writing and therefore more within our power for exact study, these psychological motives are often lost sight of. For our present purposes these mental operations, through and by which Increasing Significance is obtained in language, may be considered as Differentiative and Analogical.

The differentiative process is illustrated in its simpler operation by the word *story*. The mechanical process of decreasing effort produced the variation *'storie* from *histo'rie*, then accented on the second syllable. At first a mere mispronunciation, the variation, now spelled *story*, was soon appropriated to express a needed differentiation of the old idea of *history* into what we now distinguish by these two words. So, *bulge* and *bilge* were originally mere variants of pronunciation, now words of distinctive meaning. Under the same process we notice the vulgar discrimination of *ornery* from its original *ordinary*, and a tendency to apply *phone* to the instrument and its use, but not in such a phrase as "the telephone company."

More intricate and far-reaching is the operation of the differentiative motive in the development of English grammar. The early grammatical idea of the Indo-European languages required all the words of a sentence, except particles, to show by their form their relation to one another and to the proposition. This idea constituted those "governments" and "agreements" of the parts of speech in number, gender, person and case, so perplexing to the English speaker. Where French has *un bon homme* and *une bonne femme*, English says simply "a good" in either case. *Un bon* and *une bonne* are not exactly equivalent to the English words. The French words have a compound meaning: *bonne* is *good* and something more, because it means *good* with the idea of the feminine character of the following substantive added to the simple adjective meaning. The fundamental grammatical notion is the same where verbs agree with their subjects in person and number. Where, as in Latin, this grammatical idea was highly developed, adjectives included ideas of number, gender and case, which logically are characteristics of nouns alone, and verbs included ideas of number, person, tense and mood, all combined in one word.

Old English also was of this general structure. Now grammatical gender has disappeared. Agreements of verb and subject in person and number are exceptional. Case of nouns is indicated by their position before or after the verb or preposition. Tense and mood are expressed more and more frequently by auxiliary words. This great grammatical change is the product of the differentiative motive, separating the elements of the compound meaning of a word and selecting a particular word for each.

Thus, Anglo-Saxon *ic beo*, like Latin *sim*, in contrast with *ic eom* (now *I am*) and *sum*, contained three ideas — the person "I," the mood "may" or "if" and the substantive "be." In modern English *ic beo* has become *if I be* or *I may be*. So, the past indicative was *ic wæs* and past subjunctive *ic wære*: hence our present forms *I was* and *if I were*. But the differentiation of *ic beo* into *if I be* and *ic wære* into *if I were* leaves *be* and *were* respectively the exact equivalents of the indicative form, the subjunctive idea being fully expressed in *if*. Hence, we are beginning to say *if I am* and *if I was*.

When the speaker reaches the third word there is nothing left to express but the idea of being (and tense) and the more familiar indicative form comes easiest to mind. This process of differentiation is not yet fully dominant in the English verb, and the transition causes many errors of confusion. In *I have run*, *I* is the personal element, *have* the temporal and *run* the name of the action. *Have*, so used, monopolizes the tense idea, just as *do* and *did* are temporal signs in *I do like* and *I did like*. *Run* and *like* thus become simply nominal terms, as the person and the doing in time are already expressed. Hence the *n* of *seen* in *I have seen* is becoming superfluous, and the speaker who has not been drilled in the imitation of the useless sound says *I have see* or *I have saw*. Change of form for tense and mood is fast losing its significance in English owing to the differentiative process by which its speakers seek to express these several ideas by distinctive words.

By imitation, we say *between* two and *among* three. This is giving grammatical number to these prepositions, making *between* a compound of *amidst* and duality and *among* of *amidst* and plurality above duality. So, the *best of two* is said to be wrong because one of two can be only *better*. The error in the use of *best* as of two and *between* as of more than two is a differentiation that reminds us of Anglo-Saxon singular *ic* (I), *wit* (we two), *we* (we more than two), where the dual form has disappeared and *we* assumed the plain idea of plurality.

By this process, English adjectives have lost number. Hence, when a noun is used as an adjective it tends to differentiate the idea of number from that of qualifier. Thus we hear *two foot rule* and *twenty foot alley*. It is true the purist insists strenuously upon *two feet* this or that, but even he balks at *two horses carriage*.

English pronouns afford an interesting illustration of a differentiative process which colloquial errors are trying to continue. In old English the expression of case was made by a change of form, of which the genitive survives in our possessive suffix *s*. The other case forms have been discarded. "The boy hits the girl" and "the girl hits the boy" indicate their respective distinctions of meaning by the relative position of *boy*, *girl* and *hits*. Pronouns, however, retain some forms of case. In "he hits her" and "she hits him," although the case is shown as in nouns by the position of the words, yet we must also select the proper case form of *he* or *him* and *she* or *her*. In fact, the position and not the form expresses the case relation. If the blunderer were to say "her hits he" we should still understand that he meant "she hits him," thus submitting the grammatical interpretation of the expression to the position formula. The grammarian, however, if he be put to parsing the phrase according to his classic traditions, must necessarily find that *he* is in the nominative case, subject of the verb, and that *her* is in the objective case, object of the verb, whence he would obtain a directly opposite meaning to what would be understood by any English hearer of the incorrect phrase. A few centuries ago *ye* as nominative and *you* as objective were as correctly and carefully discriminated as *I* and *me* and *he* and *him* are now. To have said *you loved them* would have sounded just as uneuphonic as to say now *me loved them* or *him loved them*. But *you*, the case idea being differentiated from the substantive idea of the pronoun and fully expressed by position, suffices now for either use. An error at first, it has become the standard use. The same motive appears in the Quaker use of *thee* for both cases, now sanctioned among people who would shudder at *him* for *he* or *her* for *she*. The distinction between the speaker who now says *him loved* for *he loved* and the speaker who, some generations ago, said *you loved* for *ye loved*, lies only in the fact that the error of the latter is already made legitimate.

We say *he loves* and *they love*. The *s* is explained as an agreement in person and number with *he*. But this grammatical notion has almost disappeared in the differentiative development of English. This *s* is now an exceptional form and a meaningless sound, but duly imitated because it "sounds right." A similar process in French preserved a sound that has now assumed a euphonic office in place of its old significance. The Latin *amat* meant *he loves*. The *t* conveyed the idea of *he*, just as the *s* of *loves* is the representative of an old English termination of the same meaning. Pronouns came into use with verbs in popular Latin, and the *t* then lost its importance and necessity. The form *ille amat* represents the late Latin form, wherein *ille* and *t* duplicated the same idea. The corresponding interrogative form was *amat ille*. The former becomes French *il aime* and the latter *aime-t-il*, the *t* in the interrogative form being the continuously imitated *t* of *amat*. In the differentiation of the pronominal and verbal meanings formerly combined in *amat*, *ille* has appropriated the full pronominal idea. Thus *t* became superfluous and disappeared from *il aime*. It has survived in *aime-t-il* because in this phrase it was phonetically easier to keep it in than to omit it. The modern French speaker regards it as a purely euphonic contrivance, inserted, as his written form shows, to prevent a hiatus. By analogy, he actually inserts it in all like verbal forms of words that never existed in Latin. So, in English now, the *s* of *loves* has a tendency among the illiterate, because it is the form of the verb most frequently used, to become a sign of the verb generally. We hear *says I* for *say I* and *horses runs* for *horses run*. The error is always in the same direction, that of using the *s* where it does not belong: it is never omitted where it does belong. This process is an attempt to increase the significance of language by utilizing a sound, of which the former significance has been lost, to express a new significance for which a need is felt. That the verb needs a generally distinctive mark or character is suggested by the difference of pronunciation already obtained between *advise*, the verb, and *advice*, the noun, *compound'* and *com'pound*, *breathe* and *breath*, *wreathe* and *wreath*, *rise* (*s* as *z*) and *rise* (*s* as *ss*), and *record'* and *rec'ord*.

The analogical process is perhaps the most potent factor in the growth of language. It seizes some likeness in sense or sound to transfer names from old things to new. Words are continually grouping and regrouping around these relations. The meaning is repeatedly renewed or reënforced by associations of this kind. The analogical link is soon lost, and some new characteristic becomes the basis of the next transfer in meaning. It is by such processes that *right*, *rigid*, *regular*, *rich*, *regal*, *rule*, *royal* and *rack* divaricate from a common form. The moral application of *right*, now the predominant meaning, still leaves evidence of its transfer from the physical in the terms *right line* and *right angle*. That the analogy is still good is shown by our calling an action *straight* or *crooked*, and naming the bent thing and the perverted man alike *crook* and *crank*. *Fare*, to go, travel, as in *seafarer*, *wayfarer*, through its characteristic of danger, has its cognate *fear*, and through its characteristic of cost, more prominent in modern times, it becomes *fare*, passage money. *Journey* and *journal* are derivatives of Latin *diurnus* through French: the connecting analogy was the day's work in travel or product. We *equip* a railroad and *ship* goods by it. *Equip* is from Old French *esquiper*, the Gallic adaptation of a Teutonic word represented in English by *skiff*, *skipper* and *ship*, and applied to the fitting out of a ship. The analogical transfers are hidden or apparent in all these cases according to time and circumstances. In tracing the etymology of any word such transfers are discovered sooner or later.

We have noticed *mischiev'ous* and *contra'ry* as survivals of the earlier pronunciation of a class of words accented formerly on the second syllable and now on the first, such as *injury*, *balcony*, *orator* and *history*. But some of this class of words have not yet been affected by this shift of accent even according to the standard: these are legitimate survivals, kept so by special imitation. By analogy, however, the speaker extends the phonetic change to these words, thus anticipating the change of accent. Hence, we hear *in'quiry*, *cu'rator*, *va'gary*, *op'ponent*, *pre'cedence*, *i'dea*, *con'dolence* and *in'terment*. Some of us may be frank enough to acknowledge that we are surprised to find that none of these pronunciations is authorized by any existing English dictionary. This surprise shows the vigor of the accentual law, despite the "authorities."

The child says *gived* for *gave* and *writed* for *wrote*, never *lave* for *lived* or *deloght* for *delighted*. New words always assume the *d* or *ed* to form the past tense. *Telephane*, *lave* and *deloght* would be nonsense, but *gived* and *writed* and *d* or *ed* so applied to any verb are always intelligible. *D* or *ed* is the significant form: the change of *i* to *a* or *o*, as in *gave* or *wrote*, has no meaning beyond the special cases where we are carefully taught to maintain them. By analogy the *d* form has been extended to most of the English verbs, and the speaker is striving to extend it to all. He has analogical reason for saying *gived* for *gave*: he must be drilled into saying *gave* for *gived* because it is "correct." To say *gived* is simply to extend too far by the measure of one word the operation of a linguistic development that is increasing the significance of the English verb by simplifying and concentrating the expression of tense.

Words like *snort* and *grunt* in contrast with *snore* and *groan* gain in significance by associating the forceful *t* with the energy or quickness of the meaning of the word. So the definiteness of time in Old English *hwiles* is emphasized by the addition of *t* in the modern *whilst*. *Against* and *amongst* are similar attempts to strengthen the words in analogy with other forms where *t* or *st* seems to represent intensity. The superlative suffix *est*, as in *quickest*, and the perfect participial *t* in *learnt*, *burnt*, and the like, with their common idea of finality, probably play a part with the *t* of *snort* and *grunt* in giving this significance to the consonant. That it is analogically active is attested by the vulgar pronunciation of *sudden* as *suddent*, *attack* as *attackt* and *once* as *oncet*. And the last form is legitimated in German *einst*, of precisely the same origin.

When analogy has operated manifestly in open defiance of etymology, the lexicographer calls it "popular etymology." It were better termed "popular analogy." Thus we say *fore-*

most as if it were *fore* and *most*, while etymologically (that is to say, imitatively) the word is *form-est*, the superlative of *form-er*, from Old English *forme*, equivalent to Latin *prim-us*. So, *acorn* is pronounced and written in analogy with Old English *ac*, *oak*, and *corn*, although it originally had no connection with either word, being formed from *acre*, O. Eng. *æcer*, field, and meaning "of the field," as *silvern* is formed from *silver*. *Shamefast*, a word formed like *steadfast*, has become *shamefaced* in analogy with *faced*, shown on or by the face, as *double-faced*, *long-faced*. The lexicographer himself spells *foreign* and *sovereign* as if they were related to *reign*, when in fact the words come from French *forain* and *souverain*, Latin *foranus* and *superanus*. He respells Old English *rime* in the form *rhyme* in analogy with the Greek *rhythm* and writes *hiccough* as if the word were partly composed of *cough*, with which it has no connection either in origin or pronunciation. In doing these things the lexicographer was building better than he knew. He was working along analogical lines; and, while his etymologies are mistaken, his analogies are good, and the words as given by him are of more significance than they would otherwise be. So the more lowly speaker of the tongue says *defi'cit* for *de'ficit* in analogy with *defi'cient* and *defi'ciency*, and *sparrow-grass* for *asparagus* with obvious reference. We hear *architect* with *ch* as in *child*, because it is associated with *arch*, *sacreligious* for *sacrilegious* with reference to *religious*, *Arkan'sas* for *Ar'kansas*, on account of *Kan'sas*, a totally different word, and *pare'sis* for *pa'resis* in consonance with medical terms in *itis*, the first *i* sounded as *e* and accented. The word *derelict*, recently adopted to designate a floating abandoned hulk dangerous to navigation, has no associations among common English words. What a depth of significance it gains when the sailor twists it into *dilly-wreck*.

None of these are legitimate, but they owe their existence — be it temporary or lasting — to precisely the same motive of increasing significance that has made the meanings and forms of all words just what they happen to be to-day.

We began by considering the unstable mental and physical conditions under which language operates, whereby change in meaning and sound seemed *a priori* necessitated. The various motives which direct these changes toward decreasing the effort of speech and increasing its significance have been briefly illustrated by both correct and incorrect forms of English speech. Among them we find no error of speech without its analogue in a correct form, and it is suggested that further illustration would but confirm this result. All forms, correct and incorrect, seem to be the product of the same processes modifying the imitation of the language that comes to us. Such a modification is at first an error of meaning or pronunciation — an anticipant of future legitimate forms. In time, it supplants the old meaning or pronunciation — and becomes a standard form. Later still, another modification sets in and the former again becomes an error — a survival of what was once correct. Every correct form of language was or will be an error some time, and every error was once correct or represents forms that will some time be correct. The error is only an error in time. It is the sign of life. By it the living language is distinguished from the dead.

MINUTES OF MEETINGS.

SEPTEMBER 7, 1905. — Regular monthly meeting. The Committee on Programme was announced by the President. The work of John B. Burk, of Cambridge, England, on the origin of life, was discussed. Charles Potts described a curious synchronism of motion in the numerous individuals of a colony of the Tent Caterpillar. Additions to the Library: Statistical Atlas of the Census Bureau, Abstract of the Tenth Census.

OCTOBER 5, 1905 — Regular monthly meeting. Dr. L. M. Underhill, of Media, was elected to membership. A report was received from the Publication Committee. The subject of an alleged change in local climate was discussed by Lewis Kirk, Henry L. Broomall and Charles Potts. Additions to the Library: Ethnological Survey of Pennsylvania; The Bontoc Igorrote; Census Bureau Bulletins 21, 22, 24; Report of Mohonk Lake Conference on International Arbitration.

OCTOBER 12, 1905.—Adjourned meeting. Prof. Leon H. Watters addressed the Institute on "Life History in Words."

OCTOBER 19, 1905.—Adjourned meeting. Prof. Honda, of Tokio, was introduced by Joseph Elkinton, and gave an illustrated lecture on Japan.

OBTOBER 26, 1905.—Adjourned meeting. Mr. Homer E. Hoopes lectured on "The Hopi and Navajo Indians," illustrating his remarks with a large number of original photographic studies.

NOVEMBER 2, 1905.—Regular monthly meeting. Dr. E. D. Fitch, Dr. William Phraener and Miss Mary C. Wirz, of Media, were elected to membership. Mr. Samuel E. Turner presented a fine specimen of a mass of barnacles. Barnacles and their mode of growth were described by Charles Potts. C. M. Broomall exhibited a specimen of tourmaline from Marple. C. M. Broomall discussed the mathematics of "Stress in Beams." Additions to the Library: Official Record of the Confederate Navies; Bulletin of U. S. National Museum, Volume 53, Part 1.

NOVEMBER 9, 1905.—Adjourned meeting. Lecture by Mr. William P. Jervis on "Pottery." Mr. Jervis presented the Institute with a copy of his "Cyclopædia of Ceramics."

NOVEMBER 16, 1905.—Adjourned meeting. Paper on "Soaps," by Mr. John C. van Haagen.

NOVEMBER 23, 1905.—Adjourned meeting. Paper on "Horace and his Writings," by Mr. Jacob B. Brown.

DECEMBER 7, 1905.—Regular monthly meeting. Harry H. Battles was elected to membership. Carolus M. Broomall spoke at some length on the formation of mud cracks and basalt columns, giving the mathematical theory of the formation of cracks in a uniformly stressed material. Henry L. Broomall gave the history of the abbreviations used in Latin writings, from which have been derived the Spanish tilde and other signs. Additions to the Library: Cyclopædia of Ceramics, presented by the author, Mr. William P. Jervis; Trees of North America, by Charles S. Sargeant, presented by the Forestry Association of Delaware County; Bulletin of the Bureau of American Ethnology on Mexican Antiquities; Proceedings U. S. National Museum, Volume 28.

DECEMBER 14, 1905.—Adjourned meeting. Discussion: "Scientific Paradoxes."

DECEMBER 21, 1905.—Adjourned meeting. Illustrated lecture on "Pocono Pines," by Prof. L. Whitaker.

DECEMBER 28, 1905.—Adjourned meeting. Miscellaneous scientific discussion.

INSTITUTE NOTES.

EDWARD A. PRICE, ESQ., a life member of the Institute, died of heart failure October 31, 1905. Mr. Price was born at Chester in 1835. He was a lawyer by profession and occupied many prominent public charges during his lifetime. He was a member of the Institute many years, and although a very busy man found time to devote much attention to local historical matters. He was the author of a work entitled "Jacob Alricks and his Nephew Peter Alricks," a copy of which is in the Library of the Institute.

CHARLES J. BECHDOLT, a member of the Institute, died suddenly on December 5, 1905. Mr. Bechdolt was born in Germany in 1852, coming to this country when quite young. He was educated as a civil engineer, being a graduate of Lehigh University. In 1875 he entered the service of the

Pennsylvania Railroad as rodman and worked his way up until in 1891 he was made Superintendent of the Central Division of the P., B. & W. R. R. Mr. Bechdolt was elected a member of the Institute in 1896.

A member hands in the following: The crushed and lifeless body of a firefly was found to emit light for fully fifteen minutes after it was killed. At the time of death the fly was emitting almost constant light in its wild efforts to escape. How does this fit in with the various theories of the light of the firefly?

The Herbarium of the Institute is in process of revision and rearrangement. This is being done in conjunction with the preparation of a List of Delaware County Plants which will be published in the next number of the PROCEEDINGS.

As will be seen by the Minutes of Meetings the Institute is in the midst of its winter campaign of scientific work, which so far has been eminently successful. The good attendance at our meetings is a source of satisfaction.

The very mild Winter we have so far experienced is in striking contrast with that of two, three and four years ago. Although the swing of the pendulum may not be very regular, its average is practically constant.

The sun dial presented to the Institute by Jacob B. Brown has been mounted as a permanent improvement on the south side of the building. It attracts much attention and is both useful and ornamental.

The Chimney Swift (*Chætura pelagica*) was observed near Media during the past season until October 13th. Dr. B. H. Warren has seen these birds in Chester county as late as the 20th of that month.

ERRATUM:

Page 24, 13th line from bottom—

For "Brings us to the 46th day," read "Brings us to the 45th day."

Officers of the Institute:

President, - - - -	T. Chalkley Palmer
First Vice President, - -	Charles Potts
Second Vice President, - -	Henry L. Broomall
Secretary, - - -	Dr. Linnæus Fussell
Treasurer, - - - -	Carolus M. Broomall
Librarian, - - -	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Jacob B. Brown and the Officers

Vol. I, No. 3 April, 1906

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

Carolus M. Broomall, Editor.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. I, NO. 3 APRIL, 1906

LIST OF DELAWARE COUNTY PLANTS,

BY LINNÆUS FUSSELL, M. D.

Dr. George Smith prepared and published in his "History of Delaware County" a very complete list of the plants within our borders. Since the issue of that work, forty-four years ago, many other species have been found — so many that it was thought well to arrange a new catalogue. The revised list includes the names of all plants known in the county and to be seen in the herbarium of the Institute. Others have been added, many of which have been taken from Dr. Ida A. Keller and Stewardson Brown's lately published work, "Handbook of the Flora of Philadelphia and Vicinity." That admirable manual includes nearly all the plants discovered in the county, with localities of the species and authorities for the same.

A few plants not included in the work, but specimens of which are in the herbarium, have been noted. The entire catalogue has been arranged in accordance with the classification found in Britton's "Manual of the Flora of the Northern States and Canada."

Subkingdom Pteridophyta

Order FILICALES

Ophioglossaceae, Presl

Ophioglossum, L., Adder's Tongue
 vulgatum, L.

Botrychium, Sw., Moonwort
 neglectum, A. Wood
 obliquum, Muhl.
 dissectum, Spreng.
 Virginianum, (L.), Sw.

Osmundaceae, R. Br.

Osmunda, L., Flowering Fern
spectabilis, Willd.
cinnamomea, L.
Claytoniana, L.

Polypodiaceae, R. Br.

Polypodium, L.
vulgare, L.

Adiantum, L.
pedatum, L.

Pteridium, Scop., Brake or Bracken
aquilinum, (L.), Kuhn
" latiusculum, (Desv.), Underw.

Cheilanthes, Sw., Lip Fern
lanosa, (Michx.), Watt.

Lorinseria, Presl, Chain Fern
areolata, (L.), Underw.

Anchistea, Presl, Chain Fern
Virginica, (L.), Presl

Asplenium, L., Spleenwort
pinnatifidum, Nutt.
platyneuron, (L.), Oakes
trichomanes, L.
acrostichoides, Sw.
filix-foemina, (L.), Bernh.

Camptosorus, Link
rhizophyllus, (L.), Link

Polystichum, Roth
acrostichoides, (Michx.), Schott

Dryopteris, Adans., Shield Fern
Novaboracensis, (L.), A. Gray
Thelypteris, (L.), A. Gray
cristata, (L.), A. Gray
" Clintoniana, (D. C. Eaton), Underw.
Goldieana, (Hook.), A. Gray
spinulosa intermedia, (Muhl.), Underw.
Dryopteris spinulosa dilatata, (Hoffm.), Underw.

Phegopteris, Fée, Beech Fern
hexagonoptera, (Michx.), Fée
Dryopteris, (L.), Fée

Woodsia, R. Br.
Ilvensis, (L.), R. Br.
obtusa, (Spreng.), Torr.

Dennstaedtia, Bernh.
punctilobula, (Michx.), Moore

Onoclea, L.
sensibilis, L.

Order SALVINIALES

Marsiliaceae, R. Br.

Marsilia, L.
quadrifolia, L.

Order EQUISETALES

Equisetaceae, Michx.

Equisetum, L., Horsetails
arvense, L.
sylvaticum, L.
littorale, Kuehl.
fluviatile, L.
robustum, A. Br.
hyemale, L.

Order LYCOPODIALES

Lycopodiaceae, Michx.

Lycopodium, L., Club Moss
lucidulum, Michx.
inundatum, L.
" Bigelovii, Tuckerm.
alopecuroides, L.
obscurum, L.
clavatum, L.
complanatum, L.

Selaginellaceae, Underw.

Selaginella, Beauv.
apus, (L.), Spring

Isoetaceae, Underw.

Isoetes, L., Quillworts
 lacustris, L.
 riparia, Engelm.
 Engelmanni gracilis, Engelm.

Subkingdom Spermaphyta

Class Gymnospermae

Order PINALES

Pinaceae, Lindl.

Pinus, L.
 strobus, L.
 Virginiana, Mill.
 echinata, Mill.
 rigida, Mill.

Tsuga, Carr.
 Canadensis, (L.), Carr.

Juniperus, L.
 communis, L.
 Virginiana, L.

Class Angiospermae

Subclass Monocotyledones

Order PANDANALES

Typhaceae, J. St. Hil.

Typha, L., Cat Tail
 latifolia, L.
 angustifolia, L.

Sparganiaceae, Agardh

Sparganium, L., Bur Reed
 eurycarpum, Engelm.
 androcladum, (Engelm.) Morong

Order NAIADALES

Naiadaceae, Lindl.

Potamogeton, L., Pondweed
 natans, L.
 amplifolius, Tuckerm.
 Nuttallii, Cham. & Sch.
 heterophyllus, Schreb.

Potamogeton lonchites, Tuckerm.
 perfoliatus, L.
 crispus, L.
 foliosus, Raf.
 Spirillus, Tuckerm.

Zannichellia, L., Horned Pondweed
 palustris, L.

Naias, L., Naiad
 flexilis, (Willd.), Rost. & Schmidt

Alismaceae, DC.

Alisma, L.
 Plantago-aquatica, L.

Sagittaria, L., Arrow Head
 longirostra, (Micheli), J. G. Smith
 Engelmanniana, J. G. Smith
 latifolia, Willd.
 rigida, Pursh
 graminea, Michx.
 subulata, (L.), Buchenau

Vallisneriaceae, Dumort.

Philotria, Raf., Water Weed
 Canadensis, (Michx.), Britton

Vallisneria, L.
 spiralis, L.

Order GRAMINALES

Gramineae, Juss.

Tripsacum, L.
 dactyloides, L.

Andropogon, L., Beard Grass
 scoparius, Michx.
 corymbosus, (Chapm.), Nash
 Virginicus, L.
 furcatus, Muhl.

Sorghastrum, Nash
 avenaceum, (Michx.), Nash

Paspalum, L.
 laeve, Michx.
 pubescens, Muhl.

Paspalum setaceum, Michx.
    Muhlenbergii, Nash

Syntherisma, Walt.
    filiforme, (L.), Nash
    linearis, (Krock.), Nash
    sanguinalis, (L.), Dulac

Echinochloa, Beauv.
    Crus-galli, (L.), Beauv.

Panicum, L., Panic Grass
    verrucosum, Muhl.
    capillare, L.
    proliferum, Lam.
    virgatum, L.
    agrostoides, Spreng.
    rostratum, Muhl.
    stipitatum, Nash
    depauperatum, Muhl.
    linearifolium, Scribn.
    dichotomum, L.
    barbulatum, Michx.
    nitidum, Lam.
    viscidum, Ell.
    Scribnerianum, Nash
    sphaerocarpon, Ell.
    polyanthes, Schultes
    commutatum, Schultes
    macrocarpon, LeConte
    Porterianum, Nash
    clandestinum, L.

Chaetochloa, Scribn., Foxtail Grass
    glauca, (L.), Scribn.
    viridis, (L.), Beauv.

Cenchrus, L., Hedgehog or Bur G.
    tribuloides, L.

Zizania, L.
    aquatica, L.

Homalocenchrus, Mieg
    Virginicus, (Willd.), Britton
    oryzoides, (L.), Poll.

Phalaris, L.
    arundinacea, L.

Anthoxanthum, L.
    odoratum, L.

Aristida, L., Triple-awned Grass
    dichotoma, Michx.
    oligantha, Michx.
    gracilis, Ell.
    purpurascens, Poir.

Stipa, L.
    avenacea, L.

Oryzopsis, Michx.
    melanocarpa, Muhl.

Muhlenbergia, Schreb.
    sobolifera, (Muhl.), Trin.
    Mexicana, (L.), Trin.
    sylvatica, Torr.
    tenuiflora, (Willd.), B. S. P.
    diffusa, Willd.

Brachyelytrum, Beauv.
    erectum, (Schreb.), Beauv.

Heleochloa, Host
    schoenoides, (L.), Host

Phleum, L.
    pratense, L.

Alopecurus, L., Foxtail
    geniculatus, L.

Sporobolus, R. Br., Rush Grass
    vaginaeflorus, (Torr.), Wood

Cinna, L., Wood Reed Grass
    arundinacea, L.

Agrostis, L.
    alba, L.
    perennans, (Walt.), Tuckerm.
    hyemalis, (Walt.), B. S. P.

Calamagrostis, Adans.
    Canadensis, (Michx.), Beauv.
    cinnoides, (Muhl.), Scribn.

Holcus, L.
    lanatus, L.

Trisetum, Pers.
    Pennsylvanicum, (L.), Beauv.

Arrhenathérum, Beauv.
elatius, (L.), Beauv.

Danthonia, DC., Wild Oat Grass
spicata, (L.), Beauv.

Capriola, Adans.
Dactylon, (L.), Kuntze

Eleusine, Gaertn.
Indica, (L.), Gaertn.

Dactyloctenium, Willd.
Egyptium, (L.), Willd.

Phragmites, L.
Phragmites, (L.), Karst.

Tricuspis, Beauv.
seslerioides, (Michx.), Torr.

Triplasis, Beauv.
purpurea, (Walt.), Chapm.

Eragrostis, Beauv.
capillaris, (L.), Nees
pilosa, (L.), Beauv.
Eragrostis, (L.), Karst.
major, Host
pictinacea, (Michx.), Steud.

Eatonia, Raf.
obtusata, (Michx.), A. Gray
Pennsylvanica, (DC.), A. Gray
nitida, (Spreng.), Nash

Uniola, L., Spike Grass
laxa, (L.), B. S. P.

Dactylis, L.
glomerata, L.

Poa, L., Meadow Grass, Spear G.
annua, L.
flava, L.
pratensis, L.
trivialis, L.
sylvestris, A. Gray
brevifolia, Muhl.
compressa, L.

Panicularia, Fabr., Manna Grass
Torreyana, (Spreng.), Merr.

Panicularia nervata, (Willd.), Kuntze
pallida, (Torr.), Kuntze
fluitans, (L.), Kuntze

Festuca, L., Fescue Grass
octoflora, Walt.
ovina, L.
elatior, L.
nutans, Willd.

Bromus, L., Brome Grass
ciliatus, L.
Kalmii, A. Gray
secalinus, L.
racemosus, L.

Lolium, L., Ray Grass, Darnel
perenne, L.
temulentum, L.

Agropyron, J. Gaertn., Wheat G.
repens, (L.), Beauv.

Hordeum, L.
jubatum, L.

Elymus, L., Lyme Grass, Wild Rye
striatus, Willd.
Virginicus, L.
Canadensis, L.

Hystrix, Moench
Hystrix, (L.), Millsp.

Cyperaceae, J. St. Hil.

Cyperus, L., Galingale
flavescens, L.
diandrus, Torr.
rivularis, Kunth
Nuttallii, Eddy
rotundus, L.
esculentus, L.
erythrorhizos, Muhl.
strigosus, L.
refractus, Engelm.
ovularis, (Michx.), Torr.
filiculmus, Vahl

Dulichium, L. C. Richard
arundinaceum, (L.), Britton

Eleocharis, R. Br., Spike Rush
obtusa, Schultes
Engelmanni, Steud.
palustris, (L.), R. & S.
acicularis, (L.), R. & S.
tricostata, Torr.
tenuis, (Willd.), Schultes

Stenophyllus, Raf.
capillaris, (L.), Britton

Fimbristylis, Vahl
laxa, Vahl
autumnalis, (L.), R. & S.

Scirpus, L., Club Rush or Bulrush
planifolius, Muhl.
debilis, Pursh
Americanus, Pers.
mucronatus, L.
lacustris, L.
fluviatilis, (Torr.), A. Gray
sylvaticus, L.
atrovirens, Muhl.
polyphyllus, Vahl
cyperinus, (L.), Kunth

Eriophorum, L., Cotton Grass
gracile, Koch
Virginicum, L.

Rynchospora, Vahl
alba, (L.), Vahl
glomerata, (L.), Vahl
cymosa, Ell.

Scleria, Berg, Nut Rush
triglomerata, Michx.
reticularis, Michx.
Torreyana, Walp.
pauciflora, Muhl.

Carex, L., Sedge
Collinsii, Nutt.
folliculata, L.
intumescens, Rudge
Carex Asa-Grayi, Bailey
lupulina, Muhl.
lupuliformis, Sartwell
monile, Tuckerm.
lurida, Wahl.
squarrosa, L.
trichocarpa, Muhl.
riparia, Curtis
scabrata, Schwein.
vestita, Willd.
Walteriana, Bailey
lanuginosa, Michx.
filiformis, L.
stricta, Lam.
aquatilis, Wahl.
Goodenovii, J. Gay
torta, Boott
prasina, Wahl.
littoralis, Schwein.
crinita, Lam.
costellata, Britton
triceps, Michx.
Caroliniana, Schwein.
gracillima, Schwein.
tenuis, Rudge
grisea, Wahl.
amphibola, Steud.
glaucodea, Tuckerm.
granularis, Muhl.
flava, L.
conoidea, Schk.
oligocarpa, Schk.
Meadii, Dewey
laxiflora blanda, (Dewey), Boott
" varians, Bailey
" patulifolia, (Dewey), Carey
styloflexa, Buckley
digitalis, Willd.
albursina, Sheldon
laxiculmus, Schwein
ptychocarpa, Steud.

Carex Pennsylvanica, Lam.
varia, Muhl.
pubescens, Muhl.
leptalea, Wahl.
stipata, Muhl.
vulpinoidea, Michx.
rosea, Schk.
retroflexa, Muhl.
sparganioides, Muhl.
cephalophora, Muhl.
sterilis, Willd.
interior, Bailey
tribuloides, Wahl.
scoparia, Schk.
cristatella, Britton
foenea, Willd.
straminea, Willd.
tenera, Dewey
" invisa, (W. Boott), Britton
festucacea, Willd.

Order ARALES

Araceae, Neck.

Arisaema, Mart.
triphyllum, (L.), Torr.
Dracontium, (L.), Schott

Peltandra, Raf.
Virginica, (L.), Kuntze

Spathyema, Raf.
foetida, (L.), Raf.

Orontium, L.
aquaticum, L.

Acorus, L.
calamus, L.

Lemnaceae, Dumort.

Spirodela, Schleid.
polyrhiza, (L.), Schleid.

Lemna, L., Duck Weed
minor, L.

Wolffia, Horkel
Columbiana, Karst.

Order XYRIDALES

Xyridaceae, Lindl.

Xyris, L., Yellow-eyed Grass
flexuosa, Muhl.
Caroliniana, Walt.
arenicola, Small

Eriocaulaceae, Lindl.

Eriocaulon, L., Pipewort
septangulare, With.

Commelinaceae, Reichenb.

Commelina, (L.), Day Flower
nudiflora, L.
Virginica, L.

Tradescantia, L.
Virginiana, L.

Pontederiaceae, Dumort.

Pontederia, L.
cordata, L.

Heteranthera, R. & P.
reniformis, R. & P.

Order LILIALES

Juncaceae, Vent.

Juncus, L., Rush, Bog Rush
effusus, L.
bufonius, L.
Gerardi, Lois.
tenuis, Willd.
dichotomus, Ell.
setaceus, Rostk.
marginatus aristulatus, (Michx.), Coville
scirpoides, Lam.
megacephalus, M. A. Curtis
Canadensis, J. Gay
acuminatus, Michx.

Juncoides, Adans., Wood Rush
campestre, (L.), Kuntze

Melanthaceae, R. Br.

Chamaelirium, Willd.
luteum, (L.), A. Gray

Melanthium, L.
    Virginicum, L.
    latifolium, Desr.

Veratrum, L.
    viride, Aiton

Uvularia, L., Bellwort
    perfoliata, L.
    sessilifolia, L.

Liliaceae, Adans.

Hemerocallis, L.
    fulva, L.

Allium, L., Leek, Garlic, Onion
    tricoccum, Aiton
    vineale, L.
    Canadense, L.

Lilium, L.
    Philadelphicum, L.
    Canadense, L.
    superbum, L.

Erythronium, L.
    Americanum, Ker

Ornithogalum, L., Star of Bethlehem
    umbellatum, L.

Muscari, Mill.
    botryoides, (L.), Mill.

Aletris, L.
    farinosa, L.

Convallariaceae, Link

Asparagus, L.
    officinale, L.

Vagnera, Adans.
    racemosa, (L.), Morong

Unifolium, Adans.
    Canadense, (Desf.), Greene

Salomonia, Heist., Solomon's Seal
    biflora, (Walt.), Britton
    commutata, (R. & S.), Britton

Convallaria, L.
    majalis, L.

Medeola, L.
    Virginiana, L.

Trillium, L., Wake Robin
    cernuum, L.

Smilaceae, Vent.

Smilax, L., Green Brier, Cat Brier
    herbacea, L.
    tamnifolia, Michx.
    glauca, Walt.
    rotundifolia, L.
    Bona-nox, L.

Amaryllidaceae, Lindl.

Hypoxis, L.
    hirsuta, (L.), Coville

Dioscoreaceae, Lindl.

Dioscorea, L.
    villosa, L.

Iridaceae, Lindl.

Iris, L., Flower de Luce
    versicolor, L.
    prismatica, Pursh

Gemmingia, Fabr.
    Chinensis, (L.), Kuntze

Sisyrinchium, L., Blue-eyed Grass
    angustifolium, Mill.
    graminoides, Bicknell

Order ORCHIDALES

Orchidaceae, Lindl.

Cypripedium, L., Lady's Slipper
    acaule, Aiton
    hirsutum, Mill.

Galeorchis, Rydb.
    spectabilis, (L.), Rydb.

Perularia, Lindl.
    flava, (L.), Rydb.

Gymnadeniopsis, Rydb.
    clavellata, (Michx.), Rydb.

Blephariglottis, Raf.
    ciliaris, (L.), Rydb.

Blephariglottis lacera, (Michx.), Rydb.
grandiflora, (Bigelow), Rydb.
psycodes, (L.), Rydb.
peramoena, (A. Gray), Rydb.

Pogonia, Juss.
ophioglossoides, (L.), Ker

Isotria, Raf.
verticillata, (Willd.), Raf.

Triphora, Nutt.
trianthopora, (Sw.), Rydb.

Limodorum, L.
tuberosum, L.

Gyrostachys, Pers., Ladies' Tresses
cernua, (L.), Kuntze
praecox, (Walt.), Kuntze
gracilis, (Bigelow), Kuntze

Peramium, Salisb.
pubescens, (Willd.), MacM.

Achroanthes, Raf.
unifolia, (Michx.), Raf.

Leptorchis, Thouars, Twayblade
liliifolia, (L.), Kuntze
Loeselii, (L.), MacM.

Tipularia, Nutt.
unifolia, (Muhl.), B. S. P.

Aplectrum, Nutt.
spicatum, (Walt.), B. S. P.

Corallorhiza, R. Br., Coral Root
Corallorhiza, (L.), Karst.
odontorhiza, (Willd.), Nutt.
Wisteriana, Conrad
multiflora, Nutt.

Subclass DICOTYLEDONES

Series Choripetalae

Order PIPERALES

Saururaceae, Lindl.

Saururus, L.
cernuus, L.

Order SALICALES

Salicaceae, Lindl.

Populus, L.
alba, L.
heterophylla, L.
candicans, Aiton
grandidentata, Michx.
tremuloides, Michx.

Salix, L., Willow, Osier
nigra, Marsh.
" falcata, (Pursh), Torr.
fragilis, L.
alba, L.
Babylonica, (L.), Koch
cordata, Muhl.
petiolaris, J. E. Smith
discolor, Muhl.
Bebbiana, Sarg.
humilis, Marsh.
tristis, Aiton
sericea, Marsh.
viminalis, L.

Order MYRICALES

Myricaceae, Dumort.

Myrica, L.
cerifera, L.

Comptonia, Banks
peregrina, (L.), Coulter

Order JUGLANDALES

Juglandaceae, Lindl.

Juglans, Lindl.
nigra, L.
cinerea, L.

Hicoria, Raf.
minima, (Marsh.), Britton
ovata, (Mill.), Britton
laciniosa, (Michx.), Sarg.
alba, (L.), Britton
microcarpa, (Nutt.), Britton
glabra, (Mill.), Britton

Order FAGALES

Betulaceae, Agardh

Carpinus, L.
Caroliniana, Walt.

Ostrya, Scop.
Virginiana, (Mill.), Willd.

Corylus, L., Filbert
Americana, Walt.

Betula, L.
nigra, L.
lenta, L.

Alnus, Gaertn., Alder
rugosa, (Duroi), K. Koch

Fagaceae, Drude

Fagus, L.
Americana, Sweet

Castanea, Adans.
dentata, (Marsh.), Borkh.
pumila, (L.), Mill.

Quercus, L.
rubra, L.
palustris, Duroi
coccinea, Wang.
velutina, Lam.
digitata, (Marsh.), Sudw.
nana, (Marsh.), Sarg.
Marylandica, Muench
nigra, L.
Phellos, L.
alba, L.
minor, (Marsh.), Sarg.
macrocarpa, Michx.
platanoides, (Lam.), Sudw.
Prinus, L.
prinoides, Willd.

Order URTICALES

Ulmaceae, Mirbel

Ulmus, L.
Americana, L.
fulva, Michx.

Celtis, L.
occidentalis, L.

Moraceae, Lindl.

Morus, L.
rubra, L.
alba, L.

Toxylon, Raf.
pomiferum, Raf.

Broussonetia, L'Her.
papyrifera, (L.), Vent.

Humulus, L.
Lupulus, L.

Urticaceae, Reichenb.

Urtica, L., Nettle
dioica, L.
gracilis, Aiton

Urticastrum, Fabr.
diviracatum, (L.), Kuntze

Adicea, Raf.
pumila, (L.), Raf.

Boehmeria, Jacq.
cylindrica, (L.), Willd.

Order SANTALALES

Loranthaceae, D. Don

Phoradendron, Nutt.
flavescens, (Pursh), Nutt.

Santalaceae, R. Br.

Comandra, Nutt.
umbellata, (L.), Nutt.

Order ARISTOLOCHIALES

Aristolochiaceae, Blume

Asarum, L., Wild Ginger
Canadense, L.
reflexum, Bicknell

Aristolochia, L.
Serpentaria, L.
Clematitis, L.

Order POLYGONALES

Polygonaceae, Lindl.

Rumex, L., Sorrel, Dock
- Acetosella, L.
- hastatulus, Muhl.
- verticillatus, L.
- crispus, L.
- obtusifolius, L.
- persicarioides, L.

Polygonum, L., Smartweed
- amphibium, L.
- emersum, (Michx.), Britton
- lapathifolium, L.
- Pennsylvanicum, L.
- Persicaria, L.
- hydropiperoides, Michx.
- Hydropiper, L.
- punctatum, Ell.
- orientale, L.
- Virginianum, L.
- aviculare, L.
- erectum, L.
- tenue, Michx.
- Convolvulus, L.
- scandens, L.
- cristatum, Engelm. & Gray
- Zuccarinii, Small
- sagittatum, L.
- arifolium, L.

Order CHENOPODIALES

Chenopodiaceae, Dumort.

Chenopodium, L.
- album, L.
- ambrosioides, L.

Atriplex, L., Orache
- patula, L.
- hastata, L.

Amaranthaceae, J. St. Hil.

Amaranthus, L., Amaranth
- hybridus, L.
- spinosus, L.
- graecizans, L.

Acnida, L.
- cannabina, L.

Phytolaccaceae, Lindl.

Phytolacca, L.
- decandra, L.

Aizoaceae, A. Br.

Mollugo, L.
- verticillata, L.

Portulacaceae, Reichenb.

Talinum, Adans.
- teretifolium, Pursh

Claytonia, L.
- Virginica, L.

Portulaca, L.
- oleracea, L.

Caryophyllaceae, Reichenb.

Agrostemma, L.
- Githago, L.

Silene, L., Catchfly, Campion
- stellata, (L.), Aiton
- antirrhina, L.
- noctiflora, L.

Lychnis, L.
- alba, Mill.

Saponaria, L.
- officinalis, L.

Vaccaria, Medic.
- Vaccaria, (L.), Britton

Dianthus, L., Pink, Carnation
- Armeria, L.

Alsine, L., Chickweed, Stitchwort
- uliginosa, (Murr.), Britton
- media, L.
- pubera, (Michx.), Britton
- longifolia, (Muhl.), Britton
- graminea, (L.), Britton

Cerastium, L., Mouse-ear Chick W.
- viscosum, L.
- vulgatum, L.

Cerastium arvense, L.
arvense oblongifolium, (Torr.), Holl. & Britton
" velutinum, (Raf.), Britton

Holosteum, L.
umbellatum, L.

Arenaria, L., Sandwort
serpyllifolia, L.
Michauxii, (Fenzl.), Hook. f.

Paronychia, Adans.
argyrocoma, (Michx.), Nutt.

Anychia, Michx.
polygonioides, Raf.
Canadensis, (L.), B. S. P.

Scleranthus, L.
annuus, L.

Order RANALES

Nymphaeaceae, DC.

Brasenia, Schreb.
purpurea, (Michx.), Casp.

Nymphæa, L., Spatter Dock
advena, Soland.

Nelumbo, Adans., Sacred Bean
lutea, (Willd.), Pers.

Ceratophyllaceae, A. Gray

Ceratophyllum, L.
demersum, L.

Magnoliaceae, J. St. Hil.

Magnolia, L.
Virginiana, L.

Liriodendron, L.
Tulipifera, L.

Anonaceae, DC.

Asimina, Adans.
triloba, (L.), Dunal

Ranunculaceae, Juss.

Hydrastis, Ellis
Canadensis, L.

Caltha, L.
palustris, L.

Helleborus, L.
viridis, L.

Cammarum, Hill
hyemale, (L.), Greene

Actaea, L.
rubra, (Aiton), Willd.

Cimicifuga, L., Bugbane
racemosa, (L.), Nutt.
" dissecta, A. Gray

Aquilegia, L., Columbine
Canadensis, L.

Delphinium, L., Larkspur
Consolida, L.

Anemone, L.
Virginiana, L.
quinquefolia, L.

Hepatica, Scop.
Hepatica, (L.), Karst.

Syndesmon, Hoffmg.
thalictroides, (L.), Hoffmg.

Clematis, L.
Virginiana, L.

Ranunculus, L., Buttercup
obtusiusculus, Raf.
abortivus, L.
sceleratus, L.
recurvatus, Poir.
acris, L.
bulbosus, L.
Pennsylvanicus, L. f.
repens, L.
hispidus, Michx.
fascicularis, Muhl.

Batrachium, S. F. Gray, White Water Crowfoot
trichophyllum, (Chaix), Bossch

Ficaria, Huds.
Ficaria, (L.), Karst.

Thalictrum, L., Meadow Rue
dioicum, L.
purpurascens, L.
polygamum, Muhl.

Berberidaceae T. & G.

Berberis, L.
vulgaris, L.

Caulophyllum, Michx.
thalictroides, (L.), Michx.

Podophyllum, L.
peltatum, L.

Menispermaceae, DC.

Menispermum, L.
Canadense, L.

Lauraceae, Lindl.

Sassafras, Nees & Eberm.
Sassafras, (L.), Karst.

Benzoin, Fabric.
Benzoin, (L.), Coulter

Order PAPAVERALES

Papaveraceae, B. Juss.

Papaver, L., Poppy
somniferum, L.
Rhoeas, L.
dubium, L.

Argemone, L.
Mexicana, L.

Sanguinaria, L.
Canadensis, L.

Chelidonium, L.
majus, L.

Bicuculla, Adans.
Cucullaria, (L.), Millsp.

Fumaria, L.
officinalis, L.

Cruciferae, B. Juss.

Lepidium, L., Pepper Grass
campestre, (L.), R. Br.
Virginicum, L.

Thlaspi, L.
arvense, L.

Sisymbrium, L., Hedge Mustard
officinale, (L.), Scop.
altissimum, L.

Sinapis, L.
alba, L.

Brassica, L.
nigra, (L.), Koch
arvensis, (L.), B. S. P.
campestris, L.

Raphanus, L.
Raphanistrum, L.
sativus, L.

Barbarea, R. Br.
Barbarea, (L.), MacM.
praecox, (J. E. Smith), R. Br.

Roripa, Scop., Cress
palustris, (L.), Bess.
Nasturtium, (L.), Rusby
Armoraceae,
(L.), A. S. Hitchcock

Cardamine, L., Bitter Cress
pratensis, L.
Pennsylvanica, Muhl.
arenicola, Britton
bulbosa, (Schreb.), B. S. P.
rotundifolia, Michx.

Dentaria, L., Toothwort
laciniata, Muhl.

Lunaria, L.
annua, L.

Bursa, Weber
Bursa-pastoris, (L.), Britton

Camelina, Crantz, False Flax
sativa, (L.), Crantz
microcarpa, Andrz.

Draba, L., Whitlow Grass
verna, L.

Sophia, Adans., Hedge Mustard
pinnata, (Walt.), Britton

Stenophragma, Celak.
Thaliana, (L.), Celak.

Arabis, L., Rock Cress
lyrata, L.
patens, Sulliv.
laevigata, (Muhl.), Poir.
Canadensis, L.
glabra, (L.), Bernh.

Alyssum, L.
alyssoides, (L.), Gouan

Resedaceae, S. F. Gray

Reseda, L.
lutea, L.

Order SARRACENIALES

Sarraceniaceae, La Pyl

Sarracenia, L.
purpurea, L.

Droseraceae, S. F. Gray

Drosera, L., Sundew
rotundifolia, L.
intermedia, Hayne

Order ROSALES

Podostemaceae, Lindl.

Podostemon, Michx.
Ceratophyllum, Michx.

Crassulaceae, DC.

Sedum, L.
ternatum, Michx.

Penthoraceae, Rydb.

Penthorum, L.
sedoides, L.

Saxifragaceae, Dumort.

Saxifraga, L., Saxifrage
Pennsylvanica, L.
Virginiensis, Michx.

Tiarella, L.
cordifolia, L.

Heuchera, L., Alum Root
Americana, L.

Mitella, L.
diphylla, L.

Chrysosplenium, L.
Americanum, Schwein.

Grossulariaceae, Dumort.

Ribes, L., Gooseberry and Currant
oxyacanthoides, L.
floridum, L'Her.
rubrum, L.
nigrum, L.

Hamamelidaceae, Lindl.

Hamamelis, L.
Virginiana, L.

Liquidambar, L.
Styraciflua, L.

Platanaceae, Lindl.

Platanus, L.
occidentalis, L.

Rosaceae, B. Juss.

Opulaster, Medic.
opulifolius, (L.), Kuntze

Spiraea, L.
salicifolia, L.
tomentosa, L.

Porteranthus, Britton
trifoliatus, (L.), Britton

Rubus, L., Raspberry, Blackberry
occidentalis, L.
cuneifolius, Pursh
nigrobaccus, Bailey
frondosus, Bigelow
Randii, (Bailey), Rydb.
argutus, Link
procumbens, Muhl.
Baileyanus, Britton
hispidus, L.

Drymocallis, Fourr.
arguta, (Pursh), Rydb.

Fragaria, L., Strawberry
- Virginiana, Duchesne
- vesca, L.

Duchesnea, J. E. Smith
- Indica, (Andr.), Focke

Potentilla, L., Cinquefoil
- argentea, L.
- Monspeliensis, L.
- Canadensis, L.
- pumila, Poir.

Geum, L., Avens
- vernum, (Raf.), T. & G.
- Canadense, Jacq.
- Virginianum, L.
- flavum, (Porter), Bicknell
- strictum, Aiton

Agrimonia, L., Agrimony
- hirsuta, (Muhl.), Bicknell
- mollis, (T. & G.), Britton
- parviflora, Soland.

Sanguisorba, L., Burnet
- Canadensis, L.

Rosa, L., Rose
- blanda, Aiton
- Carolina, L.
- lucida, Ehrh.
- rubiginosa, L.

Pomaceae, L.

Pyrus, L.
- communis, L.

Malus, Hill, Apple
- coronaria, (L.), Mill.
- Malus, (L.), Britton

Aronia, Medic., Chokeberry
- arbutifolia, (L.), Medic.
- nigra, (Willd.), Britton

Amelanchier, Medic, Juneberry
- Canadensis, (L.), Medic.
- Botryapium, (L. f.), DC.

Crataegus, L., Hawthorn
- Crus-galli, L.

Crataegus Canbyi, Sarg.
- punctata, Jacq.
- pausiaca, Ashe
- arcana, Beadle
- Uplandia, Sarg.
- Cestrica, Sarg.
- tenella, Ashe
- insolita, Sarg.
- stolonifera, Sarg.
- Tatnalliana, Sarg.
- arcuata, Ashe
- saxatilis, Sarg.
- apposita, Sarg.
- inducta, Ashe
- definita, Sarg.
- Painteriana, Sarg.
- uniflora, Muench
- Smithii, Sarg.
- succulenta, Link
- radiosa, Sarg.
- Chadsfordiana, Sarg.
- cordata, Aiton
- Oxyacantha, L.

Drupaceae, DC.

Prunus, L.
- Americana, Marsh.
- angustifolia, Michx.
- spinosa, L.
- Avium, L.
- Virginiana, L.
- serotina, Ehrh.

Amygdalus, L.
- Persica, L.

Caesalpinaceae, Kl. & Garcke

Cercis, L.
- Canadensis, L.

Cassia, L.
- nictitans, L.
- Chamaecrista, L.
- Tora, L.
- Marylandica, L.
- occidentalis, L.

Gleditsia, L.
triacanthos, L.

Gymnocladus, Lam.
dioica, (L.), Koch

Papilionaceae, L.

Baptisia, Vent.
tinctoria, (L.), R. Br.

Crotalaria, L.
sagittalis, L.

Lupinus, L.
perennis, L.

Cytisus, L.
scoparius, (L.), Link

Medicago, L., Medic
sativa, L.
lupulina, L.
denticulata, Willd.
Arabica, All.

Melilotus, Juss., Melilot
alba, Desv.
officinalis, (L.), Lam.

Trifolium, L., Clover
aureum, Poll.
procumbens, L.
dubium, Sibth.
incarnatum, L.
arvense, L.
pratense, L.
hybridum, L.
repens, L.

Cracca, L.
Virginiana, L.

Robinia, L., Locust
Pseudacacia, L.
viscosa, Vent.

Sesban, Adans.
macrocarpa, Muhl.

Aeschynomene, L.
Virginica, (L.), B. S. P.

Stylosanthes, Sw.
biflora, (L.), B. S. P.

Meibomia, Heist., Tick Trefoil
nudiflora, (L.), Kuntze
grandiflora, (Walt.), Kuntze
Michauxii, Vail
canescens, (L.), Kuntze
bracteosa, (Michx.), Kuntze
paniculata, (L.), Kuntze
laevigata, (Nutt.), Kuntze
viridiflora, (L), Kuntze
Dillenii, (Darl.), Kuntze
Canadensis, (L.), Kuntze
rigida, (Ell.), Kuntze
Marylandica, (L.), Kuntze
obtusa, (Muhl.), Vail

Lespedeza, Michx., Bush Clover
repens, (L.), Bart.
procumbens, Michx.
Nuttallii, Darl.
violacea, (L.), Pers.
Stuvei, Nutt.
frutescens, (L.), Britton
Virginica, (L.), Britton
hirta, (L.), Ell.
capitata, Michx.
angustifolia, (Pursh), Ell.
striata, (Thunb.), H. & A.

Vicia, L., Vetch, Tare
Cracca, L.
tetrasperma, (L.), Moench
sativa, L.

Lathyrus, L., Vetchling
venosus, Muhl.
palustris, L.
myrtifolius, Muhl.

Falcata, Gmel.
comosa, (L.), Kuntze
Pitcheri, (T. & G.), Kuntze

Apios, Moench
Apios, (L.), MacM.

Phaseolus, L.
polystachyus, (L.), B. S. P.

Strophostyles, Ell., Wild Bean
helvola, (L.), Britton
umbellata, (Muhl.), Britton

Order GERANIALES

Geraniaceae, J. St. Hil.

Geranium, L., Crane's Bill
maculatum, L.
columbinum, L.
Carolinianum, L.

Erodium, L'Her.
cicutarium, (L.), L'Her.

Oxalidaceae, Lindl.

Oxalis, L., Wood Sorrel
violacea, L.
corniculata, L.
stricta, L.
cymosa, Small

Linaceae, Dumort.

Linum, L., Flax
usitatissimum, L.
Virginianum, L.
striatum, Walt.
sulcatum, Riddell

Rutaceae, Juss.

Xanthoxylum, L.
Americanum, Mill.

Ptelea, L.
trifoliata, L.

Simarubaceae, DC.

Ailanthus, Desf.
glandulosus, Desf.

Polygalaceae, Reichenb.

Polygala, L., Milkwort
cruciata, L.
verticillata, L.
ambigua, Nutt.
viridescens, L.
Nuttallii, T. & G.
Senega, L.

Euphorbiaceae, J. St. Hil.

Crotonopsis, Michx.
linearis, Michx.

Acalypha, L.
Virginica, L.
gracilens, A. Gray

Euphorbia, L., Spurge
maculata, L.
nutans, Lag.
corollata, L.
Lathyris, L.
Peplus, L.

Callitrichaceae, Lindl.

Callitriche, L., Water Starwort
palustris, L.
bifida, (L.), Morong

Order SAPINDALES

Buxaceae, Dumort.

Pachysandra, Michx.
procumbens, Michx.

Limnanthaceae, Lindl.

Floerkea, Willd.
proserpinacoides, Willd.

Anacardiaceae, Lindl.

Rhus, L., Sumac
copallina, L.
hirta, (L.), Sudw.
glabra, L.
Vernix, L.
radicans, L.

Ilicaceae, Lowe

Ilex, L.
opaca, Aiton
verticillata, (L.), A. Gray

Celastraceae, Lindl.

Euonymus, L.
Americanus, L.
atropurpureus, Jacq.

Celastrus, L.
scandens, L.

Staphyleaceae, DC.

Staphylea, L.
  trifolia, L.

Aceraceae, St. Hil.

Acer, L., Maple
  saccharinum, L.
  rubrum, L.
  saccharum, Marsh.

Balsaminaceae, Lindl.

Impatiens, L., Balsam, Jewel Weed
  biflora, Walt.
  aurea, Muhl.

Order RHAMNALES

Rhamnaceae, Dumort.

Rhamnus, L., Buckthorn
  cathartica, L.

Ceanothus, L.
  Americanus, L.

Vitaceae, Lindl.

Vitus, L., Grape
  Labrusca, L.
  aestivalis, Michx.
  vulpina, L.
  cordifolia, Michx.

Parthenocissus, Planch.
  quinquefolia, (L.), Planch.

Order MALVALES

Tiliaceae, Juss.

Tilia, L.
  Americana, L.

Malvaceae, Neck.

Althaea, L.
  officinalis, L.

Malva, L., Mallow
  sylvestris, L.
  rotundifolia, L.

Sida, L.
  spinosa, L.

Abutilon, Gaertn.
  Abutilon, (L.), Rusby

Hibiscus, L.
  Moscheutos, L.
  Trionum, L.
  Syriacus, L.

Order PARIETALES

Hypericaceae, Lindl.

Ascyrum, L.
  hypericoides, L.

Hypericum, L., St. John's-wort
  adpressum, Bart.
  ellipticum, Hook.
  perforatum, L.
  maculatum, Walt.
  mutilum, L.
  gymnanthum, Engelm. & Gray
  Canadense, L.

Sarothra, L.
  gentianoides, L.

Triadenum, Raf.,
  Virginicum, (L.), Raf.

Elatinaceae, Lindl.

Elatine, L.
  Americana, (Pursh), Arn.

Cistaceae, Lindl.

Helianthemum, Pers., Frost Weed
  Canadense, (L.), Michx.

Lechea, L., Pin Weed
  minor, L.
  villosa, Ell.

Violaceae, DC.

Viola, L., Violet
  palmata, L.
    " dilatata, Ell.
    " sororia, (Willd.), Pollard
  pedata, L.
  villosa, Walt.
  cucullata, Aiton

Viola sagittata, Aiton
fimbriatula, J. E. Smith
rotundifolia, Michx.
blanda, Willd.
LeConteana, Don
primulaefolia, L.
lanceolata, L.
pubescens, Aiton
scabriuscula,
(T. & G.), Schwein.
striata, Aiton
Muhlenbergii, A. Gray
tricolor, L.
Cubelium, Raf.
concolor, (Forst.), Raf.

Passifloraceae, Dumort.

Passiflora, L., Passion Flower
incarnata, L.

Order THYMELEALES

Thymeleaceae, Reichenb.

Dirca, L.
palustris, L.

Elaeagnaceae, Lindl.

Elaeagnus, L.
latifolia, L.

Order MYRTALES

Lythraceae, Lindl.

Rotala, L.
ramosior, (L.), Koehne

Decodon, J. F. Gmelin
verticillatus, (L.), Ell.

Lythrum, L., Loosestrife
alatum, Pursh
Salicaria, L.

Parsonsia, P. Br.
petiolata, (L.), Rusby

Melastomaceae, R. Br.

Rhexia, L., Meadow Beauty
Virginica, L.

Onagraceae, Dumort.

Isnardia, L.
palustris, L.

Ludwigia, L.
alternifolia, L.

Chamaenerion, Adans.
angustifolium, (L.), Scop.

Epilobium, L., Willow Herb
lineare, Muhl.
strictum, Muhl.
coloratum, Muhl.
adenocaulon, Haussk.

Onagra, L.
biennis, (L.), Scop.

Oenothera, L., Evening Primrose
laciniata, Hill

Kneiffia, Spach, Sundrops
longipedicellata, Small
linearis, (Michx.), Spach
pumila, (L.), Spach
fruticosa, (L.), Raimann

Gaura, L.
biennis, L.

Circaea, L., Enchanter's Nightshade
Lutetiana, L.

Order UMBELLALES

Araliaceae, Vent.

Aralia, L.
spinosa, L.
racemosa, L.
nudicaulis, L.

Panax, L.
quinquefolium, L.
trifolium, L.

Umbelliferae, B. Juss.

Hydrocotyle, L., Water Pennywort
umbellata, L.
Americana, L.

Sanicula, L., Snakeroot
Marylandica, L.
Canadensis, L.

Eryngium, L., Eryngo
Virginianum, Lam.

Chaerophyllum, L.
procumbens, (L.), Crantz

Washingtonia, Raf., Sweet Cicely
Claytoni, (Michx.), Britton
longistylis, (Torr.), Britton

Zizia, Koch
aurea, (L.), Koch
cordata, (Walt.), DC.

Cicuta, L., Water Hemlock
maculata, L.

Deringa, Adans.
Canadensis, (L.), Kuntze

Taenidia, Drude, Yellow Pimpernel
integerrima, (L.), Drude

Pimpinella, L.
Saxifraga, L.

Aegopodium, L.
Podagraria, L.

Ptilimnium, Raf.
capillaceum, (Michx.), Raf.

Aethusa, L.
Cynapium, L.

Foeniculum, Adans.
Foeniculum, (L.), Karst.

Thaspium, Nutt., Meadow Parsnip
trifoliatum, (L.), Britton
" aureum, (L.), Britton
barbinode, (Michx.), Nutt.

Angelica, L.
atropurpurea, L.
villosa, (Walt.), B. S. P.

Oxypolis, Raf.
rigidus, (L.), Raf.

Pastinaca, L.
sativa, L.

Heracleum, L.
lanatum, Michx.

Daucus, L.
Carota, L.

Cornaceae Link

Cornus, L.
florida, L.
circinata, L'Her.
Amomum, Mill.
stolonifera, Michx.
candidissima, Marsh.
alternifolia, L. f.

Nyssa, L.
sylvatica, Marsh.

Series Gamopetalae

Order ERICALES

Clethraceae, Klotsch

Clethra, L.
alnifolia, L.

Pyrolaceae, Agardh

Pyrola, L., Wintergreen
rotundifolia, L.
chlorantha, Sw.
elliptica, Nutt.
secunda, L.

Chimaphila, Pursh
maculata, (L.), Pursh
umbellata, (L.), Nutt.

Monotropaceae, Lindl.

Monotropa, L.
uniflora, (L.), Small

Hypopitys, Hill
Hypopitys, (L.), Small

Ericaceae, DC.

Azalea, L.
nudiflora, L.
" glandifera, Porter
viscosa, L.

Azalea viscosa glauca, Michx.

Kalmia, L.
- angustifolia, L.
- latifolia, L.

Leucothoe, D. Don
- racemosa, (L.), A. Gray

Pieris, D. Don
- Mariana, (L.), Benth. & Hook.

Xolisma, Raf.
- ligustrina, (L.), Britton

Epigaea, L.
- repens, L.

Gaultheria, L.
- procumbens, L.

Vacciniaceae, Lindl.

Gaylussacia, H. B. K.
- frondosa, (L.), Torr. & Gray
- resinosa, (Aiton), T. & G.

Polycodium, Raf.
- stamineum, (L.), Greene

Vaccinium, L., Blueberry
- corymbosum, L.
- Pennsylvanicum, Lam.
- vacillans, Kalm

Oxycoccus, Salisb.
- macrocarpus, (Aiton), Pers.

Order PRIMULALES

Primulaceae, Vent.

Lysimachia, L., Loosestrife
- vulgaris, L.
- quadrifolia, L.
- terrestris, (L.), B. S. P.
- Nummularia, L.

Steironema, Raf., Loosestrife
- ciliatum, (L.), Raf.

Trientalis, L.
- Americana, Pursh

Anagallis, L.
- arvensis, L.

Anagallis arvensis coerulea, (Lam.), Ledeb.

Order EBENALES

Ebenaceae, Vent.

Diospyros, L.
- Virginiana, L.

Order GENTIANALES

Oleaceae, Lindl.

Syringa, L.
- vulgaris, L.

Fraxinus, L., Ash
- Americana, L.
- Pennsylvanica, Marsh.
- nigra, Marsh.

Ligustrum, L.
- vulgare, L.

Gentianaceae, Dumort.

Sabbatia, Adans.
- angularis, (L.), Pursh

Gentiana, L.
- crinita, Froel.
- Saponaria, L.
- Andrewsii, Griseb.
- villosa, L.

Bartonia, Muhl.
- Virginica, (L.), B. S. P.

Obolaria, L.
- Virginica, L.

Apocynaceae, Lindl.

Apocynum, L., Dogbane
- androsaemifolium, L.
- cannabinum, L.

Trachelospermum, Lemaire
- difforme, (Walt.), A. Gray

Asclepiadaceae, Lindl.

Asclepias, L., Milkweed
- tuberosa, L.
- rubra, L.
- purpurascens, L.
- incarnata, L.

Asclepias pulchra, Ehrh.
amplexicaulis, J. E. Smith
exaltata, (L.), Muhl.
variegata, L.
quadrifolia, Jacq.
Syriaca, L.
verticillata, L.

Acerates, Ell.
viridiflora, (Raf.), Eaton

Cynanchum, L.
nigrum, (L.), Pers.

Vincetoxicum, Walt.
obliquum, (Jacq.), Britton

Order POLEMONIALES

Convolvulaceae, Vent.

Ipomoea, L., Morning Glory
pandurata, (L.), Meyer
purpurea, (L.), Roth
hederacea, Jacq.

Convolvulus, L.
sepium, L.
spithamaeus, L.
arvensis, L.

Cuscutaceae, Dumort.

Cuscuta, L., Dodder
Gronovii, Willd.
compacta, Juss.

Polemoniaceae, DC.

Phlox, L.
paniculata, L.
maculata, L.
pilosa, L.
subulata, L.

Polemonium, L.
reptans, L.

Hydrophyllaceae, Lindl.

Hydrophyllum, L., Water Leaf
Virginicum, L.
Canadense, L.

Boraginaceae, Lindl.

Cynoglossum, L.
officinale, L.
Virginicum, L.

Lappula, Moench, Stickseed
Virginiana, (L.), Greene

Mertensia, Roth
Virginica, (L.), DC.

Myosotis, L., Forget-me-not
palustris, (L.), Lam.
laxa, Lehm.
versicolor, (Pers.), Reichenb.
Virginica, (L.), B. S. P.

Lithospermum, L., Gromwell
arvense, L.

Onosmodium, Michx.
Virginianum, (L.), DC.

Symphytum, L.
officinale, L.

Echium, L.
vulgare, L.

Verbenaceae, J. St. Hil.

Verbena, L., Vervain
urticifolia, L.
hastata, L.
angustifolia, Michx.

Labiatae, B. Juss.

Teucrium, L., Germander
Canadense, L.

Trichostema, L., Blue Curls
dichotomum, L.

Scutellaria, L., Skullcap
lateriflora, L.
serrata, Andr.
incana, Muhl.
cordifolia, Muhl.
pilosa, Michx.
integrifolia, L.
parvula, Michx.
galericulata, L.
nervosa, Pursh

Marrubium, L.
  vulgare, L.

Agastache, Clayt., Giant Hyssop
  nepetoides, (L.), Kuntze
  scrophulariaefolia, (Willd.), Kuntze

Nepeta, L.
  Cataria, L.

Glechoma, L.
  hederacea, L.

Prunella, L.
  vulgaris, L.

Galeopsis, L.
  Tetrahit, L.

Leonurus, L., Motherwort
  Cardiaca, L.
  Marrubiastrum, L.

Lamium, L., Dead Nettle
  amplexicaule, L.
  purpureum, L.
  maculatum, L.

Stachys, L., Hedge Nettle
  palustris, L.
  aspera, Michx.

Salvia, L., Sage
  lyrata, L.

Monarda, L.
  didyma, L.
  Clinopodia, L.
  fistulosa, L.

Blephilia, Raf.
  ciliata, (L.), Raf.

Hedeoma, Pers., Mock Pennyroyal
  pulegioides, (L.), Pers.

Melissa, L.
  officinalis, L.

Clinopodium, L.
  vulgare, L.

Origanum, L.
  vulgare, L.

Koellia, Moench, Mountain Mint
  flexuosa, (Walt.), MacM.
  Virginiana, (L.), MacM.
  clinopodioides, (T. & G.), Kuntze
  incana, (L.), Kuntze
  mutica, (Michx.), Britton

Thymus, L., Thyme
  Serpyllum, L.

Cunila, L., Dittany
  origanoides, (L.), Britton

Lycopus, L., Water Horehound
  Virginicus, L.
  sessilifolius, A. Gray
  Americanus, Muhl.

Mentha, L., Mint
  spicata, L.
  piperita, L.
  arvensis, L.
  sativa, L.
  Canadensis, L.

Collinsonia, L.
  Canadensis, L.

Perilla, Ard.
  frutescens, (L.), Britton

Solanaceae, Pers.

Physalodes, Boehm.
  physalodes, (L.), Britton

Physalis, Boehm., Ground Cherry
  pubescens, L.
  Philadelphica, Lam.
  Virginiana, Mill.
  heterophylla, Nees
  viscosa, L.

Solanum, L., Nightshade
  nigrum, L.
  Carolinense, L.
  rostratum, Dunal
  Dulcamara, L.

Lycium, L.
  vulgare, (Aiton f.), Dunal

Datura, L., Thorn Apple
Stramonium, L.
Tatula, L.

Petunia, Juss.
violacea, Lindl.

Scrophulariaceae, Lindl.

Verbascum, L., Mullein
Thapsus, L.
Lychnitis, L.
Blattaria, L.

Kickxia, Dumort., Toad Flax
Elatine, (L.), Dumort.

Linaria, Hill, Toad Flax
Linaria, (L.), Karst.
Canadensis, (L.), Dumort.

Scrophularia, L., Figwort
Marylandica, L.

Chelone, L.
glabra, L.

Pentstemon, Soland., Beard Tongue
hirsutus, (L.), Willd.
Digitalis, (Sweet), Nutt.
Pentstemon, (L.), Britton

Paulownia, Sieb. & Zucc.
tomentosa, (Thunb.), Baill.

Mimulus, L., Monkey Flower
ringens, L.
alatus, Soland.

Gratiola, L., Hedge Hyssop
Virginiana, L.

Ilysanthes, Raf.
dubia, (L.), Barnhart

Micranthemum, Michx.
micranthemoides, (Nutt.), Wettst.

Limosella, L., Mudwort
aquatica, L.
tenuifolia, Hoffm.

Veronica, L., Speedwell
Americana, Schwein.

Veronica officinalis, L.
serpyllifolia, L.
peregrina, L.
arvensis, L.
agrestis, L.
Byzantina, (Sibth. & Smith), B. S. P.
hederaefolia, L.

Leptandra, Nutt.
Virginica, (L.), Nutt.

Buchnera, L.
Americana, L.

Dasystoma, Raf., False Foxglove
Pedicularia, (L.), Benth.
flava, (L.), Wood
Virginica, (L.), Britton

Gerardia, L.
purpurea, L.
paupercula, (A. Gray) Britton
tenuifolia, Vahl

Castelleja, Mutis
coccinea, (L.), Spreng.

Pedicularis, L., Lousewort
lanceolata, Michx.
Canadensis, L.

Melampyrum, L.
lineare, Lam.
latifolium, Muhl.

Lentibulariaceae, Lindl.

Utricularia, L., Bladderwort
vulgaris, L.
gibba, L.

Orobanchaceae, Lindl.

Thalesia, Raf., Cancer Root
uniflora, (L.), Britton

Orobanche, L.
minor, J. E. Smith

Conopholis, Wallr.
Americana, (L. f.), Wallr.

Leptamnium, Raf.
Virginianum, (L.), Raf.

Bignoniaceae, Pers.

Catalpa, Scop.
  Catalpa, (L.), Karst.

Phrymaceae, Schauer

Phryma, L.
  Leptostachya, L.

Order PLANTAGINALES

Plantaginaceae, Lindl.

Plantago, L., Plantain
  major, L.
  Rugelii, Dec.
  lanceolata, L.
  aristata, Michx.
  Virginica, L.

Order RUBIALES

Rubiaceae, B. Juss.

Houstonia, L.
  coerulea, L.
  longifolia, Gaertn.

Cephalanthus, L.
  occidentalis, L.

Mitchella, L.
  repens, L.

Diodia, L., Button Weed
  teres, Walt.

Galium, L., Bedstraw
  Aparine, L.
  pilosum, Aiton
  lanceolatum, Torr.
  circaezans, Michx.
  boreale, L.
  triflorum, Michx.
  tinctorium, L.
  trifidum, L.
  asprellum, Michx.

Sherardia, L.
  arvensis, L.

Caprifoliaceae, Vent.

Sambucus, L., Elder
  Canadensis, L.

Viburnum, L., Arrow Wood
  acerifolium, L.
  dentatum, L.
  venosum, Britton
  nudum, L.
  Lentago, L.
  prunifolium, L.
  " globosum, Nash

Triosteum, L., Feverwort
  perfoliatum, L.

Symphoricarpos, Juss.
  Symphoricarpos, (L.), MacM.

Lonicera, L., Honeysuckle
  dioica, L.
  sempervirens, L.
  Japonica, Thunb.
  Canadensis, Marsh.

Diervilla, Moench
  Diervilla, (L.), MacM.

Order VALERIANALES

Valerianaceae, Batsch

Valerianella, Poll., Corn Salad
  Locusta, (L.), Bettke
  radiata, (L.), Dufr.

Dipsacaceae, Lindl.

Dipsacus, L.
  sylvestris, Huds.

Order CAMPANULALES

Cucurbitaceae, B. Juss.

Sicyos, L., Bur Cucumber
  angulatus, L.

Campanulaceae, Juss.

Campanula, L., Harebell
  rapunculoides, L.
  aparinoides, L.
  Americana, L.

Specularia, Heist.
  perfoliata, (L.), A. DC.

Lobelia, L.
  cardinalis, L.
  syphilitica, L.

Lobelia spicata, Lam.
inflata, L.
Nuttallii, R. & S.

Cichoriaceae, Reichenb.

Cichorium, L., Succory, Chicory
Intybus, L.
Adopogon, Neck., Dwarf Dandelion
Virginicum, (L.), Kuntze
Carolinianum, (Walt.), Britton
Picris, L.
hieracioides, L.
Tragopogon, L., Goat's Beard
pratensis, L.
porrifolius, L.
Taraxacum, Hall, Dandelion
Taraxacum, (L.), Karst.
Sonchus, L., Sow Thistle
oleraceus, L.
asper, (L.), All.
Lactuca, L., Lettuce
Scariola, L.
Canadensis, L.
sagittifolia, Ell.
villosa, Jacq.
Floridana, (L.), Gaertn.
spicata, (Lam.), Hichc.
Hieracium, L., Hawk Weed
venosum, L.
Marianum, Willd.
paniculatum, L.
scabrum, Michx.
Gronovii, L.
Nabalus, Cass., Rattlesnake Root
altissimus, (L.), Hook.
albus, (L.), Hook.
serpentarius, (Pursh), Hook
trifoliolatus, Cass.

Ambrosiaceae, Reichenb.

Ambrosia, L., Ragweed
trifida, L.
" integrifolia, (Muhl.), T. & G.
Ambrosia artemisaefolia, L.
Xanthium, L., Clotbur, Bur Weed
spinosum, L.
glabratum, (DC.), Britton
Canadense, Mill.
commune, Britton

Compositae, Adans.

Vernonia, Schreb., Iron Weed
Noveboracensis, (L.), Willd.
Elephantopus, L.
Carolinianus, Willd.
Eupatorium, L., Thoroughwort
maculatum, L.
" amoenum, (Pursh), Britton
purpureum, L.
trifoliatum, L.
serotinum, Michx.
hyssopifolium, L.
sessilifolium, L.
verbenaefolium, Michx.
" Saundersii, Porter
rotundifolium, L.
pubescens, Muhl.
perfoliatum, L.
ageratoides, L. f.
aromaticum, L.
coelestinum, L.
Willugbaeya, Neck.
scandens, (L.), Kuntze
Kuhnia, L.
eupatorioides, L.
Lacinaria, Hill, Button Snakeroot
spicata, (L.), Kuntze
Chrysopsis, Nutt., Golden Aster
Mariana, (L.), Nutt.
Solidago, L., Golden Rod
squarrosa, Muhl.
caesia, L.
flexicaulis, L.
bicolor, L.
hispida, Muhl.

Solidago speciosa, Nutt.
sempervirens, L.
odora, Aiton
rugosa, Mill.
patula, Muhl.
ulmifolia, Muhl.
neglecta, T. & G.
arguta, Aiton
serotina, Aiton
" gigantea, (Aiton), A. Gray
Canadensis, L.
nemoralis, Aiton
rigida, L.

Euthamia, Nutt.
graminifolia, (L.), Nutt.
Caroliniana, (L.), Greene

Sericocarpus, Nees
linifolius, (L.), B. S. P.
asteroides, (L.), B. S. P.

Aster, L.
divaricatus, L.
macrophyllus, L.
cordifolius, L.
sagittifolius, Willd.
undulatus, L.
patens, Aiton
phlogifolius, Muhl.
Novae-Angliae, L.
puniceus, L.
" compactus, Fernald
prenanthoides, Muhl.
laevis, L.
concinnus, Willd.
Novi-Belgii, L.
" litoreus, A. Gray
longifolius, Lam.
spectabilis, Aiton
Radula, Aiton
salicifolius, Lam.
paniculatus, Lam.
" bellidiflorus, (Willd.), Burgess

Aster paniculata acutidens, Burgess
Tradescanti, L.
ericoides, L.
lateriflorus, (L.), Britton
vimineus, Lam.
multiflorus, Aiton

Erigeron, L., Fleabane
pulchellus, Michx.
Philadelphicus, L.
annuus, (L.), Pers.
ramosus, (Walt.), B. S. P.

Leptilon, Raf.
Canadense, (L.), Britton

Doellingeria, Nees
umbellata, (Mill.), Nees
humilis, (Willd.), Britton
infirma, (Michx.), Greene

Ionactis, Greene
linariifolius, (L.), Greene

Baccharis, L.
halmifolia, L.

Gifola, Cass.
Germanica, (L.), Dumort

Antennaria, Gaertn., Everlasting
plantaginifolia, (L.), Richards

Anaphalis, DC.
margaritacea, (L.), Benth. & Hook.

Gnaphalium, L., Everlasting
obtusifolium, L.
uliginosum, L.
purpureum, L.

Inula, L.
Helenium, L.

Polymnia, L., Leaf Cup
Uvedalia, L.
Canadensis, L.

Silphium, L.
perfoliatum, L.

Parthenium, L.
Hysterophorus, L.

Heliopsis, Pers., Ox Eye
    helianthoides, (L.), B. S. P.

Eclipta, L.
    alba, (L.), Hassk.

Rudbeckia, L., Cone Flower
    triloba, L.
    hirta, L.
    fulgida, Aiton
    speciosa, Wenderoth
    laciniata, L.

Ratibida, Raf.
    pinnata, (Vent.), Barnhart

Helianthus, L., Sun Flower
    scaberrimus, Ell.
    giganteus, L.
    divaricatus, L.
    mollis, Lam.
    decapetalus, L.
    tracheliifolius, Mill.
    strumosus, L.
    tomentosus, Michx.
    tuberosus, L.

Verbesina, L., Crown Beard
    alternifolia, (L.), Britton

Bidens, L.
    laevis, (L.), B. S. P.
    cernua, L.
    connata, Muhl.
    bidentoides, (Nutt.), Britton
    discoidea, (T. & G.), Britton
    frondosa, L.
    bipinnata, L.
    trichosperma, (Michx.), Britton
    aristosa, (Michx.), Britton
    involucrata, (Nutt.), Britton

Galinsoga, R. & P.
    parviflora, Cav.

Helenium, L., Sneeze Weed
    autumnale, L.
    nudiflorum, Nutt.

Achillea, L.
    Millefolium, L.

Anthemis, L.
    Cotula, L.
    arvensis, L.

Chrysanthemum, L.
    Leucanthemum, L.
    Parthenium, (L.), Pers.

Tanacetum, L.
    vulgare, L.

Artemisia, L., Wormwood
    caudata, Michx.
    annua, L.

Tussilago, L.
    Farfara, L.

Petasites, Gaertn.
    Petasites, (L.), Karst.

Erichtites, Raf.
    hieracifolia, (L.), Raf.

Mesadenia, Raf., Indian Plantain
    atriplicifolia, (L.), Raf.

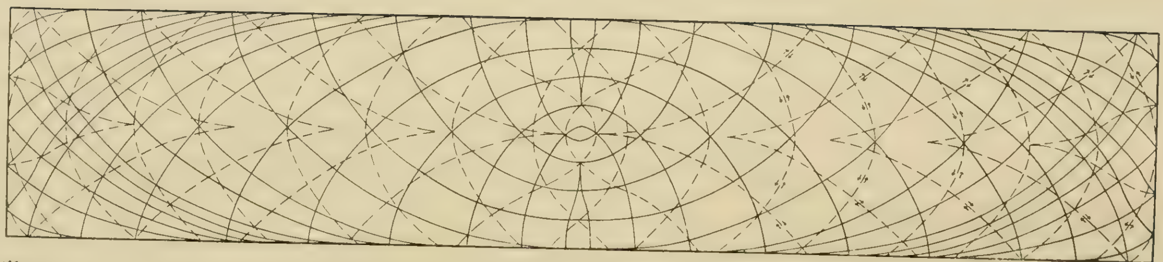
Senecio, L., Groundsel
    obovatus, Muhl.
    Balsamitae, Muhl.
    aureus, L.
    vulgaris, L.

Arctium, L., Burdock
    tomentosum, (Lam.), Schk.
    minus, Schk.

Carduus, L., Thistle
    lanceolatus, L.
    altissimus, L.
    discolor, (Muhl.), Nutt.
    odoratus, (Muhl.), Porter
    spinosissimus, Walt.
    Virginianus, L.
    muticus, (Michx.), Pers.
    arvensis, (L.), Robs.

Onopordon, L.
    Acanthium, L.

Centaurea, L.
    Cyanus, L.



Shear, - - - - - - - - -

Direct Stress, ———

LINES OF INTERNAL STRESS

LINES OF INTERNAL STRESS IN BEAMS.

Abstract of talk before the Institute.

BY C. M. BROOMALL.

Imagine a horizontal beam supported at the ends and carrying a uniformly distributed load. The investigation of the amount and direction of the maximum stresses in such a beam is so essentially mathematical that most persons are deterred from taking up the study. The theory of the subject will be found fully set forth in Merriman's "Mechanics of Materials," Tenth Edition, Chapter XI. Here also will be found a diagram illustrating the lines of stress for a portion of the beam. More or less similar diagrams are given in many works, but nowhere has the writer seen a complete diagram showing both direct stress and shear lines for the whole beam. If such diagrams exist they are not common.

By the aid of a complete diagram such as is referred to it is possible to make clear to the non-technical reader the results of mathematical investigation. It is with this object in view that the accompanying figure has been prepared. It shows, in a general way, the lines of maximum stress, tension, compression and shear, for the whole beam, supposed to be uniformly loaded. In case of a load other than uniform the curves would be of different shape, but would retain, nevertheless, their constant relationship to each other.

The equations for plotting such curves are general static equations based upon the supposition of a rigid beam subjected to "bending moment" and "vertical shear" only. They do not, therefore, take into account the effect due to the direct application of the load to the beam nor the changes produced by varying the method of supporting the ends. To do this the equations would have to be modified for every change in these factors. Again, the equations neglect the fact that in actual practice the beam suffers more or less change of shape under the load and thus certain stresses other than those necessary to produce external equilibrium are called into play. The quantities neglected by the equations are, as a rule, small, and for practical purposes the formulas give near enough the value and direction of the maximum stresses. If the beam were absolutely rigid and carried no load but its own weight, so that each element of it carried an equal share of the load, and if the supporting forces were distributed over the ends of the beam, then the equations would be absolutely correct. Let us assume we are dealing with such an ideal beam.

Referring now to the figure, the direct stress curves are shown solid and the shear curves dotted. On any line of tension or compression the amount of stress increases as the inclination from the vertical increases, being zero where the line is vertical and a maximum where it is horizontal. The tension curves are concave upward and those of compression concave downward, any two lines cutting each other at right angles. Likewise any two shear lines cut each other at right angles. Any line of direct stress cuts any line of shear at an angle of 45°. The arrows in the figure indicate the kind of shear existing at various points and the direction in which distortion begins to take place. No simple rule can be given for the variation of shear along these curves. The best that can be said is that the shear has its maximum value at the middle of the ends of the beam, reduces to zero at the central point and the four corners, and has various intermediate values at other points. At any point the two shears are always equal. Generally speaking, the tension and compression are greater toward the middle of the beam, while the shears are greater toward the ends. Of course, at any point of the beam, stresses are acting in all sorts of directions at the same time. The important matter, however, is to know the amount and direction of the maximum stresses, and this is what the theory gives.

Inspection of the figure will show that there are two types of direct stress curves and also two types of shear curves. We may speak of these as the bowed and pointed types. If the mind pictures the space between the lines filled in with other more or less similar lines, it will be seen that one type of curve shades insensibly into the other in passing the central point of the beam. In this connection, however, attention will be called to the fact that at the central point of the beam and the four corners the curves must satisfy the condition of pointing in two directions, making an angle of 45° with each other, at the same time. This indicates no fault in the theory, nevertheless, for it is precisely at these points that the formulas show the stresses to become zero and the directions indeterminate.

As mentioned before, the two right-angled shears have the same value at any point. This is a necessary condition of internal equilibrium, as otherwise the element under consideration would suffer rotation. On the contrary, the direct stresses usually have different values, there being no condition of equilibrium requiring their equality. The diagram shows how wonderfully intricate is the interplay of stresses throughout the beam.

In what has preceded, the subject has been treated under static conditions, that is, as though the beam were perfectly rigid and loaded and supported as mentioned above. Under ordinary circumstances, however, the beam bends slightly, shortening and broadening in its upper half, and lengthening and narrowing in the lower half. This change of configuration of the particles, as before stated, calls into play certain definite stresses other than those necessary for external equilibrium. For strains within the elastic limit of the material, the value of the true maximum stresses will, therefore, be slightly different from the theoretical stresses, although the direction of the lines of maximum stress will be the same. That is, the lines of the figure, supposing them to have been plotted to scale, are still valid. When, on the other hand, the strain exceeds the elastic limit so that we have to deal with internal friction and the flow of solids, then both the values and direction of the maximum stresses materially differ from those just found, In other words, while the lines in the figure give the direction of the maximum stresses in the beam when normally loaded, they by no means give the lines along which rupture will take place.

THE CAMPANILE.

Abstract of paper read before the Institute,

BY JACOB B. BROWN.

I shall have the honor and pleasure of reading to you a few pages upon a subject of general interest. "But where shall I begin?" says the mild husband in one of Balzac's novels. "Ah! Just Heaven! But begin, then, at the end!" says his sharp wife.

The end came on the 14th of July, 1902 — for then the Campanile fell. There is not the least necessity for telling what Campanile. You all know perfectly well. And now that it has ceased to exist in its original shape there is, has been and will ever be only one Campanile in the world. Other bell towers may need specification to identify them. Not so the fair and far-renowned structure the outward realization of whose grace and glory was lost to the world the other day. Let us all fervently hope — only temporarily lost.

To compare small things with great. When I think what my Newport would be to me without the spire of Old Trinity, I can form a faint notion of what Venice, without the Campanile, must be to a Venetian. Rome without St. Peter's would be bad enough. London would be an imperfect London were St. Paul's not there. To fly across the plains of Lombardy and see grand Milan without the white heap of marble and the zenith-pointing needle of the Cathedral might almost be to doubt what we are looking at. Or imagine Pisa without its Leaning Tower or Florence without the scowling majesty of the Palazzo della Signoria. But all the works that I have mentioned and many more that I could speak of are matters of yesterday compared with the Bell Tower of St. Mark's. The sailor man who sees his good ship a sheer hulk, stranded and bilged, can hardly feel a more agonized longing than the Venetian must feel to see the shapely dwelling that he loved and lived in restored to its ancient stateliness. We are told that every one, from those that wear soft clothing and are in kings' houses down to the poor ragged gondoliers have given, gold or copper as the case may be, but always something, towards the recrudesence of that lovely fabric. I read, and long to believe, that half the sum of money that is needed is within reach.

And when I remember the reverent care with which Italians go about such matters I fully know that in the necessary clearing of the ground nothing but what is actual rubbish is boated away and disposed of; that everything which bears semblance of a record is piously put in a place of safety. Such is the statement and it may be believed.

And as a natural matter of course, the most interesting facts come to light. The bricks bear marks to show that they were burned, and have probably been used, once or more, at places hundreds of miles away. For the Venetians were plunderers from the very babyhood of their nationality. When they wanted anything they took it, if they could. If they failed they waited for another chance. To build their city they pulled down the houses of any one who could not prevent them and shipped off the materials to where they would do the most good. The stamps upon these bricks are perfectly legible to the antiquarian. But one stamp that was found is current throughout humanity — the print of a goat's hoof. It may perfectly well have been 1000 years ago that "that" frisky and high flavored creature came rambling in at the gate of a brickyard in Lombardy in search of the esculent tomato can of the period; and before the yells and bits of coal of those in charge could evict him had marred or scarred a hundred yet soft parallelopipedons — one at least of which was to play a part in the history of the world.

The masonry of the tower came down, as is natural, in large, unbroken masses, many of which were not dashed to pieces even when they struck the pavement. We are told that there were many who tried to purchase these blocks as ornaments for their grounds. But not a block could money buy. They are all to be set up in the public squares, it may be of Venice, but certainly of Italy — and the record bricks will go either into the Royal Museum or back into the wall of the new structure. The fall of a dynasty is of small moment compared with the crumbling of a many and much storied Campanile.

As time goes on, we shall find precious details and fascinating bits of true history continuing to reach us from that enchanting city at the head of the Adriatic, and by the time our pressing, pinching trouble of to-day, whatever it may be, shall have passed and been forgotten, this whole country will have learned what it never dreamed of concerning the Tower that saw Marco Polo start off — the wrong way as it seemed, the right way as it proved — towards the discovery of America. The builders of old time had nothing to learn from the moderns in matters of masonry. And generally it may be remarked that the hysterical fears set out in the newspapers of a few weeks ago lest Venice should be sliding into the water would seem to be utterly vain. Buildings fall in time just as mountains, trees and men do. Trees and men, if neglected, come down the sooner. So buildings. So the Campanile, as certain facts would seem to show. Be pleased to keep one fact among many others in mind for the present. Between the time when the Campanile was founded and the disastrous hour when it fell in piteous ruins, no less than thirteen high raised towers in Venice have crumbled to the ground. I do not know of a "plumb" bell tower in all Italy. There may be such a thing, but I never saw it. The campanile of the old, old Cathedral of Fiesole comes nearer to the true line of architectural beauty than any other that I can recall. It was timbered and shored and banded, and was undergoing repairs when I saw it, in '96 of the last century. Even the Tower of Giotto in Florence overhangs perceptibly. Wherever one looks these structures are seen to be out of the vertical. There is an enormous weight upon a small base.

I will save you the trouble of looking in the proper place for a few details, historic and otherwise.

Venice was founded by certain tribes of the North of Italy, who took refuge from barbarian incursions upon the islands at the head of the Adriatic Sea — or Gulf of Venice, as it is now commonly called. Sound Venetian history does not go farther back than the ninth century, but tradition with its free foot takes us right back into the fifth century. We gather, generally, that the Campanile was begun in the former half of the tenth century. The year 913 is mentioned. It may or may not be the true year. Owing to the constant mention of the lagoons of Venice an opinion prevails that the islands are soft and marshy of soil, like those in the river Neva upon which St. Petersburgh is founded. The fact is quite otherwise. The islands are so firm and solid that few houses or palaces have suffered from settlement. Where they have come down it is for other reasons. At from ten to sixteen feet below the surface there is a firm bed of stiff clay; below this a bed of sand and gravel and then a thin layer of peat. Borings to a depth of 1500 feet show a regular succession of such beds.

As I used the freedom of remarking just now, the builders of those days knew what they were about and what they had to deal with; and the foundations which they laid were there to stay. An old historian of the time writes in formal Italian: "The foundations (of the Campanile) were laid with spurs around about, which reaching forth on every side like a star, bound together in such a way the ground destined to support the masonry as to leave no fear that to the great weight it would yield." And so far as can be known the tower did not fall from any fault in the underpinning. The idea that it could fall at all never entered a Venetian's mind. And when there occurred — as very often there did (and does) occur among the fellow citizens of Goldoni anything to excite wonder and clamorous, vivacious comment some one was sure to say: "What's all this noise about 'Xelo forse cascà el Campanil de San Marco?'" Has the impossible come to pass? Alas! To-day the impossible has come to pass.

A somewhat more businesslike account is this: "The builders of the great Campanile of St. Mark dug down to the bed of stiff clay and over the whole area of the footings of the tower drove in piles of white poplar, ten to eleven inches in diameter, nearly touching each other. On the top of these a level platform was formed of two layers of oak trees, each roughly squared, the top layer being laid crosswise upon the lower one. The oak and poplar both grew along the shores close to Venice. In later times, when the Venetian territory was extended, the red larch of Cadore and the Euganean hills was largely used. In 1885 the foundations of the Campanile were examined, and both the oak and the poplar were found to be perfectly sound. On the wooden platform massive footings are laid, consisting of five courses of large blocks of trachyte and other granitic or porphyritic rocks from the Euganean hills. Above these are six courses of similar stone arranged in steps, like offsets, forming a base or plinth to the tower. Owing to the raising of the pavement level, only two and a half of these offsets are now visible.

Before 1405 the mortar used in Venice was made of the white lime from the Istrian limestone, which possessed no hydraulic properties and was consequently very perishable. But after that year, when the Venetians conquered Padua, they were able to get supplies of a strong, dark, hydraulic lime from Albettone, which formed a very durable cement or mortar, able to resist salt water and the destructive sea air.

The Austrians occupied Venice for many years. I do not know how many. There is no difficulty whatever in finding out how many if any one should wish to know what is not here greatly to the purpose. It was long enough in any case to cast a blight. Prince Windischgraetz, I think it was, who said that nothing below the rank of baron was a man. And I would have you, if you have nothing better to do, ponder a little upon the effect of occupation by a race which can evolve such a speech as that.

In the year 1735 the tower was struck by lightning. It was on the 23rd of April, late in the afternoon. A hundred tons or so of masonry were brought down ; the interior of the tower was laid bare. Three citizens were killed and thirty-seven wounded. Whoever chooses may make what he sees fit of the circumstance that this day was the Festival of St. Mark. But the bells, which had rung, up there, every day for 600 years and were ready at any moment to plunge through the floor of the stricken belfry, failed not to ring on that day, too. And they stopped ringing on the 14th of July, 1902, for the first time since they were hung, so long ago. At the point where the bolt struck, the fatal crack began, the "crack of doom," as I feel justified in calling it. Now, put together ten centuries — mortar, inferior, though the best that could be had — a bolt of lightning, that must have made the tall structure quiver to its very midriff — and, worst of all, neglect. Surely, we have here enough to bring down any pile of masonry whose height is six times the side of its base.

But, furthermore, it is fact, attested by eye witnesses and proved by what any man may see for himself, that the tower "squatted," bulged, sank in upon itself. An American gentleman, who looked upon the catastrophe with a seeing eye, declares that the angel which was the finial subsided fifteen feet before it toppled. Your picture, which is photography, and, therefore, certified copy, shows a heap of ruins confined within comparatively small space. A volley of masonry "spirted" and stove in a corner of the Library of St. Mark. Stove in, as the sailor says, or broke a hole through without overthrowing.

That is to say — the tower did not thrash over as the tree trunk does when the axe has gashed it one single stroke too far. Beyond all reasonable doubt or question, had the foundation been in fault, the shaft would so have thrashed over, slain many men and worked a ruin which, by the blessing of Providence, it is needless now to try and estimate. But when the grave expert came up from tapping those unrotted poplar piles and those sound oak sleepers that lay across them, he said to those having authority: "Gentlemen, our forefathers are wholly justified. Their work is there as it was the day they put it there. But from causes for which they are not responsible the building itself is in a parlous state. It must be looked to speedily, extensively, thoroughly." This with the usual result. It is common talk in Europe that these instances were renewed at frequent intervals, and the somewhat dramatic incident is related that only forty-eight hours before the crash came they were once more voiced. The fact is that there was no guardian of any kind in the tower when it fell. So the crash came and it would be interesting and entirely easy to know how long it was before its thundering roar was heard round the world.

Not a waking man within five miles but must have wondered for an instant, and then felt a ghastly persuasion of what it meant.

Whoever reads of the sumptuosity and the squalor which succeeded each other at the base of the tower as time rolled on, will feed his mind upon what is as interesting as any novel. The richness and the sordidness have both passed away these many summers gone. But the Loggetta in which for 150 years the monthly lottery has been publicly drawn was, as you may see by looking at the picture, a very dream of architectural beauty, and beyond reasonable doubt will be restored whole as it was before, for the simple reason that its turn will come first. The last drawing was photographed one day and eighteen hours before the end came.

The very pigeons miss the bells of St. Mark. Of those five bells there were two which for ages have rung, at one hundred and twenty minutes after meridian, the dinner bell of these well-known creatures. And now the birds have to know when their soup is served as best they may. These pigeons carried important information to the Doge Dandolo when he was besieging Candia in the thirteenth century; they brought back news of his success. Whereupon Venice decreed that they should be maintained from that time on at the public expense. They are delightfully sentimental animals, but at the same time intolerable nuisances. Buy a soldo of tares; hold out a handful, and straightway find yourself covered, crawled over and buffetted by the wings of the dear, soft, greedy gluttons.

The tower used to serve another purpose not sentimental at all, not poetical in the least, but grim, horrible and ghastly to the uttermost degree. It was used to hang the *chebba* upon. *Chebba* is the Venetian for *gabbia*, and *gabbia* is the Italian for cage. When a priest committed blasphemy, homicide, forgery or any one of other crimes not named, he had the privilege of the *chebba*. Laymen accused in like manner were promptly fitted out with cord and stone and drowned where it was death to be seen lounging in a boat. The *chebba*, then, was a wooden cage into which the privileged shaveling was put and hoisted half way up outside of the tower. He had a bit of twine by which he let down a basket for the contributions of the charitable, who were allowed to send him up, if they were so inclined, bread of affliction and water of affliction, but nothing more. And if the poor wretch could for long endure heat, cold, hunger, scorn and despair he might live for a while. But it is probable that more corpses than living men were taken out of that grim place of torment when it was lowered to earth. Few cities contain such minute records of their own inner doings as Venice, and there are word pictures, quaint and moving, connected with this matter to show what human nature can bear and live. One certain Fra Agostino, convicted of nothing worse than blasphemy, was hung up in the *chebba* somewhere about the time that Columbus was sailing over to America. He was a priest, but he loved the Lady Perpetua and wrote poetry to her ; and she wrote to him. It seems probable, too, that all-seducing gold enabled them to get letters to each other. The papers are on record.

> Giocando biastemmai senza rispetto
> E dispregiai l'eterno et vero Idio.

He says : "In jest I shamelessly blasphemed and did despite to the true and ever living God." He had two months of the *chebba* and eight months of dark dungeon. I do not know if he lived through it all. It is probable that he did, or we should not have heard of him. The *istorie*, or accusations of such sufferers, were posted between the columns by the water-side — at that time the place of public execution — and gave encouragement, in no wise needed, to the rabble to come underneath the cage and shout out their ribaldry. It would almost seem as if men had improved a little since that time. In 1496 the Church could no longer regard this thing as a privilege, and successfully used influences to have it abolished.

The Campanile had another highly dignified function. At the seasons when the swallows are passing there were posted on the tower certain persons who launched forth upon the breeze good store of little sheets of paper each with a small hole punched through it. The swallows, for reasons better known to themselves than to us, plunged after these flying leaves, stuck their heads through the holes and were yoked to misery from that instant. They fell to the ground, of course; they were snapped up by the small boy of the period and suffered the fate which they would suffer to-day under the same circumstances.

Again and again we come back to it. Think of the hollowness about the heart which must attack a Venetian when he does not see his Campanile; or even suddenly remembers that it is no longer there. This noble shaft was not the bell tower of the Cathedral only. It bore up high above every other point what was to sound forth the signal for every public movement of the government. I am careful in this matter to say public. For you are not ignorant that five-sixths of what the Venetian oligarchy did was done in deadly secrecy. So when the Maggior Consiglio had passed a measure down to the Council of Ten and their strengthless hands had let it fall among the dreadful unknown Three, its fate was fixed. The Marangona called the people together upon the Public Square to the Arenga or Public Council. The measure was "proposed" to them and if they did not give in their adhesion the only difference made was that it was so much the worse for them.

The Marangona was the biggest of the five bells in the tower. It was rescued unbroken, and now has temporary but honorable shelter in the courtyard of the Doge's Palace. But a thousand years in the sight of man is a good deal, after all; and this is not the original Marangona. The old one may have cracked as other bells crack. Such as it is, however, you have its portrait.

Now it may be remarked by way of digression that an European becomes attached to his bells in a way that we can hardly conceive. The casting of bells is not on the other side of the Atlantic a trade merely; it is a branch of high art. It has its traditions and is practised reverently. The bells are tuned. And they are struck with a wooden clapper — a practice enormously conducive both to longevity and sweetness of tone. It does not look well. From the window of Giotto's Tower in Florence, high up, there projects an unsightly arm of rather rough hewn wood, from the end of which a rope passes slanting down through a hole in the masonry. The rope is pulled; the arm begins to sway up and down. Then at the window there is seen a black mass appearing and disappearing and a great, big, swinging, banging block of wood. But the sound that of an Easter morning floats out upon the air, no man that has heard it will ever forget. Shall I give you an idea when I say that there is no consonant at the beginning of the "boom." It is a soft, firm, rolling wave that comes in upon the ear, filling it and filling the atmosphere.

I do not know who wrote the eight lines that shall follow. I never saw them in their place, but I hardly can remember the time when I did not know them by heart.

> "Far, far, o'er hill and dell,
> On the wind stealing,
> List to the Convent Bell
> Mournfully pealing.
> Hark! hark! It seems to say:
> As melt these sounds away,
> So life's best joys decay
> While new their feeling."

There may be those who would hear a morning and evening bell all their lives and not notice it, but who would miss it if it stopped.

"A hundred cities of Italy," says the *Secolo*, "mark events sad or joyful, as the case may be, by the sound of the public bells. Down from those towers and out from those bronze mouths cities and villages receive a common thought and hear a language which every man can understand. Try what it is to tear out from those bosoms that common thought, from those bronze mouths that tongue which speaks at one and the same time the words of thousands upon thousands of human lips.

"Fasts, vigils, guard mounting, the opening of the Arsenal and the closing of its gates; return from victorious war and the sad honors paid to the worthy dead — all were told of from day to day by the bells of San Marco. The Campanile personified ten centuries of a Republic's history and of a city's life."

Just now the city of Venice is most like a stranded jelly fish. "How is the gold become dim — how is the most fine gold changed!" The Rialto where Shylock was rated by the lordly Bassanio about his monies and his usances is an ill smelling fish market. I ate there, in open day, before the public and without the aid of table gear of any kind, what looked like a small octopus. It was boiled, it tasted like lobster and was only a little tougher. But what did it all matter? There was the great Square of St. Mark looking at night like an enormous well lighted ball room and even by day like fairy land. We could go to Florian's, never shut night or day for forty years, and fail by the hour together to imagine or recall what had been passing on the pavement before us six hundred years ago. And there was the Tower to climb. No stairs, but a smooth, even stone pathway round and round and up and up. The view from the top wholly disappointing. One roof is so ridiculously like another, the canals are too small to be seen, and the far-off landscape has imprinted nothing whatever upon my recollection. So I came down and left the Tower to its fate. It had but fifty years to live.

Says the writer in the *Secolo*: "All gossipping controversy about the giant which is to be raised from the dead is vain and empty. In height it was two hundred and eighty-four Venetian feet, or ninety-eight metres. But there is no metre to tell us how high are piled the traditions, the memories, the events on which the bronze angel set up in 1513 and renewed in 1822 spread its gilded wings to the breath of the winds and the roll of the centuries. Soon shall we see, once more, *where it was and as it was*, this majestic tower. Upon its pinnacle we shall behold the gilded angel of bygone years; and from its belfry as of old will peal once more over city and lagoon those bells whose silence now saddens every Venetian soul."

THEORY OF FREEZING MIXTURES.

Abstract of talk before the Institute,

BY T. CHALKLEY PALMER.

A saturated solution of a salt in a liquid may often be cooled below the point at which the salt ordinarily separates, without causing solidification. But when a minute fragment is dropped into this so-called supersaturated solution rapid crystallization occurs. A delicate thermometer will indicate, at such a time, the disengagement of large amounts of heat. This heat is the energy which, so long as the salt continues in solution, keeps the molecules apart. When the molecules rush together, and so lose the bulk of this independent motion, the motion becomes sensible heat. Similarly, in order that the particles or molecules of a solid may part company and spread themselves abroad through a liquid, heat or some form of energy must become latent—or, more scientifically, it must cease to exist as sensible heat and be converted into motion. The process of solution calls for the expenditure of energy. If the energy is not forthcoming from the chemical reaction of the salt and the solvent, it must come from the solution itself or its surroundings. Hence the lowering of temperature when solution takes place. The amount of energy so converted from the sensible to the potential condition in case of simple solution is surprisingly large.

During the last decade we have become familiar with the analogy between solutions and gases. A body in dilute solution is found to exert an osmotic pressure equal to the vapor pressure it would exert if gasified into the same space at the same temperature. The amount of energy necessary to gasify a pound of ammonium chloride, for instance, is very large. An equal amount of energy is necessary to bring a pound of ammonium chloride into a solution of similar volume, temperature being allowed for. Now this energy is supplied in large part by the heat of the solvent and the immediate surroundings. Consequently a pound of ammonium chloride dissolving in water will create a very considerable lowering of temperature.

Freezing mixtures are therefore devised on the principle that heat is absorbed in the separation of the molecules of a solid from each other. It is obvious that this principle applies not only to the solution of a solid in a liquid, but also to the liquefaction of a solid or of a mixture of solids, however brought about.

Certain considerations will occur to almost anyone in connection with this line of thought.

Firstly, it is obvious that solution, with consequent absorption of heat, must be comparatively rapid if the local cooling is to be pronounced in degree. A slow process of solution means a slow absorption; and after a certain degree of slowness is obtained, this absorption becomes counterbalanced by the flowing in of energy from the surroundings. This being so, freezing mixtures will be efficient for this purpose, other things being equal, strictly in proportion to their rapidity of operation. If they are constituted of salts dissolving in liquids, they will be efficient just in proportion to the amount of salt dissolved in a unit of time. The amount of salt dissolved in units of time in a given volume of liquid will obviously be in proportion to the total solubility of the salt in the given liquid. Consequently, the most soluble salts are used in these mixtures.

Secondly, the volume of the resulting solution must be kept as small as possible or much of the cooling effect will be wasted upon the solution itself.

Thirdly, since salts that are mixed dissolve into liquids (all being chemically inert), each one as if it alone were present, it is quite feasible to increase the absorption of heat very greatly by making mixtures of considerable complexity.

Fourthly, that while water is the most commonly used solvent, increased effect may follow the addition of an acid to the water in case of salts that are more soluble in dilute acids than in water alone.

Lastly, that when solvent and salt can be mixed in the solid form, as in the case of ice and salt, or that of ice and calcium chloride, absorption of heat is brought about, not only by the solution of the salt, but also by the liquefaction of the solvent.

A few typical freezing mixtures, illustrating some of the principles to which reference has been made, are noted below. The table sets forth the materials, the parts by weight and the degrees Fahrenheit (above zero unless otherwise marked) that can be attained.

WATSON'S LIST:

Ammonium nitrate......1
Water..................1
40 to 4

Ammonium nitrate......1
Sodium carbonate.......1
Water..................1
50 to —3

Ammonium chloride... 5
Potassium nitrate...... 5
Water..................16
50 to 10

Sodium sulphate........6
Ammonium nitrate......5
Dilute nitric acid........4
50 to —40

Ammonium chloride... 5
Potassium nitrate...... 5
Sodium sulphate....... 8
Water..................16
50 to 4

Sodium sulphate........6
Ammonium chloride....4
Potassium nitrate.......2
Dilute nitric acid........4
50 to —10

Snow..................24
Sodium chloride.......10
Ammonium chloride... 5
Potassium nitrate...... 5
To —18

Sodium nitrate..........3	
Dilute nitric acid........2	
50 to —3	
Sodium phosphate......9	
Dilute nitric acid........4	
50 to —12	
Sodium sulphate........5	
Dilute sulphuric acid....4	
50 to 3	
Snow..................2	
Sodium chloride........1	
To —5	
Snow..................5	
Sodium chloride........2	
Ammonium chloride....1	
To —12	
Snow..................3	
Dilute sulphuric acid....2	
To —27	
Snow..................12	
Sodium chloride....... 5	
Ammonium nitrate..... 5	
To —25	
Snow..................8	
Hydrochloric acid.......5	
To —27	
Snow..................7	
Dilute nitric acid.......4	
To —30	
Snow..................4	
Dry calcium chloride....5	
To —40	
Snow..................2	
Cryst. calcium chloride..3	
To —50	
Snow..................3	
Potash.................4	
To —51	

MINUTES OF MEETINGS.

JANUARY 4, 1906. — Regular monthly meeting. Charles W. M. Guhle, Leopold Schuchardt and Charles H. Stephens were elected to membership. The Committee on Publication reported progress. T. Chalkley Palmer spoke of the use of the microscope in chemical analysis, and the subject was discussed by other members.

JANUARY 11, 1906. — Adjourned meeting. Illustrated lecture, "The Luray Caverns," by Dr. Howard Kingsbury.

JANUARY 18, 1906. — Adjourned meeting. Illustrated lecture, "Forest Trees," by Dr. E. L. Clark.

JANUARY 25, 1906.—Adjourned meeting. Lecture, "The Conflict of Languages," by Henry L. Broomall.

FEBRUARY 1, 1906.—Regular monthly meeting. Dr. William H. Furness, 3rd, was elected to membership. The Publication Committee reported the issue of the second number of the PROCEEDINGS. T. Chalkley Palmer and Dr. W. T. W. Dickeson spoke at length upon Earth and Fish Worms. Carolus M. Broomall and Henry L. Broomall referred to the so-called Horse Hair Worm and described its characteristics.

FEBRUARY 8, 1906.—Adjourned meeting. Paper on "Ecclesiastes," by Jacob B. Brown.

FEBRUARY 15, 1906.—Adjourned meeting. Illustrated lecture, "Italy," by Dr. Alice Rogers Easby.

FEBRUARY 22, 1906.—Adjourned meeting. Illustrated lecture, "Cerebral Localization," by Dr. Edwin B. Twitmeyer.

MARCH 1, 1906.—Regular monthly meeting. Thomas McCollin, Maud Josephine Josaphare and Dr. Morton P. Dickeson were elected to membership. Report was made of the receipt from Benjamin H. Smith of a complete set of the genus Crataegus, as found in Delaware county. Sanford Omensetter reported the presence of the Field Sparrow. T. C. Palmer spoke at some length on Tadpoles and Salamanders.

MARCH 8, 1906.—Adjourned meeting. Lecture, "The Care of the House Beautiful," by Dr. Trimble Pratt.

MARCH 15, 1906.—Adjourned meeting. Illustrated lecture, "The Caroline Islands," by Dr. W. H. Furness, 3rd.

MARCH 22, 1906.—Adjourned meeting. Illustrated lecture, "The Great Antiquity of Man," by Prof. A. T. Clay.

MARCH 29, 1906.—Adjourned meeting. Illustrated lecture, "Southern California," by Prof. George A. Hoadley.

VESUVIUS.

The remarkable activity of Vesuvius at the present time is noteworthy and confirms the observation that the volcano has been much more active in recent than in early historic times.

Vesuvius is situated on the eastern shore of the Bay of Naples, its summit reaching some 4000 feet above the level of the sea. It consists of two portions, the present active volcano and a semicircular cliff to the north, the remains of a prehistoric crater of vastly greater size than the present one. At the time of the Christian Era nothing was known of previous eruptions of Vesuvius and its volcanic nature was not suspected. The sagacious geographer Strabo, however, discovered its true character and called attention to it. From his account and from other references it is known that for hundreds of years before his time (born about 63 B. C.) the sides of the mountain had been cultivated and only the loose ash on its summit was a witness of its volcanic nature.

After centuries and centuries of rest the volcanic energy of the mountain for the first time in history made itself manifest in a series of earthquakes, beginning A. D. 63, and culminating in the destruction of Herculaneum and Pompeii, A. D. 79. This was, perhaps, the greatest exhibition of volcanic activity ever known. Following this, Vesuvius rested practically dormant until the great eruption of 1631. Since then subsequent eruptions have occurred from time to time, the years 1766-67, 1779 and 1822 having been marked by special activity. Again, to-day, after a restless sleep of three-quarters of a century, comes the present eruption with its enormous destruction.

The Institute has just added to its mineral collection a particularly beautiful sample of carborundum, obtained from the Carborundum Company, of Niagara Falls. Carborundum, or, chemically, carbide of silicon, is obtained by heating coke and sand, with salt as a flux, in the electric furnace. It was discovered by Acheson in the attempt to make artificial diamonds.

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Vol. I, No. 4 July, 1906

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

T. Chalkley Palmer, Chairman, Trimble Pratt, M. D., Jacob B. Brown, Henry L. Broomall, Linnæus Fussell, M. D.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. I, NO. 4 JULY, 1906

THE SUNDIAL AND THE CLOCK.

Paper read on occasion of the presentation of a sundial to the Institute,

BY JACOB B. BROWN.

MR. PRESIDENT,

LADIES AND GENTLEMEN OF THE INSTITUTE,

LADIES AND GENTLEMEN:

It is a fine thing to have the power of conferring a magnificent favour while seeming to crave a slight one.

The Institute, not long ago, and half jestingly, asked of me a possession of mine, altogether trifling in intrinsic value, but endeared to me by undying memories. My sundial, namely, which circumstances had forced me to remove from its abiding place.

Those gentlemen builded better than they knew.

I could not have saved my sundial from darkness and obscurity. The Institute has rescued it and set it up in yonder window. The sun will shine upon it. It will be in good company. It will have life and perform its function, instead of hanging on the wall "quite out of fashion like a rusty mail, in monumental mockery." Another memory will be attached to it. And I ask my friends of the Institute to believe that their kind thought has gratified a grateful man.

I shall have the honour and pleasure of setting before you certain considerations inseparably connected with the use of a sundial. The simple facts any one may find in such easily accessible books as have been made for that purpose. But perhaps you will not be ill pleased to find yourselves spared the trouble of collating and consulting.

The existence of any record, however rude, of the lapse of time implies some knowledge of the heavenly bodies and their motions: since by these only can time be measured: a statement which, being analyzed, reduces itself to this that: — to all the inhabitants of earth there has been vouchsafed but one time-keeper, the earth herself as she rolls on her axis. For the motions of the heavenly bodies, just spoken of are but apparent results of the earth's movement.

The earth has no influence upon time, none whatever. She marks time; no more, while clocks and sundials record, with greater or less approximate correctness what she proclaims, daily and nightly, to her observing children.

Sundials have, as matter of course, been known from far back in antiquity. For since man was created there have been weary lands and the shadow of great rocks in the same. And how is it supposable that one, lying under such a shadow and finding it constantly and regularly moving over and away from him could exclude the idea that this movement might be made use of?

So that 700 years before the Christian era is a comparatively modern date; and I expect to be understood at once by educated persons when I mention the Sign of Hezekiah which was wrought about that time.

The account of this occurrence, given in more than one place in the Bible, is succinct and majestic.

King Hezekiah is "sick unto the death" and the prophet Isaiah bids him set his house in order, for he must die. But the king cries unto the Lord and the prayer is heard. Fifteen more years of life are promised, and a sign is spoken of. "Behold I will bring again the shadow of the degrees which is gone down in the sundial of Ahaz ten degrees backward. So the sun returned ten degrees by which it was gone down."

The Revised Version throws light on the passage by speaking of steps instead of degrees: "Behold I will cause the shadow on the steps which is gone down on the dial of Ahaz with the sun to return backward ten steps."

ISA. XXXVIII, 8.

The dial of Ahaz, or its like is a thing by no means unknown; and such structures still exist in various parts of the northern hemisphere. They are simplicity itself. A set of stone steps facing the north with a gnomon of some kind at the top to cast a shadow on the steps. The most obvious, because the most probable and convenient form of gnomon would be the obelisk with its sharply defined point. The greater the sun's southern declination the longer the shadow would be, and the farther it would be thrown down the steps. The greater the northern declination the shorter the shadow would be, and the fewer would be the steps "by which" it would go down.

And it is giving a people credit for small intelligence indeed to suppose that they would not mark the extremes and be fully aware that the shadow was longest at a certain time in winter; and then turning back became shortest at a certain time in summer.

They might, however, very well have failed to note that when the shadow was nearly at its longest it lengthened fastest and consequently that at that time a little lowering of the point of light extended the shadow very rapidly down the steps of the dial.

This can be tried at any moment with a candle for the sun, a bit of board or a book for the inclined dial, and a pin for the gnomon.

That there was a dial at Jerusalem is of record, for it is spoken of as the sundial of Ahaz, and probability points to its being such a one as is described, for its steps and the shadow cast upon them are explicitly mentioned.

Let us suppose the time to be the winter solstice at Jerusalem, towards noon, and the shadow on the dial of Ahaz at its utmost elongation. If, now, the centre of light which casts the shadow, so to speak, were lowered the shadow would be lengthened and go farther down the steps.

Sir Thomas Bosanquet, an eminent and widely known English banker who in a chapter on this subject has set forth all these considerations originally and much better than I can do it from mere memory, wrote to Sir George Airy (1801-1892), then Astronomer Royal, to ask whether at the time of the invasion of Sennacherib (the king of Assyria out of whose hand King Hezekiah was to be delivered) any eclipse of the sun took place. To his surprise and delight he received answer that in the year 712 B. C., toward the end of December, there occurred a partial eclipse of the sun, visible at Jerusalem, and it was the sun's upper limb that was obscured.

The latitude of Jerusalem is 31° 48′ 43″ North. Nearly enough that of Savannah, Georgia.

The facts and tables within reach did not enable Professor Airy to fix the day and hour of the occurrence, but there was no reason to doubt that, later on, should it be desirable, even these details might be established.

But to darken the upper half of the sun was to lower the point of light and lengthen the shadow — it may be ten steps — on the dial of Ahaz. That would depend somewhat upon the steps.

And surely the man can hardly be called weak who is overcome by such temptation to believe that the going down of the shadow on the dial of Ahaz was an occurrence entirely natural, and the inspired comprehension of it by the prophet was the miracle accorded.

There are one or two morsels of circumstantial evidence which may guide our belief a little.

"For Isaiah had said, let them take a lump of figs and lay it for a plaister upon the boil and he shall recover."

ISA. XXXVIII 21.

A lump of figs, dried and preserved for winter.

Moreover it seems not altogether without purpose that it should be recorded, II Kings, XX, 4 how "afore Isaiah was gone out into the middle court the word of the Lord came unto him" for in that very middle court may have stood the dial of Ahaz.

A marginal reading suggests "city" instead of "court," but this alters matters not much.

Moreover we read: — "And Isaiah said, this sign shalt thou have of the Lord that the Lord will do the thing that he hath spoken; shall the shadow go forward ten degrees or go back ten degrees?" Now the margin in the Revised Version assures us that the passage will bear a somewhat different translation: — "the shadow is gone forward ten steps, shall it go back ten steps?" And Hezekiah answers in his ignorance "It is a light thing for the shadow to go down ten degrees, nay, but let the shadow return backward ten degrees."

May we not then conceive the sick monarch lying on his bed in the "Winter House". The prophet bids him set his house in order for he must die; and so goes out; but while he is crossing the court King Hezekiah is crying to the Lord. The eclipse is on; the prophet sees the shadow on the dial ten degrees farther down than ever it was before, and is divinely inspired to understand the cause and meaning of this phenomenon. The word of the Lord then comes to the prophet. He is told to announce a reprieve to the dying man, and say that the sign of the same shall be the going back of the shadow. He turns again, declares the good news and bids the king await the sign. Slowly but duly the eclipse passes off, the shadow shortens to its normal length, and the Sign of Hezekiah is complete.

A natural event miraculously comprehended in an age to which knowledge of such things had not yet been accorded.

I have read, or have been told, that in the gardens of the Tuileries in Paris there is an automatic device for proclaiming apparent noon. A suitable burning glass is so adjusted as to focus on the touch hole of a loaded gun when the sun is due south. If the sun be unobscured a report follows and those that hear it look at their much trusted watches; almost always, however, with disappointment at not finding them mark twelve o'clock.

And, generally, if we compare the hour and minute of the day as declared by a good and trusty timekeeper with that marked by a well and carefully adjusted dial we shall see a difference which is sometimes greater and sometimes less and which at four periods of the year disappears entirely.

The dial marks "apparent time" and records, in daylight and clear weather, the true position of the real sun.

The clock marks "mean solar time" and is a conventional record of the motions of an imaginary sun.

I shall set forth if I can the difference between the two records and the uses of each.

The sundial is in these days rather for ornament than for use. It is of varied forms; vertical, horizontal or inclined; on wall and column and big block of masonry. Fancy wearies herself in its decoration; whole books, and very pretty entertaining books too, have been written about the sentiment of this implement, and the stern and melancholy rhymes which motto it.

There is a vertical dial on the wall of the house at Bartram's Garden.

Inside the Gas Works domain at Market and Twenty-second or thereabouts there stands a dial on a brick pillar. It dates from the time of open field in that neighborhood; and the subway works seem to have spared it.

The most usual form of dial is a level face figured five hours on each side of noon. The style that casts the shadow is accurately adjusted on the north and south line, and raised at an angle equal to the latitude of the place so as to point as nearly as may be to the pole of the heavens. For those who know other things instead of this — the elevation of the pole is equal to the latitude of the observer. The shadow falls on the noon mark when the sun passes the meridian and the other marks are so placed as to receive the shadow at the hour they name.

As the earth goes round the sun in its elliptical orbit the sun, not being in the centre, so to speak, of the ellipse, but in one of its foci,—there must be aphelion and perihelion, that is,—certain times when the earth is farthest from the sun and others when it is nearest the sun.

When the attraction of the sun has pulled the earth back from aphelion to perihelion it has imparted the additional velocity without which the earth could not pass the dead point and escape falling into the sun. Again, when by means of this additional velocity the earth has flown off to aphelion the sun's attraction is able, and no more than able, to overcome the earth's tendency to fly off into space. So the earth once more passes the dead point and comes back.

This variable speed of the earth in its orbit has a direct influence upon our record of the flight of time. The coming of the sun, namely, and not that of a star to the meridian is used as the point of departure and there is a difference between the two. Supposing that today the sun and a certain star pass the meridian at the same time they will not do so tomorrow. The sun will have moved to the eastward; that is to say, he will, owing to the earth's movement in orbit be projected upon the star vault at a point farther east than the day before, reaching the meridian later. And the difference is of course cumulative. But the velocity of the earth in orbit is variable; therefore the sun suffers variable "retardation" in coming to the meridian.

The sun, then, comes to the meridian at intervals differing in length; and the dial correctly marks these intervals.

It would be difficult, almost impossible to construct convenient timekeepers which should follow such variations, nor would it be desirable.

Mean solar time then, as contradistinguished from apparent time is a conventional record kept by civilized man of the revolution of the earth on its axis; and, as in the case of

Leap Year, the record is purposely so kept as to accord at periodical intervals only with the natural fact.

If the sun moved eastward on the equator at the rate of one degree of arc, corresponding to four minutes of time, per day he would complete his circuit in 360 days; but he requires a little more than 360 days; — in fact, about three hundred and sixty-five days and a quarter to come round: and therefore need not move eastward quite so rapidly. In fact he would, advancing as he does at slightly varying velocities but always completing the circuit in an unvarying period move at an average daily rate of 3m. 56sec. (nearly); reaching the meridian that much behind the star he accompanied the day before.

To the already mentioned causes of difference in speed between this sun in the equator and the real sun is added that of the different arcs traversed by each in a given absolute space of time. Any two meridians, namely, intercept an arc on the equator and an arc on the ecliptic, and these are not equal. Near the equinoxes the arc on the ecliptic is the longer. Near the solstice the arc on the equator is the longer.

Neglecting, then, certain not necessary details, an imaginary sun is supposed to move in the equator with unvarying velocity and to complete the yearly circuit in the same time with the real sun. The interval at which he passes the meridian is called an even twenty-four hours; and the eighty-six thousand, four-hundredth part thereof is the mean solar second, the second of common life, told off with approximate accuracy by common clocks.

Let us now digress a moment and at the risk of going over ground more than once let us recall to memory *what is a second?*

Everything else left out of the question, the earth revolves once on its axis in an invariable space of time, marked by the return of a star to the meridian. This is called a mean sidereal revolution of the earth. The word is "invariable" and there is yet nothing to shew that we may not understand the expression in its fullest sense. This space of time is divided into twenty-four equal parts or hours; each hour into sixty minutes and each minute into sixty seconds; in all 86,400 seconds.

The second, then, is the eighty-six thousand four hundredth part of the earth's mean sidereal revolution; and it is an immutable unit.

But it is not the unit that is used, for it is not convenient.

Owing to the movement of the earth in its orbit it comes to pass that, supposing the sun and a star to be on the meridian at the same time on a given day the sun will on the next day come to the meridian some little time behind the star. The difference is rather less than four minutes, and varies according to various circumstances. For convenience it is imagined constant and a "mean solar day", in reality 86,636.96 seconds long is called an even 24 hours.

The 86,400th part of this is taken as the second of common life. It is one sidereal second and two-hundred and seventy-two one hundred thousandths of a sidereal second (1.00272). This second is told off by one beat of a pendulum — in vacuo — 62° Fahr. — latitude of London — sea level — and thirty-nine inches and thirteen-hundred and ninety-three ten thousandths of an inch long. It is the second of common life, of clocks and watches; the standard second; permanent, invariable; because it bears a known proportion to a quantity which is permanent and invariable.

The real sun is sometimes before the mean sun in yearly course and sometimes behind. The more he is before the real sun the greater his retardation, as it is called, in coming to the meridian, and the more he is behind the more he precedes the mean sun in coming to the meridian. It follows that the two are together at certain times. And it is clear that they are together whenever the real sun, being behind, is so accelerated by the causes set forth as to overtake the mean sun; and again when having thus overpassed the mean sun he is so retarded as to have lost his lead and fall behind.

The expressions "sun's yearly motion" and "earth's yearly motion " mean one and the same thing as far as visible results go. The two ideas are interchangeable, and are so treated in astronomical discussions.

As we in this North Temperate Zone face the sun in the South his yearly motion is from West to East, from our right to our left "through the button hole" ; against the hands of the watch which we hold before our face. The outward and visible sign of this is the slow movement of the constellations over toward the west. The daily motion is of course the other way.

One important use of mean solar time, it will be perceived, is to save countless millions of people the intolerable and useless trouble of trying to understand the apparently irregular motions of the true sun.

And here I may remark that I have not attempted any discussion of "dialling" or the draughting of the "hour marks" ; for the simple and sufficient reason that I know nothing, or very little about it. It is a somewhat intricate matter. There are those that earn money by means of it ; and those only find it worth their while to master the science.

The difference of time between the arrivals at the meridian of the mean sun and the real sun is called the "Equation of Time." It is given roughly in the Almanac, for every day in the year ; and in the Nautical Almanac is set out down to the hundredth part of a second. It is added (algebraically) to apparent time according to circumstances.

That is to say.

The expression "Clock Fast" is used to signify that the true sun does not pass the meridian until after mean noon.

The expression "Clock Slow" is used to signify that the true sun passes the meridian before mean noon.

"Algebraically" means added with the proper sign, plus or minus.

And dial or apparent time is taken as the basis.

So that we must add the equation with the plus sign to dial time if the clock be fast.

And we must add the equation with the minus sign to dial time if the clock be slow.

To those who do not happen to be aware of it, — to add with the minus sign is to subtract.

We have now reached the proper place for a remark.

The Medo-American who compares watch with dial will be as much disappointed as the Parisian of a few moments ago unless he remember to take account not only of time Equation but of a fatal 92 seconds which separate our local mean solar time from the mean solar time of 75° west of Greenwich.

In order to a due understanding of why this is so a word or two about Standard Time will be in order. Elementary enough to some, but not to all.

If correctly kept, mean solar time varies with every meridian at the rate of one hour of time to every fifteen degrees of arc; four minutes of time to every degree of arc, and four seconds of time to every minute of arc. For example, in our latitude, say 40° north, let it be mean solar noon at any place, — here where we are if you choose. It will then be four seconds after noon at a place 1552 yards along the parallel to the eastward; or one second after noon at 388 yards to the eastward; and equally of course one second before noon by the watch at 388 yards to the westward along the parallel. The general fact is the same in any latitude, but the number of yards would be different, for reasons easily found in the proper place.

The two extremities of the United States, Quoddy Head in Maine and Attu Island in Alaska are separated by 121° 8′ of longitude; being equivalent to 8h 4m 32sec of time.

The instant of absolute time, the same for the whole universe, is recorded as one thing in one place and another thing in another.

To lessen the inconvenience arising from these necessarily differing records the mean solar time of some suitable meridian is used over a wide tract of country. In England the time of Greenwich Observatory is in use; in France, that of Paris; in Italy that of Rome; and so on.

But the United States is very wide, so wide that no one standard will suffice. The country, therefore, is divided into four zones of fifteen degrees of longitude each, corresponding to one hour of time.

The EASTERN ZONE, 7° 30′ on each side of the meridian 75° W. of Greenwich, which meridian passes very near Philadelphia.

The CENTRAL ZONE, 7° 30′ on each side of the meridian 90° west of Greenwich. Which meridian passes very near New Orleans and St. Louis.

The MOUNTAIN ZONE, 7° 30′ on each side of the Meridian 105° W. of Greenwich, which meridian passes very near Santa Fe, New Mexico, and Pike's Peak, Colorado.

The PACIFIC ZONE, 7° 30′ on each side of the meridian 120° west of Greenwich, which meridian passes not far to the east of Sacramento, Cal. And, roughly speaking, follows the course of the Rocky Mountains.

There is also a Colonial Zone to the east of the EASTERN ZONE. It is wholly outside of the United States, and it is not often mentioned.

Those cities which are near the middle of the Zone are the most fortunate; for their local mean solar time differs but little from standard time, and the time of the contiguous Zones does not concern them. Philadelphia, for example, and, exactly speaking, The City Hall, is by the U. S. Coast and Geodetic Survey in lon. 75° 9′ 50.53″ west of Greenwich and its local time differs only forty seconds (nearly) from Eastern Standard time. Those cities, on the contrary, which are at the boundaries, have to keep three different records.

It will thus be seen at once that those Standard time pieces (so to speak for brevity's sake) those standard time pieces only which come into use on the meridians which bisect each zone of time will agree with the sun on Zero Day. For at all other points mean noon and standard noon, being parts of the same conventional system, are permanently separated from each other. Now the true sun being sometimes ahead of these mean solar points and sometimes behind them, he must be with them, with the one or the other, at certain periods of the year; — in fact at four periods of the year, as shall be shown.

The equation of time is to be added algebraically to mean solar time in order to keep it with the sun.

Generally, therefore, on those days only when the equation of time added with the proper sign to mean solar time makes the same equal to standard time, will standard time, which we carry and not local mean solar, agree with sun time.

As to the proper sign. Let it be remembered that those who live to the eastward of the bisecting meridian must subtract from local mean solar to get standard time; those who live to the westward must add.

But it is only when the clock is ahead of the sun that local mean solar may be drawn down automatically, so to speak, to agree with standard, that the standard watch can agree with the sun. That is to say while the clock is "fast"; so that those living to the eastward of the bisecting meridian add with the same sign and all dates of agreement between standard and sun will fall to the "clock fast" side.

On the contrary it is only when the clock is behind the sun that local mean solar may be brought up automatically so to speak to agree with standard, that the standard watch can agree with the sun. That is to say, while the clock is "slow." So that those living to westward of the bisecting meridian, add with the plus sign, and all dates of agreement between standard and sun fall to the "slow" side of the vertical.

I am now going to try your patience; — for a few minutes, only, however, by inquiring minutely what goes on in this connection at about 40° north and 75° 23′ W. of Greenwich. In short at Media. What is said will apply to any other point in the U. S. if the proper change of data be made. And I shall have to say the same thing more than once.

We have seen that on the 1st September at Media mean noon the sun is on the meridian and the shadow of the style covers the XII mark.

But the watch says one minute and a half after mean noon, which is standard time, the time of a place to eastward of us.

Now after Sep. 1st the sun is gaining, and on the meridian before the mean sun; in fact more and more every day; and there will be a time when the true sun will be on the meridian 92 seconds before the mean sun; that is to say on the meridian by standard noon (nearly). This takes place between the 5th and 6th of September. On the 6th of September, therefore, dial and standard watch will be together, nearly but not exactly, at noon.

From this on until Nov. 3rd the sun is more and more ahead of mean solar time. After that date he is less and less ahead of mean solar. So there comes a time when he is 92 seconds ahead of mean solar. But 92 seconds ahead of mean solar is standard and on that day standard watches will agree (nearly but not exactly) with the sundial at noon. The day is between the noons of 21st and 22nd December. The Nautical Almanac enables us to fix the hour and minute. Then comes Zero Day, 24th Dec. and the sun is on the meridian at 92 seconds past noon by standard time.

The sun now begins to fall behind mean solar and does so more and more until Feb. 11th when he begins to overtake it; and does so overtake it on the 15th April, Zero Day. At this point again the sun begins to outstrip mean time more and more, until he have done so by the space of 92 seconds. But 92 seconds ahead of mean time of Media is standard time. Sun therefore agrees with watch at some period between the noons of 22nd and 23rd April.

Nautical Almanac for details.

From 15th April on, the sun is ahead and more and more ahead until May 14, when he begins to fall behind, and about June 7 is no more and no less than 92 seconds ahead of mean time. But 92 seconds ahead of Media mean time is Standard

Time, so that on this day again standard watch and sundial noon fall together nearly enough ; not exactly.

After June 14th the sun is behind, and more and more behind until July 26th when he begins to move faster and to overtake mean sun. He does so in fact on Sep. 1st which is again Zero Day ; and completes the circuit of the year.

Now the sundial, owing to penumbra and other causes, roughness of manufacture and almost inevitable lack of accurate adjustment always allows a possible error of from ten to twenty seconds. It is not a scientific instrument at all.

Moreover, the equation of time is not the same by several seconds on the same day of every year. This is one of the apparent but self-compensating irregularities by which the Creator has provided for the stability of the system.

And, finally, though it is usually so taken for granted even in the text books the moment of exact accord between sundial and local mean solar is not noon precisely on Zero Day. As will be seen by a look into that final arbiter, the Nautical Almanac.

I shall now quit didactics altogether and offer you a kind of dream of astronomical architecture.

It would be entirely within the resources of science to study all this dream out and explain it ; but I have not done so, and do not mean to. Very vague, therefore, is my notion of the specific use to which the structures you are to hear of are put. What I wish to set before you is an idea of the mighty works that may shew themselves forth on the lines shadowed out hereinbefore, and the exemplary regardlessness of cost evinced by some Oriental rulers when they put their trust in men of science.

I read the chapter in the June number (1840) of the old Penny Magazine while I was a boy and came across it by chance only the other day.

The Guntur Muntur (or Royal Observatory) of Delhi was built by Rajah Jeysing in the reign of Mohammed Shah about the year 1710. The immediate objects for which it was erected may best be understood from his own published account.

"Sewai Jeysing from the first dawning of reason in his mind and during its progress towards maturity was entirely devoted to the study of mathematical science; and the bent of his mind was constantly directed to the solution of its most difficult problems. By the aid of the supreme artificer he obtained a thorough knowledge of its principles and rules. He found that the calculation of the places of the stars as obtained from the tables in common use gives them widely different from those determined by observation; especially the appearance of the new moons. Seeing that very important affairs both regarding religion and the administration of empire depend upon these, and that in the time of the rising and setting of the planets and the seasons of eclipses of the sun and moon many considerable disagreements of a similar nature were found" he represented the matter to Mohammed Shah; whom Jeysing terms in language that proves him as apt a courtier as he was truly an able, learned and scientific man: — "His majesty of dignity and power; the sun of the firmament of felicity and dominion; the splendour of the forehead of imperial magnificence; the unrivalled pearl of the sea of sovereignty; the incomparably brightest star of the heaven of Empire, — whose standard is the sun, whose retinue the moon, whose lance is Mars and his pen like Mercury, with attendants like Venus; whose threshold is the sky, whose signet is Jupiter; whose sentinel Saturn; the Emperor descended from a long line of kings; an Alexander in dignity, the shadow of God, the victorious king Mohammed Shah; may he ever be triumphant in battle."

A reply was given to his representation: —"Since you who are learned in the mysteries of science have a perfect knowledge of this matter, having assembled the astronomers and geometricians of the faith of Islam and the Bramins (sic) and Pundits and the astronomers of Europe, and having prepared all the apparatus of an observatory do you so labour for the ascertaining of the point in question that the disagreement between the calculated times of those phenomena and the times in which they are observed to happen may be rectified."

Jeysing justly remarks that this was a "mighty task," but "having bound the girdle of resolution about the loins of his soul" he constructed several of the instruments of an observatory in brass. "But finding that brass instruments did not come up to the ideas which he had formed of accuracy because of the smallness of the size, the want of division into minutes, the shaking and wearing of their axes, the displacement of the centres of the circles and the shifting of the planes of the instruments" he erected the existing great works "of stone and lime of perfect stability with attention to the rules of geometry and adjustments to the meridian and to the latitude of the place." He found the new instruments successful; but in order to confirm the accuracy of the observations made by them he caused others of similar kind to be constructed at Sewai Jeypur, Matra, Benares and Ougein; and found his first calculations verified.

Jeysing presented his new set of tables to the emperor, who stamped them with his approbation. The almanacs of Delhi and all astronomical computations are still made from these tables.

The observatory is situated amid piles of ruinous palaces, attesting most impressively the former but lost magnificence of Delhi; — without the gates, about a mile and a quarter distant from the city. It consists of several buildings.

The first is a large equatorial dial, tolerably entire in its outline; but the edges of the gnomon and of the circle on which the degrees were marked are broken in several places. The gnomon measures above 118 feet at its base, (each side) is computed at 104 feet and its perpendicular height at nearly 57 feet. This instrument Jeysing speaks of as "the prince of dials." It is built of stone, but the edges of the gnomon and of the arches where the graduation was were of white marble, little of which remains.

Another equatorial dial, smaller and of different construction stands at a little distance in a very perfect state. The gnomon which stands in the middle contains a staircase leading up to its top and on either side of the gnomon are concentric semi-circles having a certain inclination to the horizon. They represent meridians removed by a certain angle from the meridian of the place. On each side of this part is another gnomon of equal size to that last mentioned. The north wall of this structure connects the three gnomons at their highest end and on this wall is described a graduated semi-circle for taking the altitudes of bodies that lie due east or west from the observer. A double quadrant is described on a wall to the westward of the building. South of the great dial are two buildings apparently exactly resembling each other, and adapted for the same purpose, the observation of the altitude and azimuth of the heavenly bodies. They are circular, with a pillar in the centre of each rising to the top which is open. From this pillar at the height of about three feet branch horizontal radii of stone to the circular wall. The radii are thirty in number, the spaces between them are equal to the radii, which increase in breadth as they recede from the pillar. In the wall at the spaces between the radii are recesses with holes to enable a person to climb to the top and containing each of them two windows. On the edges of the recesses are marked the degrees of the sun's altitude as shown by the shadow of the pillar. The degrees are again subdivided into minutes. The spaces in the wall are divided into six equal parts or degrees by lines drawn from the top to the bottom. By observing on which of these the shadow of the pillar falls the sun's azimuth is determined. The altitude and azimuth of the moon and of a star may also be found by means of this erection.

The dimensions of the building are thus given by Mr. Hunter: — Circumference of the building 172 ft. 6 in.; of the pillar 17 feet. Length of each of the radii 24 ft. 6 in. The height of the building is not stated. Mr. Hunter remarks: "I do not see how observations can be made when the shadow falls on the spaces between the stone radii or sectors; and from reflecting on them I am inclined to think that the two instruments, instead of being duplicates may be supplementary one to the other; the sectors in the one corresponding to the vacant spaces in the other, so that in one or other an observation of any body visible above the horizon might at any time be made.

Between these two buildings and the great Equatorial dial is an instrument formed of mahogany in the shape of a concave hemispherical surface to represent the inferior hemisphere of the heavens. It is divided by six ribs of solid work and as many hollow spaces the edges of which represent meridians at the distance of 15 degrees from each other. The diameter of the work is 27 ft. 6 in.

See some account of the astronomical labours of Jayaschina Rajah of Amthere or Jayanaga. By Wm. Hunter Esq. in Asiatic Researches. To this paper (says the chapter in the Penny Magazine) we are indebted for the information contained in the above account.

PENNY MAGAZINE

June 6th 1840

So much for India.

Compare with all this, if you see fit, the 200,000 dollar telescope whose lens had to be packed in cotton and slung with delicate art lest its shape should change as it was being transported to its place of usefulness.

Mohammed Shah was quite right and Lick of California not wrong. Each lit the lamp of sacrifice, and did the best he knew how.

And those who remember the Rollo books may recall how Rollo bragged of the noon mark which Jonas had laid down upon the barn floor; and then was, I fear, somewhat disgusted to find that his little cousin Mary had just as true a noon mark, and far finer, laid down on a bit of cardboard with an upright pin for gnomon in a south window of her house.

There is a dial on the front of San Lorenzo in Florence which I used to pore over hopelessly. A vertical dial in marble and bronze.

Rather sombre is the effect of the stony silence in which many useful and essential facts of the universe are proclaimed by this just and emotionless monitor.

I wish I were a poet to say something worth hearing about harnessing a shadow.

I chose to write in lettered brass upon the pillar of our dial, where it stood before, the grim words of the high-hearted HOTSPUR:

> " O, gentlemen, the time of life is short!
> To spend that shortness basely were too long
> If life did ride upon a dial's point
> Still ending with the arrival of an hour!"

THE NATURE OF DIATOM MOTION.

BY T. CHALKLEY PALMER.

The reality of motile phenomena in the case of diatoms would seem to be almost the only point in the whole case whereon biologists are in agreement. Diatoms do move — so much is conceded. This is something, and we may well put it down with thankfulness as not a subject of controversy. Differences in plenty remain.

When a diatom, or a desmid, or any other small organism is seen to pass from point to point in a drop of water under the microscope, at least two questions suggest themselves to the mind of the observer.

First, Is the organism moving spontaneously and as if with a purpose, or is it passive in the grasp of "the environment?"

Second, What is the mechanism through the action of which the motion is accomplished?

Now as to the first question, it might be thought that the answer is implied in the undisputed statement that diatoms do move. If they move, not when currents of water wash them along or other organisms knock them about, but in the absence of any disturbances of this sort, and in a regular and characteristic manner, why is not this motion spontaneous? Why not indeed? The writer knows of no reason, and is ready at once to say frankly, and shamelessly if you will, that he has no doubt in the world about the essential spontaneity of the diatom motion. The moving diatom gives the plainest and most indisputable evidence that it is actuated by internal, energetic, *protoplasmic stress.* The evidence is many-sided. It consists not only of the many obvious struggles against obstacles of various sorts that chance puts in the path, but also and especially of bio-chemical facts that would seem conclusively to correlate this activity with the motile activity of protoplasmic organisms in general. Now when all the evidence obtained gives such result, one is inclined to say that the answer to the first question is obtained. But we have still to reckon with the vast subtlety of the great intellects that have set themselves of late to the task of abolishing the fetish of "vital force."

It would be impossible, at the present time, to go into the broad question of the nature of vital phenomena in general. There is no time to consider whether or not animals and plants, one and all, are merely so many shuttlecocks, so many footballs, so many packets of chemicals, all busily engaged in "reacting" to this, that and the other bat, or kick, or string, or other device brought to bear upon them by the great and wise god "Environment." If, in the end, the *Amœba* is shown to be no more than an unusually persistent foam such as any one can make with olive oil and potash; * if, presently, by virtue of some additional chemicals, these drops of foam can be made to start out in search of food, absorb it when found,

* O. Bütschli: Protoplasm and Microscopic Foams. Translated by E. A. Minchin. London, 1894.

increase in bulk, cut themselves into two new drops of foam each as large as the original; and if these two daughter-drops repeat the life-cycle of the mother-drop, and in turn give rise to four; and if at the end of a number of subdivisions, each of the now multitudinous drops of foam closes itself up tightly in a silicious cyst and rests awhile; and if, lastly, each drop again bursts its cyst and starts life anew — when all this has been brought about, then perhaps we shall be willing to say that the "vital force" is indeed a fetish. Then the diatom, along with all the rest, may be viewed merely as a plaything of the inorganic forces of light, heat, chemical attraction, osmotic pressure and so forth. Meantime such views are premature, radical, ultra-scientific.

The exceedingly tenacious and stubborn nature of the diatom motion has been the subject of frequent remark. A single comparatively minute *Navicula* or *Nitzschia* will often create great and altogether disproportionate disturbance in a drop of water containing relatively long filaments of algæ. Comparatively large masses of debris will be resolutely pushed aside. A single cell of *Eunotia*, when just assuming the motile condition and on the point of separating itself from its native filament (which may be composed of a hundred cells each as large as this), will often turn the whole system of cells upside down, drag it about and force it over obstacles apparently insuperable.

The very definite and determined manner in which the motile *Eunotia* brings itself into right relations with the solid surface of the slide has been described elsewhere.* This phenomenon, so significant of the real nature of diatom motion, is parallelled in case of other species that are of such structure as to make possible their falling upon the substratum in the wrong position. For instance, the larger *Naviculæ* are prone to fall upon their girdle sides, in which position the raphes of both valves are out of contact with the slide. If the diatoms are in good motile condition, first one and then

* Proc. Acad. Nat. Sci., Phila., 1898.

another will be seen making evident attempts to revolve itself through an angle of 90° in a direction at right angles to the longer axis. These attempts are intermittent, evidently of an energetic nature, and in the end generally successful. The cryptic mechanism is plainly situated along the raphe. Once the diatom has balanced itself upon its valve, with this raphe in contact with the slide, it proceeds to crawl, *but not until this has been accomplished.** The manifest struggle undergone in order to attain this position shows both the necessary relation between the raphe and a solid surface, and the unprecedented nature, in the diatom's experience, of a surface of such glassy smoothness as is presented by a microscopical slide. In the native pool, as a matter of course, the endless inequalities of the bottom always present themselves invitingly. Under the microscope, also, any chance filament, or large grain of sand, or collection of solid debris, is utilized when within reach of the raphe.

Several familiar motile diatoms, such as *Surirella*, most species of *Nitzschia*, etc., have no occasion for any such preliminary struggle, for the very excellent reason that it is practically impossible for them to rest upon a solid surface without some part of their raphes being in contact therewith. In the case of *Campylodiscus*, also, there is no conceivable position of stable equilibrium in which they would be helpless. On the other hand, certain species of *Navicula* avoid the necessity of such struggle by going about in groups of four joined socially girdle to girdle in the bond of a common coleoderm; and in the world-famed *Bacillaria paradoxa* we have the perfection of coördinated activity, with a correspondingly perfect ability in dealing with conditions untoward for locomotion.†

* In the paper already cited, the writer was inclined, on the strength of observations previously on record, to agree with the view that the Naviculæ swim. Further study at first hand has shown this notion to be untenable.

† The relation between shape and structure of the frustule and normal habitat and habit is a most enticing branch of diatom philosophy still largely unexploited.

The unsophisticated, simple student of diatoms, desmids, algæ and their like might well be justified, in the light of such observations as the above, in holding rather tenaciously to the belief that motion in the particular organisms now dealt with is to be classed with motion of other protoplasmic organisms, as a product of *exertion* of the living substance. But because the mechanism by which the diatom propels itself is not obvious, and because, if the remark may be permitted, the elementary bio-chemical facts of the case are not kept well in view, one attempt after another continues to be made toward drawing an unwarranted distinction.

Let us be elementary for a moment. A man exerts himself to climb a mountain, or to dig a trench, or to shovel coal. He expends energy in so doing. This energy is derived, ultimately, from certain food he has eaten; and in converting this food into work, he uses up also a quantity of oxygen. The process results in the expiration of an equivalent quantity of carbon dioxide. The chemical process involved is of the class known to science as exothermic, in that it sets free heat, or its equivalent in energy in some other form, or mostly both heat and some other form of energy. The operation is expressed in principle by the reaction

$$C_6H_{12}O_6 + 12O = 6CO_2 + 6H_2O$$

wherein a sugar is converted into carbon dioxide and water. This is the exact reverse of the typical endothermic plant reaction

$$CO_2 + H_2O = CH_2O + 2O$$

which goes on in sunlight within the chlorophyll-bearing cell and builds up from inorganic gas and liquid the carbohydrates, the hydrocarbons and their endless derivatives. Here, indeed, we have an operation that takes place by virtue of the outside energy poured into the vegetable cell in the shape of light from the sun; here, indeed, the protoplasmic structure, however wonderful, is in a sense the passive recipient of environmental influences. Moreover, here is the straight gate wherethrough comes into the world the power of motion in living things both great and small. But while this "chlorophyll reaction" is thus at the bottom of all motion, and a condition precedent thereto, it is not the effect, or the symptom, or the chemical outcome of any protoplasmic effort whatever. The symptom, the result and the chemical accompaniment of protoplasmic work, such as is typified by muscular labor, is the absorption, the disappearance of oxygen, as such, and the expulsion of carbon dioxide. To perform work the organism must have oxygen, and in performing work it gives off carbon dioxide.

Now this is the question: Does the diatom require oxygen in order to move, and does it, as a result of its motion, give off carbon dioxide?

I have had occasion to state* that whilst in a case especially studied, filamentous and vegetative diatoms enclosed in glass tubes with water slightly tinted with hæmatoxylin and partly saturated with carbon dioxide, did, in short order, under the influence of bright sunlight, absorb much carbon dioxide and generate much oxygen; the same diatoms, possibly stimulated into the motile condition by the oxygen so generated, expanding over the inner surfaces of the tubes and continuing for hours in semi-darkness their lively motions, reversed themselves and now gave out again large quantities of carbon dioxide, so that the deep-red color of the oxidized hæmatoxylin was altered to a yellowish brown. This result, which was considered significant of the essential nature of motile activity in the case of *Eunotia*, was further fortified by the observation of Müller that motile diatoms came gradually to rest under a cover glass in the absence of a sufficient supply of oxygen, and that when oxygen was introduced anew the motion was resumed. Müller's statement, moreover, was later confirmed by direct and repeated experiments on various

*Proc. Acad. Nat. Sci., Phila., 1898.

motile diatoms. Nothing, it would seem, could be more conclusive as to the essential sameness of the nature of motion in monads and diatoms, than the fact that both monads and diatoms require oxygen in order to perform motion, that they come to rest when oxygen becomes scarce, and that they resume their motion when oxygen is again supplied.

The predominant chemical process of diatom motile activity, then, is exothermic, and involves absorption of oxygen and evolution of carbon dioxide.

Since the above facts are by no means new, it is with a feeling of pained surprise that one comes to read the recent article of D. D. Jackson, on "Movements of Diatoms and other Microscopic Plants."* This writer begins with pointing out the difficulty observers have experienced in arriving at an understanding of the mechanism of motion in diatoms. Several views are referred to, including that of Nägeli, who suggested that "the motion is due to endosmotic and exosmotic currents" and that of H. L. Smith, who believed he had demonstated "that the motion of the *Naviculæ* is due to injection and expulsion of water." After stating that currents of some sort can be seen in operation along the valves of diatoms, the author says:

"That these currents exist there can be no doubt, but that the motive power is not due to the expulsion of water will shortly be demonstrated. The first intimation of the true nature of this motion was suggested by the action of a lithia tablet in a glass of water. The bubbles of carbonic acid gas given off set up the exact motions in the tablet that have been so often described for the movements of diatoms."

Mr. Jackson then describes these motions, and shows how they can be duplicated by artificial diatoms of aluminium cut to a naviculoid shape and immersed in a solution of strong caustic soda. Bubbles of hydrogen were generated, and the small pieces of aluminium repeated the movements of the dia-

*American Naturalist, May, 1905.

tom "in a remarkable manner." Still more curiously, if grooves were cut in the metal, the power of motion was greater than ever, and the comparatively active motions of the *Raphidiæ* are thus parallelled. It is therefore evident, thinks the author, that it is an evolution of gas that produces the motion of the diatom ; and we are told that since motion does not take place in diatoms unless the light is fairly strong, we are arriving at a conception of the true nature of the movements in these organisms. The stream of gas, in short, is the oxygen which diatoms give out in daylight like other plant cells. The movement to and fro, we gather, is due to the relatively greater expulsion of oxygen in first one and then another half of the cell, owing to the unequal illumination of the two ends. The diatom is supposed by some to proceed fatally toward the light. At this point, however, there is a lack of clearness. How evolving gas at the front end should drive the diatom forward one is at a loss to imagine. However: "The evolving gas seems to act at times as a propellor to push the organism forward and at other times to exert a pulling action to raise the growth on end."

Mr. Jackson then proceeds to apply the same explanation, *i. e.*, evolution of oxygen, to the movements of the desmids, the *Cyanphyceæ* and generally to plant organisms the mechanism of motion in which is not obvious. Now it is to be remarked, that the explanation palpably breaks down in the case of *Bacillaria paradoxa*, and that no such explanation is needed for those blue-green algæ that manifestly crawl along painfully like a worm. Kozlowski,* in a manner much more systematic and plausible, proposed for explanation, not the evolution of oxygen, but the absorption of carbon dioxide, etc. He supposed that, given a diatom with the two ends unequally illuminated, assimilation would go on more rapidly in the brighter light, and that the inward current would draw the diatom along toward the light source. But it must be

* Botanical Gazette, Vol. XXIV.

plain enough that the inward current of carbon dioxide of Kozlowski, and the outward current of oxygen of Jackson, so far as these depend upon the photosynthetic reaction, will go on simultaneously, will measurably balance each other, and that the effect, so far as concerns motion of translation of the diatom, will be nil. So that Kozlowski and Jackson, between them, have merely brought it about that the diatom shall stand perfectly still.

The fact is, there has been a great deal of ingenuity wasted in the endeavor to explain diatom motion as an effect of the inorganic forces operating upon a vegetable cell that is capable of nothing but a reaction. Too much stress, in this connection, continues to be laid upon the real and definite chlorophyll reaction. Also, the attraction light exerts upon the diatom has been exploited in these theories beyond what is reasonable. It is true that diatoms "react" in a manner that is "positively phototactic" in the sense that when put into a tube dark at one end and illuminated at the other, they gradually assemble about the lighted end. So, also, with the hen, that reacts positively to the first streak of dawn. But the hen modifies her reaction at a point short of insanity, and goes no farther toward sunrise than the garden where lurks the early worm; and the diatom, we must conclude (since diatoms still remain to us in the world) has been able, year by year, so to temper its desire for more and ever more light, as to avoid very often those direct rays of the sun that are so speedily fatal to it. In short, while the direction of motion in diatoms is influenced by such agents as light, and this motion is stimulated by oxygen and a certain degree of heat, there is no reason whatever for thinking that the operation of these agents "causes" the motion, or "explains" it, any more than such modifying or stimulating influences cause motion in any other organism.

The egg cells of ferns secrete malic acid, and malic acid is as attractive to the spermatozoids of ferns as it is to the small boy who is ready to steal apples to get it. As a consequence, the spermatozoids go along into the egg cell with the same vigor exhibited by the boy climbing the tree. But merely to label the phenomenon "positive chemotaxis" is not to explain the motion of the spermatozoid. The malic acid did not set the spermatozoid in motion. It was already going. A cloud of spermatozoids will be going in all possible directions. The acid of the egg cell merely makes it pleasant for the spermatozoid to swim in one special direction rather than in any and every direction. Meantime each and every spermatozoid has started forth with a certain small store of energy-producing material, starch or some other carbohydrate or hydrocarbon or the like, and is drawing upon this endowment every moment of its brief career, converting it in effect into water and carbon dioxide as it goes; until at last, in case no delicious stream of malic acid guides it to its proper place, it dies of exhaustion. The striving, agonizing piece of protoplasm has used up its food upon the quest and has worked itself to death. So far is motion in the fern spermatozoid from being explained by the operation of any force outside itself.

There is no radical difference between this case and that of the diatom. Both belong to the wrestling race of living things; both wrestle, and both expend stored-up energy in the process. Both need oxygen and both exhale carbon dioxide as they go. Details differ, since the diatom cell manufactures its own store of food, and stows it away in the shape of drops of an oil soluble in ether, while the spermatozoid's has been furnished for it by its mother plant. But no matter about details. The man eats bread and meat. It is the same in principle all the way along, from man to diatom, and so down to the *Amœba*.

As to mechanism, that is a subject of itself, and one set round with difficulties.

THE CONFLICT OF LANGUAGES.

Abstract of Lecture before the Institute.

BY HENRY L. BROOMALL.

Of the arts and doings of a community some are known or practiced by all its individuals and some by only a part of them. The arts common to all the individuals of a community are acquired in childhood and the social status of the child protects them generally against foreign influence. Language, personal morals and domestic customs are so acquired and their essential elements transmitted mainly within the family circle. The arts, business, commerce and politics, are the practice of only a part of the community and the acquisition of the individual later in life. The former are necessary to the individual as a member of society: they are easily acquired by him from his early environment: they are continued in practice throughout the individual's life. The others are but an advantage to the individual's career: they are studied and practiced with definite purpose by the adolescent and mature: they may be laid aside or interchanged. The first are rarely forgotten: the others are easily lost.

And, of all these things, speech is the first acquired, the easiest mastered and the most necessary to the individual. As these facts are the basis upon which our conclusions must rest, our first consideration should be given to the circumstances attending the acquisition of his language by the individual.

The child does not become a member of the community until he speaks and understands its language. If he is mentally or physically so defective as to be unable to acquire the language, he is socially outbarred: he is a part but not a member of the community. If he does not learn the vernacular, he never learns any language. Born with inherited tendencies to express feeling and thought by speech, the particular language he acquires is determined by his environment. In the early part of his life this environment is limited to his family and its influence upon him is exerted mainly by the mother. Her voice first responds to his and soothes or stirs his emotions. His wants and pains correlate themselves with the tones and accents of her voice and to these again his own cries accord. Thus, by constant imitation and repetition, sound and sense become associated in his mind. This is the beginning of the acquisition of the vernacular. As the child's intelligence develops, meanings and their associated sounds become more certain and definite, and his intellectual growth largely consists in working up to and into the more exact import of words and phrases which he has already understood vaguely but sufficiently for childish purposes.

An important feature of this process of language acquisition lies in the relative order in which grammar and vocabulary are mastered. The traditional notion is that the learner acquires first a small homely vocabulary and then the grammatical machinery by which these words may be put together to express a proposition. But in fact the process is compound: it is equally as much analytic as synthetic. Observation of the child shows that he learns by phrases, and that even what we term words are first used by him as phrases. His mind at this early stage of development has no use for mere nouns or names or adjectives. He only thinks of milk as something he likes or wants and to him the word is associated with liking or wanting rather than with the thing itself. The names he hears associated with objects around him he applies, self centred as he is, to his relations to the objects. Later in the process of language acquisition he analyses the thought and the sound into verbal, adjective and nominal elements and shifts his words to one or another of these particular uses.

But the most remarkable fact is the child's early mastery of the vernacular grammar. Grammar is an expression of generalization and abstraction, and the child's early blunders show his progress in this process. *Oxes* for *oxen* and *goed* for *went* show his acquisition of the English grammatical notions of the pluralizing *s* and the preterit *d*. His misapplication of the forms in these cases is a credit to his linguistic ability, and, if there be a defect anywhere, it is in the language and not in his thinking. So, also, he soon learns to place subject, verb and object in that proper order which is the essential of the English sentence. He may say *her* for *she* or *me* for *I*, but their place in the sentence, whereby their grammatical relation to the verb is indicated, he puts correctly. With this grasp of the fundamental grammar of his native tongue, the child can say anything he thinks. His errors of speech cause no misunderstanding, because they are simply failures to use distinctions of form that are not at all necessary to the sense, although proper by tradition. Later on he learns to correct *goed* with *went* and *oxes* with *oxen*, but this process, so important to the schoolmaster, is an intellectual trifle in linguistic acquirement compared with the mastering of the use and significance of the abstract *d* and *s* learned long before.

The grammatical form, thus early learned, is characteristic of a language to a greater degree than its vocabulary. Grammar is a formula of thinking, and the terms of the formula may be any sound associated with the appropriate idea. Each tongue has its peculiar grammatical formula. On the other hand, the simple mental process of a word's adoption, be it learned of parent or foreigner, is the same in all languages. The individual or the language may adopt new words *ad libitum* without affecting his or its grammar. The individual continues to adopt new words throughout his life as new things and ideas are brought to his attention. But the grammatical form learned in youth remains the same. His thinking has been trained to it. To him it is the logical formula to which any proposition new or old conforms. To him, trained to this form, it becomes the only logical form of expression.

The distinction between grammar and vocabulary in their hold upon the speaker is abundantly illustrated by those languages whose vocabulary is mainly foreign. Persian thus consists largely of Arabic words, and English of French and Latin, but their grammars are their own. Under the conditions which brought into contact Arabic and Persian, and English and Latin or French, the foreign influence was strong enough to add words but not to alter grammar. Moreover, each language, as it becomes more developed, tends rather to emphasize its grammatical peculiarities and at the same time to adopt with greater facility new and foreign words. So, too, with the individual, the grammatical forms learned in youth persist, while the vocabulary expands or contracts according to the favorable or unfavorable circumstances of his mature years.

A language, then, is mastered when the child has acquired the fundamental grammar. This mastery we find to be very early in life. The family environment affords his opportunity to acquire the vernacular. The mother is the active influence upon him. The process is imitation and repetition by a growing mind. In mature years his language acquisition is confined to new words and perhaps increased rhetorical efficiency. And these conditions recur from generation to generation until some foreign influence interferes.

With the vernacular thus safeguarded, under what conditions may a foreign tongue affect it and what conditions determine the extent of the influence?

Foreign influence may be vital or only dominative. It is vital when it arises from a struggle for life, necessitating the destruction of one or both communities or their amalgamation. In such cases the whole social fabric is disturbed. The dominative influence, on the contrary, results from a struggle simply for power — commercial, political or cultural — and the homes of the contesting communities may not be disturbed. The conflict is vital or dominative depending upon the necessities of the victor. If the stronger community needs the other's territory to live on, the struggle is vital. But if the occupant is strong, the dominative foreigner can do no more than rule, tax, teach and preach, and these acts are not permanently effective unless the subject is tractable, industrious and teachable.

The vital influence may be fatal. The stronger community may exterminate the weaker. This can occur only when there is great disparity in numbers or organization, or both, and the peoples differ physically too much to mix. The English in North America, South Africa and Australia, have so met and exterminated the native. In fact, the English language has never spread on foreign soil except by such methods.

Such vital contests are simply destructive of the weaker, and the victor gets nothing but room to expand. There is little opportunity for influence, linguistic or otherwise. In contrast with this simply destructive conflict, however, there is also a vital conflict that is constructive. By it the victor and victim are not so different in numbers, organization or race, but that they are mutually influenced. Amalgamation or absorption results because extermination is impossible. The stronger, although victor, becomes simply the predominant factor in a new people. Intermarriage is the process by which this result is in fact worked out. This insures the social equality that produces a true amalgamation of peoples. And it brings the two languages in conflict within the family circle, where either, more or less modified by the other, may become the vernacular of the child. The more numerous people have the advantage in these conditions because there will be many families where its tongue is the sole environment of the child, and this child can be influenced by the other tongue only after his vernacular is more or less established in his mind.

Another condition, however, is the proportion of the sexes. The vernacular of the mother has the first chance at the child. Even if she have acquired another language, she naturally talks to her babe in the forms associated with her own childhood. Where the mixed communities are not too unequal numerically, the tongue of the mothers will survive, especially in those essential elements of which we have already spoken — its grammar and the vocabulary of the home. This is illustrated in the history of our own language.

Scandinavians, related by blood and language to our titular Anglo-Saxon ancestors, descended in piratic expeditions upon Southern Europe from the Seventh to the Tenth Centuries. A horde of these marauders, attracted by the fair lands and booty of France, settled in what was thenceforth called Normandy. From the freebooting character of the emigration, it consisted mostly of men. Once settled and in possession of the land, the most of them married French-speaking women of the country. Their children learned to speak from the mothers, and the new generation of Northmen in France spoke French. Again, their descendants, in the Eleventh Century, invaded England in what is called the Norman Conquest. Here, too, the men were in the majority. The Normans formed a class in England, while the mass of the people were Saxon. The aristocratic Anglo-Norman-French struggled for three centuries to maintain itself, backed by office, wealth and learning, but it failed at last for want of mothers. The Saxon woman was in the majority; she was eminently marriageable, for the wars had left her often without father, husband or son, but with lands and social position among her people. And she won the day, breeding and cooing the Norman-French out of the family in all the essentials of language. Norman words survived only with things and ideas the Normans introduced or particularly encouraged in the community; the Norman language disappeared.

So, whenever men without their families constitute the invaders or settlers of a country already inhabited, they have always failed to introduce their language unless they exterminated or enslaved the natives. The history of the East and West Indies, Australia, Asia, Africa and the islands of the Pacific, since the European began his career of emigration and commercial and political expansion, repeatedly illustrates this ethnological fact.*

Another ethnic condition, fatal to the family organization and therefore to the vernacular, is slavery. Sometimes it is

*See a particularly good illustration in a series of articles on "Guam" and "Chamorro," Am. Anthropologist, Vols. 4 and 5, N. S.

an economic substitute for extermination of the vanquished. Sometimes it is solely economic in its origin, a simple stealing of men. The slaves, their mating, breeding and mode of life, are subject to the laws and customs applicable to property. Family relations can hardly be said to exist under such conditions.

The American Negro is an example of a people whose original languages have been eradicated by this vital influence. Gathered from diverse parts of Western Africa, speaking dialects mutually unintelligible, Negroes were brought to America and scattered as articles of commerce throughout communities speaking other tongues. Families were destroyed by such a process. New families, such as they were, were formed under artificial conditions and maintained as long only as the arrangement in any case might be profitable to the master. Under such conditions the Negroes of America speak French, Spanish or English, according to circumstances.

In these vital conflicts the family is affected by extermination, slavery or intermarriage. The condition necessary to affect the child's learning to speak is thus fulfilled. Any influence less than this can reach the speaker only after his vernacular has been acquired, and therefore, though the foreign influence may add to and embellish the vernacular, it cannot affect the essential character of the language. Really vital conflicts are comparatively rare in the world's history. They often require centuries to complete them. They are almost impossible among civilized nations. History, as we usually understand the term, deals rather with wars and conflicts that are not vital, but only for commercial, political or cultural objects. These dominative conflicts between peoples, seemingly so violent and important at the time, are but small affairs anthropologically unless they play a part as a step in some vital conflict perhaps too large to be appreciated by the participants.

The dominative conflict may be commercial. This is the motive behind modern European aggressions upon Asia. If the Asiatics were less numerous or less organized, the conflict would be vital. The Asiatic cannot be exterminated or enslaved, but he can be taxed and cheated. Romans in Britain and English in India are striking examples of this kind of conflict. The Romans were in Celtic Britain for four hundred years, and the English have been in India for one hundred and fifty, ruling, taxing and owning the wealth of the country, but not intermarrying — and no Briton spoke Latin only, as far as we know, and certainly no Hindoo speaks English as his vernacular. Such conflicts result linguistically only in adding to the vocabulary of the subject people words naming the new arts and things the dominant people teaches the former.

The political conflict, generally associated with the commercial, seeks dominance in purely a national sense. The Napoleonic Wars of the beginning of the last century and the Roman conquests beyond Southern Europe were such political dominative conflicts. The immediate objects of these conflicts have all passed away. The Roman Empire and the Napoleonic Empire beyond France have disappeared, and the peoples involved in each case are as they were before, excepting only where and in so far as the dominant people followed up the conqueror by a vital conflict — exterminating and displacing, or colonizing and intermarrying. Only so far as this process extended, only so far as it became a vital contest, permanent results remain. Hence, the domain of the Romance Languages covers, not the Imperial Roman territory, not the area conquered, but the country where the Italian peoples settled and intermarried or exterminated. And Napoleon could not extend the French language beyond its old territorial lines.

Thus far the contests we have considered have been between peoples generally contiguous and always contemporaneous. There is another and more subtile conflict that may continue long beyond the life of the people whose dominance started it. Such highly developed peoples as the Romans and Greeks started each a cultural dominance that affects the world to-day much more than our vanity will acknowledge. The art and literature of Greece and the jurisprudence and colonial administration of Rome have not yet taught us all they may. Perhaps we are not yet able to appreciate their full significance. This intellectual and esthetic power is still influencing the Teutonic peoples and none of them can or should escape its influence. The South-European words in the English vocabulary bear witness to cultural influence upon its speakers in philosophy, science, art, literature and law. Beneath this, the essential motives, the homely virtues and the blunt sense of the people are expressed in Teutonic words and grammatic form.

The missionary and the teacher are incited by the same spirit of dominance that impels the conqueror and the imperialist. The influence of the former is generally constructive and therefore beneficent, while that of the latter is destructive and finally retrogressive — unless, indeed, it affords unintentionally the opportunity for a cultural influence.

The success and the extent of a foreign cultural influence mainly depend upon the condition of the people to whom it comes. They must be ready to receive the message. They must be far enough advanced to recognize its worth. Teutonic Europe was thus the pupil of Southern Europe. It has taken two thousand years for the culture of the South to expend all its riches upon the Teutonic foundation, linguistically and otherwise. But the conflict has been only one of cultural dominance. The influence has never been vital. Its effects are visible only in the superstructure of modern North-European civilization; the foundation is not affected.

From this hasty sketch we may summarize our conclusions. We find that the vernacular is transmitted from the old to the young generation of a community while the latter is still individually within the family circle, and particularly under the maternal influence, and that the vernacular can be brought into actual conflict with another language only when the aggression of the foreigner disrupts the family by extermination, slavery or intermarriage. Only under these conditions can the foreign tongue affect the essential grammatic structure and vocabulary of the vernacular. The disturbance must be vital. Commercial, political and imperial power do not reach this social depth.

These considerations naturally culminate in the ever attractive questions: Will there be a universal language? If so, which language known to us is it likely to be?

The possibility of a common tongue throughout all mankind is no new idea. The belief in one original language, diversified into dialects by the dispersion of its speakers, is the traditional notion sanctioned among us by religious cult and literary inheritance from the past. Turned toward the future, the idea gathers round it strong personal and national sentiments. The scholar wishes that the literature he admires may be perpetuated in a language ennobled to him by the culture it has brought him. The practical man is impressed with the material advantages to be gained by a means of communication common to all the world's workers. To the imperialist the universality of his language is an essential element of the dominance of his own people.

The confidence with which the publicist proclaims English as the future world language is born of these aspirations, not of knowledge. His view of the subject arises from the predominating part the vernacular plays in the making of one's self, and the political, commercial and geographical expansion of English-speaking peoples.

Our present knowledge may only predicate the controlling conditions under which the solution of these questions will be worked out in fact. We know something of the conditions under which languages have survived or perished in the past, and an attempt to apply this knowledge to the present and future, while leaving the particular questions unsolved, may at least enlighten us on the real significance of the problem.

It may be assumed that a universal language that would still require or admit of the vernacular's continued use would not be universal in the proper sense. The domain of thought and life as far as expressed in the vernacular would be omitted from the universal language. Such a universal language would occupy a position not unlike the jargons of trade or the classic tongue common to scholars: each speaker of them still expresses his real personality, his essential ideas, in a vernacular. The really universal language must be exclusive of all others: it must be substituted for the present languages of the earth, not simply added to them and universal only throughout certain limited lines of action and thought. It must be universal for all human expressions. Only such universality would be worth while.

After the vernacular is mastered the child gets beyond the family circle and into the larger circles of the society about him, scholastic, commercial and political. These larger circles often bring him into contact with other tongues. In scholastic circles a classic or foreign tongue is regularly taught. Commerce and politics necessitate more or less knowledge of other languages than his own. Languages of this status in a community may be called secondary languages, the term referring to their distinct position as added over and upon the vernacular, not substituted for it. They are learned by and through the vernacular. The French teacher does not bring us a horse and say *cheval*; he does not find us a dying animal and say *il mort*; he simply recalls our own vernacular sounds *horse* and *he dies* and gives us the French equivalent.

These secondary languages, superposed upon the vernaculars, deserve a moment's fuller consideration because they are often put forth as candidates for universality. They are acquired by their users under conditions that may be termed scholastic, such as the classic and foreign languages of our schools, artificial, such as Volapük and Esperanto, or natural, such as trade jargons, Pidgin-English and the Lingua Franca of the Orient.

No man uses any of these as his only tongue. Scholar may meet scholar in Latin and Greek; traveler may aid traveler in Volapük; English and Chinese may chaffer in Pidgin-English — but beneath these special planes of contact each is a man living and thinking in his mother tongue. These secondary or added languages do not belong to a community; they are creatures of an occasion. They are used for the expression of only a part of the speaker's life, the accidental and not the essential. No child learns them first. They never have ousted a vernacular. Until — by some almost unimaginable social condition — they can be intruded between mother and child, they have no chance of success in competition with the vernacular. They play their special part and remain secondary languages. They exhibit no growth or development toward universality as we have above defined it. The conditions under which they are produced and perpetuated are not the conditions under which peoples give up their vernaculars.

Nor is the superiority of a language over others an aid to its extension. Languages do not directly compete. Any given word or form of language can be brought into antagonism with another only when and where both are understood. Generally this can only occur within the same community. This competition is well shown in the case of synonymous expressions, one of which ousts the other from their common province of meaning, either completely, when the latter disappears, or incompletely, when some previously undefined part of the meaning is left for it to adopt. Thus the good old English *witena-gemot* has been ousted by *parliament* for historic reasons explicable enough were it useful here to go beyond the fact. And so the directly derived *legal* has usurped the meaning just as properly and etymologically once belonging to the Norman form *loyal*, and the latter modified to a derivative meaning not covered by the former. On the other hand *père* never competes with *father*; they have no common area of contest. Only one of them is associated with the idea in earliest childhood, and the other, learned later as a foreign word, is simply understood through the first.

The law of the survival of the fittest, therefore, operates among forms within a language itself, but not directly between it and another language. The conflict is among the speaking communities; it is ethnic, not linguistic. Therefore, even if a language be assumed as superior to another, this superiority in itself gives it no advantage in the chances of domination and survival. If it survive and supplant others, it is due to the superiority of its speakers under the conditions which determine conflicts among communities. Hence, the superiority of the language is not an element of the problem further than as an evidence of the superiority of the community speaking it. This eliminates from our discussion the necessity to weigh the relative values of several prominent languages now candidates for universality — a judicial process too exacting perhaps for any person having one of these languages as his own.

Languages, then, prevail neither by their superiority over others nor by the aid of schools or governments. The root and stem of the living language is in the family circle and no race is without such an organization. The family originated in the animal nature of man and in all its various forms it centres in the nurture and primary education of the child. The strength of this family unit is abundantly illustrated in the many local centres of foreign speech in the United States — the Chinese and Italian quarters of our cities, the Spanish towns of the Southwest, and the Pennsylvania Dutch. These cases show how few the families need be to preserve their linguistic integrity, how little political power has to do with the matter, and how a small self-contained community, totally surrounded and outnumbered by another, may for generations postpone the surrender of its vernacular.

The conclusion, from the trite facts we have summarized, is that the conflict of languages is the conflict of the communities speaking them. A vernacular can be eradicated only by extermination, slavery or intermarriage, and the intermarriage must be in due proportion by the foreign woman. Extermination and slavery have already advanced far toward the destruction of the American, African, Australian and Oceanic tongues. Geographically they are being replaced by European tongues. If this process continue to completion, there will still be the Asiatic languages to contend against the European, and the European amongst themselves. In these latter conflicts, extermination and slavery seem impossible. If they are, then only intermarriage can bring about a universal language.

PLANT PHYSIOLOGY.

Chlorophyll is that substance by the aid of which plants are enabled to transform inorganic mineral matter into living matter. By its aid they are enabled to use the energy of the sun's light to carry through this endothermic reaction. Little is known of the constitution of chlorophyll further than that it consists of carbon, hydrogen, nitrogen, oxygen and ash. Iron is believed to be an essential constituent, but this point is disputed.

When extracted from the plant leaf by alcohol or other solvent, the chlorophyll solution appears as a dark green liquid, showing a deep red flourescence if concentrated. Spectroscopically it shows strong absorption in the blue end of the spectrum. Strange to say, however, all quantitative measurements on plant assimilation indicate that plants exposed to light from the other end of the spectrum show the most activity.

The solution of chlorophyll when exposed to strong light suffers some kind of decomposition and in a few hours loses its green color.

The pigment of chlorophyll seems to consist of two substances, one yellow and the other green. By adding benzol to an alcoholic solution of chlorophyll, mixing well, and allowing the solution to stand, it will be found after some time that the liquid has separated into two layers. The lower layer is a yellowish solution of the yellow pigment in the benzol, and the upper layer is a green solution of the green pigment in alcohol. This yellow pigment is supposed to be etiolin. There are reasons for believing that etiolin is an antecedent of chlorophyll.

In the various authorities consulted there are two theories of plant assimilation advanced, both worthy of consideration.

The first theory is as follows: The chlorophyll of the leaves, under the influence of light, acting upon water, produces formaldehyde:

$$CO_2 + H_2O = CH_2O + O_2.$$

The formaldehyde, combining with the nitrogen taken in by the plant as ammonia or nitrates, forms nitrogenous bodies, perhaps asparagin and leucin. From these is formed albumen and lastly protoplasm. The starch of the plant results from the decomposition of the protoplasm and is the immediate product not of constructive, but of destructive metabolism. That this is so is made evident from the formation of starch in parts of the plant which are not green and are not exposed to light. The sugar of the plant is formed from the starch by hydrolysis. The formation of protoplasm goes on in every living cell of the plant and independently of the presence of chlorophyll and the action of light. In green plants it goes on more actively, however, in the cells that contain chlorophyll. In the green parts of the plant this synthetic process begins with such simple substances as CO_2, H_2O and mineral salts, whereas in the white portions it begins with complex substances, asparagin, and so forth. The energy required for the formation of protoplasm in the green parts of the plant is obtained directly from the sun, while in the parts unexposed to light this energy must be obtained in the main from the oxidation of starch, sugar, etc., formed elsewhere.

The second theory, and perhaps the one most widely accepted, may be outlined thus: The chlorophyll, as before, produces formaldehyde:

$$CO_2 \quad H_2O \quad O_2 \quad CH_2O.$$

There are reasons for thinking that this reaction does not exactly represent the change that takes place, but that the chlorophyll, under the action of the sun's rays, combining with the hydrogen, forms a hydride, the hydrogen being obtained by the decomposition of water with liberation of oxygen. This hydride of chlorophyll, or chlorophyllin, gives up its hydrogen to the CO_2 and formaldehyde results:

$$H_2 + CO_2 = CH_2O + O.$$

In either case the first compound formed is formaldehyde, which by polymerizing forms $C_6H_{12}O_6$. It is thus that the plant prepares sugar, and by changes in hydration forms starch, cellulose, etc. The nitrogen of the plant is taken in as ammonia or nitrates. The nitrogen taken in acts upon the unpolymerized aldehyde, producing hydrocyanic acid, thus:

$$2HNO_3 + 5CH_2O = 2CNH + 3CO_2 + 5H_2O.$$

It may be noted in passing that the presence of hydrocyanic acid has been observed in many plants, and, further, it has been shown that hydrocyanic acid, in the presence of water and formaldehyde, can form certain amides which have been recognized among the decomposition products of albumen. It is assumed, therefore, that the origin of the albuminoid matter in the plant may be traced to some reaction between the formaldehyde and the hydrocyanic acid. The albumen once formed can then be transformed into other proteids.

The above notes on plant physiology, collected as they are from various sources, furnish food for much valuable thought.

ISAAC S. YARNALL.

Isaac S. Yarnall, a life member of the Institute, died on May 19th, 1906, at the age of seventy-two years. He was born in East Willistown, Chester County, Pennsylvania, on March 17th, 1834, his parents being Peter and Amy Yarnall. During his youth he attended the schools of the neighborhood and having a great liking for study subsequently became a school teacher. He taught school in all for a period of about ten years, in Newtown and elsewhere. While engaged in teaching school he married Susanna Williamson, daughter of Azariah Williamson, of Newtown Township, Delaware County. He subsequently gave up school teaching and came to Media to live, taking up his residence on West State Street and subsequently at the corner of Fourth and Orange Streets, at which latter place he resided until the death of his wife some years ago. After coming to Media he engaged in the phosphate business, establishing a plant here, and also having an interest in enterprises of a like nature in New Jersey. During the latter few years of his life he resided the greater part of the time at Cape May, New Jersey. He leaves to survive him his only sister, Abbie Y. Steele, of Swarthmore, Pennsylvania.

Mr. Yarnall became a member of the Institute in 1867. He always took the greatest interest in its welfare and was elected a member of the Board of Curators, of which body he served as chairman for many years. His energy and skill guided the Institute through many a perilous financial storm in its earlier existence and very much of its present prosperity is due to his untiring efforts.

JOHN T. REYNOLDS.

John T. Reynolds, a life member of the Institute and its one-time Treasurer, died May 30th, 1906. Mr. Reynolds was born September 14th, 1845, at Harrisville, Cecil County, Maryland, and in his earlier days was engaged in mercantile pursuits. He also spent about three years at the Eastman College, at Poughkeepsie, New York, first as pupil and later as instructor. He subsequently conceived the idea of studying law, and coming to Delaware County, registered as a student in the office of the late Hon. John M. Broomall. He was admitted to the Delaware County Bar in November, 1875. He was a resident of Media, and practiced law at the Delaware County Courts until his untimely death. He was the Secretary of the Second Media Loan and Saving Association and also the Media representative of the Delaware County Trust, Safe Deposit and Title Insurance Company.

Shortly after the war he married Miss Anna M. Roberts, daughter of R. Barclay Roberts. He is survived by his widow and one child, Mabel, now Mrs. John Charles Taney.

Mr. Reynolds became a member of the Institute in 1874, and served as its Treasurer for many years until he resigned that office in 1892. Although Mr. Reynolds was too busy a man to devote much time to study outside of his profession, he was nevertheless a faithful member of the Institute and served with credit as its Treasurer during its earlier years, before it became established on its present sound financial basis. Mr. Reynolds was a man of broad culture and reading and a valuable member of the community.

MINUTES OF MEETINGS.

APRIL 5, 1906. — Regular monthly meeting of the Institute. Charles N. Pierson and William N. Young, both of Media, were elected to juvenile membership. Specimens of carborundum, obtained from the Carborundum Company, of Niagara Falls, were exhibited. An interesting discussion on the subject ensued. Charles Potts exhibited a series of equal-length pendulums swung from a common supporting cord, illustrating the transference of energy from one to the other when the condition of resonance obtained.

MAY 3, 1906. — Regular monthly meeting of the Institute. Dr. Frank T. Davis, of Lansdowne, Delaware County, was elected to membership. This being the annual meeting, the annual election of officers was held. Donations to the library were received as follows: Annual Report of Smithsonian Institution, Report of U. S. National Museum, Contributions to the National Herbarium. At the close of the business session a number of miscellaneous current scientific topics were brought up for discussion.

JUNE 7, 1906. — Regular monthly meeting of the Institute. The deaths of Isaac S. Yarnall and John T. Reynolds, members of the Institute, were reported. Biographical notices of these members appear elsewhere. Mrs. John Grim, Miss Nellie Schoch and C. Edgar Ogden were elected to membership. Lewis Kirk gave an interesting talk on "The Weather," with particular attention to notable storms in this locality.

JULY 5, 1906. — Regular monthly meeting of the Institute. Short business session, followed by discussion of current scientific topics. Among other things, the matter of various alleged Indian remains existing in the county was brought up, and it was recommended that efforts be made to obtain photographs of the same before they were destroyed.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

Carolus M. Broomall, Editor.

Volume II: October, 1906, to July, 1907

MEDIA, PA.

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Vol. II, No. 1 October, 1906

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

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Delaware County Institute of Science

VOL. II, NO. 1 OCTOBER, 1906

THE SUN'S DISTANCE FROM THE EARTH,

Obtained from the Transits of Venus.

BY JACOB B. BROWN.

This paper makes no pretensions whatever to originality. It is only the best arrangement your reader can make of what others have at sundry times discovered and in divers places put on record.

The important problem of the sun's distance from the Earth was solved nearly a century and a half ago by observing the Transits of Venus; but doubt has been cast upon the trustworthiness of some of the observations made at that time though the method employed was quite correct. Other Transits of Venus have since come round in due course and of these the fullest use has been made. Various other methods, moreover, entirely different in character have been resorted to and every effort used to reach a correct result; but the fact remains, nevertheless, that men of science, while feeling that they are nearer the truth, are not even yet satisfied that accuracy has been attained.

The methods employed at the time of the last Transits do not vary in principle from the first one that was devised; but different and perhaps better means have been discovered for taking the observations.

The matter is more within the comprehension of any ordinarily educated person than might be supposed; and a general idea of it can be set before those who take an interest.

Our problem may be said to owe its solution to Dr. Edmund Halley, mathematical philosopher and Astronomer Royal, 1675-1742. In the year 1716 this eminent man of science presented a paper on the subject to the Royal Society of London. He could entertain no hope of seeing the next Transit of Venus ; but he set forth what he said would be a satisfactory method of calculating the sun's distance by means of that phenomenon and bequeathed the task to posterity. Aroused by him, the "curious" of all nations applied their minds to the question and an amazing mass of learning and labour has been brought to bear upon it. One need but refer to the Philosophical Transactions of the time in the English language, not to speak of those in other European tongues, to have the fullest realization of this fact.

The Earth moves in orbit from left to right as we face the sun. The motion is "against the clock" and is called "direct." The other planets move in the same way.

By a law of planetary motion, moreover, those bodies which are nearer to the sun move faster in their orbits than those which are farther off. Just as when the water in a bucket is set whirling the outer parts move more slowly than those which are near the little vortex in the centre.

If, therefore, an inferior planet should pass exactly between the earth and the sun it might be seen by certain of the inhabitants of the Earth as a black spot passing across the sun's disc from left to right or with what is known as "retrograde motion," for it is seen to be "with the clock."

This sometimes happens to the planet Venus when her course brings her to pass through the plane of the Earth's ecliptic, or, as it is expressed, when she is "in her nodes." And the occurrence is made use of in calculating the sun's distance from the Earth.

By Kepler's third law, *the squares of the times are as the cubes of the mean distances*, which means that if the number of days required by the Earth (say) to go round the sun squared, or multiplied by itself, be divided by the number of days required by any other planet to go round the sun squared, or multiplied by itself, the quotient so obtained will be the same as that obtained by dividing the distance of the Earth from the sun cubed, or multiplied by itself twice, by the distance of that other planet from the sun cubed, or multiplied by itself twice. For example : —

$$\frac{(\text{Time of Earth})^2}{(\text{Time of Venus})^2} = \frac{(\text{Distance of Earth})^3}{(\text{Distance of Venus})^3}$$

The Earth's periodic time is (say) 365 days.

Venus' periodic time is (say) 224 days.

As has been known for ages. Therefore : —

$$\left\{\frac{365}{224}\right\}^2 = \left\{\frac{\text{D. E.}}{\text{D. V.}}\right\}^3$$

Extract cube root from both members : —

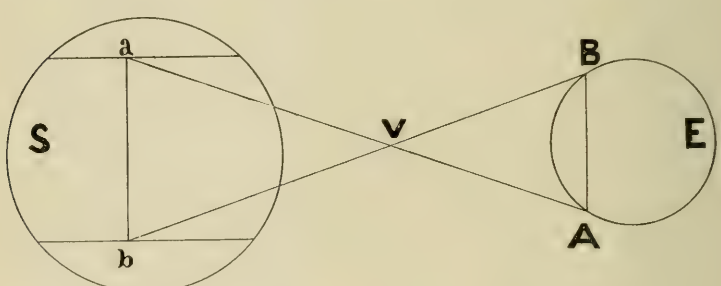
$$\left\{\frac{365}{224}\right\}^{\frac{2}{3}} = \frac{\text{D. E.}}{\text{D. V.}}$$

Applying logarithms : —

$$\frac{51.07}{36.88} = \frac{\text{Distance of Earth}}{\text{Distance of Venus}}$$

Which means that the distance of the Earth from the sun bears the same ratio to the distance of Venus from the sun that fifty-one and seven one-hundredths does to thirty-six and eighty-eight one-hundredths. Owing to neglect of fractions, this is not precisely the proportion. It will in fact be quite accurate enough for illustration and more convenient to say that the Earth's distance from the sun is to Venus' distance from the sun as 25 : 18. Very early observations gave this proportion, and the calculations of Kepler have confirmed it. In the present state of the inquiry, therefore, it is known that if the Earth be at the distance twenty-five from the sun, Venus will be at the distance eighteen, and the Earth will be at the distance seven from Venus. The dimensions of the Earth, also, are known with great precision, though at the time referred to the measurements were not quite so accurate. We have not yet computed the diameter of the sun, but we do know from elementary geometry that whatever his distance from us, his diameter bears a certain proportion to that distance. This proportion is approximately ascertained by angular measurement; and it is found that the distance of the Earth from the sun is about one hundred and eight times his diameter. By way of illustration: — A round bit of board one foot in diameter will exactly cover the sun if held at the distance of one hundred and eight feet from the eye.

Suppose now that two observers on the same or nearly the same meridian, but in widely different latitudes, observe a Transit of Venus. The path of the planet across the sun's disc, as seen by the southern observer will be to the north of the path observed from the northern station, and the zone marked out by these two paths upon the sun will have a certain width in miles dependent upon the known distance of the observers from each other, and not at all upon the distance of the Earth from the sun. For were the Earth moved in imagination nearer to the Earth or farther off from it, Venus also would have to be moved nearer to the Earth or farther from it in order to preserve the proportion mentioned above of 25 to 7.



In this little diagram let E be the Earth and S the sun. A and B are two observers; A near the south pole of the Earth and B near the north. The distance BV is equal to the distance AV without sensible error. So likewise Va = Vb. The triangle BVA is similar to bVa. Therefore : —

$$BV : Vb = AB : ab$$

$$\text{But } BV : Vb = 7 : 18$$

And AB is known (say) 6860 miles. Therefore : —

$$7 : 18 = 6860 : \text{Answer, } 17{,}640 \text{ miles}$$

on the sun's surface ; therefore, ab is 17,640 miles, whatever be the distance of the sun from the Earth.

These two apparent paths, then, are two parallel chords of a circle whose angular diameter can be observed ; and they are 17,640 miles apart. The difference in their lengths will be as the difference in the times of transit and will be the same number of miles whatever assumption of miles be made as to the distance of the sun. But as in the case of a larger assumed diameter of the sun the paths described are longer than in the case of a less assumed diameter of the sun, this difference will be a smaller part of the whole time in the former case than in the latter. Let us assume for example that the distance is 108 millions of miles and the diameter of the sun one million ; then will the difference in the lengths of the apparent paths be one fraction of the whole time of transit ; — say one-thirtieth part. Again, let us assume that the distance of the sun is 54 millions of miles and his diameter half a million of miles. The difference of duration will then be another fraction of the whole time of transit, say one-fifteenth. In point of fact, in 1769 the difference in the times of transit, owing to the difference of latitude, was about twelve minutes — a little more than one-thirtieth of the whole duration. It will be seen that by thus comparing observation with assumption an inference can be drawn as to the sun's distance, and that the true distance is somewhere between 54 millions of miles and 108 millions of miles, and that a true assumption would be nearer to 108 millions of miles than to 54 millions.

The actual diameter of the sun in miles can be computed. The value of each of the chords spoken of above can be ascertained by the time occupied in describing it — since the motions of Venus and those of the sun are known from the tables. The sun's angular semi-diameter is 15′ 51″ (nearly). Venus in 1769 opened an angle on the sun's disc of 4′ per hour or 4″ per minute. At this rate Venus would have occupied a certain time in describing the known angular diameter of the sun. The times occupied in describing the two chords would when brought together and compared give their ratio to diameter. And thus their values and those of the arcs they intercepted would become known. For example: The sun's angular semi-diameter being 15′ 51″ the planet in her transit would have occupied 3 hours, 57 min., 45 sec. in opening that angle. If now she had occupied exactly that time in describing the chord observed from either station the observer would have known at once that the chord was equal to the sun's semi-diameter and hence the arc equal to 60°. Each chord is double the sine of half the arc that it intercepts. Therefore the sine of half the arc, and of course the versed sine, becomes known; and the difference of the two versed sines is the breadth of the zone in question. The versed sine of one arc is a certain fractional part of radius; the versed sine of the other arc is another fractional part of radius. Their difference, which is known to be 17,640 miles, is a certain fractional part of radius. Thus the sun's radius, and of course also his diameter, becomes known. It is 882,000 miles. This gives the real length of the chord described on the sun by Venus and the real length of their difference. Now compute by Rule of Three what must be the distance at which 882,000 miles will subtend a given angle — in other words, of what number is 882,000 the 108th part. The number is 95,256,000, and thus another and a reasonably accurate inference can be drawn as to the sun's distance from the earth.

But the sun's semi-diameter was known at the time in question by angular measurement only, and not with sufficient accuracy to be used as the basis of so nice a calculation.

It will not, therefore, be supposed that either of these methods is the one employed. The correct result is obtained by a most complicated process of trial and error based upon the difference of times of which so much has been said, and in which much more exact cognizance of that difference is taken than in this little treatise. What has been said, however, is sufficient to show that the principles which lie at the base of the calculation are neither complicated nor abstruse.

The astronomer proceeds solely by what is called the method of Parallax.

"Parallax is the angular variation in the position of an object caused by the eccentric situation of the observer with respect to a certain point of reference."

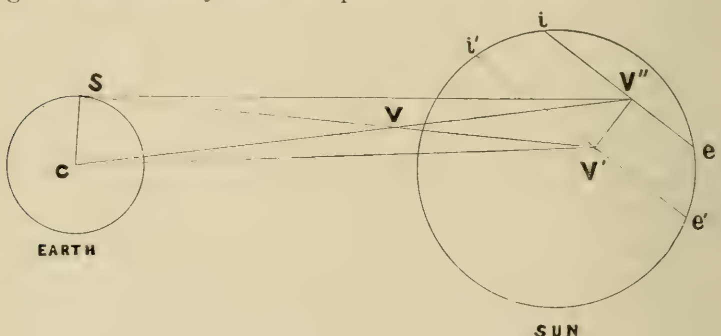
In somewhat less learned language: Parallax is the apparent change of place which bodies undergo by being viewed from different points. The centre of the sun, for instance, would be referred to a lower point upon the celestial sphere by an observer standing upon the surface of the Earth than by one at the centre of the Earth. Since, then, a heavenly body is liable to be referred to different positions upon the celestial vault and some confusion is thus created in the determination of points upon the star sphere, astronomers have agreed to consider the true place of a heavenly body as that where it would appear if seen from the centre of the Earth.

The doctrine of Parallax teaches how to reduce observations made at any place upon the surface of the Earth to such as they would be if seen from the centre.

Suppose now two observers, one at the centre of the Earth and one at the surface; both looking at the sun. The two visual rays intercept at that point and form equal vertical angles. One of these angles is the angular variation in the position of the sun's centre, caused by the different situations of the two observers; the other is evidently the angle subtended at the sun's centre by the Earth's semi-diameter. The latter is the one selected for use, and is called the sun's parallax. It is nothing in the zenith and greatest in the horizon. When calculated in the latter position it is called the sun's horizontal parallax.

The sun's horizontal parallax, therefore, is the angle subtended at the sun's centre when he is in the horizon by the Earth's semi-diameter. The equatoreal semi-diameter is chosen because it is the longest. Observations taken at any altitude can be reduced to the horizon by a simple formula, and so we are free to speak of the horizontal parallax at all times, meaning the horizontal equatoreal parallax. It is plain that if this angle be known we shall have in order to calculate the sun's distance from us to calculate the parts of a right angled triangle, right angled at the Earth's centre, all the three angles and the shorter leg of which are known — a problem entirely within the scope of the most elementary trigonometry.

It may be remarked, by the way, that the Earth's semi-diameter, 4000 miles, bears the same proportion to the distance of the sun from the earth, 93,000,000 miles, that one-sixteenth of an inch does to 121 feet (nearly). We might conceive ourselves, therefore, as measuring at 121 feet distance the date figures on a twenty-five cent piece.



In this diagram, the proportions of which are of course enormously exaggerated, let C be an observer at the centre and S an observer at the surface of the Earth. V is Venus. S will see Venus on the sun's disc at V′ and C will see her at

V″. In the triangle SVV″ the outer angle CVS is equal to the sum of the inward and opposite angles VSV″ and VV″S. But CVS is the horizontal parallax of Venus, or the angle under which the Earth's semi-diameter is viewed from Venus; and VV″S is the sun's horizontal parallax, or the angle under which the Earth's semi-diameter is viewed from the sun; and VSV″ is the angle under which the displacement of Venus on the sun is viewed from the Earth. It is called the horizontal parallax of Venus from the sun. Now as the distance of the Earth from the sun is to the distance of Venus from the sun as 25 : 7, the angle CVS will be nearly enough twenty-five-sevenths of the angle VV″S, and VSV″ will be geometrically the difference between the two horizontal parallaxes of Venus and the sun; as is right and natural, for the displacement of Venus upon the sun is due to the difference of parallaxes.

Now VSV″ is known, for it can be measured, as will be shown below. Representing then by Z the sun's horizontal parallax, unknown,—(SV′C = VV″S); by Y the horizontal parallax of Venus (CVS), likewise unknown, and by M the measured distance between these two parallaxes, we shall have two independent equations:—

$$Y = \frac{25\,Z}{7}$$

$$Y = Z + M$$

From which

$$Z = \frac{7\,M}{18}$$

$$Y = \frac{25\,M}{18}$$

Both in terms of M.

Now to measure M, or VSV″.

It will be well here to remark that V′V″ is the chord of an arc which measures an angular opening. This arc is an aliquot part of another arc which measures another angular opening, namely, the sun's angular semi-diameter. The arc, then, of which $V'V''$ is the chord is computed in the manner following: —

If the moment when the planet is in contact with the sun at i (ingress) be noted with great exactness, and also that at e (egress), this interval of time will be an enlarged measure of the chord ie as seen from the more southerly station C. In like manner the observer at S, making the same observations at i′ and e′, we shall have obtained the relative lengths of the two chords; and if their relative lengths, then their distances from the centre in aliquot parts of the sun's semi-diameter. But the angular value of the sun's semi-diameter is known, though not accurately; hence, the angle M, under which the difference of the solar parallax and that of Venus appears becomes known, and, so the others, as set forth.

It is true the difficulty of the imperfectly known angular semi-diameter of the sun has not yet been gotten over, but the substance of Dr. Halley's paper, referred to above, has been given, and the original may now be quoted.

The communication is entitled:

> "A new Method of determining the Parallax of the Sun or his distance from the Earth, by Dr. Halley, Sec'y R. S. No. 348; p. 454. Translated from the Latin."

In the abridged Philosophical Transactions, London, C. & R. Baldwin, it is to be found, Vol. VI, pp. 243, *et seq.*

"There remains, therefore, Venus' transit over the sun's disk, whose parallax being almost 4 times greater than that of the sun will cause very sensible differences between the times in which Venus shall seem to pass over the sun's disk in different parts of our Earth. From these differences duly observed the sun's parallax may be determined even to a small part of a second of time and that without any other instruments than telescopes and good common clocks, and without any other qualifications in the observer than fidelity and diligence, with a little skill in astronomy. For we need not be scrupulous in finding the latitude of the place or in accurately determining the hour with respect to the meridian. It is sufficient if the times be reckoned by clocks duly corrected according to the revolutions of the heavens from the total ingress of Venus on the sun's disk to the beginning of her egress from it when her opaque globe begins to touch the bright limb of the sun, which times, as I found by experience, may be observed even to a single second of time.

"But by the limited laws of motion Venus is rarely seen within the sun's disk; and for a series of 120 years and upwards is not to be seen there once, namely, from 1639, when Mr. Horrox (Rev. Jeremiah Horrox, 1619-1641) was favoured with this agreeable sight, and he the first and only one since the creation of the world down to 1761, at which time according to the theories hitherto observed in the heavens Venus will pass over the sun on May 26 in the morning, so that at London at 6 o'clock in the morning she is to be seen in the middle of the sun's disk and but four minutes more southerly than his centre. The duration of this transit will be about eight hours, namely, from 2 till 10 in the morning.

Supposing the sun's parallax, as was said, to be twelve seconds and a half, Venus' parallax will be 43 seconds.

$$\text{This ratio is } \frac{25}{7.2}$$

And subtracting the sun's parallax there will remain

$$43'' \qquad 12.5'' \qquad 30.5''$$

half a minute at least for the horizontal parallax of Venus from the sun

(VSV″ in the diagram)

and consequently Venus' motion will be accelerated ¾ of a minute at least by that of parallax while she passes over the sun's disk in such elevations of the pole as are near the Tropic and still more so near the Equator. For Venus will at that time accurately enough describe within the sun's disk 4 minutes an hour and consequently at least eleven minutes of time (by which the duration of this eclipse will be contracted by reason of parallax) answer to ¾ of a minute of arc, and by this contraction alone we might safely determine the parallax, provided the sun's diameter and Venus' latitude were accurately given, which as yet we cannot possibly bring to a calculation in a matter of such great subtlety.

"We must, therefore, have another observation, if possible in places where Venus possesses the middle of the sun at midnight, namely, under the opposite meridian, that is of 6 hours or 90° more westerly than London and where Venus enters the sun's disk a little before his setting and goes off a little before his rising, which will happen in the same meridian in about 56° of N. latitude, that is at Nelson Harbour in Hudson's Bay.

"And indeed I would have several observations made of the same phenomenon in different parts, both for further confirmation and lest a single observer should happen to be disappointed by the intervention of clouds from seeing what I know not if those of the present or following age shall ever see again and upon which the certain and adequate solution of the noblest and otherwise most difficult (sic) problem depends. Therefore again and again I recommend it to the curious strenuously to apply themselves to this observation.

"By this means the sun's parallax may be discovered to within its five hundredth part; which will doubtless seem surprising to some; but yet if an accurate observation be had in both places above mentioned it has already been shewn that the duration of these eclipses of Venus differ from each other by 17 entire minutes on the supposition that the sun's parallax is 12½ seconds and if this difference be found to be greater or less by observation, the sun's parallax will be found to be greater or less in nearly the same ratio. And since 17 minutes of time answer to 12½ seconds of the sun's parallax, for each second of the parallax there will arise a difference of upwards of 80 seconds of time:—

$$\frac{17 \times 60}{12.5} = 81$$

Therefore if this distance be obtained true within two seconds, the quantity of the sun's parallax will be got to within the 40th part of one second and consequently his distance will be determined to within its 500th part. For

40 × 12½ is 500."

End of Extract.

The following is a note to Dr. Whalley's paper, dated May 26th, 1803.

"The Transit of Venus in 1761 proved much less favourable to the purpose than Dr. Halley expected. The motion of Venus' node not being well known she passed much nearer to the sun's centre than he supposed she would; which made the places he pointed out for observing the total duration not proper for the purpose; indeed the entrance of Venus on the sun could not be observed at Hudson's Bay. He made a mistake, too, in the calculation in taking the sum instead of the difference of the angle of the ecliptic with the parallel to the equator and the angle of Venus' path, which affected the accuracy of his conclusions. He was mistaken, too, in thinking the external contact might be observed to a second of time. Astronomers have disagreed 20 seconds in observing the internal contact of Mercury, which is a similar phenomenon."

So far Dr. Halley in 1716.

Professor Airy, likewise Astronomer Royal, sums up his lecture on the same subject before the working men of Ipswich, in March, 1848, in words which we quote as coming from one having authority and which dispose of our only remaining difficulty, the inexact knowledge of the sun's angular semi-diameter.

"I may now mention that though the principles of the method are given with perfect correctness in the explanation given above, and though the process must thus be contemplated in order to enable him to select stations in the most advantageous positions, yet an astronomer's calculation is not made in that form. He proceeds entirely by the method of parallax. The process, strictly speaking, is algebraical, but it may be correctly described in the following manner. He assumes a certain value in seconds tor the sun's horizontal equatoreal parallax and then from the known proportion of the distances of Venus and the sun he computes the horizontal equatoreal parallax of Venus, the parallax being greater as the distance is less. Thus, if the sun's horizontal parallax be assumed at ten seconds and if it be known that at that time the distances of Venus and the sun from the Earth are in the proportion of 28 : 100 (7 : 25, as above), then he must take the horizontal equatoreal parallax of Venus at thirty-five and five-sevenths.

"Then from knowing the Earth's form he computes the horizontal parallax of each at the place of observation ; that is, how much each of them is apparently depressed by parallax. Venus being nearer than the sun is apparently more depressed than the sun and is therefore moved by parallax off the sun's limb if she is lower, or upon the sun's limb if she is higher. From this he calculates by a troublesome mathematical process how much the time of Venus' entering or leaving the limb has been accelerated or retarded by parallax. And this is done for both observations at every station ; and thus he calculates what will be the difference of the duration of the transit at different stations. All this is upon the supposition that the sun's horizontal equatoreal parallax has a certain value, say ten seconds. If they agree, the sun's horizontal parallax is ten seconds ; if not, the true value will be found by this proportion : As the computed difference of durations is to the observed difference of durations, so is the assumed horizontal equatoreal parallax to the true horizontal equatoreal parallax.

"In this manner it was found that the sun's horizontal equatoreal parallax when the Earth is at its mean distance is eight seconds and six-tenths, very nearly, and this corresponds to the distance which I have stated before of about 95,300,000 miles.

"It was thought at the time of the observations in 1769 that the sun's distance was determined with all the accuracy of which the method was capable. As previously stated, however, more recent investigations have led to the conclusion that the sun's distance so estimated to be too great by about three millions of miles."

The parallax is until further correction set down as 8.789″, eight seconds and seven hundred and eighty-nine one-thousandths of a second. As the sun is nearer, the parallax is greater, and *vice versa*.

As judged by the concensus of many methods of computation, 92,975,500 miles seems to be the most nearly accurate statement on record of the sun's distance from the Earth.

HIBERNATION.

BY SANFORD OMENSETTER.

"How wonderful is death!
Death and his brother sleep."

And, beside, another condition, that of hibernation, has at various times excited the wonder and stimulated the inquiry of observing minds. Sleep and hibernation are similar periodical manifestations differing only in degree, and the latter is extraordinary simply because less common than the first.

Hibernation may be defined as the term used by naturalists to denote that peculiar state of torpor in which many forms of life inhabiting cold or temperate climates pass the winter. The influence of cold in producing this state is due only to its tendency to cause sleep, and if carried too far, instead of inducing lethargy leads to death.

Every phase may be distinguished between ordinary sleep and that profound coma in which the functions of life are almost suspended. In true hibernation, respiration and the production of blood nearly or entirely cease, no food is taken, and the excretory functions are dormant. The circulation, though very slow, is continuous; the heart beats regularly, and the blood, from the absence of respiration, becomes practically venous. Upon the action of this venous blood alone, circulation depends. In a hibernating animal in which the brain had been removed and the spinal marrow destroyed, the heart has continued to beat about ten hours, while in the same species in a natural state it ceases after two hours.

Extreme cold will rouse a hibernating animal from its lethargy and speedily kill it, hence many animals congregate in carefully prepared nests, and others, like the snakes, entwine themselves for mutual protection from cold. Most winter sleepers lay up under the skin a store of fat, which is slowly absorbed during the period of their long repose.

Subject to an annual lethargy are various species of animals, fish, reptiles, mollusks and insects. This is in many cases a wise provision, since the lean seasons of the year are passed in safety, the difficulty of obtaining food in rigorous weather being dispensed with. The lower animals generally seem to possess a remarkable power of resisting cold and may be reduced to a condition of apparent death, yet not identical with the torpidity usually produced by low temperatures. It is debatable whether in animals this torpidity arises more from a question of escaping cold than from avoiding starvation. But be that as it may, very many of the dwellers in field and forest spend the Winter months in that deep and dreamless sleep which breaks only with the genial warmth of Spring.

Among the more familiar animals of our latitude which hibernate during the colder months may be mentioned the various species of bats, the chipmunk or "hackie," the marmot or "ground hog," and some field mice. Frosty weather in Autumn, or such as makes insects dormant, has the same effect on all our bats in varying degrees. By that time they have become excessively fat, and in this condition go into hibernation in such places as are not subjected to very low Winter temperatures, preferably caves. From their retreats, with the appearance of nocturnal insect life, they emerge in Spring. Sometimes they come out during a February thaw, and go back again until April.

The following are the most marked peculiarities presented by bats when in a state of perfect hibernation : —The respiration is very nearly suspended, as is shown — First, By the absence of all detectable respiration ; second, By the almost entire absence of any change in the air of a bell jar or case in which the animal is placed during the investigation ; third, By the subsidence of the temperature to that of the atmosphere, and fourth, By the capability of supporting, for a great length of time, the entire deprivation of air. The circulation is reduced to an extreme degree of slowness. In an observation made by Dr. Marshall Hall the heart of a bat was found to beat but twenty-eight times in the minute.

The chipmunk (*Tamias striata*) seeks its winter resting place on the approach of frosty weather and comes out about the first of April.

The animal in different sections known either as ground hog, woodchuck or Maryland marmot (*Arctomys monax*), with astonishing regularity and precision, and utterly regardless of the state of the weather or condition of his food supply, sinks into his burrow about the middle of October, and reappears early in March or some time in February. It frequently, indeed, usually happens that the time chosen for entering upon the practice of this singular habit is during fine, warm weather and at a time when the fields are clothed with a luxuriant growth of his favorite food, clover. In fact, the woodchuck retires to the cold, dark recesses of his cheerless, subearthly abode to commence a period of voluntary seclusion, to enter a state of complete oblivion and absolute lethargy, at the very time when one would naturally suppose he would most enjoy himself above ground. That the ground hog, like the prophets of old, may be without honor in his own locality, can be surmised from the following complaint by an unappreciative farmer:

"He is a gross feeder, devouring nearly as much as a full grown sheep; he eats to give him strength to dig holes, and then he digs holes to give him an appetite for more clover. He takes supreme delight in tearing the bark from young fruit trees, and will wipe out entirely a good sized bean patch in a day. He will make truck gardening impossible in many localities, and his subterraneous excavations make it dangerous to drive teams over our fields. It is said that he hibernates in Winter and ceases for a time to follow his damaging occupation, but it would seem that he simply retires where he can spend the long Winter months in making diagrams for new and more extended operations for the coming season. Whether or not he could be domesticated and educated so as to be utilized in promoting subirrigation and laying drain tile is an unexplored field for scientific investigation."

One of our most familiar folk lore tales refers to the species under consideration. Candlemas, or the second day of February, is awaited by the countryside with expectation. The story goes that on such date the ground hog comes into the open to take observations on the weather. If the day be clear and the sun casts a shadow, the observer, in anticipation of a severe season, returns for six weeks more of slumber. On the other hand, if no shadow can be seen, the marmot confidently starts on a renewed round of activity. Such a legend has no foundation in fact. That the animal may be above ground at the time mentioned, during mild weather, is very probable. But that this is a fixed rule of life, or that the future can be read, is altogether another matter. Such a belief ranks with that in Walpurgis Nacht, in the Hartz district, and both may be included in the Phœnix-like maze of other superstitions which has come down to us, the heritage of by-gone days.

After the first few killing frosts the jumping mouse retires to some snugly prepared corner, where he curls up in a spherical nest of leaves and grasses until the cold has departed. In this latitude the hiding place generally seems to be placed far enough beneath the ground to escape freezing. No food provision appears to be made for Winter, as with the chipmunk. Really, the mice would be helpless to use it, as a freezing temperature soon begins to stupefy them. Abbot, on the contrary, states that this species seems to store up chinquapins in November. The animals can be thawed and frozen several times artificially before they succumb to such inhuman treatment. When going into Winter quarters the mice are excessively fat, but by Spring the adipose tissue is nearly gone.

During the hibernation of animals the temperature of their bodies falls to a point corresponding nearly to that of the surrounding atmosphere. In this condition they may for a considerable time be placed in carbon dioxide or under water, though they would die in a very few minutes if they were in their normal state.

Birds, by nature fitted for extensive migration, can readily follow the supply of food stuffs, and are not put to the necessity of hibernation. It has been estimated that the swift can fly at the rate of one hundred and fifty miles an hour, while even so sedate a traveler as the crow can cover thirty miles in the same period. But it is curious that in former times the swallows, who are among the more speedy migrants, should be credited with spending the colder season in a torpid state. It has been asserted, and even believed by some, that these birds pass the Winter immersed under the ice, at the bottom of lakes or beneath the waters of the sea.

Olaus Magnus, Archbishop of Upsal, seems to have been the first who adopted this opinion. He informs us that the swallows are found in great clusters at the bottom of the Northern lakes, with mouth to mouth, wing to wing, foot to foot, and that in Autumn they creep down the reeds to their subaqueous retreats. "That the good archbishop," Mr. Pennant slyly remarks, "did not want for credulity in other instances appears from this, that after having stocked the bottoms of the lakes with birds, he stores the clouds with mice, which sometimes fall in plentiful showers on Norway and the neighboring countries!"

Mr. Kalm, the Swedish naturalist, states that "swallows appear in the Jerseys about the beginning of April and are on their first arrival wet, because they have emerged from the seas or lakes, at the bottom of which they had remained in a torpid state during the whole Winter."

Another writer has endeavored to support the notion that swallows lie under the water during the Winter, and gives the following account, which he collected from some countrymen, of their manner of retiring. They asserted, he tells us, that the swallows sometimes assembled in numbers on a reed till it broke and sunk them to the bottom; that their immersion was preceded by a kind of dirge which lasted more than a quarter of an hour; that others united, laid hold of a straw with their bills and plunged down in company; that others, by clinging together with their feet, formed a large mass, and in this manner committed themselves to the deep."

Dr. Benjamin Smith Barton was informed that about the year 1765 a number of bank swallows were found in a gum tree, some four miles from the town of Lancaster. This was in the depth of winter. They were all torpid, but part of them, upon the application of heat, recovered.

These accounts, ludicrous as they may appear, were readily accepted in the olden time by a gullible public. The first doubt seems to rise in the mind of a more accurate observer.

Gilbert White was a clergyman of the Church of England, whose memory, be it said without disparagement, is cherished more for his interpretation of nature than for his service to religion. Born in 1720, for nearly a half century this faithful chronicler found

> "Tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

In his "Natural History of Selborne" he has brought the humble Hampshire parish almost to the door of every nature lover and hallowed the modest village of his birth by the recollections of a life work beside which the exploits of the Percys and the Howards sink into mediocrity.

To Gilbert White no phase of the moving natural panorama claimed greater interest than that of the migration of birds. Mr. White says: "As to swallows being found in a torpid state during the Winter in the Isle of Wight or in any part of this country, I never heard any such account worth attending to. But a clergyman of an inquisitive turn assures me that when he was a great boy some workmen in pulling down the battlements of a church tower early in the Spring found two or three swifts among the rubbish, which were at first appearance dead, but on being carried toward the fire, revived. He told me that out of his great care to preserve them he put them in a paper bag and hung them by the kitchen fire, where they were suffocated. Another intelligent person has informed me that when he was a schoolboy in Sussex a great fragment of the chalk cliff fell down one stormy Winter on the beach, and that many persons found swallows among the rubbish; but, on my questioning him, whether he saw any of those birds himself, to my no small disappointment he answered me in the negative, but that others assured him they did."

Speaking of an Autumn sojourn at Sunbury, a pleasant village on the Thames near Hampton Court, Mr. White was much amused by the swallows of those parts. But what struck him most was that from the time they began to congregate, forsaking the chimneys and houses, they roosted every night in the osier beds of the river. Now resorting to that element, at such season of the year, serves to give countenance to the Northern opinion (strange as it is) of their retiring under water. A Swedish naturalist is so much persuaded of this fact that he talks, in his Calendar of Flora, as familiarly of the swallows going under water in the beginning of September as he would of his poultry going to roost a little before sunset.

All the reptiles of cold climates become torpid during the Winter, and the phenomena they exhibit do not differ essentially from those of quadrupeds. Below the temperature of 50° they soon fall into a state of lethargy, which continues until Spring, and by exposing them in an ice house where the atmosphere remains constantly below such degree of heat, rèptiles have been kept in a torpid state for three years and a half and have at the end of this time been readily revived. No limit can be set to the period during which reptiles might thus be kept in a dormant state, without the extinction of life, and some related circumstance would seem to lend credence to the finding of toads imbedded in stone.

Land tortoises bury themselves in holes in the ground, and fresh water tortoises in the banks or at the bottoms of lakes and rivers. Lizards and snakes retire to holes in trees, under stones or among dead leaves, where many species congregate in large numbers and pass the Winter closely entwined, and in a still more lethargic state than that of the hibernating mammals, digestion and respiration being entirely suspended.

Frogs generally hibernate in masses in the mud in the bottom of the water, and if awakened from this state by warmth can remain under water without drowning eight times longer than frogs in the mating season. The toad appropriates some cosy burrow in the ground, where he defies the freezing weather.

Hibernation has been observed in many of the fishes of the temperate zones. Fishes do not fall into a condition of complete torpidity, as do reptiles and mammals, but their vital functions are simply lowered, and they hide in sheltered holes and cease to go abroad in search of food. It is stated that in India, where ponds may become dry at certain seasons for the depth of many feet, fish which have been imprisoned for several years in hardened mud have assumed their wonted activity when released from their uncomfortable position by copious rains.

When the temperature of water reaches the freezing point yellow perch become torpid, but above 38 or 40 degrees they suffer no inconvenience. Black bass do not seem to closely depend on temperature. Having no opportunity of escaping the cold they sink to the deepest part of their watery domain at the approach of Winter and if the chill penetrates to their retreat their vitality is diminished, their blood flows more slowly, they feel no need of food, and forthwith enter into hibernation. A gentleman kept a bass in his aquarium nearly all of one Winter. It ate nothing and seldom moved any member except its eyes.

The eel generally retires to the sea in Winter, but where migration is impossible it avoids the cold by burrowing in the mud. In these situations it has been captured by spearing through holes cut in the ice.

Many species of mollusks hibernate. The land snails bury themselves in the ground or conceal themselves under the bark of trees, in holes in walls, or even in the stems of some plants. They close the mouth of the shell with a calcareous plate, secreted by means of their mantle, and which is perforated by a small hole to admit the air. In Winter they bury themselves with the head upwards and do not grow at all during that time. While increasing in bulk they bury themselves in Summer at intervals for several days, with the head downwards, meanwhile growing rapidly.

In dry weather and during the heat of Summer snails also close their shells to protect themselves from drought, but this covering is thinner than that which they construct in Winter.

It is said that in the British Museum is preserved the shell of an Egyptian snail which revived after having been gummed to a board for four years in the Museum, and lived two years afterward. Other instances of the revival of land mollusks after a still longer period are equally well authenticated.

Some species retire to Winter quarters earlier than others, and their pulsation, which ranges from 30 to 110 during the Summer, ceases entirely in these creatures throughout the reign of cold. Slugs likewise bury themselves in the ground and become torpid during frosts and droughts, but it is questionable if their condition is that of genuine hibernation. Slugs differ from snails in not being protected by a shell.

The fresh water mussels hibernate before the close of Autumn and cover themselves in the mud until the beginning of Spring. They have been observed traversing the beds of our creeks as soon as early March.

It is believed that many of the marine mollusks hibernate, but very little is known of their habits at this time.

Most of the insects which pass the Winter as larvæ or perfect insects become torpid during the period when food is not to be obtained. Larvæ which are full grown in Autumn frequently lie dormant during the Winter and do not assume the pupa state till Spring. In the case of insects which have more than one brood in the year, the last brood generally hibernates, sometimes retiring to Winter quarters quite early in Autumn, while the perfect insects of the previous brood are still flying about and while the weather is yet fine and warm.

Insects which hibernate in the perfect state do not pair before Spring and are probably not fully developed until after hibernation.

Hive bees, in all likelihood, do not really hibernate. It is well known that they require food during the Winter.

The assertion has been made, in instancing the delicate adjustments of the natural world, that the plant lice, on whose sweet secretions ants chiefly subsist in inclement weather, become torpid at exactly the same low temperature as the ants themselves.

One of the most familiar of our Spring butterflies is the *Vanessa antiopa*, or Mourning Cloak. The wings of this species expand from three to three and one-half inches. Above it is of a rich purple, the wings bordered with yellow and dotted along the inner margin with blue. It is one of few butterflies common to this country and Europe, and has doubtless been introduced on this continent. The Mourning Cloak passes the Winter in some sheltered place in a torpid state. It has been found in midwinter, sticking to the rafters of a barn, and in the crevices of walls and stone heaps, huddled together in great numbers, the wings doubled over the back and apparently benumbed and lifeless, but it soon recovers its activity on being exposed to warmth. *Vanessa* comes out of Winter quarters very early in Spring, often before the snow has entirely left the ground, with ragged and faded wings, and may be seen sporting in warm and sheltered spots in the beginning of March and throughout the months of April and May. Wilson, in his beautiful lines on the blue bird, alludes to its early coming: —

"When first the lone butterfly flits on the wing."

During the Autumn may be seen in our gardens and fields, and even by the wayside, a caterpillar whose appearance must frequently have arrested attention. It is very thickly clothed with hairs, which are stiff, short and perfectly even at the ends like the bristles of a brush, as if all had been shorn by shears to the same length. The hairs on the first four and last two rings are black, while those on the six intermediate rings are tan red. The head and body of the caterpillar are also black. When one of these larvæ is taken up, it immediately rolls into a ball like a hedge hog. Owing to its form and the elasticity of the diverging hairs with which it is covered, the caterpillar readily slides from the fingers and hand of its captor. This species feeds upon the leaves of the clover, dandelion, narrow leaved plantain, or of various other herbaceous plants, and upon the approach of Winter creeps under stones, rails or boards on the ground, where it remains quiescent until Spring. In April or May the recluse makes an oval, blackish cocoon, composed chiefly of the hairs of its body, and comes forth a perfect insect in June or July as the Isabella tiger moth.

The greater number of mature crickets die on the advent of cold weather, but a few survive its rigors by sheltering themselves under stones or in holes secure from the access of water.

If insects can boast of enjoying a greater variety of food than many other living creatures, this advantage seems at first sight more than counterbalanced in our climate by the temporary nature of their supply. To the great majority of insects the earth for nearly half the year is a barren desert, affording no appropriate nourishment. As soon as cold has stripped the vegetable world of foliage, the vast host of insects that feeds on the leaves of plants must necessarily fast until the return of Spring. How is this difficulty provided for? By a beautiful series of provisions founded on the faculty of passing the Winter in a state of torpor — by ordaining that the insect shall live through that period either in an incomplete state of its existence, when its organs of nutrition are undeveloped, or, if the active epoch of its life has commenced, that it shall seek out suitable Winter quarters and in them fall into a profound sleep, during which a supply of food stuffs is equally unnecessary.

To the insects which hibernate in the larval state belong, of course, in the first place, all those which exist under that form for more than one year. There are also many larvæ which, though their term of life is not a year, being hatched from the egg in the Autumn, necessarily pass the Winter in that state. Many of these, living in the ground or in the interior of trees, need no other refuge than the holes which they constantly inhabit; some, as the aquatic larvæ, merely hide themselves in the sides or muddy bottom of their native pools, while others seek a retreat under moss, dead leaves, stones and the bark of decaying trees. Most of these can boast of no better Winter quarters than a simple unfurnished hole or cavity; but a few, more provident of comfort, prepare themselves an artificial habitation. A very considerable number of insects, especially beetles, hibernate in the perfect state.

Toward the close of Autumn the whole insect world is in motion. A general migration takes place. The various species quit their usual haunts and betake themselves in search of secure retreats. Different species, however, do not select precisely the same time for making this change of abode. For instance, many lady birds, field bugs and flies are found out of their Winter quarters even after the commencement of frost, while others make good their resting place long before severe cold has been felt.

The sites chosen by different perfect insects for the period of their repose are very various. Some are content with insinuating themselves under any large stone, a collection of dead leaves, or the moss of the sheltered side of an old wall or bank. Others prefer for a retreat the lichen or ivy covered interstices of the bark of old trees, the decayed bark itself, especially that near the roots, or bury themselves deep in the rotten trunk, and a very great number penetrate into the earth to the depth of several inches. The aquatic tribes burrow in the mud of their pools, but some of these are occasionally found under stones. Most insects hibernate in solitude.

The degree of cold which the majority of insects in their various states, while torpid, are able to endure with impunity, is very various. The habits of the different species, as to the situation selected to withstand the Winter are regulated by their greater or less sensibility in this respect. Many insects, though able to sustain a degree of cold sufficient to induce torpidity, would be destroyed by the freezing temperature, to avoid which they penetrate the earth to hide themselves under non-conducting substances. There can be little doubt that it is with this view that so many species, while chrysalids, are secured from cold by cocoons of silk or other materials. Yet a very great proportion of insects, in all their stages, are necessarily subjected to extremely low temperatures. Many eggs and chrysalids are exposed to the air without any covering, and many, both larvæ and perfect insects, are sheltered too slightly to be immune from frost. This they are able to resist, remaining unfrozen though exposed to the greatest severity ; or, what is still more surprising, are uninjured by its intensest action. They have recovered their vitality even after turning into lumps of ice.

But though many larvæ and chrysalids are able to resist a very low temperature, when it falls to a certain extent they yield to its influence and become solid masses of ice. In this condition we might think their revival would be an impossibility. That a creature whose juices, muscles and whole body have been subjected to a process which splits bomb shells, and so congealed that it may be snapped asunder like a piece of glass, should ever recover its vital powers, seems at first view little less than a miracle. If the resuscitation of the wheel animal and of snails, after years of dessication, had not made us familiar with similar prodigies, such a feat might have been pronounced impossible. It is probable that many insects turned to ice never do revive.

Of the return to life of several species, however, there is no doubt. This was first noticed by Lister, who relates in his work on insects that he found caterpillars so frozen that when dropped into a glass they clinked like stones. Notwithstanding, they revived. The chrysalids of the cabbage butterfly had been exposed to a temperature of 0° Fahrenheit, became completely frozen, and yet produced perfect insects. Indeed, the circumstance that creatures of a much more complex organization than insects, namely, serpents and fishes, have been known to recover after being thoroughly congealed, is sufficient to dispel any doubts on this head.

The scattered observations of the writer have been supplemented by citations from authorities other than those who have received specific mention.

MIZZEN:

AN ETYMOLOGICAL NOTE,

BY HENRY L. BROOMALL.

Kluge's German Etymological Dictionary gives the following account of this word:

"Besanmast, m., mizzenmast, Besansegel, n., mizzen-sail, from Du. bezaan, mast nearest the stern of a ship, which is connected with Eng. mizzen, Fr. mizaine, Ital. mezzana (the Rom. word a deriv. of Latin medius, is properly middlemast.)"

Mizzen is phonetically derived from the stem of the Latin *medius*, as thus outlined by Kluge. The etymologists and lexicographers agree in this origin of the word, and agree also in the explanatory assertion that the mizzen owes its name to a so-called middle-mast or middle sail. This semasiology seems obvious to them because Latin *medius* means *middle* and one of the three masts of a ship may be described as the middle mast.

Nautically and historically, however, the "middle" mast, which I assume is the landsman's term for mainmast, is the very mast with which the mizzen has nothing to do. To the sailor this needs no demonstration. For the student may be cited the following definitions of *mizzen* by authors and lexicographers ranging in date from 1643 to 1891.

Mizzen: The aftermost fore-and-aft sail in a ship (Century Dictionary, 1889): the hindmost of the fore-and-aft sails (Webster's International, 1891): *misaine*, le mât, la voile qui est entre le beaupré et le grand mât; *mât de misaine*, foremast; *mizzen*, a mast in the stern or back of a ship, artimon; *mizzenmast*, mât d'artimon (Chambaud's Eng.-Fr. Dict., 1805): *misaine*, the foremost sail; *mizzen*, voile d'artimon (Boyer's Eng.-Fr. Dict., 1794): *mesana*, mizzen mast or sail; *mizen*, mesana; *mizenmast*, palo de mesano (Velasquez, Sp.-Eng. Dict., 1872): *mesana*, fore-mast; *mizzen*, vela de la mesana; *mizzenmast*, subst., mesana, trinquete (Gattel's Eng.-Sp. Dict., Paris, 1803): *mizzen*, mezzana, albero di poppa (Meadow's Ital.-Eng. Dict., 1876): *mizen*, the spanker or driver is often so named; *mizen-mast*, the aftermost mast of a ship (Admiral Smyth's Sailor's Word Book, 1867): *mizen-mast*, the mast which stands abaft, and from which its rigging and sails are named as . . . . mizen, mizen-top-sail (Bowditch's Navigator, 1826): the mizen-mast is the aftermost or smallest mast of the three (Nare's Seamanship, 1877): *mizaine*, c'est la voile qui est entre le Beaupré et la grand'voile, de Focke; *Focke*, *Focke zeyl*, le voile qui est à la proüe, le trinquet, boulingue ou bouringue; *trinquet*, voyez artimon; *mezane*, *bezane*, la mizaine ou bezane, voile à la poupe (D'Arsy's Fr.-Flemish Dict., Rotterdam, 1643): *misaine*, voile qui est entre le Beaupré et la grand'voile, de Focke (Marine Vocabulary in same).

The sails here named as equivalent to mizzen, namely, Fr. artimon, Sp. trinquete, Eng. spanker, driver, and O. Flem. Focke are sails that never were or are on the middle mast or mainmast.

None of these descriptions of the sail or mast is applicable to a "middle" mast. On the contrary it appears that *mizzen* is the name of a sail or mast specifically near the bow or stern, and, when more fully described, the sail is classed as a fore-and-aft sail. The definitions can apply only to a stay-sail, jib, driver or spanker near the bow or stern. The later authors cited and the modern sailor confine the term to a sail or mast nearest the stern. *Mizzen*, then, comes from *medius* by some other line of thought than "middle" mast or sail.

Nor should we, a priori, expect the sail to be named from the mast. Masts form rigid supports for the rigging, are few in number and have only position and size to distinguish them. Sails on the other hand are of many kinds and vary greatly in shape, size and manner of setting and handling. From some of these characteristics they are usually named in order to distinguish them from the primitive and standard square sail. Compared with a square sail, slung athwart-ships, spread broad from side to side of the ship, with the mast rising along its middle line to support the yards which suspend the sail, any triangular sail, as a stay-sail, or a lateen, or any fore-and-aft sail with its gaff and boom ending at the mast — one of which kind of sails the mizzen is or always has been — is in contrast, a halved or middled sail.

And the idea of "middled" or "halved" is derived from the meaning of *medius*, as logically as the strict sense of *middle* or *in the middle*. The two shades of meaning are neatly illustrated by the Italian words *mezzogiorno*, which means the middle of the day, or noon, and *mezzocerchio*, which means a half circle — not the middle of a circle. So, too, the Post-Classical Latin *medio* means to halve, divide in the middle, *medians*, halving. Hence it is submitted that just as *mezzocerchio* means a part of a circle, so *mizzen*, as the name of a sail, refers to it as a part of the standard sail, a middled or halved sail.

WEIGH OR WAY.

W. Clark Russell, the sea-novelist, contended that *under weigh* is always the proper form of this nautical phrase, totally ignoring the other and equally proper form *under way*. They are really two distinct phrases confused in use partly because their pronunciation is the same and partly because they are often applicable at the same time.

Under weigh refers to the position of the anchor. A vessel is said to be *getting under weigh* when her crew are weighing the anchor; the anchor is *aweigh* when it is broken from the bottom and hangs by the cable; and a vessel is *under weigh* when the cable has been weighed — she is under, in the condition of having, a weighed anchor. But as she is then generally in motion the phrase is sometimes transferred to the result, and a vessel *under weigh* means a vessel in motion in contrast to one at anchor.

Under way means in motion, having way, and in its nautical use intimates that the vessel is under control of the helm. So a vessel is said *to gather way* or *to lose way*, to increase or decrease the rate of motion, to have *headway* or *sternway* or to make *leeway*, and the oarsman *gives way* to his boat with oars. A similar use of *under* appears in *under one bell*, *under a full head of steam*, *under sail*, designating the source of way. Compare German *unter Weges*.

Hence the two phrases need not be discriminated in all cases, but a vessel "hove to" is *under weigh* and not *under way* — her anchor has been weighed but she has no appreciable *way*. Steam vessels, manœuvring about wharves and other vessels in a harbor, where sailing vessels must anchor or be towed or warped, may not use an anchor for weeks at a time and yet may get *under way* several times a day. A steamship disabled at sea is not *under way*, though, strictly speaking, she is still *under weigh*. In these cases *way* is the proper spelling because it is the motion of the vessel and not the position of the anchor that is under consideration.

The question whether or not a vessel "hove to" should be considered as under way came up in the Marine Conference at Washington in 1889. The purpose was to decide whether or not a vessel under such circumstances should be allowed the privileges of a vessel not under control. It was said that the United States courts hold that a vessel "hove to" is not under way, and is, therefore, entitled to such privileges, while the English courts hold the contrary. In other words, the English are construing *under weigh* and the Americans *under way*, the former stretching the meaning of the phrase "under control," and the latter confining it, to the true meanings of the expressions they respectively have in mind.

FAIR OR FARE.

Our dictionaries give the terms *fair weather*, *fair wind* and *fairway*, and leave us to infer that the first component is the adjective *fair*, Icelandic *fagr*, Anglo-Saxon *faeger*, bright, beautiful, used in the general sense of clear or open. When we recall the sea terms applied to bad weather, such as *foul*, *greasy*, *thick* and *dirty*, *fair* seems their appropriate opposite to designate what is called also *good weather*, French *beau temps*, Italian *bel tempo*. But compare the following English, Icelandic, Old Flemish and German words:

Fair weather: O. Flem. *vaerweder*, weather fit for sailing, for faring.

Fair wind: Ger. *Fahrwind*, a wind for faring, a favorable wind.

Fairway: Eng. *wayfarer;* Icel. *farveger*, track; O. Flem. *vaerwech*, highway; Ger. *Fahrweg*, *Fahrgang*, carriage way, *Fahrbahn*, fairway, *Fahrleise*, wheel rut; *Fahrwasser*, O. Flem. *vaerwater*, navigable water, channel, fairway.

Moreover, in all these languages *fare* is a favorite nautical term, as in Icel. *ferja*, Ger. *Fähre*, O. Flem. *vaerschip*, Eng. *ferry;* O. Flem. *varen voor wint*, to sail before the wind;

Ger. *fahren ein Boot*, to row; Eng. *fair-leader*, a block or other apparatus to direct the course of a rope clear of other rigging.

These quite synonymous forms and their common nautical application suggest that *fare* is the source of *fair* in the English terms, just as Icel. *fara*, O. Flem. *varen* and Ger. *fahren* are of the foreign words.

RARE LOCAL FERNS.

BY T. C. PALMER.

Many species of ferns, as for example the green Christmas fern, the rock polypod, the cinnamon fern and the swamp-loving sensitive fern are so plentiful and so familiar that the botanist on his prowl pays them scant attention. Others there are, like the adder's tongue, which may not really be rare, but only difficult to find. Still others, like the walking leaf, are somewhat special in their demands as to environment, present notable peculiarities of growth, and become, therefore, worthy of a second glance. Lastly there are the rarities, the diligently sought-for prizes. Rarities are either absolute or relative. The adder's tongue, for example, is known to grow in all the continents of the earth except South America, and in Australia as well. Yet the local collector may go tramping for years without ever seeing it. The wall-rue fern (*Asplenium ruta-muraria*) chokes the crannies of the walls of Europe, yet is recorded from but six localities within sixty miles of Philadelphia. On the other hand, *Asplenium ebenoides* is absolutely rare, a thing of note wherever found.

The walking leaf (*Comptosorus rhizophyllus*) is recorded from about twenty-five localities in Philadelphia, Bucks, Montgomery, Chester and Delaware counties by Keller and Brown, in their recent work, "The Flora of Philadelphia and Vicinity." Some of the Delaware county localities are evidently duplicates, as "Rockdale," "Mount Misery," etc.

But it is safe to say that the eleven localities credited to Delaware county could easily be quadrupled. This species grew most luxuriantly at Castle Rock for many years, and probably would grow there yet but for the lamentable destruction of that famous place through the short-sighted greed of a corporation. Thence down Crum creek, almost wherever fitting conditions obtain, it is to be seen in more or less abundance. So, also, along Darby, Ridley and Chester creeks, down to the 180 foot contour line, it may be discovered by the trained eye in many places. But the eye must, for best results, be trained not only to see the plant itself, but also to recognize the characteristics of a probable habitat. The fern demands for its growth and welfare a rock that is not too dry, not too much exposed to direct sunlight ; and in most instances it is the north side only of the rock that is occupied, though in certain cases the fern grows well upon the very top, among grasses and weeds. When this happens, however, the rock is in a place overshadowed by trees. The kind of rock seems to matter very little, provided it be not too new and bare. On limestone the fern absolutely riots. On serpentine, as at the Black Rocks locality on Mill creek near Bryn Mawr, it was for many years scarcely less luxuriant. On serpentine, near Media, it does excellently well. For the rest, there are the igneous masses of Castle Rock and the gneissic hugeness of Mount Misery, at Rockdale. In no place is the species more at home than in that last mentioned, and nowhere else does it present more of those sports and oddities of form which indicate a condition of prosperity that has lifted it above the stern warfare of life and given the wherewithal to try experiments. But nowhere does the walking leaf wax wanton, nowhere does it really seem happy or contented, or even well conditioned, save where there is something more for it to grow in than a mere crack in the face of a rock. There must be retained moisture, some little dark woods earth, some humus. Moreover, it is frequently crowded out, as the years elapse, by that coarse barbarian, the rock polypod.

Much resembling the walking leaf is the pinnatafid spleenwort, *Asplenium pinnatifidum*. This species is to the manor born. Nuttall discovered it on the banks of the Schuylkill above Philadelphia in the year 1818. It has since been found in other places in Pennsylvania, as also in New Jersey. Its range is now stated as "New Jersey and Pennsylvania to Illinois, south to Georgia, Alabama and Arkansas." (Britton and Brown). It is much less frequent than the walking leaf. Unlike that species, also, it habitually grows in the smallest of cracks on the faces of bleakest rocks. This, however, is possibly not a preference on the part of the fern. There is some reason to think that the plant is still more lacking in strenuosity than the walking leaf, still less able than it to withstand the encroachments of more vigorous species like the rock polypod, and so is forced to find foothold in the most restricted of unoccupied territory. You shall find it, if at all, in the most improbable places. In Fayette county, Pennsylvania, two years ago, Mr. Crawford, of Philadelphia, detected it upon the bleakest, the most sun-scorched rock in the vicinity. Rocks there were by the thousands, about the slopes of the vale, many of them ideally sheltered from the intensest cold of winter and the extreme heat of summer. On them, or some of them, were to be seen the walking leaf, the mountain spleenwort, and others, but no *A. pinnatifidum*. In 1880, in company with the late Lewis Palmer, the writer had the extreme pleasure of finding it very nearly in the place of its botanical origin. It grew at that time out of the smallest possible crack in the face of a bare and overhanging rock on the west side of Wissahickon creek. The rock at that point is a much-contorted mass of Wissahickon gneiss. Again, in 1895, during a lonely scramble along Ridley creek, in Delaware county, the writer saw a single flourishing example, situated in the smallest of cracks, on the barest of rocks, where it was exposed to the direct rays of the sun nearly half of each day. (Here again the rock is Wissahickon gneiss). This plant was watched for years. It spored profusely, and sent out new fronds from time to time, until 1905. In the summer of that year it began to show signs of declining. At present its fate hangs in the balance. Notwithstanding the thousands and tens of thousands of spores shed upon the air by this plant, the most determined search failed to show another specimen anywhere in the region. This occurrence, therefore, is as it were a sporadic case, a fortuitous and evanescent case, of *Asplenium pinnatifidum* in Delaware County. But when it comes to a species as rare as this, a case is a case, and to be noted.

The gentlemen of the Philadelphia Botanical Club have collected remarkably large and handsome specimens of this species on the Susquehanna near York Furnace, and it is understood that the extraordinary thrift of these plants is due in all probability to the fact that they have, by some happy chance, been permitted by their competitors to grow in a spot less lean and exposed than usual. They have managed, somehow, to preëmpt a little patch of rock where there is some moisture, some shade, some depth of dark, rich earth. And this is one of the reasons for saying that small cracks on blistering rocks are, probably, for this species, locations not of choice but of stern necessity.

One of the most beautiful local ferns is the cliff brake, *Pellæa atropurpurea*. In the Philadelphia region this species is confined strictly to the limestone. It occurs in some scarcity on the limestone ledge along Gulf creek, in great quantity on the cliffs near Norristown, and thence south-westwardly along the Chester Valley. It is known to grow from Canada west to British Columbia and southward, mostly on limestone, into Mexico. Another species, somewhat smaller, the *Pellæa Stelleri*, has somewhat the same range, and should be found, though it has not been, in this same vicinity.

The wall-rue spleenwort (*Asplenium ruta-muraria*) has been referred to. It is another limestone species. Dr. Darlington, in his "Flora Cestrica," edition of 1837, gives:—
"Hab. Limestone rocks; near Brooke's Mill; not common."

In the third edition, published in 1853, the note is changed to "Limestone rocks and cliffs; Great Valley; rare." Keller and Brown give six localities in as many counties, and one of them is the "Brooke's Mill" of Dr. Darlington. Another is "Conshohocken," on the authority of Charles E. Smith. The writer has seen it nowhere except at Brooke's Mill, where he had sight of it during a trip with the late Lewis Palmer, in 1880. It grew rather sparsely on the top of a much-weathered, well-shaded limestone rock. Never abundant there, it was for many years sought in vain by some botanists, and no doubt it had been practically exterminated by those who loved but too well to "lend an air of verisimilitude to an otherwise bald and unconvincing narrative" by the exhibition of a specimen or two. However, these rare species come and go in a mysterious manner. The spores become disseminated generally, and when they alight in congenial surroundings some of them give rise to prothallia. The prothallia lurk unseen, and eventually send up sporophytes. So it is, that after an interval of a few years the fern is re-established in the old, the original, the altogether fitting spot. It was not, therefore, a matter of very great surprise to learn that *A. ruta-muraria* had been seen within a few years not far from Brooke's Mill. One does not hesitate to mention this, for the reason that the locality is already on record. Also, it has come to pass that the local collectors have now mostly reached that stage of enlightenment which guarantees a proper self-denial in the presence of rare ferns. Lastly, the name "Brooke's Mill" expresses nothing to the non-elect. You shall not find it on any modern map, and only the oldest of the native inhabitants in the region could tell you where it is. And, if by any combination of favorable circumstances the neophyte arrives, he will have earned his view of the fern before he obtains it.

A species worthy of passing mention is the bladder fern (*Filix bulbifera*). This fern grows in damp and shady ravines, and may be overlooked because it resembles somewhat the more common species. Keller and Brown give nine localities in six counties of South-eastern Pennsylvania. One of these is at Conshohocken, another at Coatesville. We may add to these one more. In 1882 it grew in the ravine near the eastern end of the high railroad bridge west of Media. With it were *Osmunda cinnamomea*, *Dickonia* and other fern species, including some of the genus *Aspidium*. The fronds bore almost no indication of the bulblets that give the fern its specific name, and it was only by a careful examination of the other characters that its identity was fixed. The vicinity has undergone some changes, and it is not at all certain that the fern has survived. But there are many shady ravines hereabouts, and while this part of Pennsylvania is on the very edge of the range of this species, it may still lurk here and there. Another species of the same genus, *Filix fragilis*, is a species of almost world-wide distribution. However, it is here near its south-eastern limit. It is scarcely known to occur in Southern New Jersey. It is discoverable among the shaded cliffs along the larger streams down to the ancient shore line of the Delaware Bay, known now as the "180 foot contour above tide." Below that point, riverward, where the conditions are somewhat similar to those in New Jersey, it is rare or absent. It may be said to belong to the Piedmont Plateau, and not to the Coastal Plain.

By contrast, the chain ferns are in this region distinctly of the Coastal Plain. *Woodwardia areolata*, the rarer of the two in Pennsylvania, is quite common in New Jersey, where it thrives especially in inundated, shaded places. It is recorded from Tullytown, in Bucks county, and from Tinicum. The Tinicum locality was mentioned in Dr. George Smith's original list of Delaware county species, and specimens from there are in the herbarium of the Institute. It is impossible to say, now, whether the fern was once abundant in Tinicum. For many years past it has apparently been confined to two closely associated places. One of these is on the edge of a woodland between Lester and the pond known as Long Hook.

The other is in a small open copse near at hand, in the immediate vicinity of the large, high tower of the lighthouse. In both places the fern "has its feet in water" at most seasons. During the drought of summer the swale at the first-named place sometimes becomes almost or quite dry, and the fern then nearly disappears. But it has a good, serviceable, creeping rootstock, and can stand a certain amount of hardship without entirely perishing. So, amid the mutations of its lot, it stays on from year to year, not very mighty, yet now and again with the aspect of a fern thoroughly at home. The fertile leaves do not fail to appear, nor the spores to shed themselves upon the air. May the shadow of its fronds never grow smaller in this, the only station (if we count the two spots as one) that warrants us in naming *Woodwardia areolata* among the rarities that queer Tinicum contributes to our Delaware county flora!

Woodwardia Virginica, the other chain fern, is a much larger plant. While *W. areolata* recalls in a general way the common sensitive fern of the swamps, the aspect of the present species is roughly that of one of the large cinnamon ferns. Keller and Brown give fourteen localities in New Jersey, one in New Castle county, Delaware, two in Bucks county, and one, that is to say Tinicum, in Delaware county.* This species, also, was probably collected by Dr. George Smith, and it has at any rate been known as a Tinicum plant for many years. It is not so scarce in that neighborhood as the other species, though it appears to be confined to the woodland around Lester. It also is a lover of water, and in New Jersey it sometimes grows in veritable small ponds. In Tinicum it affects the swales in the sandy woods, but is by no means confined to them. It can be found at times in abundance at places where, in midsummer, there is no sign of

* Both the Bucks county localities, Bristol and Tullytown, are of the same general nature as Tinicum. Not only among ferns, but among other orders of plants as well, the unusual species that occur in Tinicum are apt also to occur near Bristol, or near Tullytown, or at Penn Valley.

water. But during the wet months all this tract is found to be more or less inundated, and so we are able to understand how the fern, with its disposition what it is, can successfully bring around the cycle of the seasons. It is a fine, large, ornamental fern, and we shall by no means relish the inevitable, though perhaps not imminent, changes that the future has in store for Tinicum — changes that will wipe out this fern, and with it the purple lady slipper, Nuttall's lobelia, the Turk's cap lily, and a dozen other treasures that Tinicum has cherished since ancient times.

We come to *Asplenium ebenoides*. This is not (to speak literally) an easy thing to do, for the species, if species it is, must be counted as among the rarest of native ferns. It has, like *Asplenium pinnatifidum*, a special local interest, because it was first discovered in the vicinity of Philadelphia. Mr. R. R. Scott,* born in Belfast, Ireland, was a lover of botany from his youth. He was at one time connected with the celebrated Kew Gardens. Some time prior to 1852 he came to Philadelphia and found a situation with Robert Buist. Shortly thereafter he began issuing the first horticultural journal of that city, "The Philadelphia Florist." This publication, which survived for three years, was of a high order of merit, and Mr. Scott's pleasing style and his fund of general knowledge added much to its charm. He removed to New York in 1857, returning to Philadelphia in 1860. At this time he became head gardener to an estate on the west bank of the Schuylkill, and in the immediate vicinity he discovered, in 1862, the fern of ferns, *Asplenium ebenoides*. From Mr. James G. Scott, of Germantown, a son of the discoverer, it is learned that the location was "on the estate of Algernon P. Roberts," which lies "just back of the Pencoyd Iron Works, but the roadway to West Laurel Hill Cemetery now covers the exact spot." Mr Scott adds: "The strip of woodland is

* For the biographical facts as to Mr. Scott we are indebted to the "Fern Bulletin" of April, 1903.

still there, but in a semi-cultivated state, and there are few ferns (of any kind) to be found." The fern was first described by Mr. Scott in the "Gardeners' Monthly" for September, 1865. The citation of the original description, however, is given: "R. R. Scott, Journ. Roy. Hort. Soc., 87, 1866," in Britton and Brown's "Illustrated Flora." Asa Gray, in his "Manual," edition published in 1880, stated that it grew "on limestone cliffs on the Schuylkill, near Philadelphia." In subsequent editions, *e. g.* 1889, we find: "Limestone cliffs, Conn. and Penn. and southward; very rare * * ." So, also, Britton and Brown*: "On limestone, Connecticut to Indiana, south to Alabama. Rare and local, except in the last named locality." Lastly, Keller and Brown†: "Limestone" — with recent (?) location: "East side of Schuylkill," on the authority of Charles E. Smith, or on the strength of specimens so labeled in his herbarium.

It must be so — the species must grow on limestone. But where are these cliffs of limestone on the east bank of the Schuylkill? Where are there any limestone cliffs, anywhere, on either bank of the Schuylkill, "near Philadelphia," or "near Manayunk," as the thing has been variously stated? The writer has looked for such during the last twenty-five years — sought them carefully, and with tears. Barring some strange misunderstanding, the very nearest limestone cliffs are far away up river at the eastern extension of Chester Valley. So say the geological maps, so say all of us who have tramped, and peered, and cracked rocks up and down the Schuylkill. It is strange.

It mends matters not at all, that after one has at last located the nearest limestone cliffs, has with much labor scrambled all over them and made minute search into their every cranny, he shall find himself, at sundown, still without the fern, and in the immediate vicinity of the celebrated

* The "Illustrated Flora" was published in 1896.

† "Flora of Philadelphia," p. 11.

Norristown Insane Asylum. There is something ominous in all this, one is inclined to say, and the wierd quest is, for that season, abandoned.

Next year the same thing happens. Near Philadelphia there are no limestone cliffs, and on the limestone cliffs near Norristown there is no *A. ebenoides*. Indeed, there does not seem to be a single frond of it on any sort of cliff. Once upon a time there was much talk of an alleged Mrs. Harris, and could it be that * * ? But no, the fern must exist. Prof. Merrill finds it in Virginia, Mr. H. P. Wells collects it near Delaware Water Gap, Mr. Eggleston records it as collected by Mr. Ross at Rutland, Vermont, and Dr. T. C. Porter takes two specimens near Easton. It turns up in Connecticut and elsewhere. Nowhere, indeed, is there very much of it — a single plant, or two, perhaps three or four in a place — except in Havana Glen, Alabama, where it grows in profusion, according to Dr. Underwood.

To be anxious, and diligent, and determined, is very well; but sometimes it is less wearing, and equally fruitful, to take things quietly as they come, to saunter along, to be anxious about nothing. There were five of us in the party. We were not looking for *Asplenium ebenoides*, nor for anything in particular, except refreshment of mind and body, in our wanderings in Chester Valley that beautiful afternoon. We had, however, become interested in the unusual development of the walking leaf (*Camptosorus*) along a certain mossy and shaded ledge of limestone. One or two of the party had not, in fact, made this fern's acquaintance until then, and none of us, possibly, had seen it anywhere in greater abundance. There were other fern species of interest, such as *Pellæa atropurpurea* and *Asplenium platyneuron*. We were following along this ledge, with no thought of Mrs. Harris, or the limestone cliffs "near Philadelphia," or anything vexing or puzzling, when to our goggle-eyed gaze unfolded themselves three plants of the celebrated fern. They grew within a few feet of each other and were closely accompanied by *Camptosorus* and

Asplenium platyneuron. They looked demure enough. There came no clap of thunder from the sky, and Nature generally retained her wonted calm. Somehow this seemed surprising in the face of that inner tumult which caused one to look wildly about, to utter incoherencies, and finally to recline upon the ground while gathering a fresh store of breath. There was something distinctly uncanny in the stoical silence of the trees, the unchanging murmur of the stream, the general unresponsiveness. One gathered that Nature rated at nothing the achievement of a quest lasting a quarter of a century, and cared very little about such small things as *Asplenium ebenoides.*

The companion ferns of this rare form, as we found it, have been mentioned. It is a significant fact that in the original locality, and in almost or quite every other situation where it has since been found, the walking leaf and the ebony spleenwort have accompanied it. This circumstance, taken in connection with the fact that this scarce fern is intermediate in almost all its characters between the two species mentioned, has led most observers to view it as a hybrid between them. Dr. L. M. Underwood, chiefly, as it would appear, from the relative abundance of the plant in question, and the relative scarcity of its supposed parents, at the Havana Glen locality in Alabama, vigorously combats the theory of hybridity, and is firm in the assertion that *A. ebenoides* is a good natural species. Hybrids, whether natural or artificial, are usually inclined to sterility. This fern, it appears, shows every evidence of a self-continuing fertility in Alabama. These facts unquestionably have weight, and the opinion of Dr. Underwood is not of small importance. The plant is, indeed, accustomed to form spores in a normal manner, and probably these spores often do form prothallia, giving rise to new plants. One of those observed in Chester Valley was evidently several years old, and was sporing abundantly, while the other two had the aspect of a second generation from the same stock. But nothing could be concluded with certainty on this head. Indeed, the whole question is by no means simple. Fertility in hybrids, whether natural or artificial, is an exceedingly variable quantity, as we have reason to know. Apparent sterility may often be something else, as for instance the unpreparedness of a new organism to meet all the many environmental influences that have been met and conquered, one by one, by those forms that have, by virtue of this warfare of theirs, become the valiant survivors of the struggle of the centuries. Long experience, and hard knocks, have made them what they are. Every new form, whether a variation or a hybrid, must take the knocks, and do the best it can in the absence of experience. The outcome depends upon whether or not it can do well enough.

It is quite conceivable that *A. ebenoides* is a fertile hybrid, and in view of the Havana Glen situation, when this is taken with the other facts, such is the probable inference. For it must not be forgotten that the plant is rare; that it occurs always, so far as known, in company with its supposed parents; that its characters are intermediate. Above all, it must be remembered that Miss Slosson has produced a hybrid form, apparently identical with the naturally occuring *A. ebenoides*, by placing in juxtaposition the archegonial parts of one, and the antheridial parts of the other, of these companion species. (Whether this artificial hybrid has proven fertile is not known to the present writer). Now it is quite possible that the cryptic conditions which elsewhere work against the survival of the hybrid, if it is a hybrid, are in abeyance at Havana Glen; and that the plant is there able to continue itself indefinitely. It is thinkable, indeed, that in the course of many generations the fern may gain such stability and stamina at that place as to be able to spread abroad and survive elsewhere.

Meantime, as has been said, the fern is of a pronounced rarity. So seldom is it met with that students and collectors in all parts of the country are chronically in want of specimens. All lovers of ferns, especially, are looking for it in all probable places. To announce its discovery is to receive from afar requests for specimens, and from near at hand demands for specific descriptions of the location. One therefore hesitates to be quite frank about the matter, and comes at last to appreciate the origin of the mysterious, impenetrable cloud that has settled over the "limestone cliffs near Philadelphia," and rested there these many years. For, hybrid or no hybrid, the three plants in Chester Valley, if the writer and his friends have their desire, shall remain there unvexed of the collector, with every opportunity that Nature permits them to work out their own destiny. There, in the sequestered nook where they were hidden by the great, impersonal mother, let them do, unmolested of mankind, what is possible to them. Let the trees that shade them still keep silence and let the stream still ignore them in its prattle. If they survive, well and good. If they succumb, "well also, though not so well."

MINUTES OF MEETINGS.

SEPTEMBER 6, 1906.—Regular monthly meeting of the Institute. Reports of Curators and Committees. On motion the repairs to the roof of the building, done under the direction of the Board of Curators, were approved, and the bill directed to be paid. The Publication Committee reported the completion of Volume I of THE PROCEEDINGS and was awarded an appropriation of one hundred dollars. Plans for the proposed improvement to the entrance to the building were submitted by the tenant, The Media Title and Trust Company, and the matter referred to the Board of Curators. The following additions to the Library were reported: "Proceedings of the United States Museum, 1906;" "Browning's Complete Poetical Works." Charles Potts exhibited some specimens of live tortoise beetles, which had the faculty of changing color. The matter was discussed at length. Lewis Kirk called attention to some unusual relations to be met with in the geometrical figure used to demonstrate Euclid's famous "Forty-seventh Proposition." Adjourned.

OCTOBER 4, 1906. — Regular monthly meeting of the Institute. Reports of Curators and Committees. The matter of new stoves for the hall was discussed, and the Board of Curators directed to purchase same. The President announced the appointment of the Programme Committee for the coming season, as follows: Henrietta K. Broomall, October; T. Chalkley Palmer, November; Henry L. Broomall, December; Dr. Trimble Pratt, January; Robinson Tyndale, February; Carolus M. Broomall, March; Sanford Omensetter, April. Additions to the Library were announced as follows: "The Magnesian Limestone of New Jersey and the Search for Bacillaria in It" and "On a Deposit of Bacillaria from New Mexico," by Arthur M. Edwards, M. D.; "Census Reports, Mortality Statistics." An open discussion on current scientific topics closed the business for the evening.

INSTITUTE NOTES.

In connection with the recent record made by Lieutenant Peary in his arctic expedition, reaching 87° 6′ of North Latitude, it may be of interest to members of the Institute to remember that it has among its membership one of the survivors of the famous Kane Arctic Expedition. Amos Bonsall, a life member of the Institute, is one of the last, if not the last person living who accompanied Dr. Kane on his expedition in 1853-1855. The expedition was made at a time when much less was known of the rigors of northern travel, and when the equipment of vessel and crew was far less complete than nowadays. The dangers encountered and sufferings undergone by the members of this expedition were probably greater than on later ones for this reason. Mr. Bonsall, who has of recent years been a resident of Philadelphia, became a member of the Institute in 1856.

Lewis Kirk, a member of the Institute, suggests the following method of making a simple form of storm glass: Into a large mouthed bottle partly filled with colored water insert an inverted bottle with a long, thin neck, so that the mouth of the inverted bottle will be just below the surface of the water. Warm the air in the upper bottle with the heat of the hand until enough air is expelled from the bottle to draw the colored water about half way up the neck of the inverted bottle when the apparatus has cooled off. If the bottles in this shape are kept in a place of uniform temperature, the apparatus will act as a very serviceable weather glass, rising and falling with the barometric pressure. Its extreme sensitiveness to heat changes, however, very seriously interferes with its usefulness.

Among the recent accessions to the Museum of the Institute are a number of samples of garnet from what appears to be a new locality in this county. These samples were found in a comparatively new quarry on the east bank of Darby creek, near Burmont Station, on the Baltimore Central Railroad, close to the old "Kelly Spring." The quarry seems to consist of Wissahickon gneiss, with some streaks of granite gneiss. The garnets occur in a very foliaceous, thin stratum, and do not appear to be in great abundance. The crystallization is of the dodecahedron type, largely modified, the garnets occurring some of them jammed together in masses, but many of them in loose crystals.

The Institute has among its records a number of photographs of old historic buildings, bridges, millsites, etc., made by Dr. W. T. W. Dickeson. The collection is quite a valuable one. To students of local history it will be interesting to know that there has recently been added to the collection a series of photographs of log cabins still existing in this county and still occupied. The photographs were made by John W. Palmer, of Media.

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OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

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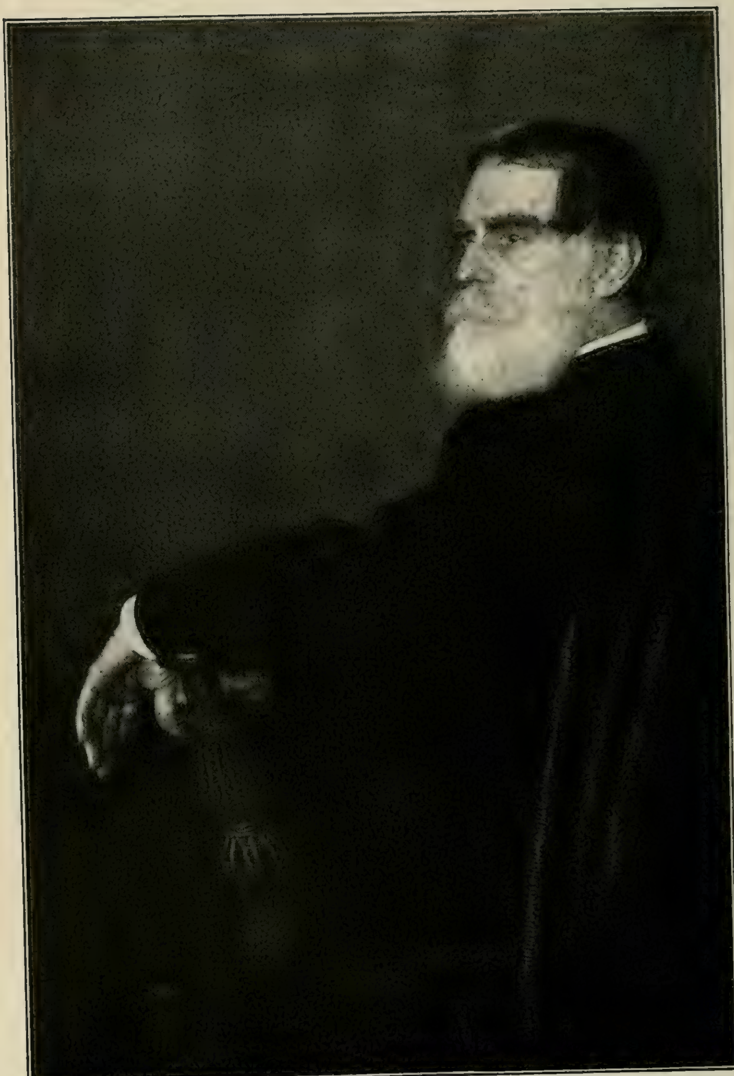

JACOB B. BROWN.

PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. II, NO. 2 JANUARY, 1907

JACOB B. BROWN.

1831 — 1906.

It is with the deepest regret that the Institute records the death, on December 6th, 1906, of Jacob B. Brown, Member and Curator.

Mr. Brown became a member of the Institute in 1894 and always took a most active interest in its meetings and welfare. He read many papers before the Institute on various scientific and literary topics. A number of these have been published in THE PROCEEDINGS, and it is hoped that the Institute will have the privilege of publishing others.

Mr. Brown was especially interested in astronomy, and his papers on this subject are of the highest type. In this connection, a few years ago he presented to the Institute a sun dial and with painstaking effort attended personally to the mounting and orientation of the apparatus, which occupies a permanent position upon the south wall of the building.

Although well known and honored by those with whom he came in contact, even Mr. Brown's most intimate friends knew little of his life history, as he seldom spoke of the past other than in an impersonal manner. What follows, therefore, will be most welcome.

Jacob Brown Brown was born December 10th, 1831, in Newport, R. I., where his father, Major Thompson S. Brown, U. S. A., was then stationed at Fort Adams. The family, whose American ancestor came to this country with William Penn, settled originally in Bucks county, Pennsylvania, the grandfather and grand uncle of the deceased migrating from that locality in 1799, and founding, a few years later, the town of Brownville, in Northern New York.

The grand uncle, Jacob, from whom Mr. Brown was named, gave evidence of marked ability early in life. After a journey of exploration into Ohio, then an absolute wilderness, and after some three years in New York city, where he taught school, contributed literary articles to the newspapers of those days, and held for a time the position of secretary to Alexander Hamilton, we find him in 1806, at the age of 31, on the St. Lawrence river, as surveyor and land agent for the French "Compagnie Nouvelle de New York," whose purpose was to found a colony in Northern New York for French families expatriated as a result of the revolution of 1789.

Both Jacob and his brother, Samuel, the grandfather of Jacob B. Brown, became men of prominence on the northern frontier of the United States early in the nineteenth century. Samuel Brown, after some service in the War of 1812, settled in Brownville, Jefferson county, New York, and devoted his energies to business, farming and lumbering. The other brother, Jacob, who had acquired a very accurate knowledge of the topography and conditions of the country from Lake Ontario to the rapids of the St. Lawrence, distinguished himself as a military leader and strategist in our second war with England. He rose to the rank of major general, and for his services in command of the American forces in the battles of Niagara, Chippewa and Erie, received the thanks of Congress and the award of a special medal. From 1821 to his death in 1828 he was the commanding general of the United States Army, dying in Washington at the age of 53, after a life of the most unremitting activity.

Thompson S. Brown, son of Major Samuel Brown and nephew of General Brown, graduated at West Point in 1827, with assignment to the engineer corps, in which he attained the rank of major, resigning some years later to take up engineering in civil life.

His son, Jacob, the subject of this sketch, entered Columbia College, New York, and was in the second year of his course when his father, who had been for some years chief engineer of the Erie Railroad, was selected by the Russian government to fill the same position on the St. Petersburg and Moscow R. R. At the age of 18 Jacob Brown accompanied his parents to Russia, where for eight years the family lived in St. Petersburg.

Jacob Brown spent a portion of this time in Moscow, pursued a special course at the University of Berlin, and made one visit to England. Subsequently, his father's health failing, the family removed to Italy, where Mr. Thompson Brown died at Naples.

For some ten years the family made Florence their home, Mr. Brown conducting during a portion of the time, in company with an English friend, a school for English-speaking boys and young men at Nice, France, and devoting a portion to the care of his mother in Florence. During this period he became thoroughly familiar with the language, literature and history of that part of Italy, a region which among the many places visited in his wide travels was always endeared to him by its associations of home and family ties.

A younger sister had married in St. Petersburg, and on his journeys between Italy and that city he had the opportunity of seeing much of the life of various cities, on one occasion making a driving tour through a part of Finland.

About 1870 Mr. Brown returned on family business to the United States, which he had not visited (except for a very short time in 1859) since his days at Columbia College, and in his reminiscences one can readily see how greatly he was impressed by the gigantic changes through which our country had passed in the intervening years — a period which had witnessed the Civil War, the acquisition of our Pacific coast, and an enormous development of New York and San Francisco. He crossed the continent in some eight or nine days and spent some time in San Francisco and interior towns of California, attending to family business and traveling with his good friend and uncle, Mr. Robert Brown. His return was made via Panama. For the next two years he divided his time between his native town of Newport and visits to the homes of several families, related to his own, and where he was always welcome, his kindliness of heart, tact and rare mind endearing him to those with whom he came in contact in the intimacy of family life.

In 1875 an opportunity presented itself to visit the East on an American cruiser. The berth of captain's clerk was offered him and accepted. Under orders to report on board the "Ashuelot," Captain (now Rear Admiral) Matthews, Mr. Brown sailed for San Francisco, again traversing the Isthmus, and continuing his voyage in the old side paddle steamer "China." This voyage he loved always to recall — four weeks of slow steaming, of level sea and brilliant sunsets day after day, of brilliant starlight night after night, as the vessel continued westward, through that most equable climate of the globe. During this voyage, and a later one from China to France, he stored away a myriad of finely graduated impressions of ocean, sky and sunlight éffects which enabled him, in later years, to present to English readers his exquisite and accurate translation of de Amicis' "Sull'Oceano," published under the title "On Blue Water."

For the next two years he lived the routine life of the navy on board the "Ashuelot," along the coast of China and Japan, from time to time making excursions to points of interest, and once, in company with several others, ascending the Yang-Tse river many hundred miles into the interior, reaching a portion of country which had at that time been visited by comparatively few Europeans. He spent some time in Pekin, and when visiting the Great Wall of China made notes and measurements of its various dimensions, the character of its material, etc. (See Proc. Del. Co. Inst. Sci., Vol. I, No. 1.) Mr. Brown was on board this vessel on the coast of Japan when the great typhoon of 1874 took place, witnessing vessels swept ashore and enormous destruction of life and shipping.

After two and a half years of this life in the East, having interests demanding his return to Europe, he resigned his berth in the navy, and took passage on a French vessel from Hong Kong to Marseilles. The voyage carried him south through the Straits of Malacca to Ceylon, and then through the Indian Ocean to Aden and up the Red Sea to Suez, where the canal had been recently finished. It was now some six years since he had left the Reviera and the sparkling shores of the Mediterranean; he felt a keen delight to be once more upon her waters, and but a few days from the country he looked upon as home. The interval had taken him around the world, affording him observation of the rushing life of the California towns, the social side of New York and Newport, and a sojourn in China and Japan — as yet but slightly influenced by Western civilization. Probably in no one decade of the last century could a keen and thoughtful traveler have gained more from a leisurely encircling of the globe than in the years from 1870 to 1880.

After some time passed in Italy and Russia, where relatives were living, Mr. Brown decided that his life could be better and more usefully passed in his native country. The early ties and associations had passed away, nothing bound him to Italy, and he felt more of attraction to Newport, where his mother's family had lived for many generations, than to any other spot.

Until 1886 he lived in that city, occupying himself with researches in astronomy and mathematics, and with literary study and compilation. Always fond of the sea, he spent much time, summer and winter, on the water, generally in his rowboat "Snooks." Very active and wiry, and a good swordsman in his younger days, he would often pull twenty miles through a rough sea, and was a favorite with the ancient tars of the town, with whom he passed many genial hours in

Mr. Alger's boat shop. The latter named a boat after him, calling it the "Jacob B. Brown," but he did not like the prominence thus given to his name, and that of "Mr. Brown" was substituted. He also passed much of his time in and near New York, as companion and adviser to an intimate friend, in failing health, whom he later accompanied on a long stay in South Carolina.

Mr. Brown never married. He is survived by one widowed sister living in England, and by several nephews and nieces in England, Russia and Italy.

Mr. Brown was a man of very high attainments, a natural linguist, uniting with a fine literary taste very keen powers of mathematical analysis — a rare combination of mental faculties. He translated many poems and prose works from the German, and from the Italian of de Amicis "Sull'Oceano," under the title "On Blue Water," as before noted. He made also a rhythmical translation of "The Æneid" and of many odes of Horace, and the Institute is indebted to him for many essays connected with astronomical and mathematical subjects.

Those who knew him well look back upon an attractive and original character, upon a man of very winning manner, who yet carefully avoided putting himself forward. Very tenacious in his friendship, and finding something worthy of study in all with whom he came in contact, his sympathy and interest were always at the service of his friends, and he well exemplified the saying of Robert Louis Stevenson that it is the mark of a modest man to take his friends as chance gives them to him. Gifted with a very acute perception and an intuition rarely found in the male sex, he had the power of often divining an anxiety or trouble on the part of a friend or associate, and of adapting his conversation to its lightening and aid. This faculty was at times so acute as to suggest mind reading.

The Institute acknowledges its indebtedness to Mr. Thomas Brown Whitney, a cousin of the deceased, for the above information. Through his kindness it is enabled to record this humble tribute to the memory of Jacob B. Brown.

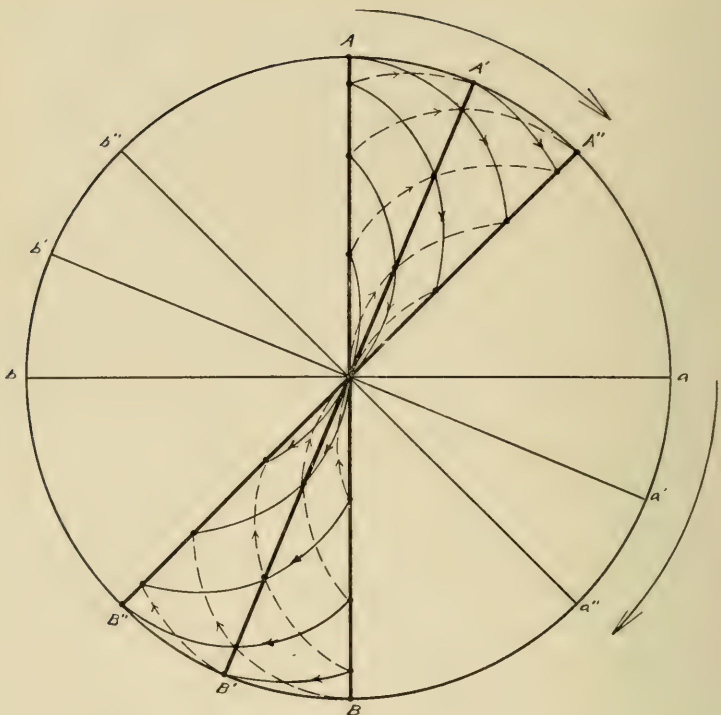

Figure 1

Figure 2

Figure 3

Figure 4

THE GYROSCOPE.

BY C. M. BROOMALL.

It has always seemed to the writer that an explanation of the action of the gyroscope in every-day language and free from mathematics was something to be desired. It is with the idea of offering such an explanation that what follows is written. No claim for it can be made other than that it is a straightforward, practical treatment of a difficult subject.

All gyroscopic phenomena take place as the result of the operation of a certain dominating influence known as the gyroscopic force. No matter how complicated and apparently unexplainable the action may be, it is to this force, modified more or less by the attending circumstances, that all the phenomena exhibited by the gyroscope, top, or other instrument, are due. An understanding of the nature and cause of the gyroscopic force is therefore the first essential to an understanding of the matter in question.

In Figure 1, let AB represent a circular plane perpendicular to the plane of the paper rotating, for instance, in a direction so that A approaches and B recedes from the reader. Let ab be the axis of rotation of the wheel. Suppose now the axis constrained to move in the plane of the paper in the direction shown by the arrow. Let AB, $A'B'$, $A''B''$ and ab, $a'b'$, $a''b''$ be successive positions of the wheel and axis at successive instants of time. Assume for consideration any convenient number, say sixteen, symmetrically situated points around the wheel. It goes without saying that what applies to these sixteen points will apply to any and all such symmetrical systems of points.

Suppose now that while the wheel is rotating as before assumed the axis moves in the plane of the paper from ab through $a'b'$ to $a''b''$. The wheel will then pass from AB through $A'B'$ to $A''B''$ as shown. While this is occurring each of our sixteen particles is forced to move through a certain curved path as a result of the combination of the two rotations. The curved lines in the figure are meant to represent the paths of the particles as projected on the plane of the paper. The arcs described in front of the plane of the paper are shown in solid lines and those behind the plane of the paper in dotted lines. The arrows show the direction of the motion. In the figure the angular velocity of the wheel and axis are assumed the same.

As the various particles describe the curves centrifugal forces are of course developed. These centrifugal forces at all times except when the particles are in the plane of the paper have moments around the line of intersection of the plane of the wheel with the plane of the paper. A glance shows that the particles above the plane of the paper and likewise those behind the plane of the paper conjoin to make the end a of the axis recede and the end b advance.

Let us examine the matter more in detail. As will be seen each particle in the figure is shown in three successive positions of its curved path. This together with the known velocity of the particle supplies the information necessary to determine the direction and amount of the centrifugal force of the given particle at any moment. The centrifugal force of any particle, say when the wheel is in the position $A'B'$, is a function of the path of the particle in space as the wheel changes from AB to $A''B''$. Considering the position $A'B'$ therefore we see that there is a perfect symmetry of motion of all the particles in front of and behind the plane of the paper by which all components of centrifugal force except those tending to move the axis perpendicular to the plane of the paper are neutralized. In other words, the various particles pair off with one another in such a way that the only unbalanced forces left are those tending to push a perpendicularly back from the plane of the paper and to draw b forward. This constitutes what is known as the gyroscopic force. It is of the nature of a couple the middle of whose lever arm is at the centre of the wheel. It can of course only be balanced by an equal couple.

The gyroscopic force, as has been shown, always acts at right angles to the plane in which the axis is moving, changing in direction as the plane of motion of the axis changes, and neither tending to increase nor decrease the velocity of motion of the axis, but only to deviate it in direction.

The amount of the gyroscopic force is greater the greater the centrifugal force of the particles. Since the centrifugal force of a body varies directly as the square of its velocity and inversely as the radius, obviously the gyroscopic force increases as the velocity of rotation of the wheel increases and also as the motion of the axis is more rapid. Again, for the same amount of material in the revolving plane and the same angular velocity of rotation it follows that the gyroscopic force will be greater the further the mass of the wheel is disposed from the centre. Likewise is the gyroscopic force greater as the rotating mass is greater, as, other things being equal, more particles or systems of particles join together to produce this force.

What has been found regarding the gyroscopic force may be summarized as follows:

I. The gyroscopic force always acts at right angles to the plane of motion of the axis, neither accelerating nor retarding it and only tending to change its direction. The gyroscopic force is of the nature of a couple, and can only be balanced by an equal couple.

II. The gyroscopic force is greater, other things being equal, as the velocity of motion of the axis is greater, as the velocity of rotation of the wheel is greater, as the mass of the wheel is greater and as this mass is more distantly situated as regards the centre of the wheel.

Having now traced out the cause and nature of the gyroscopic force, let us see what part this force plays in the action of the gyroscope. In order to investigate the matter properly it is necessary to first treat of the motion of the theoretically perfect instrument and then afterwards to ascertain the effect of friction and other causes in modifying this motion.

The theoretical gyroscope we are to consider is one that runs with constant wheel velocity, unaffected by friction of any kind, and whose axis is subjected to an applied couple. It will be assumed supported by the pivot at some point of the axis, the weight of the wheel and the reaction of the pivot constituting the couple, and the apparatus being free to fall if unrestrained. A special case arises when the wheel is mounted in gimbals (which is equivalent to supporting it at the middle of the axis), but in this case a weight must be applied to one end of the axis, which weight, in conjunction with the reaction of the support, supplies the couple.

Consider now the first method of mounting, which is the general case. Suppose the wheel to be in rapid rotation and one end of the axis to be supported on the pivot. Let the instrument be suddenly released. The free end of the axis will of course begin to fall. The moment it starts to fall, however, the gyroscopic force or couple, begins to act, developing a couple at right angles to the plane of its fall, that is, horizontally. The end of the axis at the pivot being fixed in position the effect of the gyroscopic couple is to act on the free end of the axis so as to deviate it from the vertical fall, carrying with it the whole mass of the wheel. The path of the free end of the axis is now inclined so that the gyroscopic force, always in a plane at right angles to the plane of the motion, is now directed slightly upward as well as horizontally. The fall of the free end of the axis is now still further deviated from the vertical and at the same time its downward fall is somewhat checked by the vertical component of the gyroscopic force or couple. This deviating force continues until finally the axis is moving horizontally and the downward motion has been entirely checked. The gyroscopic force or couple is now directed upward and reacting on the pivot as before begins to deviate the free end of the axis upward. As the path of the axis begins to curve upward the gyroscopic force is directed upward and backward, raising the wheel and at the same time destroying some of its horizontal velocity.

The deviating effect of the gyroscopic force continues until the end of the axis just comes to rest with the tangent to its path vertical. The axis is now at the same level as it was when first released, all the velocity gained in its fall having been lost in bringing the mass up to the same level again. The end of the axis now begins to fall again, the gyroscopic couple once more exerts its deviating force and another arc is described. The free end of the axis henceforth describes a series of small cycloidal arcs, the axis coming up to the same level after each arc, (Figure 2). Under ordinary circumstances with high wheel velocity the nutations of the axis are too small to be perceived. The motion of the end of the axis is analogous to that of a vibrating pendulum with its constant interchange of potential and kinetic energy, the gyroscopic force taking the place of the supporting rod or cord in the pendulum. In the operation of the apparatus no exhaustion of energy of rotation of the wheel occurs, since no external work is done and the average orbital velocity is constant. The axis necessarily moves with constant average orbital velocity because the loops of the path are equal and similar, a necessary consequence of being described under similar circumstances.

The two halves of each cycloidal arc are similar and equal, as may be shown by the following reasoning: The velocity of the end of the axis at any point, resulting from the conversion of potential into kinetic energy, is a function only of the distance the axis has fallen. The deviating gyroscopic force being always at right angles to the path of the axis cannot alter the velocity in any way. On the upward arc the loss of velocity at any point is a function of the distance the axis has risen, or in other words, the velocity remaining at any point on the upward arc is a function of the distance it has yet to rise to regain the original level. The total energy of the system being constant and equal to the sum of the potential and kinetic energies, it is evident that for every elevation of the axis there must correspond a given velocity of the axis. Obviously therefore at every level on the two arcs the velocity is the same. Again, the deviating force being a function of the velocity of the axis, it follows that at points on the same level on the two arcs the deviating force is likewise the same. The velocity and deviating force being the two factors which determine the curvature of the path at a given instant, we see that the two arcs are described under such a law that they have always the same radius of curvature at points on the same level. Hence the curves must be similar and equal.

The greater the velocity of rotation of the wheel, the greater is the gyroscopic force and hence the arcs described by the end of the axis are smaller and more frequent. The result is the average orbital velocity is less because the fall now being less the maximum horizontal velocity at the bottom of each loop is less, and hence the average horizontal velocity is likewise less since the curves are in all cases similar. On the other hand, if the weight of the mountings of the wheel is increased or the weight of the wheel itself increased in such a way as not to compensate for the increase of weight by an increased gyroscopic force, the orbital velocity will be greater. This will result from the fact that it will take the gyroscopic force longer to deviate the fall of the mass into horizontal motion and longer to reconvert the horizontal motion into potential energy at the same level again. The loops will hence be longer, the fall greater and the average resulting orbital velocity greater. The nutations will be more nearly perceptible, if not indeed visible.

The direction of the orbital motion depends of course upon the direction of rotation of the wheel. In order that the apparatus shall not fall, the deviating force must be such as to act upward when the axis is moving horizontally. If in Figure 1 we assume that we are looking down upon the top of the gyroscope in operation it is obvious that the gyroscopic couple acts in such direction as to make the apparatus self-supporting when the end *a* of the axis rests upon the pivot.

We may therefore deduce the rule that the free end of the axis always moves in the opposite direction to that in which the top of the wheel moves.

Such is the action of the theoretical gyroscope under ordinary circumstances. Before taking up the phenomena of the practical instrument it is well to consider the effect of certain external influences upon the theoretical instrument.

First: Let us consider the effect produced by an external force tending constantly to accelerate or retard the orbital velocity of the axis. Suppose the force to be accelerative. The result will be that the applied force acting on the apparatus combines with the force of gravitation so that the instrument operates as though the gravitational force were directed downward and slightly ahead. The axis tends to keep the same average "level" with regard to this new force, or in other words to describe an average path at right angles to the force. The axis must therefore rise. The work done upon the axis by the horizontally directed force appears in the potential energy due to the more elevated average position of the wheel. If the applied force is retarding, the circumstances are all reversed and it follows necessarily that the wheel falls. The potential energy due to the fall of the wheel now appears as the work done by the apparatus on the external retarding medium.

Second: Consider the effect of starting the gyroscope with an initial horizontal velocity and then leaving it to itself. The idea at once suggests itself that if this initial velocity is just sufficient to make the gyroscopic couple equal to the gravitational couple that it is possible to have an orbital motion free from nutation. This is true, although this condition of things is essentially unstable (except under certain conditions to be mentioned in treating of the practical gyroscope) and upon the least disturbance the ordinary nutating motion will supervene. The nutating motion is essentially stable, on the other hand, and will reëstablish itself after any disturbance.

If the instrument is put under way with a velocity less than the above value the path described will be that of a prolate cycloid. At the moment of release the axis is moving horizontally, but the gyroscopic force is not sufficient to retain it in a horizontal path. It begins to fall, therefore, and it is only after it has gained velocity by a considerable fall that the gyroscopic force is able to reverse the curvature and bring the axis to horizontal motion. On the up half of the arc a similar curve must be described in reverse order, as will be shown below, and a uniform prolate cycloidal path therefore results, (Figure 3).

It is necessary at this point to digress a moment in order to prove that, no matter what the circumstances of starting, provided the apparatus is left thereafter to itself, the two halves of each loop of the curve are of the same shape and size. A process of reasoning similar to that used in the case of starting from rest may be applied. Suppose the axis has a certain velocity at starting. The deviating gyroscopic force being always at right angles to the direction of motion, obviously cannot alter this initial velocity. The variations of velocity due to the interchange of potential and kinetic energy as the axis rises and falls under the dominance of the deviating force, are superposed upon this initial velocity. As before, then, we have that at each level on either arc there is the same velocity (the initial velocity plus the velocity due to the elevation) and as a consequence the same deviating force. The two halves of the curve, therefore, have equal radii at equal elevations, a symmetrical condition of affairs that necessarily makes both halves of the arc similar and equal.

To resume: We have seen that if the apparatus is started with a velocity less than a critical value, a prolate cycloid will be described, the summits of which are at the original level. If the axis is started with an initial velocity equal to the critical value, a horizontal path results, as has also been shown. If the apparatus is started with an initial velocity greater than the critical value, the axis will at first rise, then reverse curvature and finally move horizontally; it will then fall, gain velocity and reverse its curvature, finally moving horizontally at the bottom of the loop. The other half of the loop will be similar and the curve as before will be a prolate cycloid, but with the summits at a greater elevation. If the initial velocity be made still greater and equal to twice the critical value, it can be shown mathematically that the common cycloidal motion will be again resumed with the bottom of the loops at the level of starting. The motion being cycloidal once more, we know that the initial velocity must have been the same as the horizontal velocity generated at the bottom of the loop in the case where the axis starts from rest. Hence the critical value is one-half the horizontal velocity which is attained at the bottom of a loop when the apparatus starts from rest. If an initial velocity still greater than twice the critical value be given to the axis, the curve, as can be shown by analysis, will be a curtate cycloid with the small loops uppermost, the summits being at a higher elevation than ever. If, to pass to the other extreme, the axis is started with an initial velocity directed backward, we will find described another curtate cycloid with the small loops upward, the summits being at the level of starting.

The action of the theoretical gyroscope having been investigated, it now behooves us to ascertain wherein the practical instrument differs in its action from the theoretical. As has been intimated before, the principal modifying factor is friction, tending as it does to slow down the rotation of the wheel and to oppose the orbital motion.

The results of the modifying influence of friction may be reduced to two classes: (a) Those due to the decrease of velocity of rotation of the wheel, and (b) Those due to forces opposing the orbital motion.

(a) Perhaps the most important effect of friction is found in its opposing the rotation of the wheel. It is necessary to examine in detail the action of the apparatus as the rotational velocity becomes less and less. As we have already seen, since the deviating force is always at right angles to the direction of motion and cannot influence the velocity of the axis, to every level of the axis there corresponds a certain velocity over and above any initial velocity the axis may have had. This additional velocity results from the interchange of potential and kinetic energy which is constantly occurring as the axis rises and falls. Let us assume in what follows that no initial velocity existed. Since the rotation of the wheel is becoming slower, and consequently the deviating force a smaller and smaller function of the velocity of the axis, obviously a time must come when this force will be so weakened at the higher levels, where the velocity of the axis is small, as to be unable to bring the path to a cusp. A reversal of curvature will take place and the axis pass through a rounded summit, beginning the second descent with a certain initial velocity. The elevation of the summit will be less than the original cusp since only by a fall could the energy be obtained for this initial velocity. The axis henceforth will be expected to describe a series of prolate cycloids. The prolate cycloids thus resulting, however, become flatter and flatter with successive arcs because the decreasing gyroscopic force is less and less able to raise the axis from its lowest level in each loop, (Figure 4). Obviously the effect of the decreasing gyroscopic force is to ultimately produce a horizontal path, since sooner or later the deflecting force will be only just sufficient to support the axis when moving horizontally with its maximum speed without being able to deflect it upward. The attainment of this path is delayed by the fact that the successive summits being lower and lower there is a continual increase of horizontal velocity. The effect of this is to prevent the deflective force from decreasing as rapidly as it otherwise would. The ultimate result, however, is the production of a horizontal path, the velocity being now uniform and equal to the critical value. If henceforth no further diminution of rotational velocity ensued the subsequent path of the axis would be horizontal, supposing the absence of pivotal and atmospheric friction, the gyroscopic force just balancing the attraction of gravitation. The path would be the unstable horizontal path of the theoretical gyroscope already referred to as resulting when the initial velocity is equal to the critical velocity. The rotational velocity continues to decrease, however, and consequently the gyroscopic force also decreases, becoming now too weak to sustain the horizontal motion. The path of the axis hence inclines slightly downward. The axis gains velocity by the fall, a result which has the effect of preventing the deviating force from decreasing as rapidly as otherwise. The inclined course of the axis continues henceforth, the velocity gained by the fall being insufficient to compensate for the continual loss of velocity of rotation of the wheel. The mass of the wheel in falling also supplies the energy necessary to overcome the friction of the pivot and the atmospheric resistance. The subsequent path of the axis winds slowly downward, the rotational velocity becoming less and less and the velocity of the axis greater. The final result would be that the wheel would stop rotating and the apparatus swing around the pivot at a low level, sustained only by centrifugal force, provided the axis did not slip off the pivot or the wheel strike the standard. Within certain limits this helical path is stable and restores itself after a disturbance, since no matter how often interfered with the same factors which produced it are always at work to restore it. This result is in striking contrast with that obtained with the theoretical instrument, as in that case the stable path was the nutating one.

The slowing down of the wheel being the most prominent feature in the action of the practical gyroscope, it follows that under ordinary circumstances this downward non-nutating helical path will be the one ordinarily met with.

(b) Turn now to the effect of friction in opposing the orbital motion. It will be seen that the opposing force due to this cause, acting horizontally, combines with the gravitational force, producing a primary couple constantly directed downward and slightly backward. This, as we have seen before, will continually cause the orbital motion to be directed more or less downward, and the wheel will therefore tend to slowly fall. Owing to the slowness of the orbital motion this action is small compared with that due to the slowing down of the wheel, and cannot interfere with the production of the non-nutating motion just described.

Another curious action due to friction must be considered. As a matter of experiment it is found that if the end of the axis of the gyroscope be raised above the support and then released it will, under certain circumstances, begin to rise. This difference between theory and practice is due to the fact that the apparatus consists of two parts — the first, the wheel, rotating with friction inside the second, the supporting ring, which does not rotate with it. The friction of the axle tends to produce in the mounting a rotation similar to that of the wheel. The mounting, however, is only free to rotate around a vertical axis, as for instance, if the plane of the wheel were horizontal and it were standing with the end of its axis on the pivot. This ideal position is the only one in which the wheel and its frame could rotate together. In all other positions this force tending to produce rotation of the mounting can be decomposed into two couples, respectively about vertical and horizontal axes, the first acting with full effect, while the latter is destroyed at the point of support. If the axis of the wheel is horizontal, the couple about the vertical axis also disappears. If the end of the axis is above the horizontal, this couple about the vertical axis acts in the same direction as the orbital motion. If the axis is below the horizontal, the couple acts in the reverse direction. The result therefore is the same as if an extraneous horizontal force (constantly increasing with the angle from the horizontal) were applied to the free end of the axis, acting in the one case with the orbital motion and in the other against it. The effect will therefore be to cause the end of the axis to rise, if above the horizontal, and to fall, if below the horizontal. The effect just described rapidly becomes unimportant as the rotational velocity of the wheel decreases.

Another action, which occurs both in the theoretical and practical gyroscope, must not be left unmentioned. When the apparatus is in operation and the axis not horizontal, the centrifugal force of the mass around the pivot has some very slight effect. When the axis is raised the result is as though the wheel weighed more than it really does. When the axis is depressed the result is to apparently lessen the weight. A very slight alteration of the path due to this cause hence occurs, negligible, however, in comparison with the effects of friction.

The action of the practical gyroscope therefore under ordinary circumstances may be briefly summarized as follows: When first released the axis describes a series of cycloidal curves such as the theoretical instrument would describe; in other words, the orbit is nutating. Very soon, however, the effect of friction in slowing down the wheel comes into play, resulting in the transformation of the nutating path into the uniform non-nutating helix already described, wherein the gyroscopic force is just sufficient to counterbalance the attraction of gravitation. Henceforth this path continues until the limits of operation of the apparatus are passed.

IRISH POETRY.

(Abstract of paper read before the Institute)

BY PROF. JOHN RUSSELL HAYES.

I am to address your honorable society this evening upon Ireland,— Ireland, the kindly land, the land of warm hearts and tender greetings, the fair Green Island so passionately beloved by her children in all parts of the world,— Ireland, the last home of the fairies, the last abiding-place of imagination and beauty and romance,— Ireland, trampled under the heel of British injustice through the centuries and winning anguished tears of sympathy from every lover of liberty; and yet, in spite of her wrongs, Ireland, the home forever of mirth and wistful humor, and of the pathos which is sister of the finest humor.

At its best, Irish Poetry is surpassed by the songs of no land for its fire and intensity. The music of the old Irish songs can never be forgotten by those who have heard its wild and mournful cadences crooned by old women who remember the Gaelic speech of their fathers.

The old Irish speech is unhappily not common, save in the western parts of the island. At Oxford and at Dublin one may study Irish literature; but among the folk, from Donegal to Kerry, there are not many who can recite the ancient epic poetry, or the wondrous fairy legends, in the olden native language. The English commissioners of education, filled with the idea of Imperialism, have performed the pious labor of stamping out Gaelic from the schools, thereby doing immeasurable wrong to the grand ancient song, and fairy and folk literature of Ireland.

English poetry written in Ireland is no new thing. Edmund Spenser composed his "Faerie Queene" amid the lovely scenery around his Castle of Kilcolman in County Cork. To lovers of this noble epic there is a fascination in thinking of Spenser dreaming his great pageant of Christian knighthood and idealism, and setting it to the music of the most beautiful stanzas in the language, amid the remote streams and woodlands of southern Ireland.

Again, Ireland is dear to the muses as the home of Lycidas, the high-souled young scholar, whose death on the Irish Sea drew from Milton the meed of tears immortally melodious.

Oliver Goldsmith, Irish and warm-hearted to the core, with other native poets, gave Ireland a place in Eighteenth Century poetry. But not until the end of that century did the new United Ireland find her poetic voice, and that through William Drennan, who invented the name "Emerald Isle," and whose song "When Erin First Rose from the Dark Swelling Flood" drew Irishmen together in national brotherhood. Sir Charles Gavan Duffy and Thomas Davis, and the poets who wrote for "The Nation" newspaper (founded by Duffy in 1842) carried on the work. Since their day the Irish passion for national recognition has become a world-wide cry.

From patriotism the poetry of Ireland passed to literary themes drawn from Celtic mythology, in the work of Ireland's most tragic poet, James Clarence Mangan. In his song "Dark Rosaleen" this poet lamented the griefs of Ireland in "melancholy of majestic music."

The present notable "Celtic Revival" had its chief impetus from Sir Samuel Ferguson's "Lays of the Western Gael" (1864). Here were awakened the ancient medieval traditions of the Green Isle, and poetry found fresh and entrancing themes in the long-slumbering native sagas and ballads.

Throughout the finer poetry of the Irish bards, as in that of their Scotch and Welsh brethren, one feels the Celtic glamour of which Matthew Arnold spoke, "the gift of rendering with wonderful felicity the magical charm of nature . . . the intimate life of nature, her weird power and her fairy charm."

The honest, warm Irish humor plays half pathetically and caressingly about the beloved home-places, "Belashanny and the winding banks of Erne," Gweedore, Kerry, Limerick and old County Mayo and a hundred other villages and shires of romantic and melodious names.

> "Warm are chimney-corners there, warm the kindly heart."

(Professor Hayes illustrated his lecture with readings and recitations from typical Irish poets, giving serious and beautiful poems as well as several in the quaint brogue. He closed as follows:)

It is Lionel Johnson, a poet of fine dignity, who seems to echo the mystery and great pensiveness of the bards of old,—a devout lover of the Druids, dreaming of the glories of the "far, fair Gaelic days,"—it is he who touched the true note when he prophesied that it is the *idealism* of Ireland, her reverence, her beautiful piety, which will lift her in the end above the aggressive and mercenary nations from whom she holds pityingly aloof,—

> "And yet great spirits ride thy winds: thy ways
> Are haunted and enchaunted evermore.
> Thy children hear the voice of old days
> In music of the sea upon the shore,
> In falling of the waters from thine hills,
>   In whispers of thy trees:
> A glory from the things eternal fills
> Their eyes, and at high noon thy people sees
> Visions, and wonderful is all the air.
>   So upon earth they share
> Eternity: they learn it at thy knees."

BOTANICAL NAMES.

(Abstract of paper read before the Institute)

BY LINNÆUS FUSSELL, M. D.

Although it would be interesting to study the origin of many of our common names of plants, this paper will be mainly confined to the botanical names, as they are less known, offer more difficulties and are popularly at least supposed to be unnecessarily long and unmeaning. As to length, the less said the better; as to necessity, an endeavor will be made to show that the plan of Latinized botanical names is the only one possible, and that the names themselves are not altogether meaningless and are not difficult to learn.

Throughout the world there are probably one hundred and fifty thousand plants known to botanists, but only a very small portion of these need occupy the attention of any but the professed botanist. The latest "Manual of Botany," by Nathaniel Lord Britton, contains all plants in Canada found from Newfoundland and Labrador to Manitoba, and in the United States to the southern boundary of Virginia, Kentucky and Kansas and to the western boundary of Kansas and Nebraska, and it discusses only about five thousand species and varieties.

Kellar and Brown's "Handbook of the Flora of Philadelphia and Vicinity," lists less than twenty-three hundred and the "List of Delaware County Plants"* less than fourteen hundred, and Delaware County has an unusually large flora for a place of its size. It may be seen, therefore, that except to the professional botanist the number of names we need to learn is comparatively few.

It may be asked, why not use common English names? If there could be one common name, and only one, for each species, it would be very desirable. As it is, most of our

* Fussell: List of Delaware County Plants. Proc. Del. Co. Inst. Sci., Vol. I, No. 3.

plants have no common name, and of those which have, too many are undistinctive. In many cases a common name is applied to more than one plant. For instance, snakeroot is applied to no less than twenty different plants, belonging to eight different genera and four different orders. On the other hand, the same plant has very often more than one common name. For instance, *Houstonia cærulea* is known in some parts of the country as bluets, in this locality as Quaker ladies, elsewhere as dwarf pink, innocence and eyebright, and of these bluets and eyebright are applied to other plants.

Any English name for a plant would answer a good purpose, if we could decide on any one as the best name for that plant, but even that, desirable as it would be, would only answer for English-speaking people.

Botanical names are the same all over the world, and as Latin is the language of science everywhere, the names are Latin or Latinized Greek.

Two words are used for each plant, one for the genus and one for the species, just as we say "John Smith," only in case of plants we follow the usage of the Latin, put the genus first and say "*Quercus alba*" for white oak, *Quercus* meaning oak and *alba* white.

The generic name is always a substantive and is often the old classical name as known to the Greeks or Romans. A few of such names are *Acer*, maple; *Æsculus*, horse chestnut; *Alnus*, alder; *Smilax*, brier, and *Rhamnus*, buckthorn.

Often the name is formed from that of some distinguished botanist or other eminent man, giving us such names as *Claytonia*, *Magnolia*, *Darlingtonia*, *Kuhnia*, *Linnæa*, etc.

Some names are purely fanciful, such as *Abelmoschus*, father of musk; *Ambrosia*, food for the gods (a very inappropriate name for our common ragweed); *Belladonna*, the beautiful lady, and *Agave*, the noble or wonderful plant.

Allusions to animal life are found in a very large number of names, such as *Arctostaphyllos*, bearberry (the common name being a translation of the Latin one); *Cheledonium*, swallow (appearing in flower at about the time the swallow comes in Spring); *Chenopodium*, goose foot; *Leontodon*, lion's tooth, the Greek form for our Fall dandelion; *Dandelion*, through the French *dent de lion* and that from Latin *dens leonis* making *dandelion* a very appropriate name for *Leontodon*, but unfortunately our common dandelion is a *Taraxacum*, one of the old classical names, and not *Leontodon*. Other animal names are *Geranium*, crane; *Erodium*, heron; *Pelargonium*, stork; *Dracocephalum*, dragon's head; *Elephantopus*, elephant's foot. A long list of such names might be given.

Number furnishes a large list, principally however of specific names, although for generic names *Penthorum* and *Myriophyllum* may be cited, *Penthorum* from the Greek *pente*, five, and *orus*, order; *Myriophyllum* from *myrios*, a myriad or ten thousand, and *phyllos*, leaf. A number of names are mythological, as *Achillea*, *Adonis*, *Ajacis*, *Archemorus*, *Arethusa*, *Asclepias*, *Artemisia*, *Atropa*, *Cillirhoe*, etc. Some are named for their properties, real or supposed, such as *Alcea*, strength; *Althea*, to cure; *Alyssum*, opposed to madness; *Argemone*, curing argema, a disease of the eye.

The great majority of names are, however, fortunately more or less descriptive. Such names are *Raphanus*, quickly appearing, applied appropriately to our radish; *Helianthus* and *Helianthemum*, sunflower; *Heliopsis*, like the sun; *Heliotrope*, turning to the sun; *Arenaria*, growing in sand; *Clematis*, a vine; *Ampelopsis*, like a vine; *Menispermum*, moonseed; *Sanguinaria*, pertaining to blood; *Camelina*, dwarf flax, etc.

The way different roots are combined to form a large number of words may be illustrated by several combinations with the Greek *Kallos*, beautiful, such as *Callitriche*, beautiful hair; *Callistemon*, beautiful stamens; *Callistephus*, beautiful stems; *Callicarpe*, beautiful fruit, and *Callichortus*, beautiful herb.

The specific names are nearly all adjectives, which as in

Latin must agree with the generic name in gender. Thus we say *Euonymus american-us*, *Cimicifuga american-a*, *Xanthoxylum american-um*.

Some of the specific names are those of either existing or discarded generic names. When these are used they retain the capital letter and are uninflected. Examples of these are *Flammula*, flame colored; *Cucullaria*, hooded; *Sinapistrum*, like *Sinapis*, or mustard; *Raphanistrum*, like *Raphanus*, or radish; *Acetosella*, a diminutive of *Acetosa*, sorrel, which itself is from a root meaning sour.

A large number of specific names are dedicated to distinguished botanists. If the botanist is the discoverer of the plant it is expressed as a substantive in the genitive singular, such as *Fraseri*, *Bootii*. If named in honor of some one not the discoverer, it is expressed as an adjective, *Nuttallianus*.

The place where a plant is found or from which it first came, furnishes names for a very large number of plants. *Canadensis*, *Virginianus* and *Americanus* furnish even for the limited flora of Delaware County names for about two hundred species.

Like the generic names, the larger number are descriptive of the plants.

Color gives us a large number, *alba*, white; *nigra*, black; *viridis*, green; *fulvus*, *flavus* and *luteus*, yellow; *rubrus*, red; *leucus*, white, etc.

The place of growth gives us many names, *agaricus*, *agrestis* and *campestris*, found in fields; *alsodes*, in the woods; *aquaticus* and *aquatilus*, in or by the water; *dumetorum*, in thickets; *hortensis*, in gardens; *littoralis*, by the shore; *uliginosus*, in swamps.

Most of the descriptive terms are hard to classify, and a few only will be added:—*Acaulis*, stemless; *usitatissimus*, most useful; *brachycarpus* and *brachylobus*, short fruited and short lobed; *formosissimus*, most beautiful; *spectabilis*, splendid; *major*, larger; *minor*, smaller; *primulafolia*, leaf like *Primula*, or primrose; *nudicaulis*, naked stemmed. Such combinations furnish an almost inexhaustible supply of names.

A method of naming plants resembling another plant is in making frequent use of the Greek *eidos* and *opsis*, like; the former taking the Latinized form of *oides*, giving us such names as *Agrostoides*; Agrostis-like; *Cinnoides*, Cinna-like; *Scirpoides*, Scirpus-like; *Graminoides*, grass-like, and *Chrysopsis*, golden-like, and *Ampelopsis*, vine-like.

In addition to the generic and specific names, it is necessary to add the name, or the initial of the name, of the botanist who first described the plant and gave it the name. Thus *Sinapis alba*, L. Changes in names of plants, several years ago, made it necessary to adopt a rule that the oldest name given to a plant should stand. If the name of the genus has been altered, this fact is indicated by adding to the name of the plant, in parenthesis, the name of the botanist who first gave the name to the species, following it with the name of the botanist responsible for the combination; giving it such a form as *Brassica nigra* (L.), Koch.

The rule, a good one, making it necessary to use the oldest name, is responsible for some queer combinations; for instance, making the generic and specific names the same. Of this we have many instances, such as *Hystrix Hystrix*, *Hepatica Hepatica*, *Sassafras Sassafras*.

The effect of carrying out this rule has, in late years, caused temporary confusion by the large number of changes of names, all of which, however, tend to permanence. It is, however, a little confusing to learn for yourself and to teach to others that our common Virginia creeper, which was *Ampelopsis quinquefolia*, is now *Parthenocissus quinquefolia*; or to find that our showy orchis, which was *Orchis spectabilis*, is now, by the necessity of separating it from the genus *Orchis*, *Galeorchis*; that *Hepatica triloba* is now *Hepatica Hepatica*, etc.

These changes, though necessary, make one wish that there were more of such common names as sweet fern, lily of the valley, blue-eyed grass, trailing arbutus, balm, blue curls, bitter sweet, bouncing bet, blazing star, columbine, cowslip, daisy, evening primrose, forget-me-not, fringed gentian, grape hyacinth, fringed orchis, golden rod, hawthorn, honewort, etc.

Britton and Brown, in their "Illustrated Flora," and Dr. Nathaniel Lord Britton, in his "Manual," make a long stride toward the adoption of common names by assigning to each species given in these books a common name, "accepted either from popular usage or chosen in reference to some more or less distinctive feature of the plant."

It is to be hoped that this action will go a long way toward the adoption of a common name for each plant. This was the case in regard to birds, when the American Ornithological Union added to their "Check List of Birds" a common name for each species.

A FRESH WATER JELLY FISH FROM DELAWARE COUNTY, PENNA.

BY EDWARD POTTS.

The well-known *Medusæ*, or Jelly Fish, are of course familiar objects to all who visit our sea coast and its estuaries; but many persons are possibly ignorant of the fact that similar forms have been found inhabiting fresh waters.

At the present date but three of these have been reported. The first was discovered in the warm-water tanks in which the giant water lily (*Victoria regia*) was grown, in the Regent's Park Gardens, of London, England. The second was found living under purely natural conditions in Lake Tanganyika, Central Africa. The third and last disclosed itself to the writer in his own culture-jars in the neighborhood of Wawa, Delaware County, Penna.

To bring this interesting group briefly and not too technically to the attention of our readers, the editors have copied a few of the plates used in illustration of an article upon this subject, published by the "Quarterly Journal of Microscopic Science," of London, England, in November, 1906, page 623, etc., as follows: —

Figure 1. *Limnocodium sowerbii*, of Allman and Lankester; discovered by Dr. Sowerby in 1880 in the *Victoria regia* tanks, as above; described by above in "Nature," 1880, pages 147 and 178, etc.

Figure 2. *Limnocnida tanganyicæ*, Dr. R. Bohm; first seen by him in Lake Tanganyika in 1883; described from preserved specimens by R. T. Guenther, A. B., in "Annals and Magazine of Natural History," 1893, page 269, etc.

Figure 3. A lateral view of the medusa of *Microhydra ryderi;* its development from which was first seen at Wawa, Delaware County, in small culture-jars, August 1, 1897; discovery announced in "American Naturalist," 1897, page 1032, etc.

Figure 4. An optical section of the same, as shown when looking down through the top of the dome (or umbrella).

(Numbers 3 and 4 were drawn by Dr. J. Percy Moore, of the University of Pennsylvania, from specimens that had been preserved for more than nine years in dilute formalin.)

It will be noticed that in the case of Figures 1 and 2 the *Medusæ* have been named agreeably with the recognized practice in regard to Marine Jelly Fish (possibly because the hydroid forms from which they have been presumptively derived have rarely been definitely determined, while the *Medusæ* themselves often grow to be conspicuous objects.)

My experience with Figure 3 has been different, making me familiar with the almost invisible *Microhydra* for a dozen years before the *medusa* presented itself. Having therefore named the *father* before I saw the *foundling*, I incline to retain *his* designation.

The order of development above referred to, and now well known as the Law of the Alternation of Generations, I find described fifty years ago by Philip Henry Gosse, as follows :—
"The polyp, a fixed plant-like animal, increases its own individual life for a while by putting forth a succession of budding heads ; but at a certain period gives birth to a number of beings that bear no resemblance to itself in form or habit, but are, to all intents and purposes, free-swimming medusæ. Each of these, after pursuing its giddy course for a time, produces a number of eggs," which, hatching, ultimately produce not medusæ, but, plant-like, shoot up into the hydroids that I am about to describe. "Hence, to use the striking, though homely, illustration of one of the first propounders of this law, "any one individual is not at all like its *mother* or its *daughter*, but exactly resembles its *grandmother* or its *granddaughter*."

These hydroids then resemble plants, in that they are fixed in position : but instead of feeding almost solely upon inorganic matter through roots, they put forth heads with mouths, stomachs, and, generally, with grasping organs, by whose agency they are nourished with animal food; and, instead of bearing flowers ripening their seeds *within themselves*, the medusoid's correspondent organs are liberated, live and grow (sometimes to a large size) independent, free-swimmers, distributing their eggs and young at great distances; in turn, to grow up into *new* hydroids, the parents of other medusæ.

The following is a brief history of *Microhydra ryderi*. I found it in 1885 living as a *messmate* among colonies of certain polyzoa that were like itself of a fixed habit of growth, upon stones, gathered in Tacony Creek, a mill stream flowing into the Delaware River; and, later, in the Pennsylvania Canal, at Flat Rock Dam, on the Schuylkill River; in both situations far above tide water. I have called it a *messmate*, not only to describe its *association*, but the *purpose* of it, as will appear.

When seen as a larva, this hydroid is an inert, cylindrical, worm-like body, about one-fiftieth of an inch in length, with a breadth of about one-fifth its own length. No organs at first exist, by which it may move or feed itself, but in a week or two, one end becomes attached to the surface upon which it has lain and the other gradually develops a head or capitulum covered with 30 to 40, so-called, lasso or thread cells, resembling those of the common *Hydra*, but without a trace of tentacles. The mouth is hidden at the extremity of this head.

Imagine, then, its disabilities as a self feeder. Fixed in position, with a power of motion that can barely be detected even when highly magnified, it reminds the observer of the "dog under the rich man's table," dependent almost entirely upon falling "crumbs" or small organisms that are drawn down by the whirlpool vortices created by the relatively powerful polyzoa standing around them. This single form is often made bi- or tri-capitulate by branching near the point of support.

As to its method of multiplication or reproduction; it is most important to call attention to a singular, apparently a unique habit that may be called its asexual germination, by a species of subdivision,—neither longitudinal nor transverse, but *partially lateral*, caused by the budding out and eventual separation of a portion of the middle-third of the body. This is shown highly magnified in Figure 6, carefully drawn by Dr. J. A. Ryder from longitudinal sections of his own cutting. This figure, probably better than any words of mine, may explain itself. It must be told, however, that the *notches* that may be seen to originate at each end of the swollen portion, rapidly deepen, and eventually join, near the lower extremity. The progress and final result of this constriction I have tried to show by the diagram, Figure 7, when the asexual larva is represented as growing and finally liberated in the condition above described.

The verity of the second and higher *sexual* method of reproduction in *Microhydra*, by the budding, development and liberation of true *medusæ*, I hold to be well established by the discovery among my papers of Figure 5, the original of which, dated September 5th, 1897, represents a bicapitulate hydroid with its *pedal-disc;* bearing also a budding medusoid at an early stage of its development. The interest was increased when I read in my letter-copying book the following extracts from a letter dated two days later:—

"Most important was my success in removing a swelling bud to the stage of my microscope, where its connection with the stem of one of a colony of two hydroids was unquestionable. The *pup*, of course, grew faster than his *daddy*, who curled his head to one side in evident disgust; the pedicle of the medusa-bud assuming the position of the main stem. I made a rude camera lucida sketch at the time. (Figure 5).

"On the following morning I was pleased to see that development had gone on unchecked by its removal. When examined that evening the tentacles had been projected to nearly their full length, the expansion and opening of the disc was nearly complete, and pulsations had evidently continued for some time. This morning (September 7th) the jelly-fish was swimming about the little dish.

"Another important point.—At the time of my last evening examination, the cellular structure of the nearest hydroid stem, as well as that of the pedicle of the medusa, had entirely disappeared, leaving the struggling creature attached only by a diaphanous cuticle, almost impossible to define; within which were a very few spherical floating cells and numbers of detached thread-cells. This disintegration of tissues serves to account for my previous failures to discern the supporting stems, and to explain the long detention of the medusa when there seemed to be no attachment.

"I do not mean that the *Microhydra* had entirely disappeared. The stem bearing the other head had, in fact, elongated, and the nearer stem seems to be re-adjusting its conditions and reforming a capitulum."

The circular portion at the right end of Figure 5 is the roughly drawn *medusa* bud as it then appeared, to become a few hours later the free swimming medusa represented in Figure 3. (If any are unfamiliar with the fact, I may be allowed to state that the rounded surface or umbrella of these budding forms is always nearest to the stems upon which they grow, leaving the disc of the jelly fish with its tentacles extended *outward* like the stamens of a flower.) As we watched the maturing forms it was a constant surprise to see what a period of violent throbbing was required to finally *liberate*, although we could discern nothing to *detain* them as described in above letter. The violence of these spasms reminded me (comparing small things with great) of Milton's curious description of the creation of the lion (with the other animals) literally from the "dust of the Earth."

"Now half appeared
The tawny lion, pawing to get free
His hinder parts — then springs as broke from bonds
And rampant shakes his brinded mane."

When comparing the two medusoids, Figures 1 and 2, said to have been found in *swarms*, it will be instructive to observe that both seem to have grown in quiet waters; while *Microhydra* passed its earlier stages in rapidly flowing, sometimes deep currents. It may be supposed, therefore, that these different conditions promote the frequency of one or the other of the described modes of reproduction, and help to explain the fact that even after twelve years of study the *medusoid* of the last was only found in the artificial condition of my culture-jars and that it has never been seen either in Creek or Canal.

In conclusion I take pleasure in acknowledging the courtesy always shown me by Dr. E. Ray Lankester, by reprinting here the note that he appended to my original article: —

"Mr. Potts has been so very kind as to send to me, at my request, a specimen of the minute medusa liberated by *Microhydra* and preserved in formalin. It is one of two which remained in his possession. Whilst further study of *Microhydra* and its *medusa* is urgently called for, it is clear that further research is needed in order to settle the doubt entertained by Mr. Potts as to the actual genetic connection of Bourne's hydroid with the medusa *Limnocodium*. It is within the bounds of possibility that that hydroid is a native European polyp, similar to *Microhydra*, and not connected with the *Limnocodium* life-cycle."

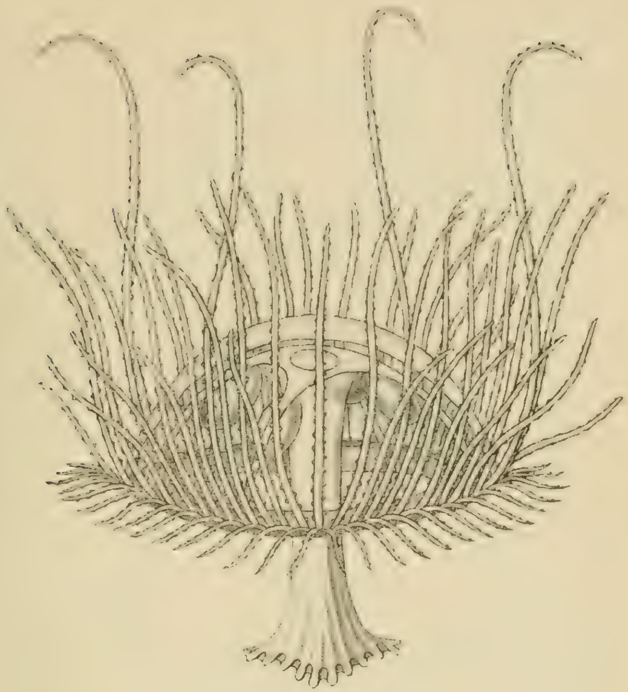

FIGURE 1

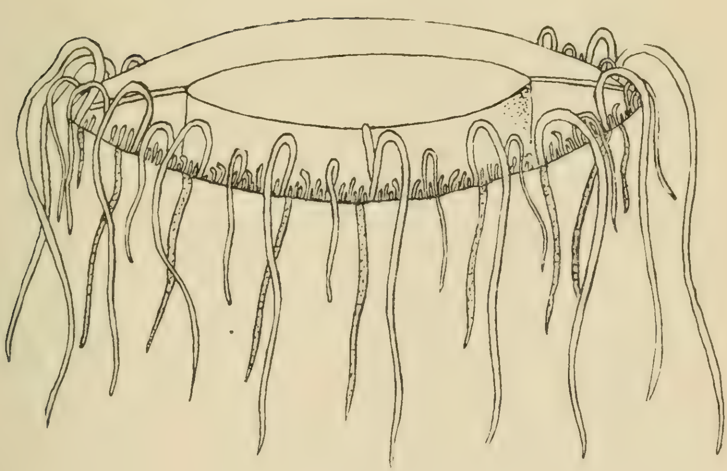

FIGURE 2

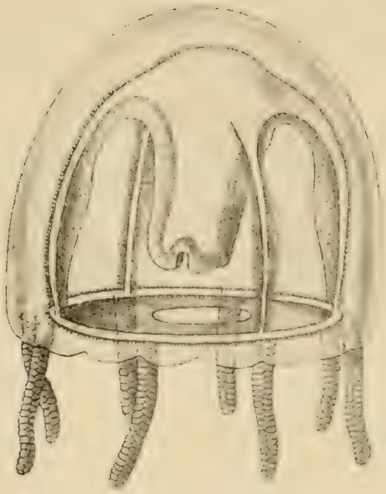

FIGURE 3

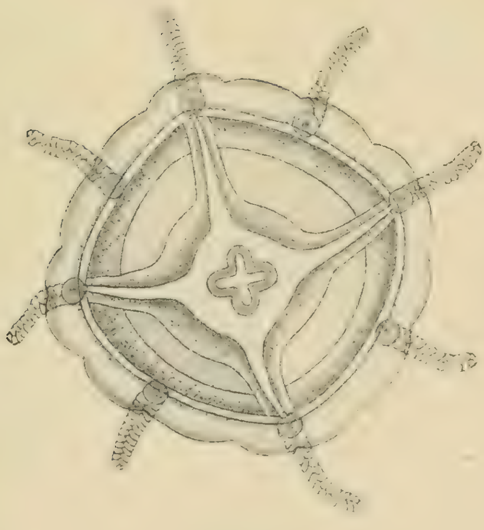

FIGURE 4

FIGURE 5

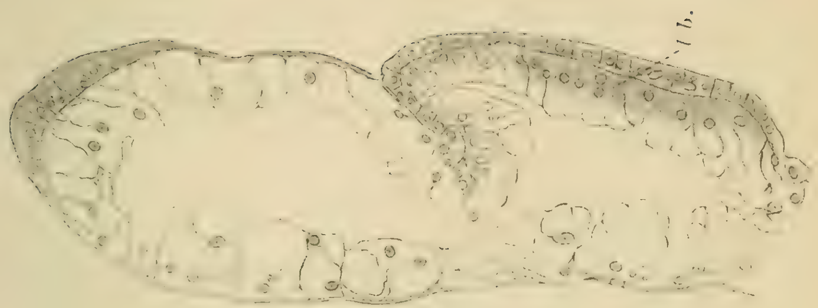

FIGURE 6

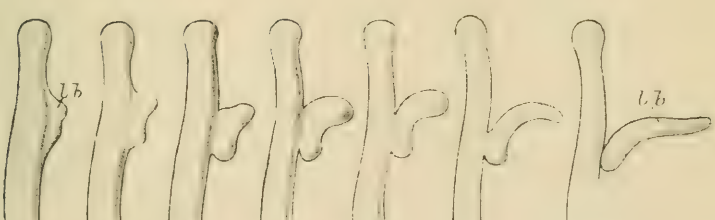

FIGURE 7

NATURALISTS' UNION MID-WINTER MEETING.

REPORT OF DELEGATE, PROF. L. H. WATTERS.

The mid-winter meeting of the Delaware Valley Naturalists' Union was held in Memorial Hall and Horticultural Hall, Fairmount Park, Saturday, February 2nd, 1907.

The Union is composed of scientific societies in southeastern Pennsylvania, Delaware and western New Jersey, and has for its object the advancement of science and the enlistment of public interest in the study of nature in all its forms. The meetings of the Union are held twice a year; usually in May and January or February. The May meeting takes the form of an excursion to some locality of interest to botanists, geologists and bird-lovers; and they have been so planned that every one interested in any kind of nature study may always find something of interest. An important feature of all these meetings is a lecture or two by persons well versed in the subjects upon which they speak.

Although the weather was unfavorable, the attendance at the mid-winter meeting was unusually large, and, so far as could be ascertained, every organization belonging to the Union was represented.

At two o'clock the meeting in Memorial Hall was called to order by the President, Mr. Charles L. Pennypacker, of Haddonfield, New Jersey, who, in a few appropriate remarks, introduced Mr. Edgar A. Barber, Curator of the Museum. Mr. Barber gave the visitors a very cordial welcome, and gave instructions as to where the various exhibits were to be found; after which those assembled broke up into small parties and visited the various departments to which their interest or curiosity led them. The Curator himself led a party to the rooms containing the exhibit of American pottery, where he gave an interesting account of the development of the industry in this country, and explained the process of manufacture of the various kinds of ware. The exhibit contains specimens of the potter's art from the early Colonial period to the present time ; some of the early attempts at the manufacture of ornamental pottery being very crude ; stiff and inartistic representations of General Washington being the favorite device for ornamentation.

A very interesting feature of the afternoon program was an address by Mr. H. Clay Borden on the eruptions of Vesuvius and Mount Pelee, in which he compared the destruction of Pompeii with that of St. Pierre, and discoursed in general upon the action of volcanoes and earthquakes. The views on exhibition in the museum gave point and interest to his remarks.

The time was all too short for viewing the things of interest in the various collections, and by 4.30 P. M. all the party had been transferred by coaches to Horticultural Hall, where, under competent guides, an exceedingly interesting collection of tropical and native plants was viewed, and their habits and peculiarities of growth pointed out and commented upon.

Mr. Oglesby Paul, who is Curator of the Hall and scientific landscape gardener of the Park, took particular pains to call the attention of the visitors to matters of interest that would otherwise have been overlooked. He is an enthusiastic botanist, and was able to give a vast amount of valuable information concerning the exhibit.

At six o'clock the party was transferred to Belmont Mansion, where an excellent supper was served to the two hundred and twelve members and guests of the Union. The tables were then cleared away and the hall was made ready for the evening's entertainment.

The President in a brief address gave an account of the labors and researches of Constantine Samuel Rafinesque, who in the early part of the last century was a unique and interesting character in scientific circles in the city of Philadelphia, where he died in poverty, and his grave is still unmarked. By a unanimous vote of the Union it was decided that his grave should be marked by a suitable monument, and the President was authorized to appoint a committee to raise funds for that purpose. Several liberal contributions were offered at the time, but it was thought best to appeal to the several organizations belonging to the Union by circular letter, which will in due time be sent out by the committee.

The President then introduced Mrs. Charles Schaffer, who gave an illustrated lecture on "Six Weeks in the Canadian Rockies with Tent, Horse and Camera." She is a delightful lecturer, and her views, which are the product of her own camera, are unusually fine. The scene of her travels and explorations is the headwaters of the Saskatchewan.

Dr. G. B. Gordon, Curator of the Free Museum of Science and Arts, gave an illustrated lecture on "Archæological Researches in Central America," which was very interesting and instructive, and brought out the fact that prior to the invasion of Mexico by Cortez, Central America must have possessed a civilization of no low order. Dr. Gordon delivered a lecture on the same subject before the Institute of Science in December last.

MINUTES OF MEETINGS.

OCTOBER 17, 1906.—Adjourned Meeting. Illustrated Lecture on "Student Life at Oxford," by Dr. Jesse Holmes, of Swarthmore College.

OCTOBER 24, 1906.—Adjourned Meeting. Paper on "Old Chester and its Surroundings," by Mrs. Clara B. Miller, of Media.

NOVEMBER 1, 1906.—Regular Monthly Meeting, Vice President Henry L. Broomall presiding. Reports of curators and committees and routine business. Lewis Kirk spoke at some length on certain interesting points in connection with Euclid's Forty-seventh Proposition, suggested by the discussion of this subject at the previous regular meeting. C. M. Broomall exhibited some test tubes illustrating the peculiar action of chlorophyl with various solvents. In response to a query, Henry L. Broomall gave an account of the various universal languages that had been invented from time to time, Esperanto, Volapük, etc., describing their characteristics and possibilities.

NOVEMBER 8, 1906.—Adjourned Meeting. Illustrated Lecture by Mr. S. L. Shumo, of Philadelphia, on "Jerusalem and Damascus."

NOVEMBER 15, 1906.—Adjourned Meeting. Illustrated Lecture by Prof. Charles W. Palmer, of Westtown School, on "Insect Architecture."

NOVEMBER 22, 1906.—Adjourned Meeting. Paper on "Tidal Phenomena," by Theophilus P. Saulnier, of Media.

DECEMBER 6, 1906.—Regular Monthly Meeting, President T. Chalkley Palmer presiding. The President announced the death of Jacob B. Brown, a member of the Board of Curators and of the Publication Committee. Dr. Trimble Pratt and Henry L. Broomall were appointed a committee to prepare a minute expressing the Institute's sentiment of the great loss it had sustained in Mr. Brown's death. A donation to the museum was received from Prof. Charles W. Palmer in the shape of a specimen of worm-eaten wood. Mr. Alonzo Baker, of Media, presented a specimen of garnet from a new quarry at Burmont, this county. John W. Palmer presented to the Institute several photographs of log cabins still existing and in use in various sections of the county. Lewis Kirk exhibited a simple form of bottle barometer, an account of which appeared in the October number of the PROCEEDINGS.

DECEMBER 13, 1906.—Adjourned Meeting. Illustrated Lecture by Dr. George B. Gordon, of the University of Pennsylvania, on "Archæological Researches in Central America."

DECEMBER 20, 1906.—Adjourned Meeting. Illustrated Lecture, "A Journey to Pekin," by General Henry C. Cochrane, of Chester, Pa.

JANUARY 3, 1907.—Regular Monthly Meeting, President T. Chalkley Palmer presiding. Carlota Broomall, Robert Smedley and Ober Baker were proposed for juvenile membership. Stanton Worrall was elected to juvenile membership. Mrs. Clara B. Miller and Mrs. Henrietta K. Broomall were appointed representatives to the Delaware Valley Naturalists' Union mid-winter meeting. John W. Palmer exhibited a specimen of andalusite from the James Worrall farm, in Upper Providence, near Holland's Bridge. T. Chalkley Palmer made some remarks concerning this mineral. C. M. Broomall reported some observations made with the bottle barometer, as suggested by Lewis Kirk at a previous meeting. Lewis Kirk made some extended remarks on weather statistics.

The death of Jacob B. Brown, a member of the Institute, being announced, the following Minute was adopted and the Secretary instructed to record the same:

In the death of Jacob B. Brown the Institute loses from its membership a man of rare culture and character. He had traveled much during his early and middle life, and to this experience and observation he added the tastes and industry of a student. The Italian, Latin and English literatures particularly were his constant study to the last and his renditions and translations from them have been of the greatest benefit to his friends and the Institute. His publications have been in these studies and their scholarly and literary qualities give them a value not often reached by translations.

His studies in astronomy and upon the calendar led to lectures before the Institute and contributions to its PROCEEDINGS of the greatest interest and value. He endeavored to treat those subjects so as to avoid the necessity of a knowledge of the higher mathematics for the comprehension of the forms, relations and movements of the heavenly bodies.

His literary style was terse and strong, with a quaint touch or turn of phrase here and there that none but the true artist could attain. This style, accompanied by a delivery of speech clear and incisive, rendered him a welcome guest in any intelligent circle and upon any platform.

He was a man without pretension or assumption of any kind. He always presumed the same frank intellect and culture in others that he himself possessed. There was something of the old-time chivalry about him, the strong man with the gentle ways, the kindly thought, the delicate courtesy that is and ever will be the ideal of manhood.

INSTITUTE NOTES.

The Institute is indebted to one of its members, Mr. William R. Newbold, Jr., for a number of photographs and specimens from Panama. Mr. Newbold has been for some considerable time engaged in the Construction Department on the Panama Canal, and has been kind enough to send from time to time specimens that might be of interest to the Institute. Among other things received are some two dozen photographs of various scenes along the Canal, some sharks' teeth, a monkey's skull (with the atlas and axis vertebræ still held in position by the ligaments), a number of pieces of native money, some quite rare, etc.

The pictures are very interesting and show that Mr. Newbold has become quite an adept at photographic work, despite the bad effects which he says the climate has on films. The pictures comprise many views in the neighborhood of Panama City and along the Canal, showing the various stages of the work. In addition are a number of photographs showing the houses and customs of the natives.

Among them also are pictures of the native cemeteries and the cemeteries used by the Chinese laborers on the Canal. In reference to these Mr. Newbold, in one of his letters, says: —

"Let me speak to you about a very disagreeable sight. Directly beside my house there is a Chinese cemetery, and on the other side a native cemetery, and opposite these again are two more, one the Jewish cemetery and the other for foreigners generally. In the native cemetery the graves are dug four or five feet deep, and one out of six graves contains no coffin. The bodies are laid out in caskets rented for such purpose, then taken to the grave and dumped. Others are put in cheap caskets and placed in niches in the wall, where they remain as long as the rent is paid. When this is over-due, out comes the corpse and is thrown in a heap with others in a rear lot and burned whenever the pile gets large enough to warrant the hiring of a man to do it and one who can stand the odor. The Chinaman buries his dead in a coffin, allows it to remain eighteen months and then takes it up, packs the remains in a box and ships it home."

The pictures of the native cemeteries which Mr. Newbold sends show the piles of bodies ready for burning and the cemetery wall with its niches, some filled, some vacant. Several views of the Chinese cemetery illustrate the ceremonies performed at the time of preparing the bodies for shipment home. These rites are gone through at the large stone altar within the cemetery, in front of which are seen offerings of roast pig, eggs, fruit, wine, etc.

Another very interesting view is that of an ancient public drinking fountain in the village of Chorrello, near Panama, a plaster-covered stone structure, with arched top. Its exact age is unknown.

In his letters Mr. Newbold refers to the attempt of the government to exterminate the mosquitoes by the use of crude oil. He does not think the effort will succeed on account of the many breeding places for the insects along the line of the Canal. Another interesting point mentioned is the fact that the sea shells found along the coast are very brilliant in color. but unfortunately these colors fade rapidly after removal from the water.

The Institute is very glad to publish in this number an article by Edward Potts, of Media, on Fresh Water Jelly Fish. The cuts are reproduced from the "Quarterly Journal of Microscopic Science," with the exception of Figure 2, which is published now for the first time.

ERRATUM:

Page 53, eleventh line from top—"Reviera" should read "Riviera."

OFFICERS OF THE INSTITUTE:

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Edgar T. Miller and the Officers

Vol. II, No. 3 April, 1907

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

T. Chalkley Palmer, Chairman, Trimble Pratt, M. D., Henry L. Broomall, Linnæus Fussell, M. D.

Carolus M. Broomall, Editor.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. II, No. 3 APRIL, 1907

THE SYCAMORE MILL.

Of all the relics of the old days left to a community by its forefathers, none appeal so strongly to the delver in local history as the remains of former mill sites along its water courses. Delaware County, with its four goodly sized streams, Darby Creek, Crum Creek, Ridley Creek and Chester Creek, has been well favored in inheriting numerous mills and mill sites, all in various stages of dilapidation.

In old times these creeks furnished power for many a busy miller. But steam power and the segregation of industries has been rapidly bringing about the disappearance of the old-time grist mill, and its disappearance from the landscape removes one of its most picturesque features. Few of the old mills are now in operation, and the abandoned ones are fast disappearing from the sight and memory of man.

However, one of the most beautiful spots in the county of this character has fallen into good hands, and its present owner is doing everything possible to preserve it in a condition agreeable alike to antiquarian and artist. Sycamore Mill, or Bishop's Mill, or, as it was known in old times, the Upper Providence Corn Mill, has now become the property of Mr. H. H. Battles, of Newtown Township, and it is due to his kindness that the Institute is enabled to publish the history and pictures of this beautiful and historic corner of our county.

It may be added that the Sycamore Mill is particularly interesting to the local historians for the additional reason that one of the buildings on the property was for many years the home of the Union Library, one of the oldest libraries in Delaware County.

The title of the Sycamore Mill property has passed through many hands, and is a somewhat complicated one. Hence, before going into the historical details connected with the mill and its surroundings, it may be well to set forth concisely the chain of title of the property from William Penn down. No more reliable account of this matter can be found than that given in Minshall Painter's "Reminiscences," published in 1870, from which the following abstract is made:

"William Penn, proprietor of Pennsylvania, under his commissioners, Samuel Carpenter, Robert Turner and John Goodson, did grant, on the 24th of June, 1690, to James Swaffer five hundred acres of land situated in Providence, Chester County; and the said James Swaffer by two several deeds, dated 13th of September, 1693, and 11th of December, 1695, did grant the said five hundred acres to Jeremiah Collett; and Jeremiah Collett, by indenture dated 11th of June, 1696, did grant the same five hundred acres to Josiah Taylor; and Josiah Taylor, by deed 14th of June, 1696, did grant the said five hundred acres to John Edge; and John Edge made his will, 10th of 5th mo., 1711, by which he gave to his son, John, three hundred acres of land, to be taken off the upper part of said five hundred acres, and gave to his son, Jacob, the residue of his lands; John Edge, the son, purchased of Philip Yarnall a small piece of land on the west side of Ridley Creek, in Edgmont, to secure a right for a mill pond, and which was ever after conveyed with the mill property.

"The said John Edge and Jacob Edge and Henry Miller by mutual agreement erected a water corn mill on a part of the above mentioned land of John Edge, who allotted for that purpose about twenty acres in addition to that purchased of

Philip Yarnall. John Edge and Mary, his wife, by deed dated 17th December, 1719, conveyed in fee to Henry Miller one-third part of the said corn mill and one-third part of the two recited parcels of land whereon the mill stands, containing in the whole twenty-two acres, three roods and ten perches; and the said Henry Miller made his will, 14th of 12th mo., 1731, and gave to his son, George Miller, his share of said corn mill and lands belonging, now called 'Providence Mills;' and George Miller conveyed on the 10th of December, 1740, to Roger Pugh the one-third part of the said mill and land undivided. Roger Pugh and Sarah, his wife, sold the one-third part of said water corn mill and land to Lawrence Cox on the 8th of 5th mo., 1746, and Lawrence Cox and Sarah, his wife, conveyed said share to their eldest son, John, on the 25th of 1st mo., 1752; and John Cox and Mary, his wife, conveyed, on the 22nd of February, 1755, their share to Thomas Bishop.

"Again, John Edge granted to Jacob Edge, 17th of December, 1719, one-third part of said mill and two tracts of land, and Jacob Edge made his will, 3rd of 2nd mo., 1720, and gave to his wife, Sarah, his share of Providence Mills, being the one-third part, during her life, and afterwards to be divided among his four daughters, Jane, Hannah, Sarah and Abigail. Hannah and Sarah died before their mother, and their shares descended to Jane and Abigail. On the 2nd of January, 1771, James Webb and Jane, his wife, John Louns,* Owen Biddle† and Robert Park conveyed to Thomas Bishop the one-sixth of said mill and tracts of land, and on the 21st of March, 1771, Abigail Edge conveyed to Thomas Bishop the one-sixth of the same premises also.

"On the 29th of November, 1721, John Edge and Mary, his wife, conveyed to William Hammons one-third part of the

*Or Lownes, who had married Agnes Cowpland, daughter of Caleb Cowpland by Sarah, widow of Jacob Edge.

†Who had married Sarah Park.

mills and two parcels of land, the same as to Jacob Edge and Henry Miller; and the said William Hammons by will gave one-third part of said mill and tracts of land to his son, Thomas, who devised the one-third part of said mills and tracts of land to his wife, Susanna, and son, William, and Susanna dying intestate, the whole descended to the said William; and on the 28th of March, 1781, William Hammons sold the third part to Thomas Bishop, so that the whole of the mill and two tracts became united in Thomas Bishop.

"On the 29th of November, 1785, by Proceedings in Partition, the above described mill and tracts of land were adjudged to Thomas Bishop, eldest son of Thomas Bishop, deceased, and Thomas Bishop, by will dated 23rd of 2nd mo., 1833, bequeathed to his wife, Priscilla, this mill property with other real estate. Priscilla Bishop, by will, 12th of 3rd mo., 1845, bequeathed to her son, Amor Bishop, that portion of her real estate designated as the mill property, and on which he then resided; and Amor Bishop by will, 28th of July, 1856, bequeathed this same property to his son, Washington; and Washington Bishop and Louisa, his wife, conveyed, 21st of March, 1862, the mill and a portion of his land to Joseph D. Velotte."

On January 1st, 1868, Joseph D. Velotte and Catharine, his wife, conveyed the mill property to William L. Lewis. After the death of William L. Lewis, his son, William F. Lewis, by deed from the other heirs, on March 22nd, 1869, became the owner of the mill. William F. Lewis held the property until February 18th, 1902, when he sold it to Jesse W. Hoopes. Later the mill passed into the ownership of Ann Sharpless and Sarah T. Sharpless, and was by them conveyed on December 23rd, 1905, to the present owner, Mr. Battles.

In 1717 it was that John Edge, Jacob Edge and Henry Miller formed the copartnership above mentioned for the purpose of erecting a "water corn mill" and carrying on the milling business. In the following year the mill, which was called "Providence Mill," was built. The original old mill, with various additions and alterations, remained standing up to the time of its total destruction by fire on August 30th, 1901. It was a stone building, thirty feet by thirty-two feet, and two stories high. Previous to this there had been purchased, in the name of John Edge, a tract of two and three-fourths acres in Edgmont township for the purpose of obtaining dam and race privileges, each partner contributing £5 2s. 8d. toward the purchase. This small tract was thereafter always conveyed with the mill property in its various transfers.

Some thirty years after the erection of the grist mill, there was erected a saw mill in connection with the business. This was located on the creek side of the race, near the grist mill, and was more or less regularly operated until the flood of 1843, when it was washed away, being, however, subsequently rebuilt and operated for many years thereafter.

In connection with the saw mill there was an arrangement by which "when the grist mill wanted water from the dam and there was not enough for both, the saw mill was to stand idle." No doubt this condition was the cause of considerable ill feeling at times.

In addition to its complicated line of title, the mill property has been singularly favored in the matter of the number of persons who have from time to time held it under lease. Thus, on September 16th, 1746, William Hammons leased his one-third interest in the Providence Mill to Lawrence Cox for twenty-one years, which lease was endorsed to Thomas Bishop for the remainder of the term. Again, Lawrence Cox on April 25th, 1751, leased to Thomas Minshall, John Minshall, Thomas Yarnall and John Cox for fourteen years a certain saw mill adjoining the grist mill.

On February 17th, 1753, John Cox, doubtless with the consent of the other owners, leased the grist and merchant mill, with two pairs of stones and three bolting sheets, to John Williamson, Henry Howard, Henry Caldwell, Lawrence Cox, Edward Farr, James Sill, Nehemiah Baker, Philip Dunn, Robert Register, James Scott, Aaron Baker, Abel Green, Thomas Minshall, John Scott, Jesse Woodward, James Massey, John Baker, Joseph Black, Nathan Lewis and William Wall for seven years. Tradition has it that every man having a share in the mill took his own grain there and ground it himself whenever the inclination prompted, and did so without giving thanks or pay to anyone. On February 22nd, 1755, Caleb Cowpland and wife, Sarah, Thomas Park and Jane, his wife, and Abigail Edge leased their share of the corn mill and property to Thomas Bishop for ten years.

In this connection Minshall Painter says: "We cannot understand why so many farmers thought it necessary to rent the grist and merchant mill, unless to gain precedence in having their grain ground as early as they might desire, and who were perhaps their own shippers. We notice that John Minshall sent his flour to Barbadoes in 1746, and to Jamaica by the brig "Dolphin," of Wilmington, in 1749, in charge of his brother, Moses, who was a sea captain, and received sugar in part in return."

After Thomas Bishop, the younger, had acquired absolute ownership of the property, which occurred in 1785, a frame third story and an overchute were added to the mill, the eastern end of the latter resting on three stone piers, the public road passing underneath.

During Thomas Bishop's ownership of the mills many changes of management took place. He, himself, operated the mills until 1802, when Francis Bishop began operating them. In 1807 Thomas was again conducting the grist mill, while in 1811 he operated the saw mill, and Amor Bishop the grist mill.

In 1810-11, during the ownership of Thomas Bishop, the rolling and slitting mill was built; it was about seventy feet by fifty feet, one story high and adjoined the southern end of the saw mill. It stood on the site of an old plaster mill which had been in operation for half a century before it was taken down in 1810, and was four times as large as the latter building. This iron mill was used for making boiler plates, sheet iron, for slitting, and for other work; the iron for it, which was in bars about two feet long, was carted from Philadelphia in wagons.

The fuel used was the soft, bituminous, Virginia coal. The war, however, made it difficult to obtain the fuel, the cargo being of such character that the masters of coaling vessels refused to carry it, for if chased while at sea it was almost impossible to escape capture. The attempt was then made to use charcoal, but that was expensive, and could not be obtained in sufficient quantity. Fortune, however, came to the relief of Malin & Bishop, and at the same time introduced the use of anthracite coal. The incident is thus reported in the first report of the Pottsville Board of Trade:

"In the year 1812 our fellow citizen, Colonel George Shoemaker, procured a quantity of coal from a shaft sunk on a tract he had recently purchased on the Norwegian, and now owned by the North American Coal Company and known as the Centreville Mines. With this he loaded nine wagons and proceeded to Philadelphia. Much time was spent by him in endeavoring to introduce it to notice, but all his efforts proved unavailing. Those who designed to try it declared Colonel Shoemaker to be an imposter for attempting to impose stone on them for coal, and were clamorous against him. Not discouraged by the sneers and sarcasm cast upon him, he persisted in the undertaking, and at last succeeded in disposing of two loads for the cost of transportation, and the remaining seven he gave to persons who promised to try to use it, and lost all the coal and charges. Messrs. Mellon (Malin) & Bishop, at the earnest solicitation of Shoemaker, were induced to make a trial of it in their rolling mill in Delaware County, and finding it to answer fully the character given it by Colonel Shoemaker, noticed its usefulness in the Philadelphia papers, and from that period we may date the triumph of reason, aided by perseverance, over prejudice."

Tradition says that the employees in charge of the furnace at the Delaware County Rolling Mill, when the load of coal first came to the works, late in the afternoon, threw into the fire a considerable quantity of the material with the oft expressed opinion that the "boss had been fooled," an opinion which became more and more confirmed when the coal refused to ignite, although frequent attempts were made to kindle it. Late in the evening the fireman gave up in despair and went to bed. An hour or two later, being restless, he arose and went to the mill, when he found the furnace door red hot, the building intensely heated, and the woodwork almost ready to burst into flame. There had never been such a fire in the mill before. From then on, Enos Helms was sent to Mauch Chunk with a five-horse team, and hauled the fuel for the rolling mill from that place. The coal cost two dollars a ton at the mine.

In addition to the buildings already mentioned, the farm house and the several tenant houses on the other side of the creek, there are yet two others of interest that must not be omitted. In 1812, as is shown by the date stone thereon, there was erected a small, two story building between the race and the road to Upper Providence store, which building was originally intended as a sort of office in connection with the mills. This building later on became, at least as regards the second story, the home of the Union Library, of which an account is given later on. There is also located on the opposite side of the race and further up stream a building which was for many years occupied as a blacksmith and wheelwright shop. The date of its erection does not seem to be known, nor who its various occupiers were. At one time James Stirk had a wheelwright shop in the second story and George Dutton a blacksmith shop on the ground floor. The entrance to the wheelwright shop was from the side next the road, by crossing over the race. The blacksmith shop was entered from the side next the creek, after first crossing the race and passing around the end of the building. These buildings are all clearly shown in the views which accompany this narration.

The question as to the length of time the various mills were in operation is interesting. As has already been mentioned, the grist mill was in constant operation from the time it was built in 1718 until it was burned down in 1901, a period of one hundred and eighty-three years. The saw mill was erected somewhere about 1747, and was used until washed away in the flood of 1843. It was rebuilt after that and kept in intermittent use thereafter until the burning of both it and the grist mill in the year named. As regards the rolling and slitting mill, history tells us that it was operated by Malin & Bishop in 1812; that it was operated by Amor Bishop, son of Thomas Bishop, the owner, in 1826, producing about a hundred tons of rolled and slit iron in that year; and that it was assessed as "not occupied" in 1829. It is probable that it did not run after that date.

Early in the history of the neighborhood naturally arose the necessity for some safe and sure method of crossing the creek at this important and comparatively busy spot. In 1763 a fund was raised by subscription to erect a bridge over Ridley Creek, about one hundred yards below the mills, on the site of the present bridge, and shortly thereafter the first bridge at this point was erected. At the March Term of Court in 1799, a petition was presented, signed by a number of the inhabitants of the county, setting forth that the bridge over Ridley Creek near Bishop's Mills was in bad condition, and praying that a sum of money be allowed out of the county treasury to repair the same. The grand jury allowed $40 for the repairing of the bridge. The subscription bridge stood until 1843, when it most seriously suffered in the noted flood of August 5th, that year, and had to be rebuilt. According to the Report of the Delaware County Institute of Science on the Flood of 1843, published in 1844, the abutments of the bridge were almost entirely washed away, although the framework of the span itself still remained in place after the storm, supported by the tottering walls.

The dam at Sycamore Mills has been washed away four times, once in the great flood of 1793, again on February 22nd, 1822, a third time in the destructive ice flood of January 26th, 1839, and the last time in the noted flood of August 5th, 1843.

REGISTER'S NAIL FACTORY.

This industry, which has been abandoned for over three-quarters of a century, was the direct outgrowth of the rolling mill, and although it was situated across Ridley Creek just above the bridge at Bishop's Mills, its story is so connected with the latter that it properly should be related with the history of Sycamore Mills. The nail factory was a small frame structure owned by Jesse Reece and was rented to David Register, who at an advanced age, in 1812-13, employed men and began making wrought iron nails entirely by hand. Register had been a Tory during the Revolution, and fled with the British troops to Nova Scotia, but subsequently returned after the passage of the Amnesty Act. The building, which had many years before ceased to be used as a nail factory, was washed away in the flood of August 5th, 1843.

THE UNION LIBRARY.

On the east side of the creek, between the old race and the road leading to Upper Providence store is a small, square, two-story building, bearing the date 1812. This building is interesting, not only because it is one of the group of buildings comprising the mill-site, but for the additional reason that it was for many years the home of the Union Library. This library, one of the earliest circulating libraries in the county, deserves more than passing interest in connection with an account of Sycamore Mill.

Although it is not known just who the founders of the Library were, a number of well known persons of the neighborhood from time to time took active part in its affairs. Among these may be mentioned Minshall Painter, Jacob

Painter, George B. Howard, Baldwin Howard, John Miller, Sarah L. Miller, Levis Miller (father of Edgar T. Miller, of Media), Jeremiah Bishop (father of Henry C. Bishop, of Media), Thomas Reece, and many others.

The date of the organization and establishment of the Library does not appear to be definitely known, but it must have come into existence early in the last century.* The farmers of the neighborhood, living far removed from the large communities and at a time when books were rare, no doubt early felt the need of some educational centre. This praiseworthy desire it was, no doubt, that brought the Union Library Company into being.

The building occupied by the Library was originally erected by Amor Bishop, father of Pratt Bishop, the latter at the time of his death a resident of Media. The first floor was used as a sort of office in connection with the mill, while the second story of the building was occupied by the library. The association flourished and soon became the possessor of a number of valuable works. In addition there were on exhibition in the building many scientific specimens, including minerals, stuffed birds, foxes, 'coons, squirrels,† etc.

The library early became the centre of scientific knowledge of the neighborhood, and would probably have existed many more years as such had it not been for the advent upon the scene of a more pretentious organization. This was the Delaware County Institute of Science, organized in 1833, and which, previous to coming to Media in 1867, had its home near the Rose Tree Inn, not so very far from Sycamore Mills. The rising Institute of Science soon became the educational centre of the neighborhood, and the activity of the Library waned. Despite this, however, the latter association kept in

* Minshall Painter, in a letter to Caleb Yarnall concerning the Union Library Company, written in 1868, speaks of its having been organized about fifty years previously; that is, about 1818.

† The latter were the handiwork of Thomas Bishop, one of the sons of Amor Bishop, a school teacher and a taxidermist of some skill.

existence well on into the latter part of the "sixties," when it finally dissolved. The letter of Minshall Painter, above referred to, indicates that the Union Library Company, at the time of writing, was at the point of disbanding. Its last days were sad ones, as history has it that it was distrained upon for rent during the time that Joseph D. Velotte owned the property. A public sale of the books was held in the building of the Institute of Science, in Media, shortly after the latter society erected its new home here.

Many of the books of the old Library came into the possession of the Institute by purchase or donation, and some of the books are still on the shelves of the latter institution. Dr. George Smith, in his "History of Delaware County," writing about 1862, gives the Union Library, among others, as containing 1400 volumes, while the Institute of Science in the same year is credited with only 1000 volumes.

The views accompanying this article are explained by their respective legends. To aid in properly orienting the pictures it may be mentioned that the creek at this point runs in a general southeastwardly direction, the old mill ruins and the majority of the buildings being on the northeast bank.

The majority of the photographs for the illustration of this article were furnished by Mr. Battles, and it is through his kindness that the Institute is enabled to reproduce them herewith.

Despite diligent search, the Institute has been able to obtain but one view of the mill as it was before its destruction. This is a photograph of modern times, taken by Dr. W. T. W. Dickeson, of Media, who has kindly furnished a copy for reproduction.

REMINISCENT.

The foregoing comprises, so far as the information is available, what may be termed the formal history of the Upper Providence Mill and its surroundings. There still remain, however, many personal reminiscences of those who knew the property back in its days of activity which ought not to be omitted. Reminiscences, incidents and traditions there are by the hundreds, a few of which have been gathered together from time to time and are herewith presented.

Edgar T. Miller, of Media, a son of the late Levis Miller, and a great-great-grandson of Henry Miller,* one of the founders of the mill, passed many of his younger years at the old Miller homestead on Ridley Creek, just below Sycamore Mills, this being the property now owned by Shirley Borden. The Miller tract was the southern portion of the original five hundred acre grant to James Swaffer. Although in 1843 Mr. Miller was a very little boy, he still carries a vivid recollection of the great flood of that year. He remembers the morning after the flood his father took him up to see the damage done at the mill, and he still recollects the impression made upon him by the woe-begone expression of the then operator of the mill, Amor Bishop. The mill, while not washed away, was very badly damaged, and the miller felt he was ruined. Fortunately, however, in view of what an important factor the mill was to the farming interests of the vicinity, a number of neighbors put together after the flood to help Mr. Bishop get it in operation again as soon as possible.

Another of Mr. Miller's recollections centres around two frame houses belonging to Jesse Reece, at that time located on the west side of the creek, opposite the mill property. These were washed away in the flood and landed in the Miller meadow, from whence they were carted back piecemeal by the owner.

In speaking of the saw mill on the property, Mr. Miller says that back in the "forties" it was the custom to cut down the black oak trees of the neighborhood and bring them to the mill to be sawed up into boards. The boards naturally

*Who came from Devonshire, England, and settled in Upper Providence in 1714, on lands southeasterly of and adjoining the mill property.

were rough and liable to warp, but would answer for many purposes. The bark from the oak trees was sent to various tan yards to be used in the manufacture of leather. One of these tan yards was located on the east side of Crum Creek, on the farm lately owned by William Bartram, deceased. A direct road led from Bishop's Mills by way of the Blue Hill school house over to this point and beyond. This tan yard was locally known at that time as Pratt's tan yard (from a previous owner of the property) * or later as Bartram's tan yard. The tan yard at this point was situated to the south of the Bartram homestead, but at that time the public road passed on the north side of the house instead of on the south side, as at present.

Henry C. Bishop, of Media, son of Jeremiah Bishop, and great-grandson of the Thomas Bishop who first owned the property, spent his boyhood days in the neighborhood of the old mills, and calls to mind many reminiscences of the property. He says:

My recollection of Sycamore Mills carries me back over more than three score years, to my boyhood; back to my early school days, when I first attended the old Blue Hill school — an old, one-story building that stood a short distance in front of where the present two-story structure now stands; and to the memory of Mrs. Rachel Green, my first preceptress, who taught what was called in those days a "pay school" in that old school house.

The word "Sycamore" had no reference to the old mills until long after I remember them. They were known in my early days as Bishop's Mills, or, more familiarly, as Bishop's Hollow. The name was changed to Sycamore Mills after the property went out of the Bishop name. About the time of the great flood of 1843 there were at this place many houses as well as the mills. But more particularly two houses that

* Thomas Pratt, grandfather of William Bartram.

stood on the west bank of Ridley Creek, near the bridge, come back to my memory from the fact that Mrs. Green, above mentioned, and her family lived in one of those houses at the time of the flood, from which they barely escaped with their lives, as both houses were washed away.

In those days it was the custom of the farmers within a radius of three or four miles to take their grain to these mills to be ground into feed for the stock and flour for family use. They also hauled logs to the saw mill to be sawed into lumber for building purposes. My father was a farmer and I the only son, and it was often my part to go to mill with grain. I remember on one occasion, on a cold winter night, father's hired man and myself, with two bags of grain of two and a half bushels each, were sent astride of two horses to the old mill for the purpose of getting it ground into feed for the cattle. On arriving the miller carried the grain into the mill. We asked him when it would be ground and he replied: "Hitch your horses and come in. I will grind it while you wait. It won't take over two or three hours." We hitched and went in. The miller poured the grain into the hopper and took out the "toll" with a round wooden measure about five inches high and six inches in diameter, holding one-tenth of a bushel, which was the amount of grain they received in those days as pay for each bushel ground. He then pulled the head gate and turned on the water which supplied the power that ran the wheel. After considerable screeching, cracking and thumping the operation of grinding commenced. We then betook ourselves to the lower story of the mill, where the meal ran out from the burrs into a large chest. After adjusting the burrs so the meal should be of the proper consistency we sat down by the old fire-place to await the completion of the grinding. The fire-place was about six or eight feet long, filled with several large chunks of burning wood which made a roaring hot fire, very agreeable on such a cold night. In front of this was a long bench made of a slab from the saw mill, with four round sticks as legs. On this we took our seat, smoked cigars and related anecdotes until the grist was finally finished. It was on this occasion that I smoked my first cigar. I smoked two at that time, and the most remarkable thing was they did not make me sick, although I could taste cigar for two or three days thereafter.

Fifty years ago, when a member of a family died and while the remains were in the house, it was the universal custom for two persons to sit up all night and to visit the room in which the corpse lay at intervals of two or three hours. At the time of the death of Amor Bishop, who lived in the large stone homestead on the mill property, I was called upon to sit on watch one night in that house in company with a young man, a friend of mine, a sleepy-headed fellow, who slept all night with the exception of lunch time. Hence it fell upon me to visit alone the room where the body lay, with only the light of a tallow candle. My feelings can better be imagined than described.

In the bank on the opposite side of the road, east of the mills, was built a large stone ice house, which was used as public property on private grounds. It was the only ice house in my early days in that section. All the farmers who were patrons of the mill and wished to get ice from this house were welcome, provided they assisted in the filling.

Hon. Isaac Johnson, President Judge of the Delaware County Courts, who plied his occupation as a miller at Sycamore Mill previous to the breaking out of the War of the Rebellion, has many interesting recollections of the historic old spot. At the time he was employed at Sycamore, the mill was leased and operated by the late Lewis Palmer, of Media, who at the same time owned and operated the mills on the same creek near Media, where the present borough water works are located. Judge Johnson was employed as miller, and spent his time alternately between the two mills, but principally at the upper, or Sycamore Mill. He had served his apprenticeship as a miller at Willistown, Chester County, under

Isaac Thomas, and from that place came to Palmer's Mill.

Judge Johnson, while at Sycamore was granted the use of the Union Library by Thomas Minshall, one of its members, and much of his lifelong love for reading he attributes to this circumstance. He says the big, iron key of the Library used to hang in the office of the mill, where the various members could obtain it when needed. At the sale of books of the Library Company held in the Institute of Science building in Media, above referred to, Judge Johnson, among others, purchased a number of the books. Recently in glancing over one of these old books the Judge found in it the mark of the Willistown Library, Willistown Township being a bordering township in the neighboring County of Chester, and not very far distant from Sycamore. From this circumstance he hazards the conjecture that the Union Library might have been formed around a nucleus of books from the still older Willistown Library.

LOG CABINS.

Within no great distance of Bishop's Mill * there remain to-day several landmarks of old times which, although but little is known of their history, form part of the romance of the neighborhood. These are several log cabins, one on the Painter Road, two on the Honeycomb † Church Road, and one on the Providence Road, still used and occupied as dwellings. The old landmarks of this character have almost entirely disappeared from our county, and for that reason it is thought well to preserve here some little record of those of this vicinity. What little is known of them is here given.

The first, and that about which most is known, is shown in Figure 1. It is located on the road leading from the

* Be it borne in mind that the mill has, from time to time, had various names: The Providence Corn Mill, Providence Mill, Bishop's Mill, Velotte's Mill, Sycamore Mill.

† So called from the "honeycomb stone" in the locality.

farm late of Dr. Jack to the Barren School House. Ambrose Smedley [great-grandson of George Smedley, who came from Derbyshire (?), England, about 1682] inherited ninety acres of land in Middletown Township. Upon this land, as is shown by a stone above the roof in the chimney in the east end, the original house had been erected in 1785. From time to time additions have been made to it, but the old portion and the date stone still exist.

This property has been occupied until recently by the Smedleys. The last of the family to live there was John H. Smedley, a son of Ambrose Smedley, above named. John H. Smedley is a mineralogist of wide reputation, and one whose knowledge of the mineral products of the county is unsurpassed. Mr. Smedley now resides with his son, Ambrose, in Village View, a suburb of the Borough of Media.

One of the traditions related by Mr. Smedley is that on the opposite side of the Painter Road from the house and somewhat nearer the Barren School House, there existed years and years ago an Indian village. There have been many Indian relics found at this point and an excavation in the side of the hill would substantiate some adaptation to human use.

Of the other log cabins but little is known. The cabin shown in Figure 2 is located on the west side of the road leading from the Middletown Road to Honeycomb A. M. E. Church, about one hundred yards south of where the former intersects the Barren Road. It is owned and occupied by the widow of the late George Green.

Cabin No. 3 is on the same side of the same road as No. 2, just north of Barren Road, and hence nearer to the church.

The fourth cabin, Figure 4, which no longer exists, was located on the north side of the Barren Road, some five hundred yards east of the Honeycomb Road, adjoining the house formerly of Henry Garnett, now occupied by James Moat.

The last cabin, shown in Figure 5, is located on the Providence Road, about a quarter mile northeast of Sycamore. It is at present occupied by Thomas Pyle.

"INDIAN ROCK."

BY SANFORD OMENSETTER.

Years before the coming of Onas,* when the waters of Ridley Creek swept through woodland aisles cooled in the shade of the forest primeval, the neighborhood of Sycamore Mill was the haunt of the Lenape.

These red men, called by the English "Delawares," were a branch of the Algonkin stock, part of whose holdings fell within the basin of the river Delaware. The Pennsylvania Lenape included three sub-tribes, the Minsi, the Unami and the Unalachtigo, whose totemic emblems, or animals from which a mysterious descent was claimed, were respectively the wolf, the turtle and the turkey. The Minsi occupied the highlands of the Delaware north of the junction of the Lehigh. The hunting grounds of the Unami lay south of the Lehigh valley, while still further to the south roamed the Unalachtigo, whose chief town nestled near the site of modern Wilmington. The banks of Crum and Ridley Creeks and the lands between were peopled by the Okahoki, a band said to have been a division of the turkey clan. Such was the situation when, in the quaint lines of the "Walam Olum,"†

> "At this time whites came on the eastern sea."

After a northward course through Middletown Township there flows into Ridley Creek below Sycamore Mill an humble stream called Dismal Run. At a certain point in the path of the latter, flanked by wooded hillsides studded with fern-draped rocks, a purling brook comes out of the west. From a deep, rich soil giant trees stretch forth their arms as if to catch the great, white boats that sail the boundless sea of blue

*William Penn. "To explain the name Penn to the Indians a feather was shown them, probably a quill pen, and hence they gave the translation Wonach, corrupted into Onas."—D. G. Brinton, M. D., in "The Lenape and their Legends."

†The national epic of the Delawares.

above. Not among the least of these, "fit to stand before Valhalla," is a kingly poplar, silent sentry over "Indian Rock," which slumbers at its base.

This ancient landmark, whose handwork tradition charges to the red man, is flat-topped and roughly circular in shape. It is some four feet in diameter and nine inches at its greatest thickness, gently rounding in places to a rather sharp edge. The rock is of Baltimore gneiss, formed in part of feldspar, quartz, hornblende and black mica,* grooved as shown in the illustration.† The four main lines trend midway to the cardinal points, the minor A-like figure being in the west corner.

What means this witness of the by-gone age? Did a vengeful war-lord set it as a seal of victory? By it, in gathering twilight, has some dusky Minnehaha crooned the love-song in the liquid dialect of the Unami? ‡ Does it guard the ashes of a famous chieftain, long since mingled in the dust of forgotten days? Can it be an altar of the prophets of the olden mysteries? Alas! Cold inquiry has with cruel finger drawn aside the gauzy veil of romance, and found it a stone for domestic use, perhaps for dressing the rude utensils of savage life. We had hoped a nobler fate.

That this was its object seems fairly well proven by the nature of its markings. Such remains are to be seen in various parts of the country. The wider furrows could have been made by sharpening stone axes and larger implements, the narrow lines by pointing spear and arrow heads.

Minshall Painter relates that in the deep valley of Dismal Run Andrew, Isaac and Nanny, the remnant of a tribe of Indians, lived in a cave. There they remained until the death of Andrew, when the other two moved to unite with

* For this determination we are indebted to T. Chalkley Palmer.

† Previous to picture taking these grooves were whitened with chalk. The channels have somewhat lost their smoothness through the march of years.

‡ Spoken also by the Unalachtigo.

their kindred in New Jersey.* Andrew was laid to rest in the Friends' graveyard, in Middletown, but the date of interment is unknown.

On a portion of the broad acres held by the Minshall family there was an Indian burial ground. One of those fire-side tales that have been handed down from remote years sets forth that several old clearings in the "Barrens" were used by Indians, who tilled these tracts or lived thereon.

A village called Macocks was located on Smith's map of 1608 (Smith, Virginia, I, repr. 1819) some distance north of Chikohoki, which, according to Brinton, was near the present Wilmington, Delaware. This would make Macocks a Delaware village in southeastern Pennsylvania, and Brinton thinks it may have been the village of the Okahoki, a band of the Delawares, formerly in Delaware County, Pa. †

The Okahoki were transferred, about 1702, to a small reservation of five hundred acres in what is now Willistown Township, Chester County. ‡

The region of Dismal Run is idyllic. Within its calm retreats the spirit of change moves slowly. Over it broods a sense of peaceful rest. Among its leafy glades, rich in the song of birds and the bloom of flowers,

> "Far from the madding crowd's ignoble strife,"

one may drink as from the font of youth eternal. Nature scarce has loosed her sway since, by the dim and flickering light of the council brand, some aged warrior has retold the wierd tale of departed glories, and the artless children of the forest were cradled in the everlasting hills.

May Time deal gently with the "Indian Rock!" It calls up visions of a race that has passed — who left in a quiet glen in Middletown this mute impress of their passing.

*Early in the last century, according to Ashmead.

† Bulletin No. 30, Bureau of American Ethnology.

‡ "History of Delaware County, Pa.," by Dr. George Smith.

MINUTES OF MEETINGS.

JANUARY 10, 1907.—Adjourned meeting. Paper on "Irish Poetry," by Prof. John Russell Hayes, of Swarthmore College.

JANUARY 17, 1907.—Adjourned meeting. Illustrated lecture, "Life in the Sea," by Henry S. Pratt.

JANUARY 24, 1907.—Adjourned meeting. Lecture, "Dr. Daniel Kirkwood," by President Swain, Swarthmore College.

FEBRUARY 7, 1907.—Regular monthly meeting, with President T. Chalkley Palmer in the chair. Ober Baker and Carlota Broomall were elected juvenile members The donation to the Institute of thirty-two volumes from the library of the late Jacob B. Brown was announced, presented by Miss Anne Knapp Whitney. J. C. Noblit presented to the library a copy of "Genealogical Collections." There was also reported the receipt of ten volumes of the Annual Reports of the Bureau of Ethnology, making complete the Institute's set of these valuable works from the beginning to date. The contamination of the springs and wells on the outskirts of the town by the deep cesspools at the court house and elsewhere intercepting underground streams of water was discussed. C. M. Broomall exhibited a curious composite ring, made up of four links like a chain, which could be fitted together in such a way as to make a ring of four bands. This device was formerly the property of the late Mr. Brown, who had obtained the original of the ring in India. Eugene Walker spoke of an outbreak of anthrax at Kennett Square, Chester County, said to have arisen from cattle being allowed to range over ground where years before there had been a tanyard. After further discussion of scientific matters the Institute adjourned.

FEBRUARY 14, 1907.—Adjourned meeting. Lecture on "Strange Tongues," by Henry L. Broomall.

FEBRUARY 21, 1907.—Adjourned meeting. Illustrated lecture on "Some Observations of Canadian Glaciers," by George Vaux, Jr.

FEBRUARY 28, 1907.—Adjourned meeting. Lecture on "An Evening with the English Poets," by Hon. John B. Robinson.

MARCH 7, 1907.—Regular monthly meeting, President T. C. Palmer presiding. Usual reports of committees and curators and routine business. Donations to the library were announced as follows: Smithsonian Annual Report, 1905; Proceedings National Museum, Volume 31; Contributions to the United States National Herbarium, Volume X, Part 3. William R. Newbold, Jr., of Panama, formerly of Media, presented to the museum a monkey skull found at Tavoli Hill, Panama, and also a number of pictures of scenes along the Canal. The subject thus suggested was discussed at length by the members present.

MARCH 14, 1907.—Adjourned meeting. Illustrated lecture, "Glimpses of Europe," by Joseph Elkinton.

MARCH 21, 1907.—Adjourned meeting. Lecture, "Mars and its Canals," illustrated by charts, by Dr. E. D. Fitch.

MARCH 28, 1907.—Adjourned meeting. Illustrated lecture, "The Bryology of Delaware County," by A. F. K. Krout, Ph. D.

APRIL 4, 1907.—Regular monthly meeting, with President T. C. Palmer in the chair. After usual routine business President Palmer gave an interesting talk on "Diatoms," illustrating the subject by drawings and microscopic slides. The subject of "living" crystals, which was being so widely discussed in the scientific and popular press, was brought up for consideration. C. M. Broomall recounted some of the interesting experiments of the workers in this field of research.

APRIL 11, 1907.—Adjourned meeting. Lecture, "The Wanderings of a Word," by Henry L. Broomall.

With this meeting the winter course of lectures came to a very successful termination.

INSTITUTE NOTES.

One of the departments of human knowledge contemplated for study under the Constitution of the Institute is that of Local History. For this reason it may not be amiss, now and then, to devote a number of the PROCEEDINGS to that line of inquiry. We hope our more strictly scientific readers will not feel the perusal of this number altogether a waste of time.

The article on the "Indian Rock" in this issue of the PROCEEDINGS calls attention to a very interesting relic of our predecessors in this vicinity. The rock can hardly be anything but the work of the Indian, as no white man would waste his time on such a laborious piece of work that promised no financial advantage. The rock has been, no doubt, noticed before in the local press, but we think this is the first time a photograph of it has been published. The photograph of the rock was taken by John W. Palmer, of Media, who likewise took a number of other views presented in this number of the PROCEEDINGS.

The museum of the Institute has been enriched by the donation of the fine mineral collection formerly belonging to John T. Reynolds, a deceased member. The collection is particularly valuable by reason of the beautiful groups of quartz crystals which it contains.

T. Chalkley Palmer, President of the Institute, recently presented to the Institute a number of typical specimens of Indian arrow and spear heads and Civil War relics, collected in Virginia. Likewise he is the donor of some fine examples of "slickensides" from the serpentine quarry in Willistown Township, Chester County, near the junction of the West Chester Road and the Street Road.

The unusual luxuriance of "poison vine," *Rhus Toxicodendron*, is very evident this year, and probably correlated with the cold, damp and tardy Spring, which sort of weather seems very suitable for certain kinds of vegetation.

Ruins and Library Building (from South)

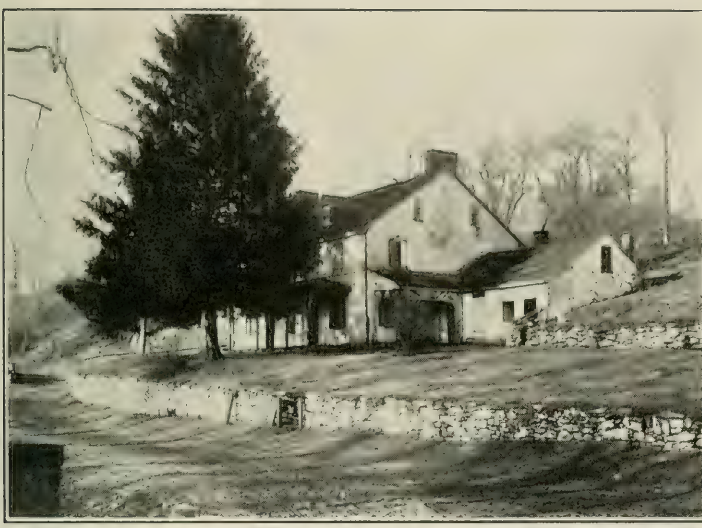
Ruins and Farm House (from West)

Former Blacksmith and Wheelwright Shop, Library in Distance
(from West)

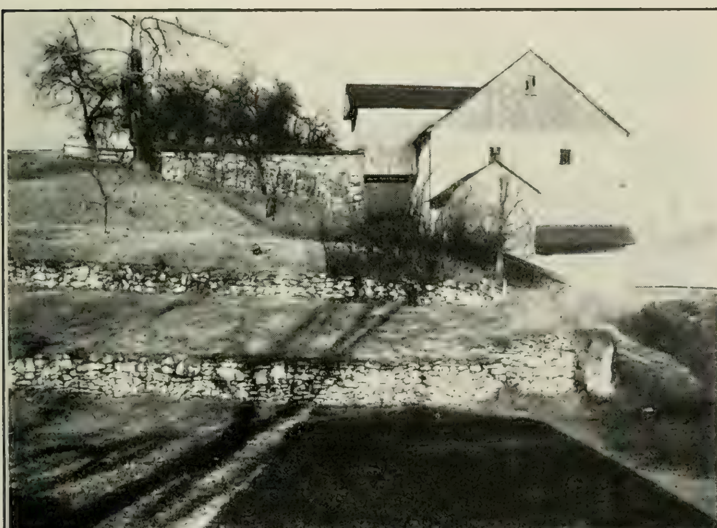
Former Blacksmith and Wheelwright Shop, Library, Ruins
and Farm House (from West)

Former Blacksmith Shop and Library (from South)

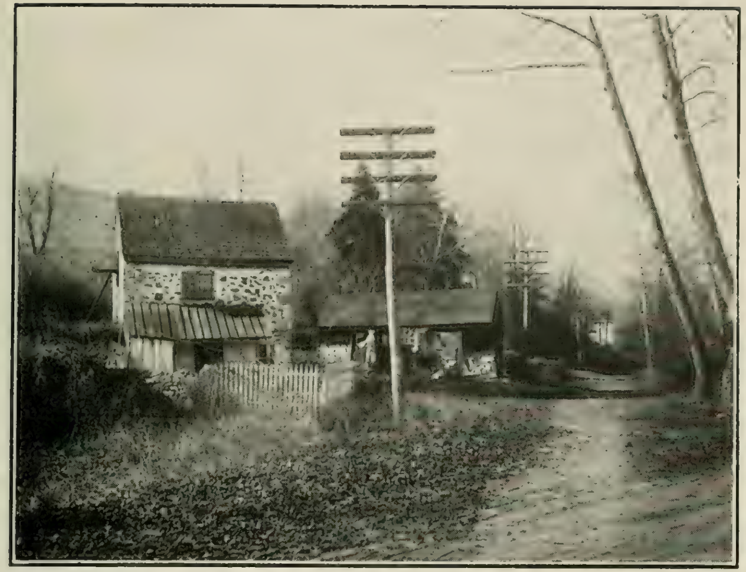
Bridge and Farm House (from South)



Farm House (from South)



Barn from Southwest)



View on Southwest side of Creek near Bridge (from Southeast)

View across Creek below Bridge (from Northeast)

View across Dam (from Northeast)

View of Falls (from Northeast)

Falls.

Creek below Falls.

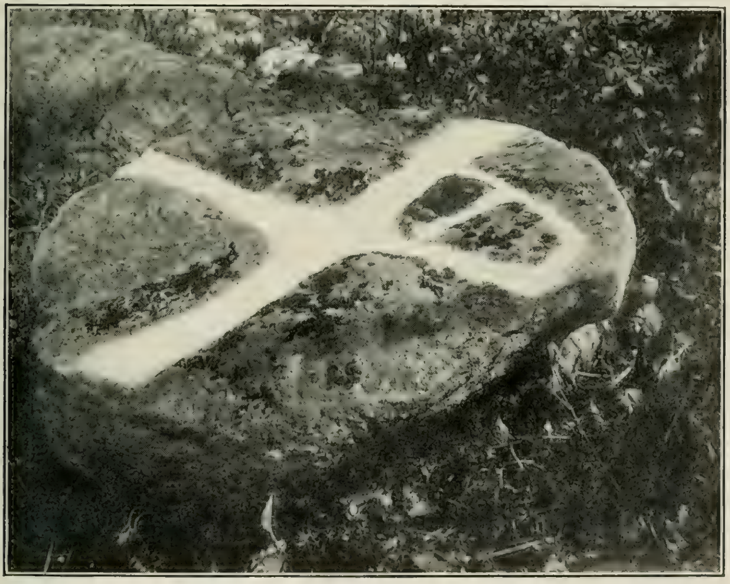
Figure 1.

Figure 2.

Figure 3.

Figure 4.

Figure 5.



The Indian Rock.

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Vol. II, No. 4 July, 1907

PROCEEDINGS

OF THE

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PUBLICATION COMMITTEE:

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PROCEEDINGS

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THE EVOLUTION OF THE HORSE.*

BY B. M. UNDERHILL, V. M. D.

To read that the ancestors of our horses hundreds of thousands of years ago had three toes and were no larger than sheep may be entertaining, but unless such facts are brought into connection with principles that arrange them in their relation to other facts, they can only serve to conduct us through mere description to blank amazement. The popular treatment of topics of science has been objected to on this score, and much that has been so written upon the beginnings of the horse is so fragmentary and scattered that it can only bring to the unprepared mind a disordered conception of the subject. I am not competent to write anything more profound, but have attempted in this brief paper to present connectedly and relatively the outlining facts which I have derived from a number of authors who have recorded the results of more recent research in the fossil fields of North America. The evolutionary line is that of Professor Marsh, while for the description of fossils I have relied principally upon the study of specimens at the American Museum of Natural History at New York.

When Sir Isaac Newton demonstrated gravitation from falling apples the law which he asserted did not apply to

*Presented at the April Meeting of the Keystone Veterinary Medical Association of Philadelphia.

apples alone, but was a universal one. And so if evolution had been demonstrated only by what we know as to the origin of the horse, this would be sufficient to establish it as universal in its application. In America, where the record is most complete, the horse has been traced from the Mammalian Dawn down to historic times through eight successive stages without a break of importance in the line, and, as we study these steps that lead up to the most highly specialized of modern animals, with their accompanying phenomena of environment, we are furnished with the best exemplification in existence of the laws which govern animal evolution.

It is of course not to be inferred that the distinguishing characteristics in this series were abrupt departures from prevailing forms; the horse with one functional digit between two that were useless was not a direct product of the preceding genus in which the two lateral hoofs reached the ground and contributed to support, nor did this three hoofed horse thus descend from the one which stood upon four. Between these stages there was an intermediate series in which the tendency to discard what had become an incumbrance went hand in hand with adaptive development. If a variation is of advantage in the struggle to sustain life, nature tends to retain it and intensify it in future generations until it finally predominates over the older forms. To be sure nature also tends to propagate defects, but this retrogression cannot be long sustained amid constantly unfolding enemies to life, and, as the contest becomes sharper and the range more restricted, only those responsive to the change can survive. It is a clear application of Spencer's "Survival of the Fittest."

The significance of these variations as factors in the evolution of species can be better appreciated if we consider the vast stretches of time in which they were having their influence. As an example we may take the case of the so-called wolf-tooth of our present day horses. In the ancestral types this first of the four premolars was fully developed and had its opposing tooth in the lower jaw. As the lower tooth was the first to go the atrophy of disuse attacked the upper one, though it remained constant for a long period of time. Then an occasional individual appeared without it; later as many appeared without it as with it, and still later it had disappeared from most all and became very rudimentary as at present. The process of discarding this tooth absolutely has already occupied a period of probably not less than 50,000 years and it is still unaccomplished. Thus it will be clear that in the slow progress of evolution a long series of related forms must have intervened between the stages that we recognize as genera.

Inserted below is a tabular view of the American and European generic lines in their relation to each other and to the divisions of geological time. The Middle Era, in which we find the first mammals, is included.

Eras	Ages	Periods	American Equine Series	European Equine Series
	Quaternary	Recent Pleistocene	Equus	Equus
Cenozoic	Tertiary	Pliocene	Pliohippus Protohippus	Hipparion
		Miocene	Miohippus Mesohippus	Anchitherium
		Eocene	Epihippus Orohippus Eohippus	Hyracotherium
Mesozoic	Cretaceous Jurassic Triassic	Reptiles, First Mammals, Birds		

Mesozoic, 7,000,000 years; Tertiary, 3,000,000 years; Quaternary, 50,000 years. (Rough approximation).

Figuratively speaking, our highly individualized animals of to-day represent the topmost twigs of a tree. In the preceding branches there is a tendency to combine these characteristics in more comprehensive types, and we find ancestral forms the more generalized as we pass downward towards the trunk. At the point where we meet the first Ungulate we find evidences that a branching has already taken place into odd-hoofed (Perissodactyla), where the middle toe is the centre of support, and into pair-hoofed (Artiodactyla), where the support is distributed between the middle and fourth. The paleontologist can by most probable outlines trace these two groups to the present, where they reach their highest expression in the *Equidæ* and *Bovidæ*. Primitive Ungulates first appear in the lowest Eocene formations of the western lake basins. These belong to a single genus, *Coryphodon*, having five toes in front and behind, with the third or middle toe decidedly the best developed, thus showing the odd-hoofed tendency. But this largest mammal of the Lower Eocene sheds very little light upon the five-toed beginnings of our little four-toed horses, and it leaves a gap yet to be filled to the first incomings of the Hoofed Animals. Indeed the obscurity is general as to the source of the mammalian assemblage that here makes its appearance. Though it has left us a record through the Tertiary Age that is almost complete, below the Tertiary it seems lost, only a few diminutive mammals of very low type having been yielded thus far by the Cretaceous. The case is thus referred to by Le Conte: "It is impossible to explain this unless we admit times of rapid evolution. But even this is not sufficient. We must suppose, also, that these new types appeared here in America by migration about the end of the Cretaceous from some other country, where we hope yet to find the intermediate links."

Over forty years ago a skull was found in the Lower Eocene of England belonging to an animal which was at that time named the Hyracotherium by Professor Owen and which has since been recognized by paleontologists as representing the most primitive stage known in the horse's ancestral line. The molar teeth have six cusps on the upper and four on the lower ones, and these are just beginning to fuse into crests. In each jaw the fourth premolar has three cusps, the third two, and each of the first and second premolars one. The teeth are short crowned and like those of omnivora. The fact that this skull is more primitive than any yet found in America would seem to indicate that the original stock was Eurasian, and that it migrated eastward, by land connections then existing, to North America, here to continue its evolution. The succeeding genera in North America are increasingly numerous, while in Europe the line is disconnected, its occasional representatives probably being derived from those that had found their way westward from this country.

The American Series starts with the Eohippus, or "Dawn Horse." It comes from the Lower Eocene of Wyoming and New Mexico, and is much more available for study than the Hyracotherium. It is about the size of our domestic cat, and is like the Hyracotherium except that the fusing of the cusps into crests has progressed and the fourth premolar is beginning to look like a true molar. The hand of this animal has four functional fingers, while the thumb is rudimentary and reduced to a splint. The foot has three functional toes, no trace left of the first toe, and the fifth reduced to a splint. It might be explained parenthetically that terms applied to the human digits are used here in describing the front feet in order that we may more readily follow these changes by reference to our own fingers.

The second in the series is the Orohippus or "Mountain Horse." It is found in the Middle Eocene of Wyoming, and in size is somewhat smaller than a fox. Like the Eohippus it has four functional fingers and three functional toes, but the splint of the thumb has disappeared, as has the splint of the fifth toe. The radius and ulna and tibia and fibula are still distinct. The crests on the molars are clearer than in the preceding stage and the last premolar is like the true molars, while the next to the last is beginning to become so. The canines are well forward and the diastema, or "place for the bit," is distinct.

The Epihippus is from the Upper Eocene, and is about as large as a fox. In this stage the four fingers and three toes of the Orohippus are still retained, but the central finger and central toe are becoming larger. The once rounded knobs of the molar teeth are now almost completely converted into crests, while the third, as well as the fourth premolar, have become like the molars.

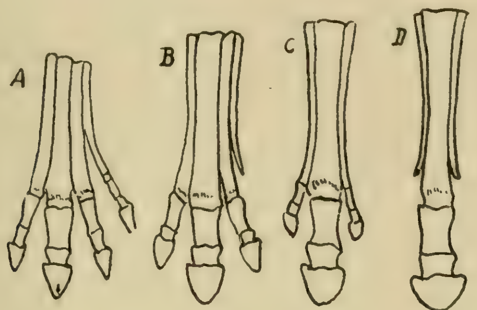
The fourth in the line is the Mesohippus, found in the Lower Miocene White River Formation. It is somewhat smaller than a sheep, and stands upon three fingers and three toes, the fifth finger of its Eocene ancestors being reduced to a splint. The side digits are now bearing little weight, while the central ones are much the largest. The crests on the molars are completely formed and three of the premolars have become true molars.

The Miohippus from the Upper Miocene is about as large as a sheep. Like its predecessors in the series, it has three fingers and three toes, a rudiment of the fifth finger still remaining. The radius and ulna are loosely united, and the tibia and fibula are co-ossified at their distal ends.

The Protohippus is found in the Lower Pliocene. It is nearly as large as an ass, and represents the first stage where the lateral hoofs are not functional. It stands upon the middle finger and middle toe. The side digits, that is, the second and fourth, are still complete, but much more slender than in the preceding stage, and they are clear of the ground. The hand still retains tiny nodules of bone at the back of the wrist, or so-called knee, which are the remains of the first and fifth digits.

In the Pliohippus from the Upper Pliocene we have the last stage before reaching the true horse. It is as large as an ass, and in some species the side digits have almost if not completely disappeared.

The last in the evolutionary line is the genus *Equus*, which is first met with in the Upper Pliocene, an animal in all essential details of structure similar to our modern horses.



A, Orohippus (Eocene) ; B, Mesohippus (Miocene) ; C, Protohippus (Pliocene) ; D, Equus (Pleistocene and Recent). (After Marsh).

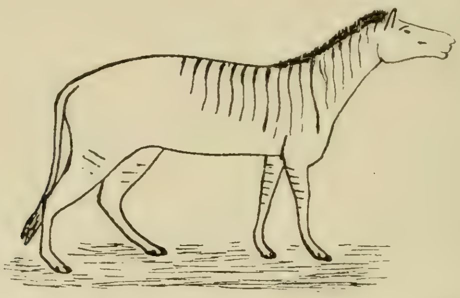
Briefly reviewing this coördinating degeneration and development in its relation to environment, there appears a remarkable example of the power of the animal organism to keep pace with changing surroundings in adapting itself to new requirements. At the beginning of the Age of Mammals, where we find the four-toed Eohippus, the North American climate was tropical, and dense forests covered the greater part of the country ; the ground was moist, and there was an abundance of tender, green food. The spreading, lateral toes of the little primitive horses were well adapted to the soft turf ; their short, tuberculate teeth were sufficient for the tender herbage, and the dense, tropical vegetation offered them protection against their enemies. Horse and climate now evolve together, the continent is steadily rising, the forests become thinned, the land is getting drier, the climate colder, and beasts of prey are becoming more formidable and swifter of foot. The animals must adapt themselves to these changed conditions or become extinct. The ancestors of the horse take the former course ; they become larger, the lateral elements of the limbs fall away while the axial ones develop, giving more speed and a foot better fitted to the harder turf of the more elevated land. The neck and head are elongating to conform to the increasing height, while the teeth gradually lose their omnivorous characters and become adapted to the tougher grasses of the plains. And so it all goes on through the Tertiary Age. It would appear that the horse develops with the plains until, when we reach the beginning of the Quaternary, we find him one of the most specialized of animals in his adaptation to these plains which have become his natural environment.

During an expedition sent out by the American Museum of Natural History into Northern Texas in 1899, there was found, among fragments of others, a complete skeleton of one of these Pleistocene horses, which is now set up in this museum, and represents the last of its race in America. There are no features in this skeleton to distinguish it generically from that of existing species. It is somewhat larger than the zebra, with bulging forehead, short neck, rather long body, and short legs. The lateral digits of its ancestors are gone from both front and hind feet, and there are two rudimentary metacarpal and two rudimentary metatarsal bones. The dentition is three incisors, one canine, three premolars and three molars on each side above and below, making forty teeth in all. The first of the four premolars of an earlier stage having disappeared from the lower jaw, its corresponding tooth above has ceased to be functionally developed, and the remaining premolars have assumed all of the characters of the true molars.

It is this horse that before the great ice sheets covered the northern parts of North America and Europe, roamed over the open lands of all the continents except Australia and then, during the Glacial Period, became extinct in America and later disappeared from the scene in Europe. Here his trail sinks beneath the geological horizon just as the first scratchings and chippings of man are appearing above it. Why, we do not know. It has been assigned to the ice during the

Glacial Period, but they also became extinct in Central and South America, where there was no ice sheet, and survived in Europe until the Postglacial. But we might now be in a horseless age indeed had not a sufficient number of species survived in Asia and Africa to continue the line, and to-day we have the horse, the ass and the zebra — three branches that have come down to us from this prehistoric wild horse. These descendants are still to be found in Asia, where we have Przewalsky's Wild Horse, of which little is known, and the Asiatic Wild Ass; while in Northern Africa we have the African Wild Ass, and in the south of that continent there are several species of zebra. The so-called wild horses that until recently roamed the plains of North and South America, were feral, that is they were not truly wild, but were the descendants of domesticated horses brought here by Europeans and abandoned. That these three branches sprang from a remote common parentage is pretty well proven by similarity in striping. The ass and zebra show the strong back stripe which occasionally crops up in our domestic horses, the circular leg stripes rarely showing in all three. A beautiful example of this reversion recently came under the observation of the writer. Among the farm animals at the Williamson School of Mechanical Trades is a dun (clay) colored horse with not only the black band from mane to tail exceptionally well marked, but with seven distinct circular stripes upon each leg, conforming to those of the zebra in their peculiar pattern. This community of marking strengthens our presumption that, as the Tertiary ancestors of the horse lived in an environment of sunlight and shade, they were striped like the zebra, for this coloring makes less contrast in the sifting sunlight or moonlight of the forest, and affords a degree of concealment against prowling carnivora. But at present we have no means of telling at what period this branching occurred that led away from the stripes, though the change in both conformation and color was undoubtedly due to change in environment.

It is inferred that the Old World horses came from America because of their appearance in England, Northern Italy and Northern India in the same geological period in which they are found so abundantly in America, and also from the fact that a distinct connecting link between this horse and his three-toed ancestors has been found only in America. The fact that the camel appears simultaneously with the horse in the European series, lends support to this conclusion, as there is no doubt that the camel is an exclusively American bred animal, sharing the Preglacial uplands with the horse, and it is most likely that he migrated to the Old World at about the same time. At the end of the Tertiary Age the continents



RESTORATION OF FOUR-TOED ANCESTOR OF HORSE

Pen sketch from photo in American Museum Booklet by Dr. W. D. Matthew, from watercolor by C. R. Knight, based on mounted skeleton.

stood higher above sea-level than at present, and the plains, with their covering of grass, had come into existence. At this time there was land connection between North America and Asia, and it is then that our American Wild Horses are supposed to have started on their journey to the Old World. Among these immigrants was the *Equus stenonis*, which has left its remains in the Pliocene deposits of Britain, France, Switzerland, Italy and North Africa. Two others, *Equus sivalensis* and *Equus namadicus*, found their way into India, while other species probably settled in Central Asia. It is believed by some paleontologists that *Equus sivalensis* and *Equus namadicus* became extinct, and that *Equus stenonis* gave rise through one branch (*Equus robustus*) to our modern domestic horses (*Equus caballus*), and through another (*Equus ligeris*) to the Burchell group of zebras (*Equus burchelli*).

Though man probably lived in Western Europe before the Ice Age, no trace of him has been found associated with the remains of the Preglacial Wild Horse. Postglacial man came in contact with him in Europe, but they had become extinct in North America before its supposed colonization by the original inhabitants of Asia, though in South America there are indications that they persisted until man's advent. It is in the Rough Stone Age that the remains of horse and man are first found together, and, as they are here associated with chipped stone implements, fire debris and pottery, we conclude that the horse was at that time hunted and eaten by this cave-dwelling man. The taming and breeding of horses did not take place until thousands of years after man and horse first came together. They were probably first domesticated in Central Asia and North Africa, but are not represented upon Egyptian monuments earlier than the eighteenth dynasty. The first Spanish explorers to the New World found no horses and the Indians knew nothing of them either by contact or tradition, yet when the horse was reïntroduced to this country by the white men in the sixteenth century, he thrived and increased, showing how well he was adapted to the native home of his ancestors.

As man's companion in the harness of civilization we find the modern horse almost perfect in his adaptation to his native habitat, yet the rudiments of his conformity to a tropical environment still linger, and it is not quite correct to say that the lateral hoofs have absolutely disappeared. It is thought by some that the chestnuts, or horn-like processes on the fore and hind legs, are the remnants of the first digits; others regard them as the remains of cutaneous glands, which seems less likely, but any doubt that in the horn-spurs of the fetlocks we have the coalesced second and fourth hoofs should be cleared away by recorded cases of reversion to the three-hoofed type, in which the horn-spurs are entirely absent. Nature is slow to get rid of these vestiges while they do no harm, but, as the hard ground crust or frozen snow of the northern plains would frequently tear the spurs from their attachments, and the consequent bleeding make the wild horses an easier prey to their carnivorous enemies, they should, in the course of adaptive modification, be discarded, and this is exactly what has occurred in the case of the Celtic pony of Iceland, which represents in this and in some other respects the highest degree of specialization yet reached by any member of the Horse family. Though we might naturally look upon our modern wild horses, asses and zebras as the nearest to the primitive Equine type, this is only true as to colors and conformation. Here we have the retention of those features most suitable to an environment that is but little changed, while the discarding of the useless remnants of primitive organs has made the greatest progress because there has been no interruption; natural selection has not given place to artificial selection, and the line remains unbroken. It is among our domestic types, produced by cross-breeding, that we find tapir-like muzzles and the most prominent fetlock spurs and chestnuts; crossing tends to ativism, and the more the bloods are mixed, the more gross become these ancestral vestiges.

In any age in which he may be found, the horse, wild or domestic, will possess some characters of a group which predominated in a former age, united with some characters of a group not yet in existence, and with these characters possess those of a group already existing. Thus he clearly demonstrates a principle applicable to the evolution of all animal life.

Thanks to the energies of Professor Henry F. Osborn and his associates in the work, Dr. W. D. Matthew and Mr. J. W. Gidley, there is now available for study at the American Museum of Natural History at New York city, a series of fossil skeletons illustrating the horse's evolution that in number and completeness is probably unequaled in any other museum in the world. Those who share the popular interest in the ways of nature will be well repaid for a journey to this collection, while to the one having a special interest in the subject, it affords a rare demonstration.

SOME OBSERVATIONS ON DIATOM MOTION.

BY T. CHALKLEY PALMER.

In a recent contribution to these PROCEEDINGS the opinion was expressed that certain theorists, in their endeavor to evolve a non-protoplasmic explanation of diatom motion, had unduly emphasized both the attractive force exerted by light upon the moving diatom, and the chlorophyll reaction as a motive force. A recent writer* was quoted to the effect that motion does not take place in diatoms unless the light is "fairly strong." The osmotic theory, indeed, based as it is on the action of light upon the endochrome of the diatom cell, needs above everything that this be so. But the statement is not based upon facts cited, nor warranted by any known to the present writer.

That diatoms may move in almost complete absence of light is highly probable. That they do move, and with vigor, under conditions that forbid any but the most feeble sort of photosynthesis, appears demonstrable. In April, of the present year, experiments as to the effect of one kind of light were made upon motile diatoms in a fresh, healthy gathering abounding in naviculoid forms. The conditions were as follows:

A Continental microscope stand, with large, square stage, was adjusted with a two-thirds objective, an achromatic condenser of 100° aperture, and such tube length and eyepiece amplification as to make the apparent field fourteen centimeters in diameter. The stage having been inclined at such an angle that no direct rays from the lamp should fall upon it, the condenser was screwed up until the image of the flame sharply focussed upon the centre of the field. The iris diaphragm was then closed until the image was sharp but mild, all irradiation having been cut off. The source of light in all the experiments was a Welsbach mantle. In the first series (Figures I to III) the image of the whole mantle was used.

*Mr. D. D. Jackson, "American Naturalist," May, 1905.

In the second series (Figures IV to VII) the illuminated area was much reduced by the interposition of a card, close up to the mantle, pierced by a rectangular hole of such dimensions that the sharply focussed image made a light area of the apparent dimensions of one and a half by four centimeters. In both series, the top illumination of the stage was negligible, being only such diffused rays as came from the dull gray walls of a dimly lighted room. In the second series, especially, the gloom of the room was marked, owing to the screen placed in front of the mantle. Under these conditions a small diatom, unless in or near the lighted area in the centre of the field, was only barely visible, and small, inert and motionless objects could be seen only with much difficulty. Conditions being as stated, a drop of the gathering was put upon a glass slip having a shallow cell open at the ends, a cover glass was superposed, and a particular diatom, observed as in active motion, was brought nearly into the centre of the field, and often into the illuminated area. A diagram of the field being at hand, the first position of the centre of the diatom was marked, and simultaneously the hour and the minute. Successive positions were marked at intervals of a minute or less, until the diatom either came to rest or passed from view. These positions were connected in the diagram, at the time of observation, with a line representing as nearly as possible the veritable track of the diatom.

The observations were all made at night, but not all during the same night. Times are given in hours, minutes and fractions of a minute.

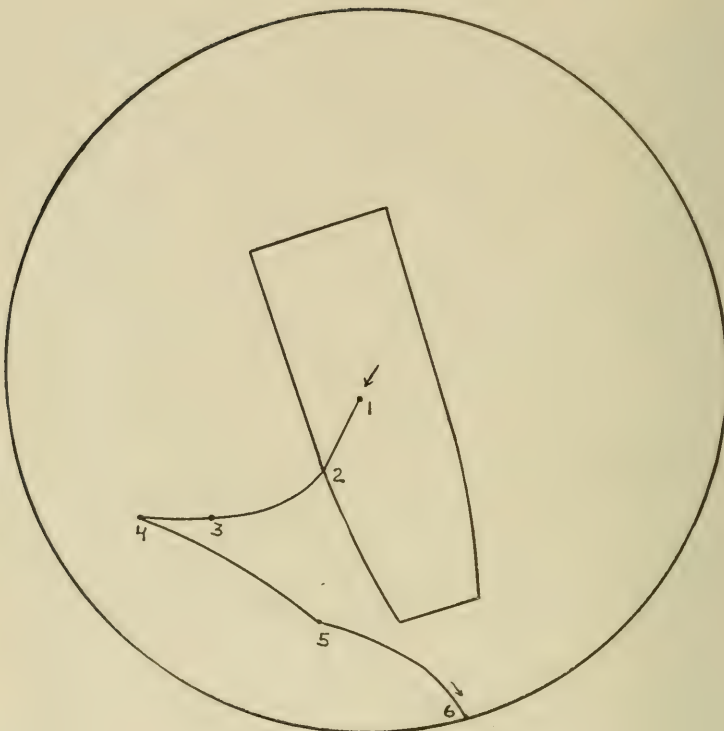


FIGURE I. *Navicula Bacillum*, Ehr.

POSITION	TIME	
1	8.25	
2	8.25½	
3	8.26	
4	8.26½	
5	8.27½	
6	8.29	Passed out of the field.

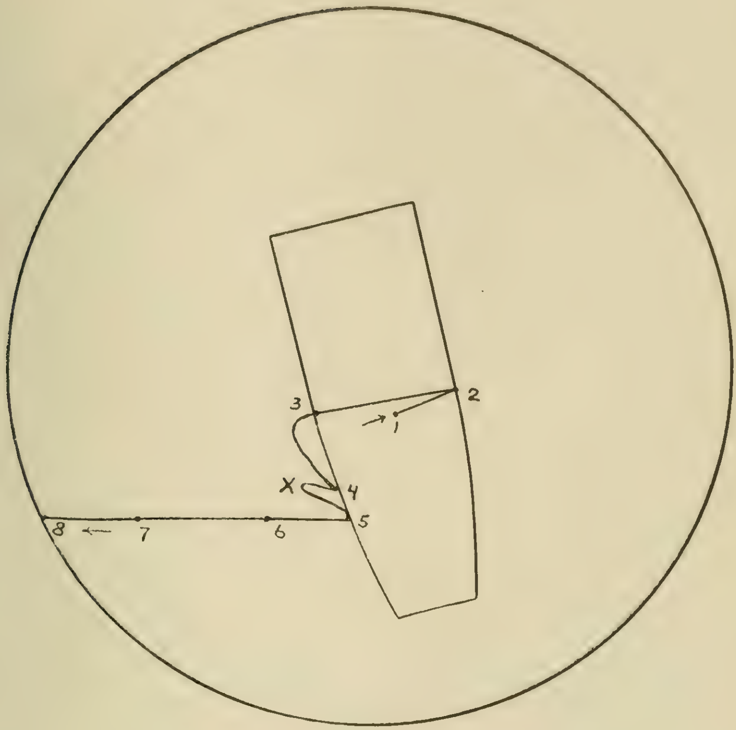


FIGURE II. *Van Heurckia rhomboides*, Breb.

POSITION	TIME	
1	7.15½	
2	7.16	Motion reversed.
3	7.16½	
4	7.17	Motion reversed.
5	7.18	Diatom turned on its posterior end at X,
6	7.18½	and reversed its motion at 5.
7	7.20	
8	7.20½	Passed from view.

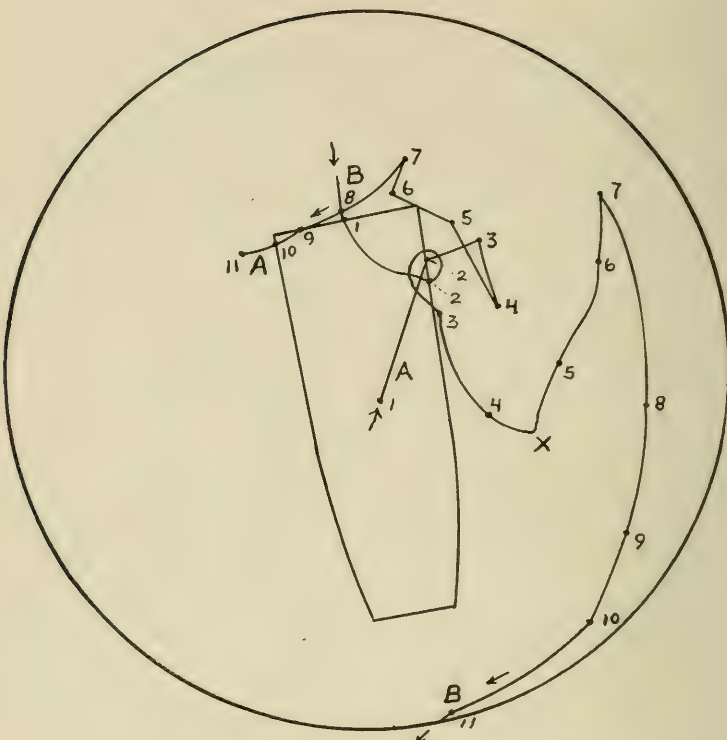


FIGURE III, A. *Nitzschia*, a minute species.

POSITION	TIME	
1	7.28½	
2	7.30	
3	7.31	Revolved on one end.
4	7.32	Reversed motion.
5	7.33	
6	7.33½	
7	7.34½	Reversed motion.
8	7.36	
9	7.37	
10	7.38	

11	7.39	Rested six minutes. The iris diaphragm was then opened wide, and the whole field flooded with light. No resumption of motion occurred in four minutes, and the experiment terminated.

FIGURE III, B. *Cymbella gastroides*, Kutz.

POSITION	TIME	
1	7.51	
2	7.53	Revolved on one end.
3	7.54	
4	7.55	At X, the diatom turned through about 90°
5	7.55½	on its centre.
6	7.56	
7	7.57	Reversed motion.
8	7.58	
9	7.59	
10	8.00	
11	8.01	At 8.04 the diatom had not returned to the field. On moving the slide it was found at a point about half the diameter of the field from the last position, and still proceeding in the direction 10 — 11.

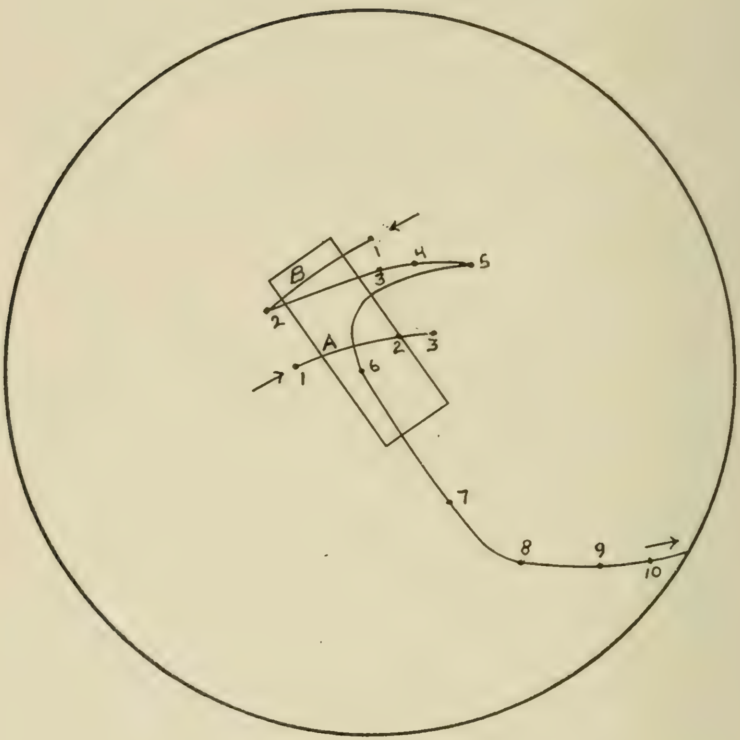


FIGURE IV, A. *Stauroneis Phoenicenteron*, Ehr.

POSITION	TIME	
1	12.33	
2	12.35	
3	12.36	Remained at rest four minutes.

FIGURE IV, B. *Cymbella gastroides*, Kutz.

POSITION	TIME	
1	12.41	
2	12.42	Reversed motion.
3	12.43	
4	12.44	
5	12.45	Reversed motion.
6	12.46	
7	12.47	
8	12.48	
9	12.49	
10	12.50	Passed out of field and did not return in two minutes.

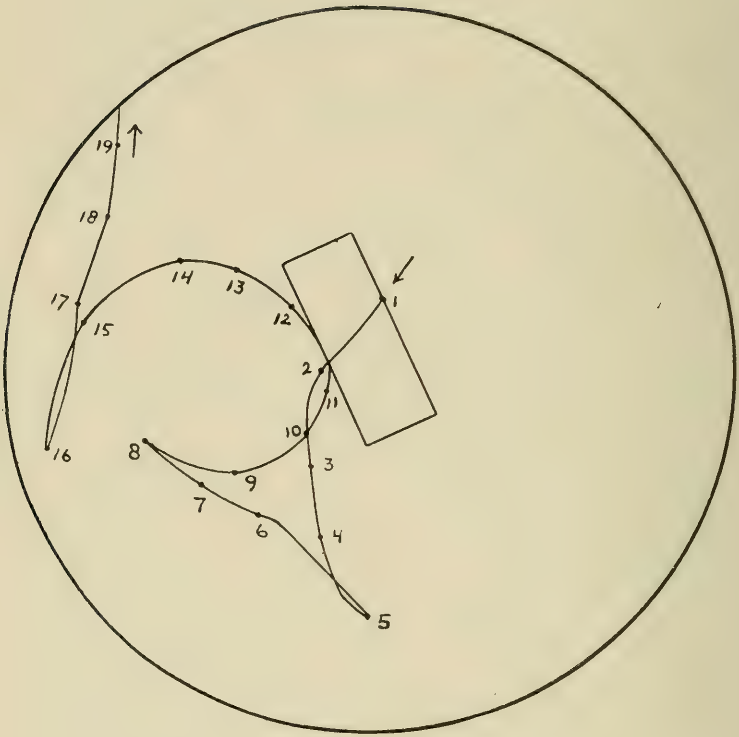


FIGURE V. *Navicula gibba*, Kutz.

POSITION	TIME
1	12.51
2	12.52
3	12.53
4	12.54

POSITION.	TIME	
5	12.55	A rest of 1½ minutes, then motion reversed.
6	12.58	
7	12.59	
8	1.00	Reversed motion.
9	1.01	
10	1.02	
11	1.03	
12	1.04	
13	1.05	
14	1.06	
15	1.07	
16	1.08	Reversed motion.
17	1.09	
18	1.10	
19	1.11	Passing out of view.

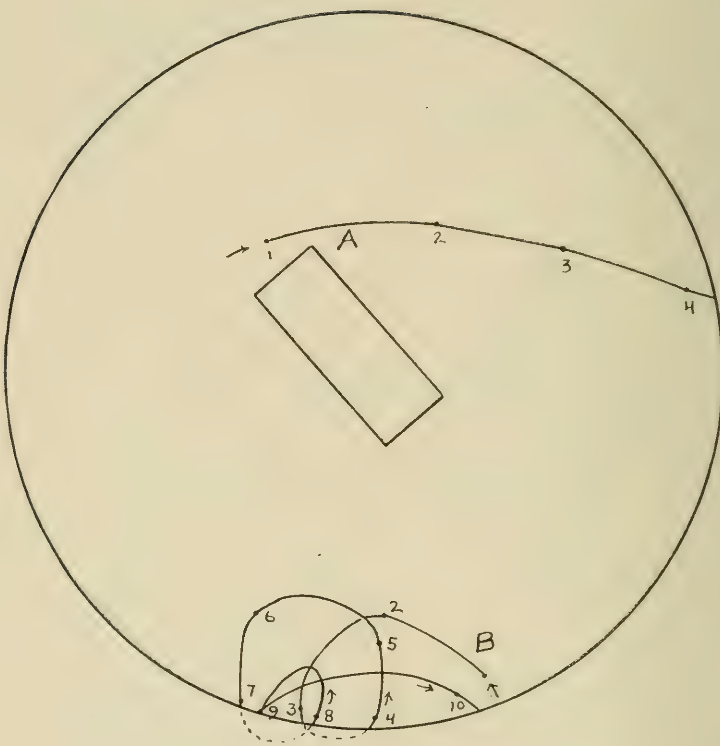


FIGURE VI, A *Navicula gibba*, Kutz.

POSITION	TIME	
1	1.25	
2	1.26	
3	1.27	
4	1.28	Disappeared at 1.28½.

FIGURE VI, B. *Navicula gibba*, Kutz.

POSITION	TIME	
1	1.32	
2	1.33	
3	1.34	Disappeared.
4	1.35½	Returned.
5	1.36	
6	1.37	
7	1.38	Disappeared.
8	1.39½	Returned.
9	1.41	Reversed motion.
10	1.42	
11	1.42¼	Disappeared, and did not return after 2½ minutes.

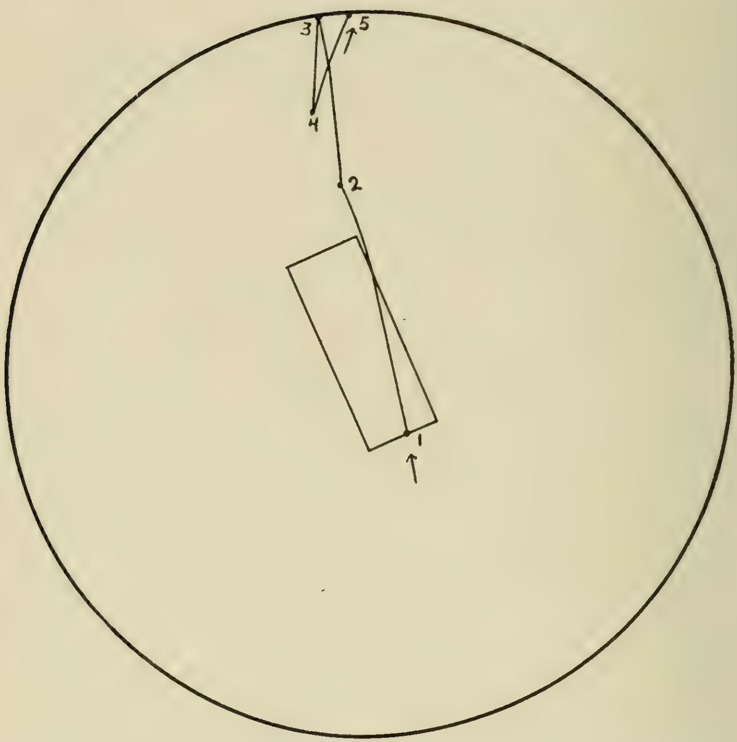


FIGURE VII. *Stauroneis Phoenicenteron*, Ehr.

POSITION	TIME	
1	1.14	
2	1.15	
3	1.16	Reversed motion.
4	1.16¼	" "
5	1.16¾	Passed out, and did not reappear in five minutes.

A study of the diagrams and their accompanying data seems to show : —

Firstly, That the localized area, illuminated by the particular quality of light that is given by a Welsbach mantle, has no noticeable attraction for the species of *Navicula*, *Cymbella*, *Stauroneis* and *Nitzschia* used in these experiments.

Secondly, A very inefficient illumination — an illumination, especially in the second series, quite too feeble to operate with any vigor on the chlorophyll — was no bar to continued motile activity, at least in the case of these particular species, and for the length of time the observations continued.

NOTE.— These observations were made with an amplification of 70 diameters. The original diagrams having been drawn to scale, it becomes possible to deduce the rate of motion by measurements of straight portions of the paths between timed points, as follows : —

Navicula gibba..........	Greatest	observed	speed,	0.557	mm.	per minute.
Van Heurckia rhomboides,	"	"	"	0.782	"	" "
Nitzschia, species.........	"	"	"	0.266	"	" "
Cymbella gastroides......	"	"	"	0.586	"	" "
Stauroneis Phoenicenteron,	"	"	"	0.714	"	" "

These figures mean, approximately, that Van Heurckia traveled at the rate of one and thirteen-sixteenth inches, and Nitzschia at the rate of five-eighths of an inch, per hour.

A NOTE ON SPELLING.

BY HENRY L. BROOMALL.

The Latin alphabet had no letter *W*. The letter *V* was used to represent the vowel sound *u* (*oo* as in *brood*) and also the consonant sound *w*. It is said that in the first century after Christ the Roman Emperor Claudius, recognizing the need of a distinct letter for this *w* sound, devised the form Ⅎ, an inverted digamma, and ordered its use. The new letter thus had both rational and imperial backing. It appears on a very few monumental remains of the period — and that was the last of it.

Nevertheless the difficulty brought about its own solution in due time in a way quite irrational and democratic. As the practice of writing without lifting the pen until a word is completed tends to round the angles of the letters, the eye grew accustomed to both the forms *V* and *U* for the same letter. Of these two forms *V* was oftener maintained at the beginning of a word because there it was not subject to the curving swing of the pen which a preceding joined letter would have produced. Moreover the *V* or *U* had the *w* sound oftener at the beginning of a word, because such a sound usually resulted from the combination of *u* before a vowel, just as the French *oui* seems to English ears the exact phonetic equivalent of *we*. Hence there occurred an adjustment under these two conditions by which the form *V* became generally associated with the *w* sound and the form *U* with the original vowel sound. There was thus evolved a new letter *U*, and this with the old letter *V* appropriated respectively the two sounds whose imperfect representation troubled Claudius some centuries before.

Some things are beyond remedy by imperialistic fiat, but the old Emperor did not know it. There are modern instances.

Human things never stay fixed. Letter and sound again lost precise correspondence. *V*, owing to phonetic changes and new sounds in the languages using the letter, became again representative of two sounds, whence, by another readjustment of form, were produced the modern *V* and *W*, the name "double U" still remaining in English to suggest the origin of the new letter.

This is typical of the history of the alphabet. By such evolutionary processes it has been adapted to many languages and become a more precise instrument of phonetic representation. While by no means perfect, it seems practically sufficient for the European languages. It is to be noted that every change in the alphabet since we first know of its use in the Semitic languages has been toward its better phoneticism.

The phonetic idea of writing is based on the principle that our thoughts are too many and intricate to be represented by signs addressed to the eye. The picture, the statue, the gesture and the numeral are all signs whereby another's thought may reach us, but this method of conveying ideas is limited and lacking in definiteness. The alphabet itself began as just such ocular signs of ideas and by gradual development became signs of mere sounds, and thereby capable of representing anything that can be said. Without this phonetic idea, alphabet and spelling are meaningless, and the line of development by which the alphabet has been evolved is toward the "unfit."

But the written word is subject to conditions that are not phonetic. Its series of letters, at first arrayed in orderly presentation of its sounds, soon becomes impressed upon the eye as a whole. Each letter is addressed to the eye as a merely physical part of the total form. We recognize this fact practically when in doubt about spelling a particular word, for we then write it in two or more likely ways and select whichever "looks right." So, too, writing spelled phonetically to represent our actual pronunciation cannot be read as rapidly as when spelled in the usual way, although the spelling as such is really better.

Thus arises traditional as opposed to phonetic spelling. It stands opposed to any change of spelling to represent a word as it is now pronounced. The traditionalists intimate that this change of sound is a degeneration, a perversion, and that the real word in its purity remains in its written form to restrain further phonetic backsliding.

The maintenance of traditional spelling is supposed to be logically supported because it preserves the etymology of words. But this avails nothing much to the student and nothing at all to the speaker. The student does not need the repetition in daily life of some old spelling to dun him with what he already knows. And to the reader the etymological character is a positive disadvantage. Conscious of the origin of *September*, *October*, *November* and *December*, the etymologist does not easily transcribe them into *Ninth*, *Tenth*, *Eleventh* and *Twelfth Months*, and vice versa, while the other month names and their corresponding numbers are associated without difficulty. The present accord of meaning and sound is only jarred by the intrusion of the word's history.

In a country where there are few writers, traditional form is strong. They alone are burdened with learning, using and transmitting forms of writing that no longer represent the sounds. This knowledge distinguishes them, and they like it. But where there are many writers, as in our modern days, writing is no longer an art distinctive of a learned class, and the hold of the traditional form extends throughout the community. It is never wholly absent except where an alphabet is first applied to a language. When the Latin alphabet was first used to write the North European languages, the spelling was phonetic, as far as the alphabet itself had appropriate signs. In modern days when the student writes down the words of some unwritten tongue of America or Asia, it is phonetic in the same way. These conditions, however, are but momentary in the history of writing.

While the pronunciation changes, the old spelling continues. The lack of correspondence increases with the inevitable phonetic development of language. Tradition at last gives way and there results a change of either alphabet or spelling to restore phonetic representation. And this process is continually recurring in the history of spelling.

The readjustment by a change of alphabet occurs where a general shift of sound takes place throughout a language. An English vowel may illustrate this. In Old English *he*, *me*, *we*, were pronounced as we now pronounce *hay*, *may*, *way* (omitting a final short *i* sound). *E* of the English alphabet then represented the sound it now has in the continental European languages. Under the operation of certain phonetic changes in English, however, this sound shifted to its modern sound, just as if *fête* were to become *feet*, and the change occurred in so many words that it carried the letter with it. *E* was re-named by the sound it came to represent, and is now known and used as the sign of a sound entirely different from what it had when *he*, *me*, *we* were first spelled. By this change of the sound associated with the letter, these words, without any literal change, continue to be phonetically spelled. In short, the alphabet was changed to suit the spelling.

So with the alphabetic names of *A* and *I*. They were formerly sounded as *a* in *father* and *i* in *pique*. Phonetic changes occurred in English so generally, whereby a sound, then spelled *i*, became *a-ee*, or our modern long *i*, and *a* as in *father* became *a* as in *mate*, that it was easier to change the notion of the letters than to change the spelling of so many words in the face of traditional form. But there were words in which these sounds did not shift. It depended upon certain conditions of accent and surrounding sounds. Hence *a* in *mate* conforms to its new name and sound as an alphabetical sign, while *a* in *father* maintains the old sound and the letter is there unphonetic. The readjustment of the alphabet here is only partial, for while we now learn *A* as in *mate* we must also remember its sound as in *father*.

Here an accident has afforded the means of an approximate readjustment. In many cases the final *e* of English words was sounded when the preceding *a* was pronounced as in *father*. When the *e* ceased to be pronounced and the *a* (in *father*) changed to *a* (in *mate*), the letter *e* was still kept, so that it has now appropriated the office of indicating that the preceding *a* has the new sound. Precisely the same adaptation occurred in the case of *i*. Thus we now easily distinguish *mat*, *mate*, or *mit*, *mite*.

In German, where somewhat similar phonetic changes took place, the old *a* (in *father*) which became *a* (in *mate*) was indicated by adding *e*, making *ae*, now usually written *ä*, where the diacritical mark is the remnant of an over-written *e*. This alphabetic readjustment, then, is by the growth of a new sign, in German *ä*, in English *e* mute after an intervening consonant.

Readjustment by a change of spelling is easier and more frequent. It proceeds word by word. Again the illustration may come from a vowel. We have seen how *a* (in *father*) became *a* (in *mate*), and *i* (in *pique*) became *i* (in *kind*.) In the same way *oo* sounds properly represented by *U* in many positions became *ou* (in *out*) sounds. Thus, *ut*, *thu*, *nu*, *cu*, have become *out*, *thou*, *now*, *cow*. *Utter* and *utmost* retain the old form *ut* because there the change to *ou* did not occur. Here the change of sound did not affect the alphabet. While many *u* sounds became *ou* sounds, yet *U* was not re-named "*Ou*" because the change was not extensive enough. The readjustment was orthographic, not alphabetic.

Therefore readjustment of letter to sound is always going on, either generally by alphabetic change of name, or specially by orthographic change of this and that word as its spelling becomes more or less unphonetic. The phonetic idea which underlies the alphabet and proper spelling is always urging the change. Traditional learning, conscious of literary forms handed down to us, is always opposing the change. The first would spell *vittles*, and the latter *victuals*.

Perfectly phonetic writing and fixed forms of spelling are inherently inconsistent. To be phonetic, each act of writing must be an original representation of sounds according to the alphabetic symbols. The spelling would vary with peculiarities of pronunciation, local and personal. Correct spelling would not consist in remembering a set series of letters, only partly suggestive of the sounds, but in discriminating the sounds and selecting their corresponding symbols. Particular spellings would no longer be learned: simply the art of spelling would be acquired.

On the other hand, Traditional Spelling makes the alphabet a mere series of convenient forms out of which to construct complex outlines of words which impress themselves upon the mind through the eye. Once formed, the spelling is a matter of memory.

Neither of these ideas can wholly overcome the other. The more or less good spelling of any particular period in the life of a language is a compromise between the ear and the eye.

Our so-called Spelling Reform is the expression of the Phonetic Idea. In itself it can do little, if anything, to advance the process we have outlined by which traditional forms of spelling laggardly give way as the sounds of language change. And as literary education becomes more general, any such reform becomes more difficult because of the immense number of people subject to the influence of the traditional form. The remedy may come gradually, as it has in the past, by a succession of isolated changes, each small in itself and in the opposition which it excites. But any sweeping change at one fell swoop seems beyond the power of any man or class — literary or political. At present English happens to be at a stage where the sounds and letters are more at variance than ever before in it or any other European language. But this condition is due to particular historic causes beyond the scope of this note to examine. We may expect a closer approximation of letter and sound from the very pressure of present confusion, but, in the nature of things human, there can never be more than approximate correspondence between the word, which is ever changing, and the written form, which resists change.

VACUUM TUBES.

BY C. M. BROOMALL.

About three years ago the writer, in the course of some electrical studies, was surprised to find that an ordinary incandescent electric light globe could be made to faintly glow without the use of electrical apparatus. All that was necessary to produce the light was to rapidly and lightly stroke or rub the glass globe with the bare hand, when it would be found that the interior of the bulb would glow with a momentary faint bluish light. This light filled the whole interior of the globe more or less, but was more intense at the point of contact with the hand.

The experiment excited some interest among the Institute members, and as the various text books at hand gave no reference to such a phenomenon, many theories were advanced to account for it. Although the light seemed in some way attributable to electricity, its indifference to atmospheric conditions, insulation, etc., made it difficult to reconcile with this explanation.

With the hope of obtaining a satisfactory explanation of the phenomenon, a communication was sent to the *Scientific American* under date of October 11th, 1904, which communication appeared shortly after in the columns of that journal. As the *modus operandi* of producing the light is fully described in this communication, it is reproduced here, as follows : —

"In some recent experiments the writer was astonished to find that a vacuum tube could be made to glow without the use of apparatus. This fact, perhaps familiar to some, will be new to others, and being easily demonstrated, seems worth describing.

"If an ordinary incandescent light bulb or a Crookes tube or radiometer tube is subjected to rapid friction with the hand, it will be found that the whole interior of the tube glows with a faint bluish light. The light lasts only during the actual friction against the tube, fading out almost instantly. It does not matter how the tube is held, the only condition being that the motion shall be rapid and light, several times a second, the hand leaving the tube after each stroke. The glow fills the whole interior of the tube, but is usually more intense at the point of rubbing. The condition of the atmosphere, the matter of insulating or grounding the tube, heat and cold, have no apparent effect upon the light. Of the various substances used as rubbers nothing was found to answer better than the hand. The intensity of the light depends to some extent upon the state of the vacuum, as some tubes respond more readily than others. Tests with the photographic plate show that the light possesses but feeble actinic power. In order to see the glow it is necessary that the room be absolutely dark.

"The existence of the light probably depends upon the production of electricity, although its apparent indifference to atmospheric conditions, insulation, heat and cold, is difficult to reconcile with this view."

The phenomenon, however, remained without satisfactory explanation.

Some time after the above was published there appeared in the *Literary Digest* of September 30th, 1905, a translation from *Cosmos* (Paris) describing some quite similar experiments by Professor Sommer, of the University of Giessen, Germany. The phenomenon described in this article is apparently the same thing as that observed by the writer, although the production of the light is attributed to a physiological rather than physical cause. The translation referred to is as follows: —

"Taking hold of the bulb of a small electric lamp, he observed one night that whenever his hand touched the bulb the latter showed a light like a luminous mist which illuminated certain parts of the bulb as well as his fingers, even before the electric current was turned on. This remarkable phenomenon could be reproduced several times by rubbing the bulb with the hand. It should be said, however, that the experiment did not succeed with all bulbs and that those that had been used for some time and had on them the well known dark deposits of carbon were apt not to show the effect. When, on the contrary, the lamp was new or unused, even without any metallic conductor at all, if rubbed smartly on the skin, for example on the forehead or forearm, and suddenly removed, it showed the phenomenon described above. If, after removing the lamp, it is suddenly stopped, its contour is seen to be distinctly illuminated, and a bright spot is observed in the middle of it.

"When, after having rubbed the lamp on some part of the body, another part is touched — the cheek, for instance — the same luminosity is produced, even without further rubbing, by the simple contact, lighting up part of the face. If the breath strikes a lamp that has been rubbed on some part of the body, a well marked light is also produced. The phenomena in question, according to Professor Sommer, are partly physiological, that is to say, they belong to the human or animal organism. But as, on the other hand, a part of the phenomena may be also produced by rubbing on other substances, they must be governed in part by a physical law, which presents itself in the human body under special conditions. This luminosity may also produce photographic effects."

The observations of Professor Sommer are the same as, or at least closely related to, those of the writer, the difference consisting more in the explanation than in the facts. Neither theory, however, explains the phenomenon satisfactorily. Thus, on the one hand, a theory attributing the light partly to some physiological or other action of the skin is militated against by the fact that other substances than the skin will serve to excite the glow, although not so well as the bare hand. Again, on the other hand, it seems difficult to reconcile a purely electrical explanation of the phenomenon with its apparent indifference to the question of insulation. As an example of this indifference it may be stated that the light can be produced about as readily with the globe held in contact in various ways with a water spigot as when the observer stands on an insulated stool.

Neither theory, therefore, seems satisfactory, and the cause of the light, at least so far as can be gleaned from the literature at hand, still remains an open question.

MINUTES OF MEETINGS.

May 2, 1907.—Adjourned Meeting for Nomination of Officers, President T. Chalkley Palmer in the chair. After a short business session and the nomination of officers the meeting adjourned.

May 2, 1907.—Annual Meeting of the Institute, President T. Chalkley Palmer presiding. The minutes were read and approved. The Annual Report of the Treasurer was presented and showed a balance on hand of $134.54. Dr. Trimble Pratt and James G. Vail were appointed auditors. T. Chalkley Palmer presented to the Museum a collection of arrow heads from the lowlands of the Chickahominy, near Richmond, Virginia. The following addition to the Library was reported: "Smithsonian Miscellaneous Collections, Quarterly Issue, Volume III, Part 3, 'Mammals of the Mexican Border of the United States.'" The annual election of officers for the coming year was held with the following result:

President, T. Chalkley Palmer;
First Vice President, Charles Potts;
Second Vice President, Henry L. Broomall;
Secretary, Dr. Linnæus Fussell;
Treasurer, Carolus M. Broomall;
Librarian, Henrietta K. Broomall;
Curators, Edgar T. Miller and Homer E. Hoopes.

At the conclusion of business, the meeting was thrown open to scientific discussion, but owing to the lateness of the hour but few matters were considered.

June 6, 1907.—Regular Monthly Meeting, President T. Chalkley Palmer in the chair. In the absence of the Secretary,[1] James G. Vail acted as Secretary pro tem. Charles P. Adams, of Media, was elected to membership. The Treasurer reported a balance of $120.76 in the treasury. The auditing committee, Dr. Trimble Pratt and James G. Vail, reported that they had examined the accounts of the Treasurer and found them correct. Announcement was made of the presentation to the Museum of the collection of minerals of the late John T. Reynolds, a life member of the Institute. A vote of thanks was extended to Mrs. Reynolds for her kindness in donating the collection to the Museum. T. Chalkley Palmer presented to the Museum a number of fine specimens of "Slickensides" from Willistown, Chester County, and in response to a query described the formation of the mineral. After general discussion meeting adjourned.

JULY 4, 1907. Regular Meeting of the Institute. By reason of there not being a quorum present, the meeting was adjourned to meet July 11th, 1907, at 8 p. m.

JULY 11, 1907.—Adjourned Meeting of the Institute, President T. Chalkley Palmer in the chair. In the absence of the Secretary, Walter Palmer was appointed Secretary pro tem. Mrs. G. O. Gaskill, of Media, was elected to membership. The Board of Curators reported certain repairs to the building as necessary, which were directed to be made. The following additions to the Library were announced: "Twenty-fourth Annual Report of the Royal Observatory of Belgium" and the "Astronomical Annual of the Royal Observatory of Belgium for 1907." At the close of the business meeting the subject of the extinction of the horse in America and its subsequent importation* was discussed at length. The discussion was suggested by an article published in a foreign journal and read by one of the members. At the conclusion of the discussion the meeting adjourned.

*This subject is quite fully treated in the article by Dr. Underhill, in the present issue of the PROCEEDINGS.

INSTITUTE NOTES.

Attention is directed to an error in Vol. II, No. 3, page 98, sixth line from bottom, in the article on "Sycamore Mill," where the name George Dutton should read George Dunn.

The Institute is indebted to Homer E. Hoopes, of the Board of Curators, for the copies of *Science* which the Library has been receiving for the past year or more. Likewise is it indebted to the President, T. Chalkley Palmer, for the *Journal of the Franklin Institute.* Both of these publications are much appreciated by the members.

The following extract from Gautier's "Chimie Biologique," touching upon the most recent investigations regarding the function of chlorophyl in plant life offers interesting subject for thought. The similarity of the relationship existing between this reduced chlorophyl and ordinary chlorophyl to the relationship existing between the hemoglobin and oxy-hemoglobin of the blood, suggests similarity of function. In both cases we seem to be dealing with an "oxygen-carrier," but strangely enough in one case the oxygen is carried uphill, and in the other downhill: —

"On obtient un produit de réduction jaune paille, ou rouge quand la solution est concentrée: c'est la chlorophylle réduite. Ainsi produit, elle possède la propriété de s'oxyder rapidement à l'air en verdissant. Les solutions de ce substance . . . enfermées dans des tubes contenant de l'acide carbonique pur, verdissent rapidement à la lumière du soleil en se transformant en chlorophylle, tandis qu'elles restent jaunâtres ou rougeâtres à l'obscurité. Des tubes de solution protophylline (chlorophylle réduite) enfermée dans une atmosphère d'hydrogène pur ne changent de couleur ni à la lumière, ni à l'obscurité. L'agent qui réduit l'acide carbonique sous l'influence de la lumière est donc bien cette protophylline ou chlorophylle réduite."

OFFICERS OF THE INSTITUTE:

President, - - - -	T. Chalkley Palmer
First Vice President, - -	Charles Potts
Second Vice President, - -	Henry L. Broomall
Secretary, - - -	Dr. Linnæus Fussell
Treasurer, - - - -	Carolus M. Broomall
Librarian, - - -	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

PROCEEDINGS

OF THE

Delaware County Institute of Science

Carolus M. Broomall, Editor.

PUBLICATION COMMITTEE:

T. Chalkley Palmer, Chairman; Henry L. Broomall,
Trimble Pratt, M. D.

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THE STAR VAULT AND THE MOVING OBSERVER.

BY JACOB B. BROWN.*

I have in mind to describe in this paper certain appearances on the star vault which ensue upon certain changes in the position of the observer; and, as many of the circumstances conceived to exist are wholly imaginary, and as some of the positions supposed to be assumed are entirely beyond the limit which it is at present possible to attain, I shall have nothing but the just inferences of science to bear me out in my various statements.

In order, therefore, to insure greater accuracy of conception I may, perhaps, be allowed to remind you that astronomers have the *visible horizon*, whose plane passes perpendicular to the earth's radius through the eye of the observer, and the *rational horizon*, whose plane passes parallel to this through the centre of the earth. This latter need not concern us, the distance measured on a perpendicular between the two being a question of high science. When, therefore, the horizon is spoken of it is the visible horizon that is meant, and this is, as far as our intents and purposes extend, identical with the rational horizon; as will, indeed, appear clear when it is remembered that the distance between the two is the length of

*Through the kindness of Miss Anne Knapp Whitney, the Institute is enabled to publish this article from the pen of its deceased member, Jacob B. Brown.

the earth's radius — about four thousand miles, a quantity which wholly vanishes in face of the other distances which are under contemplation.

As already hinted, it has hitherto been found impossible to reach the neighborhood of the terrestrial pole; and, even had this extreme latitude been attained, it would be very difficult, with the small, portable instruments in use, to locate precisely the point on the surface of the ground about which all others revolve. But there is nothing to prevent our imagining a victory over all these obstacles; and the idea entertained by some men of science that owing to causes, surmised but not perfectly understood, the pole of the earth undergoes a small displacement so as to affect the records of latitude, is not yet sufficiently rooted and grounded in general faith to detain us at this stage of progress.

The observer, then, at the pole of the earth has the pole of the heavens directly above his head, and his horizon is the equator of the heavens. All the fixed stars of his hemisphere are, theoretically, visible to the polar observer; not practically; for there are refraction, twilight and obscured horizon to take into account. These fixed stars constantly move round him in circles parallel to the horizon-equator. He never sees the stars of the other hemisphere.

The pole of the ecliptic is at 23° 30′ from the zenith-pole, and revolves round it as any other point does. The equinoxes are, of course, in the horizon-equator, and can be only vaguely pointed out by reference to stars. The vernal equinox is in the constellation Pisces; the autumnal in the constellation Virgo. These points revolve around the pole as the others do.

It will be noticed that the equinoxes are spoken of sometimes as points, sometimes as seasons of the year. Perhaps it would not be amiss if the language had means of distinguishing for us, as we go along, between the two ideas; but, after all, it matters very little. There is no great difficulty in remembering that the seasons called the equinoxes come round when the sun in his course passes those accurately determined points in the heavens called also equinoxes. It will dwell in your recollection, moreover, no doubt, that one equinox, the vernal, is called the first point of the sign Aries; the other, the autumnal, the first point of the sign Libra.

It follows from all this that the belt of the zodiac, about 18 degrees in width, or nine degrees on each side of the ecliptic, is always half above and half below the equator. Let me say that the visible portion, regarded as a whole, is a semicircle seen in perspective — that is to say, a semiellipse, standing on the platform of the horizon like an arch whose crown is 23° 30′ above the same, and seeming to slide in that position so as constantly to make the circuit of the heavens.

When the sun is coming towards, and reaches, the equator, he will be seen by the observer at the pole in the horizon; and will, to all appearances, make one daily circuit in that position. But he is constantly changing declination on the ecliptic, and will, next day, be clear of the equator; and next day still farther away from it. The result is that he rises in a slow spiral until at the solstice, or sun-halt, he is 23° 30′ above the horizon. He then turns and goes down again, by the same steps but in a reversed spiral, to the equator, where, at the other equinox, he disappears for six months from the view. He then offers, in turn, the same phases to the eye of one at the opposite pole.

And, generally, it will be sufficient to discuss what is to take place at points of the northern hemisphere; the same being true of the southern, with the proper change of data.

The plane of the moon's orbit is inclined to the plane of the ecliptic 5° 9′. This means that the moon moves on the starry vault within a belt or zone 10° 18′ wide, half on one side of the ecliptic, half on the other. The moon covers, at one time or another, every point of this zone. It follows from what has been said that, as the ecliptic is always half above and half below the horizon, its highest point being at an altitude of 23° 30′, the moon will almost imitate the motions of the sun, though with irregular monthly, instead of yearly, periods. As to her being seen, that is another matter. During the long polar day her light, when she is "up," is wholly lost in the beams of the sun; and during the polar night she will revolve within view in a path generally horizontal for about half the time of her circuit; sometimes more than half, sometimes less; the reason of the difference being that she is not on the ecliptic, but only near it, above or below, as already stated. A little pondering may be necessary in order to see this clearly, since the fact is only darkly set forth by the astronomers' statement that the nodes of the moon's orbit are in a constant state of retreat upon the ecliptic.

The movements of the planets are not so simple. The paths they trace upon the heavens are the combined result of their own motions and those of the earth.

Such planets as need concern us remain much nearer the ecliptic than the moon does. Venus, the most extravagant in the correct sense of the word, moves within a zone 3° 23′ above, 3° 23′ below the ecliptic. Mercury pervades a belt in all fourteen degrees and a quarter wide, but he is rarely seen. (I saw him the other evening, February 9th, 1895, by the way, after my attention had been called to him by our lecturer on astronomy.) As for the Asteroids, as they are invisible without the aid of a telescope, and not at all impressive when so seen, it will interest us but little to remember that the most extravagant of them, Pallas, has an orbit whose plane is inclined to that of the ecliptic at an angle of more than 34½ degrees.

Let the time be summer solstice at the North Pole. The sun is 23½ degrees above the horizon. Let the observer now be transported, instantly, down the meridian on which the sun is, and towards the sun. When he has been moved 23° 30′ it is clear that he will be on the Arctic Circle; the time of day noon; and the sun at its greatest possible altitude for that parallel. But if the same movement from the pole had taken place away from the sun the observer would have found himself on the Arctic Circle all the same, but at 180 degrees of longitude distant from his previously imagined position. His time would be midnight. The sun would be 23° 30′ lower than before he moved — in the horizon, therefore, and in the northern horizon, for the visual ray from the sun would pass over the pole.

This is another way of arriving at results which have been stated elsewhere — namely, that the sun just touches the northern horizon at midnight of the summer solstice for the observer on the Arctic Circle; and that at this latitude the extreme altitude of the sun is twice 23° 30′, or 47 degrees above the southern horizon.

It follows also that the Arctic Circle is, theoretically, the lowest latitude at which the midnight sun can be seen. Theoretically is the word. The fact is, that as the sun is raised by refraction, one can see, as the poet words it,

> "The midnight Norway sun set into sunrise"

at a latitude lower by more than half a degree — at Tornea, for instance, at the head of the Gulf of Bothnia, latitude 65° 50′ 8″ north.

In a paper headed "A Visible Ecliptic" this matter will be discussed somewhat more in detail.

Let us not forget to notice at this point an illustration of the difference between absolute time and recorded time which is given by our last conception. The observer, namely, passes instantly from the pole, where it is all hours of the day at once, to noon or, at our will in the same instant to midnight. Our earth has no influence upon time — none whatever. Its motions may be made to record time with more or less correctness; but the responsibility is ours.

Our observer may cross the Frigid or the Temperate Zone at what season or hour he shall see fit, but he will never find a vertical sun.

At the Tropic of Cancer, which is a boundary, he will, at the June solstice, have the sun directly overhead at noon.

For one on the other Tropic, on the same meridian and at the same hour, the sun is 47 degrees north of the zenith.

The sun is vertical at noon twice a year for all parts of the Torrid Zone, as will be instantly manifest when we remember that precisely one year elapses between the departure of the sun southward from Cancer and his return northward to the same declination.

For an observer on the equator the two poles are in the horizon ; and the equator of the heavens divides the visible vault into two equal portions. It follows that at the equinoxes the sun rises at the east point and passes in a circular arch directly overhead to the west point.

The observer at the equator sees theoretically every star in the heavens in the course of the year. To the same observer the sun's daily course is like that of the stars perpendicular to the horizon, whatever be his declination. It follows that he is, on any given day, as long a time below the horizon as he is above it, and that day and night are equal throughout the year. It is for this reason that the equator is called the equinoctial.

It is a necessary consequence of all this and of what has been said concerning the starry sphere as seen at the poles, that at all points between the equator and the poles there are certain stars near the one pole that never rise and others near the other pole that never set. These last are said, somewhat grandiloquently, to be within the circle of perpetual apparition ; the others within the circle of perpetual occultation. They are also called, more simply, circumpolar stars. The greatest possible number of circumpolar stars is, of course, one half of the whole.

This word "number" is the most convenient under the circumstances, and, though inexact, is hardly calculated to mislead. What is meant is merely those contained within the confines of one half of the heavens. The number of these may or may not be equal to that of those contained within the other half.

The circumpolar stars at any latitude are readily distinguished. Let the observer conceive a line drawn in his horizon towards the visible pole. This line may easily be conceived as reaching the star vault, and, by the rotation of the earth, describing among the stars a circle with radius equal to the elevation of the pole. All stars within this circle will be manifestly circumpolar. But the elevation of the pole is the latitude of the observer. It follows at once that all stars are circumpolar which are at an angular distance from the pole equal to the latitude of the observer.

The extreme cases are: — First, that of the pole, latitude 90°, where one half of the stars are circumpolar; and second, that of the equator, latitude 0°, where none are so.

The amplitude of a heavenly body is the arc intercepted on the horizon between the east or west point and the meridian passing through the body.

The amplitude of the fixed stars at a given latitude, though affected by precession, is, to all ordinary intents and purposes, a constant quantity. I say, to all ordinary intents and purposes, which means that any change supervening is so minute that unless there be special occasion to notice it the change may safely be neglected. There is however, possibility that in the near future we may be addressed by one having authority upon a matter which will include the orientation, as it is called, of Egyptian temples, and alterations in the structure of these from dynasty to dynasty. Both orientation and alteration will be found to have intimate connection with the amplitude of the fixed stars and changes in the same.

The change, on the contrary, from day to day, of the sun's amplitude at rising and setting, is a phenomenon which can hardly fail to impress itself upon any one in the least accustomed to observe the heavens.

We shall endeavor to show that the sun can, when in the horizon, have any amplitude between 0° and 90°, according to day and hour and position of the observer. In plainer words, the sun can be seen at certain times and from certain positions in any point of the horizon.

At the time of the equinoxes the sun rises in the east point and sets in the west point for all the world except the very pole. At the pole, namely, there is but one way to look, and that is directly towards the equator. On that day, accordingly, the sun moves in the horizon, which is the equator for the polar observer.

Confining ourselves for the sake of simplicity, now as before, to the northern hemisphere, since the same reasoning applies to both, it is clear that the inhabitants of the Torrid Zone will, as the sun moves toward the Tropic, see him rise and set more towards the north. For a line drawn in the horizon through the sun, the observer and the centre of the earth will make an angle towards the north with the plane of the equator, and, consequently, with the observer's parallel.

At the solstice the polar observer can mark no amplitude, as it is defined, when the sun is rising or setting; for the sun is here, for a season, wholly free throughout the twenty-four hours from the circle on which amplitude is reckoned, the horizon namely.

But if it be remembered that at the equator the horizon is perpendicular to the plane of the same, and at the pole parallel to it, and that between these positions its angle with the plane of the equator is constantly changing as the observer moves on a meridian, it will be seen that he at the pole can make the sun touch the northern horizon by moving southward to the polar circle. If the expression may be permitted, he tilts up his horizon to meet the sun. The sun's amplitude at this moment of rising-setting is said, technically, to be east or west 90° north. And, proceeding with the idea, the observer tilts up his horizon more and more as he goes farther south. Now sunrise and sunset are points common to ecliptic and horizon. As the southward movement continues the two circles intercept greater arcs each from the other. The extreme amplitude of east or west 90° north is seen constantly to diminish, until the Tropic is reached.

And thus, as the Torrid Zone has already been discussed, the whole hemisphere is accounted for.

When, now, the same has been said, with the proper change of data, concerning the southern hemisphere, it will appear, as stated, that the sun can be seen in every point of the horizon by proper adjustment of season and latitude.

Our conclusions thus far have been reasonably practical; though fancy has aided us to devise the problem which science was to solve. We may look a little farther in the same direction and, if we gain no other advantage from so doing, we shall, at least, have had a wholesome exercise for the imagination.

If one start from the equator and move constantly north-east, his course will be a curve of double curvature, and he will of necessity strike the north pole. For he moves on the surface of a sphere, at an angle of 45 degrees, with a constant series of meridians which converge to the pole. And when the very pole is reached there is but one way to move or look, and that is southward. This fact has been mentioned before, but not the proof of it. We look, namely, east or west along our parallel; and one must leave the pole some short distance behind in order to have a parallel.

It will be understood, with but little effort of memory or imagination, that if one could be instantly transported, say, 90 degrees eastward on his parallel, he would find the time by the clock six hours later than at his starting point; but if the same movement had been made westward he would have found the time by the clock six hours earlier than at his starting point. This state of things is virtually realized by the telegraph. A message leaves London at noon and arrives at Philadelphia, longitude 75° west of Greenwich, so quickly that the time of transit may be wholly neglected. But when it is noon at London it is seven o'clock in the morning here; so that, although starting and arriving at the same moment of absolute time, the message may be said to reach its destination five hours before it starts. If the message went the other way, it would, by the same process of reasoning, take five hours for the transit.

Now these considerations are elementary enough; but see what comes of them if we give our imagination the rein for a moment or two. Suppose our friend at the pole, so often mentioned, should start to warm himself by running round the pole. Whichever way he moved, whether to right or left, he would bring the sun again and again to the meridian before he stopped to take breath; and, unless he took heedful note of the turns and carefully ran the same number in the opposite direction, he would completely upset his record of the day of the month. In fact, by diligent running in the proper direction he might make himself any age he chose. In other words, he could place himself as far back in the past or as far forward in the future as his muscles would carry him.

Again, if he advanced from the pole southward, say, twenty-eight hundred and one yards and a fraction, and then moved on his parallel, he would make the circuit of the earth in ten miles of walking, and as long as he could cover one-twenty-fourth part of this, or seven hundred and thirty-three yards and one foot per hour in a westerly direction, he would keep the sun on his meridian and prevent the date from changing. The great globe would be to him neither more nor less than a magnificent treadmill.

We have gone so far in our conceptions and placed our observer in such hitherto impossible places, that we may as well pass over into miracle for a moment, eliminate gravity, station him, without visible means of support, directly above the pole of the earth, and see what comes of it.

The atmosphere, which is virtually part of the earth, and whirls around with it, has no influence whatever upon this suspended man, for he is at the neutral axis. He sees the earth revolve beneath him once in twenty-four hours, and points upon it have but a slow motion; for, as we have seen, an object 8404 feet from the pole would move but 733 yards in an hour, and a point close to the pole only twice as fast as the hour hand of a watch.

The stars have no courses; they are fixed forever in their places. They are but a permanent background. The sun appears at the equinox, moves in six months through the half of the ecliptic which is above the horizon-equator, then disappears at the other equinox, and is seen no more for half a year.

The moon rises at her appointed time, and not far distant from the point where the sun appears. For about a fortnight she is constantly above the horizon; then goes down, on the side opposite to her rising. Needless, perhaps, to remind you that during the polar day her beams are lost in those of the sun.

The planet Mercury and the planet Venus, being inferior planets, will be seen before the sun's yearly rising in the constellation Pisces, and after his yearly setting in the constellation Virgo. The path they trace upon the heavens will be as it is to the ordinary observer upon the earth's surface, a curve far from simple — the combined result of their own movement and that of the earth.

The superior planets may at the appointed times be seen, all through the long polar night, just as they may all through the short terrestrial night. When, namely, they are on the opposite side of the equator to the sun they will be seen; when they are on the same side they will not be seen.

Now, I wish my observer to move down the meridian toward the equator, still preserving his disconnection with the earth. But if he do so move he will, from causes set forth above, have a wind abeam to contend with, constantly increasing in force until, at our latitude, for instance, it will have a speed of 766 miles per hour, and at the equator a velocity of 1000 miles per hour. He could not endure this. It would tear him into little pieces just as if he had been blown from a gun. So we will suppress the wind as we have suppressed gravity; the one operation being as easy as the other; and we will have him move at will up and down the meridian, merely taking care not to be in the track of on-coming terrestrial protrubances.

Nor must he in his wholly unaccustomed freedom from the influence of gravity forget, lest his records fall into confusion, that a straight line drawn through him away from the centre of the earth is said to point upwards, and through him towards the centre of the earth, downwards — wherever he may be.

Let his first stop be at the Arctic Circle at the time of the summer solstice. If he have moved down the meridian away from the sun he will, at the halt, find the sun in his northern horizon. But the horizon is here the ecliptic of the heavens, as set forth elsewhere; and it follows that as long as he remains over the polar circle he will see the sun make yearly circuit of the horizon; never rising, never setting. The surface of the earth moves away eastward beneath him at the rate of more than 400 miles per hour, and he does not distinguish objects.

But when he has reached the latitude of the equator, all is flying beneath him at the rate of a thousand miles an hour, and is reduced to one uniform color and surface; though he may, possibly, distinguish land from sea. He looks up and finds that one half the stars he saw when at the pole have disappeared from view and others have moved up from the opposite quarter to fill their places. They are all now moveless, as before.

The moon and the planets order themselves as when he was at the pole, but at different levels.

The sun rises in Pisces and sets in Virgo after six months; but the altitude he reaches is 66° 30′ above the horizon, instead of 23° 30′.

And, now, when our privileged associate has assured himself by the faithful witness of the eye concerning these and many other wondrous things which he knew before by theory, and when he has duly steeped his soul in the tremendous loneliness of his position, he may, if he sees fit, return to his native latitude and drop back among his friends.

FUNGI.*

BY SANFORD OMENSETTER.

In all the fields of botanical research there can be no more interesting subjects than the fungi, which comprise cellular, flowerless plants, nourished through their spawn or mycelium; living generally above ground and propagated by spores of various colors. They are closely related to algæ, but grow in different situations — in green pastures, in meadows and woodlands, on decaying trees; some on cereals, potatoes and other vegetation, which they destroy; others on books in damp situations, and some on man or animals under certain conditions.

The spores correspond to the seeds in other plants, but differ from the latter in being composed simply of cells and not containing an embryo. Under favorable conditions the spores develop into the spawn or mycelium, which is the vegetative part of a fungus and consists of inconspicuous white down and strings, and may be either filamentous or cellular.

Almost every earthly thing is liable to be infected by this ubiquitous race. Some spread themselves over our fruits; others attack our bread, cheese, pickles or other manufactured articles of food. "When our vinegar becomes mothery," writes one observer, "the cause of the mischief is a fungus; if pickles acquire a bad taste, if catsup turns ropy and putrefies, the fungi have a hand in it all. Their reign stops not here — they even prey on each other. The close cavities of nuts occasionally afford concealment to some species; others like leeches stick to the bulbs of plants and suck them dry; some (the architect and ship builder's bane) pick timber to pieces as men pick oakum. One variety has a particular fancy for the hoofs of horses and the horns of cattle, sticking to these alone. The body of the domestic fly is liable in autumn to be attacked by a parasitic fungous growth."

The word fungi has been adopted into the English language directly from the Latin, though originally from the Greek

* Synopsis read before the Institute.

sponggia, a sponge, doubtless in allusion to their texture.

The members of the fungus tribe are similar in structure, and form an important and most remarkable division of the vegetable kingdom. Many of the species are exquisite in shape and coloring, while others are extremely valuable as articles of diet or of medicine.

In the program of the world's development, fungoid growths have been found as early as the carboniferous period, or coal age.

The chemical structure of fungi is said to be the most highly animalized; or, in other words, to partake more of the nature of animal composition, than that of any other vegetable. Besides the intimations of this circumstance that are afforded by the smell of some of the species in decay, which partakes much of the character of that of putrid meat, and the strong, meat-like flavor which some of them possess when cooked, we find the following fact stated — that, "like animals, they absorb a large quantity of oxygen and disengage from their surfaces a large quantity of carbonic acid; all, however, do not exhale carbonic acid, but in lieu of it some give out hydrogen and others azotic gas (now known as nitrogen). They yield, moreover, to chemical analysis the several components of which animal structures are made up; many of them, in addition to sugar, gum, resin, a peculiar acid called fungic acid,* and furnish considerable quantities of albumin, adiposine and osmazome, which last is that principle which gives its peculiar flavor to meat gravy."

Crystals of calcium oxalate are to be met with on the surfaces and in the intercellular spaces of many of the larger fungi.

Chemical analysis of the cell membrane shows that it possesses the elementary constituents of cellulose; but since the uncolored and unthickened membrance does not commonly exhibit the characteristic reaction of cellulose towards

*An acid contained in the juice of most fungi. It is said to be a mixture of citric, malic and phosphoric acids.

iodine* nor towards many of the reagents commonly used in testing typical cellulose, it is necessary to apply to it the special term fungal cellulose.

A great distinction between the fungal cell and other vegetable cells is that the former is wholly destitute of chlorophyl. Chlorophyl is the essential constituent that imparts the green coloration to the leaves and stalks of plants. Its nature is still doubtful, never having been obtained in a perfectly pure condition.

George Murray states that "in their mode of life fungi are controlled by this absence of chlorophyl. Without it they cannot assimilate, and are therefore driven to obtain their nourishment by taking up the carbon compounds assimilated by other organisms. Their mode of life is either parasitic or saprophytic. As parasites they inhabit the bodies of living plants and animals, and even of other fungi. In some cases they kill their hosts, and in others encourage growth, as in the case of the lichens,† and between those two extremes various degrees of parasitism occur. As saprophytes they promote the decomposition of dead organic bodies, and thus aid in the production of carbonic acid, water and ammonia, the elements of which return to the course of organic life."

Jodin relates that "some fungi absorb as much as six per cent. of their nitrogenous content in the form of nitrogen gas from the atmosphere. In the decomposition of fungi, ammonia is formed from the nitrogenous compounds. As parasites and saprophytes their influence as regulators in the economy of nature may be compared with that of the lower animals living the same mode of life."

*Cellulose moistened with iodine tincture and then treated with strong sulphuric acid assumes a blue color.

†According to Schwendener, "a lichen is not an individual plant, but rather a community made up of two different kinds of individuals belonging to two distinct classes of cryptogams, viz.: — A master fungus and colonies of algal slaves, which it has sought out, caught hold of, and retains in perpetual captivity in order to provide it with nourishment."

Of more immediate interest are the esculent fungi. Of these by far the greater number are comprised in the family of Agarics, a division which takes its name from Agaria, a region of Sarmatia. Our English word mushroom, by which all kinds of edible fungi are commonly designated, has a French origin and comes from the word *mousseron*.

Among one thousand American fungi described by Charles McIlvaine, some seven hundred are catalogued as fit to be eaten, having more or less commendatory flavors, while less than a dozen are fatally poisonous. With most persons, but one species, the well-known meadow mushroom, is worthy of confidence. Their creed is expressed in the quaint words of the old herbalist, Gerard, who said,

> "The meadowe mushroom is in kinde the best;
> It is ill trusting any of the rest."

And yet, by those living in the country, what teeming wealth of nutriment is allowed to go to waste because of lack of knowledge.

It is a pleasant thing to sally forth early in the day, under the first burst of sunshine which breaks out on a soft, clear morning in September, and to see how the night dews have been at work hastening the growth of fungi.

We need hardly say that mushrooms are excellent pickled. The way to preserve them is to select all the buttons; place them, skins and all, in a stewpan with allspice, salt and pepper; stew them until they have given out every drop of their juice and have re-absorbed all those juices, charged with the flavor of the spices among which they had been stewing. When this process is completed, add as much hot vinegar as will cover your mushrooms, boil them just for a minute, and they are finished. The large, broad specimens are delicious broiled with salt and pepper, and the middle sized kinds stewed in their own juice, with a little pepper, salt and butter.

Throughout the continent of Europe, plants of the fungus tribe are eagerly sought by all classes of men, and form the chief, if not the sole diet of thousands, who would otherwise be scantily provided with aliment. But fungi are not only the tolerated food of the poorer classes; they are also highly prized by the rich man and the epicure.

In Italy and Germany immense numbers of the various species of this tribe are sold in the markets, and produce an almost incredible amount of income. It is said that in Rome, so important are the fungi as an article of commerce, there is a public officer appointed to inspect those exposed for sale and superintend this branch of the revenue; for in that mart a tax is laid on quantities exceeding ten pounds weight, which may be offered for sale. All shipments brought to Rome are weighed and sealed up, and those destined for the day's consumption sent to a central depot. If, among the contents of the baskets, any stale, maggot-eaten or dangerous specimens are found, they are sent under escort and thrown into the Tiber. Another remarkable circumstance is the law, that if a specimen of the common mushroom be discovered, it also is to be thrown into the river. Whatever the Romans may say, the latter fungus is a delicious article of food, and very rarely an injurious effect arises from partaking of them.

All those more or less spherical fungi called puff balls, furnished with a membranous, white covering, and filled, when young, with a white, compact, homogeneous pulp, are fit to eat. Personally, when in good condition, the writer prefers them to mushrooms. Their integument removed, they may be cut in cubes and stewed, or sliced and fried like egg plant. They are of delicate flavor and very nutritious.

Several species abound in the vicinity of Media. The puff balls are frequently pre-empted by a sort of beetle, which burrows therein, spoiling desirable specimens. It is said that cows are partial to this variety of fungus.

For the purpose of benumbing bees, dried puff balls have been burned under hives, while the spoilers rifle them of their hoarded treasure. In former days, as they will, when old, hold flame for a long time, these fungi were used as tinder, and were often carried in a state of ignition by rustics, for the purpose of lighting their cottage fires.

One more noted species, as yet undiscovered in America, may close our very imperfect account of edible fungi. The truffle is found growing in clusters in clayey or sandy soil some inches under the ground, likewise in chalk, and is common on the Wiltshire downs, as well as in woods both in England and Scotland. The form of truffles is nearly spherical, and their color approaching black. They are studded with pyramidal tubercles, and their spawn is phosphorescent. In England they seldom exceed a few ounces, but on the Continent a weight of several pounds is said to have been attained. As there is above ground no sign by which truffles may be located, discovery is difficult; but so keen have men been in their appetite for this delicacy that they have hit on the plan of having dogs to scent them out. When the animals nose the prize, they stand and whine and scratch on the spot until their masters dig and take possession of the tubers. It is reported that there was known a man capable of exercising this extraordinary function, detecting truffles in the earth by sense of smell.

The expansive growth of fungi may next call for a few remarks. An account has been given of a paving stone, twenty-one inches square and weighing eighty-five pounds, which was raised an inch and a half from its station by a cluster of toadstools growing beneath. Many other facts, that attest the rapid growth of fungi, have been related by different authors. One of these peculiar plants was known in three weeks to reach a girth of seven feet, five inches and the weight of thirty-four pounds, and others the weight of twelve pounds in a few days.

But none of these statements, remarkable as they seem, are so wonderful as one made by Sir Joseph Banks, of a circumstance which occurred under his own roof. He avers that a friend having sent him a cask of wine which was too new and sweet for immediate use, it was locked in a cellar to mature. At the end of three years, Sir Joseph, supposing that time had now done its work, proceeded to open the cellar and inspect its contents. Little did he think how nature had been employed, and of the surprise which lay in wait. The door refused to open. Being invincible by gentle means, it was fairly cut away, but entrance was no nearer than before. The cellar was found literally full of fungous growth, which had borne the cask to the ceiling, where it stuck, upheld by fungi, the produce of the wine, which had leaked and formed this monstrous growth.

Another English writer, Dr. Withering, says: — "Mr. Stackhouse had repeatedly mentioned to me a large, esculent fungus found on the sea coast in Cornwall, which is, I believe, a monstrous variety of this species. Its whole habit is very large, the button as big as a potato, the expanded pileus (or cap) eighteen inches over, the stem as big as a man's wrist, etc." He also tells of a specimen which weighed fourteen pounds, and was found in an old hotbed.

But huge as this fungus must have been, it by no means equals one grown in Pannonia, and noted by Clusius in his "History of Plants." Of this immense specimen (supposed to have been *Polyporus frondosus*) "after satisfying the cravings of a large, mycophilous household, enough remained to fill a chariot!"

The phosphorescence or luminosity observed in several fungi has given rise to many absurd conjectures. Such a phenomenon depends on the respiration of oxygen, luminosity ceasing when oxygen is unavailable.

The coal mines of Dresden exhibit the interesting circumstance of fungi which emit light like pale moonbeams. A Mr. Gardner states that while passing along the streets of a Brazilian town he "observed some boys amusing themselves with what appeared to be large fireflies, but which proved on inspection to be a fungus belonging to the genus *Agaricus*, which gave out a brilliant, phosphorescent light of a pale green." He next day obtained considerable quantities, and found that a few of them in a dark room gave sufficient light to read.

Concerning a native luminous species, *Clitocybe illudens*, observed by the writer in Lower Providence, but not tested, Charles McIlvaine has this to say : —

" Grows in clumps or large masses about stumps or decaying trees, from August to October. Its bright, deep yellow is attractive from a distance. As many as fifty plants may form a cluster.

" The mysterious property of phosphorescence is possessed by this fungus. As heat is known to develop in masses of the fungus, it is of interest to know whether it is from the phosphoresence or a ferment. Its radiance by night surpasses its splendor by day. Mr. H. I. Miller, of Terre Haute, Indiana, first drew the writer's attention to this quality. A large box of specimens sent by him retained their luminous quality after three days of travel to such an extent that the print of a newspaper could be read when held close to the mass.

" Mr. Miller writes : ' There is something about this fungus which generates heat. When I bring in a basketful of it, for the pleasure its phosphorescence affords my friends, I find that after having been in the basket for two or three hours, and while piled one bunch on top of another, that to insert one's hand among the different clusters is like putting it close to a red hot stove.'

" This fungus is so inviting in quantity and beauty that one turns from it with a regret that lingers."

The species in question contains a minor, irritant poison, acting locally on the gastro-intestinal tract, and should not be eaten.

Where in woodland borders there stands a stately toadstool, siren-like, immaculate — beware the tempter, for within that queenly beauty lies the draught of death.

Perhaps if all cases of fatal poisoning by supposed mushrooms were traced to their source, the *Amanita phalloides* would be found to blame. Not less relentless than the Socratean hemlock, its insidious alkaloid stealthily clasps its victim in a grip that scarce knows mercy. The poison of *Amanita* has in some cases been counteracted, in early stages of an attack, by minute hypodermic injections of atropine sulphate.*

"*Amanitæ*," relates Charles McIlvaine, "are the most beautiful and conspicuous of fungi. While there are comparatively few species of them, the individual members are plentiful in appearing from spring until the coming of frost. They are solitary or gregarious in growth. Occasionally two or three are found together. They frequent woods, groves, copse, margins of woods and land recently cleared of trees. They are seldom found in open fields. A careful study of all their botanic points should be the first duty of the student of fungi. Familiarity with every characteristic of the *Amanitæ* will insure against fatal toadstool poisoning, for it is the well-grounded belief of those who have made thorough investigation that, with the exception of *Helvella esculenta*, now *Gyromitra esculenta*, the *Amanitæ*, alone, contain deadly poison.

"They are the aristocrats of fungi. Their noble bearing, their beauty, their power for good or evil, and above all their perfect structure, have placed them first in their realm; and they proudly bear the three badges of their clan and rank — the volva or sheath from which they spring, the kid-like apron encircling their waists, and patch marks of their high birth upon their caps.

"The *Amanitæ* are of all colors, from the brilliant orange of the *Amanita Cæsarea*, the rich scarlet or crimson of *A. muscaria*, to the pure white of the *A. phalloides* in its white form." †

A prominent writer has fittingly observed: "It is exceed-

* Reported by Dr. J. E. Schadle, Shenandoah, Pa., August, 1885.

† The color of the pileus of A. phalloides is quite variable, white and brown being the prevailing effects. A familiar case of color phasing in birds occurs in the screech owl, whose plumage may be red or gray.

ingly unfortunate that these deadly poisonous toadstools do not give some warning either in an unpleasant taste or contain an irritant which would act locally to cause emesis and purgation, for in that case the patient would get rid of the poison before such large quantities were absorbed and fatal poisoning would be less frequent. They are not at all unpalatable, and sometimes large quantities are eaten by mistake."

Professor Charles H. Peck, New York State Botanist, in his Forty-eighth Report gives the following very explicit directions for distinguishing between the poisonous *Amanita* and the common mushroom : —

"Poison Amanita—Gills persistently white. Stem equal to or longer than the diameter of the cap, with a broad, distinct bulb at the base.

"Common Mushroom — Gills pink, becoming blackish-brown. Stem shorter than the diameter of the cap, with no bulb at the base. The mushroom does not grow in the woods."

An extremely poisonous species found in this locality, the fly agaric (*Amanita muscaria*), formerly grew in great luxuriance beneath coniferous trees in Media cemetery. It attains a larger size than *A. phalloides*, and the top of the cap is at first red, turning to orange and becoming paler with age. Warty excrescences, the remnants of the universal veil originally enclosing the young fungus, are also plentiful.

The particular toxic principle of these plants is known as muscarine, a well-known alkaloid isolated by Schmideberg and Koppe in 1869. Its chemical formula has been represented as follows : —

$$C_2H_3 {<}^{N(CH_3)_3.OH^*}_{(OH)_2}$$

An enthusiastic mycophagist has described his experience in testing the fly agaric : "A raw piece of the cap, the size of

* Known technically as oxy-choline. It may be prepared synthetically through the oxidation of choline by nitric acid. Small wonder that such a compound plays havoc with the interior.

a hazel nut, affects me sensibly if taken on an empty stomach. Dizziness, nausea, exaggeration of vision and pallor result from it. The pulse quickens and is full, and a dreaded pressure affects the breathing. I have not noticed change in the pupil of the eye. Nicotine from smoking a pipe with me abates the symptoms, which entirely disappear in two hours, leaving as a reminiscence a torturing, dull, skull pervading headache."

Small amounts of the dried *Amanita muscaria* are said to be used by inhabitants of northern Asia for the stimulating effect upon the nervous system, producing, like other narcotic poisons, a dreamy state of intoxication, deepening into sleep.*

Dr. W. S. Carter, of Galveston, Texas, who has made a careful study of fungal poisoning and its treatment, groups the toxic species in two classes: —

First — Those containing minor or irritant poisons, which act locally on the gastro-intestinal tract, such as *Clitocybe illudens* and others. From the prompt way in which vomiting and purging begin there seems to be no doubt of their local irritant action on the alimentary canal. Such symptoms may not be regarded as dangerous unless the poison be taken in enormous quantities or by one in poor health.

Second — Those containing major poisons which act on the nerve centres after absorption, causing symptoms to appear a long time after the poison has been taken and very often terminating fatally. This group includes the various species of *Amanita*. From eating them, vomiting and purging may also happen as prominent symptoms, but generally only occur late — ten to fifteen hours after partaking — and are due to the action of the poison on the nerve centres. This is clear from the fact that these symptoms appear when the poison is given either hypodermically or intravenously to animals.

By means of over one hundred experiments upon lower animals, Dr. Carter has arrived at the following conclusions: —

*Von Boeck, Ziemssen's Cyclopedia of Medicine, Vol. VII, p. 927.

The deleterious principle common to toxic fungi of the second group is muscarine, above named.

Acting upon the nerve ganglia of the heart, a frequent result of its absorption is cardiac inhibition, which may be controlled by atropine.

Owing to the presence of other toxins, life generally ceases in two or three days after poisoning begins.

Toward counteracting late effects, physiological salt solution (.6 per cent. table salt), in conjunction with other remedies, has been recommended.*

The experiments would seem to show that *Amanita phalloides* is much more fatal than *A. muscaria.*

Toadstool poisoning differs from most poisonings in the long time elapsing before death in fatal cases.

No statement can be made as to the cause of this late death, but it would appear to be due to some disturbance of nutrition.

Late death occurs not only in animals, but in most of the cases of poisoning in man recorded in medical literature.

In the case of *Amanita phalloides*, the serious symptoms appear early and continue till the end.

With *Amanita muscaria*, the early effect of the muscarine soon passes off or can be removed by atropine, but the late symptoms still prevail and remain until death.

* Delobel, in "Presse medicale," September 30th, 1899, reports a remarkable case of recovery after the injection of a large amount of normal saline solution. A man, aged fifty-two, ate some A. phalloides. Two full doses of atropine were given hypodermically, as well as 10 cc. of ether, and 200 cc. of strong coffee with 20 cc. of rum were given by the mouth and hot bottles applied externally. The patient becoming worse, one liter (one quart) of normal saline solution was injected hypodermically. Improvement began in fifteen minutes after the injection, and the patient went to work the next day.

FINDING OF THE BACILLARIAN BEDS ON THE OCEAN BOTTOM.

BY ARTHUR M. EDWARDS, M. D.

The finding of Bacillarian beds, in fact the layers of diatoms, on the ocean bottom, is not new, although the importance of it is just now shown. For as the Bacillaria make up the clayey stones of vast regions in the world, they are also seen in the rock that is forming now, called "recent" by geologists, in the bottom of the sea.

They have been observed since 1818. In fact Bacillaria, or diatoms themselves, were not known much before then. And the discovery that they are synonymous with the great deposits of the world, those namely of Denmark, Spain, Greece, Africa, North America, South America, Japan and New Zealand, is likewise not new. In Denmark they are placed, tentatively, in the Late Tertiary, near the Recent strata containing living forms; in Spain in the Miocene, or still lower in the Oligocene Tertiary; in Greece, by Ehrenberg, who discovered them, below, in the Cretaceous; in Africa, also by Ehrenberg, in the Tertiary; in North America, by Rogers, in the Tertiary; in California, by Blake, who follows Ehrenberg in this, in the Tertiary. But here they are first studied thoroughly, and I put them in the Recent, because holding Recent forms identical with those brought home by the "Challenger" and "Tuscarora." In South America, in the North, in Peru, where geology has not been studied, they have not been placed at all. But from the South, in Patagonia, they were sent by Darwin to Ehrenberg, and placed by doubtful evidence in the Tertiary. Hatcher brought back some rock which he thought was Tertiary. I have examined this and I find Bacillaria in it. From Japan Pompelley brought back some rock which he submitted to me, and placed it doubtfully in the Tertiary. I reported on it at the time in the "Smithsonian Transactions" and found it was the same as the Virginian and Californian rock, in the way of

Bacillaria. In New Zealand, Hector considers the Bacillarian rocks to be Cretaceous — or rather, Upper Cretaceous. Now I have to announce that in my opinion they are Recent. And so they have been thought for some years. These all contain marine forms of Bacillaria, or rather those that live in the ocean water. I do not mean along shore, but in the midst of the ocean. But marine, brackish and fresh water are misleading terms. For we find them in ocean and along shore where they are influenced by fresh water, and even in fresh water away from the influence of the sea.

But let me state exactly what is known of the deposits as revealed in soundings.

The first successful attempt to bring up and examine the soundings was made in 1818 by Sir John Ross, who made a voyage to the Arctic regions in that year. This is detailed in the appendix to the narrative of his soundings in Baffin's Bay in 72° 30′ N. and 77° 15′ W., when he succeeded in bringing up from 1050 fathoms (or 6300 feet) "several pounds" of a "fine, green mud" which formed the bottom of the sea in that region. No microscopical analysis of this mud is recorded. Captain (afterwards Sir Edward) Sabine, who accompanied Sir John Ross at one time on this cruise, says this mud was "soft and greenish and that the lead sank several feet into it." Microscopical science was young then, and in 1818 Foramenifera, Radiolaria and Bacillaria were comparatively unknown. At any rate, the soundings were essentially the same microscopically as those brought home by the U. S. S. "Tuscarora," which I have examined and reported upon. A similar "fine, green mud" was found to compose the sea bottom in David Straits by Goodsir, in 1845. As I have said, nothing was spoken of the microscopic examination of this mud, but it was reported on by Sir J. D. Hooker, who first described it as coming from the Atlantic Ocean region. In this case it was green, but light colored, almost white, and came from near the southern pole. It was almost entirely made up of the loricæ of Bacillaria. As it is described in two scarce books

I will detail it here. First: It is in "The Cryptogamic Botany of the Antarctic Voyage in H. M. Discovery Ships 'Erebus' and 'Terror' in the Years 1839-1843," by Joseph Dalton Hooker, 1845, and in "The Transactions of the British Association for the Advancement of Science, Oxford, 1847." In the latter Dr. Hooker says: —

"The waters and especially the newly formed ice of the whole Antarctic Ocean between the parallels of 60° and 80° south were found by the author to abound in an order of organisms, whose true nature had until very recently been disputed; but which the recent discoveries of Mr. Thwaites in England had proved to belong to the vegetable kingdom. This order occurred in such countless myriads as to stain the sea everywhere of a pale, ochreous brown, in some cases causing the surface of the ocean, from the locality of the ships as far as the eye could reach, to assume a pale brown color. Though particularly abundant in the Icy Sea, these plants are probably uniformly dispersed over the whole ocean; and being invisible from their minuteness, can only be recognized when washed together in masses and contrasted with some opaque substance. They were invariably found in the stomachs of Salpæ and other sea animals, in all latitudes between that of the north tropic and the highest parallel attained by the Antarctic expedition. Many processes were employed for obtaining the species, which on being brought to Europe were placed in the hands of Prof. Ehrenberg, of Berlin, for examination and publication. A consideration of the results of Prof. Ehrenberg's examination, and of his observations on these plants, has led Dr. Hooker to the following results: —

"I. That a vegetation very different from Lichens, Mosses, etc., (orders which had hitherto been supposed to comprise the most Antarctic vegetables), abound in the waters of the Antarctic Circle, the species increasing in numbers with the latitude up to the highest point attained by man.

"II. That on this vegetation the whole of the animal kingdom, which swarms in the waters of the Antarctic Ocean, perhaps ultimately depends for its existence. It maintains that balance between the animal and vegetable kingdom which prevails through all other latitudes; probably also purifying the vitiated atmosphere as plants of higher orders do in most temperate regions.

"III. The genera and species of Diatomaceæ collected within the Antarctic Circle are not all peculiar to those latitudes; on the contrary, some of the latter occur in every country between Spitzbergen and Victoria Land. Others, or even some of these, have been recognized by Prof. Ehrenberg as occurring fossil in both Americas, the south of Europe and the north of Africa, in tripoli stone and volcanic ashes ejected by living and extinct volcanoes; whilst others again have been found floating in the atmosphere which overhangs the tropical Atlantic; for Mr. Darwin during the voyage of the "Beagle" collected an impalpable dust which fell on Captain Fitzroy's ship when to the west of the Cape de Verde Islands, and which on examination was proved to consist of the remains of Diatomaceæ, including species common to the Antarctic regions.

"IV. The death and decomposition of the Antarctic vegetation are gradually producing a submarine deposit or bank of vast dimensions. This bank consists mainly of the shields (the siliceous coatings of Diatomaceæ) intermixed with Infusoria and inorganic matter. Its position is from the 76th to the 78th degree of south latitude, and between the meridians of 26.5 east and 160th west longitude, thus occupying an area of 400 miles long by 120 wide. All the soundings taken over this deposit were in the finest green mud, occasionally mixed with sand, and a depth of between 200 and 400 fathoms. The lead sometimes sunk two feet into this peaty deposit, and on examination of what it brought up, showed the bottom to consist in a great measure of the remains of the species living on the surface.

"V. This deposit may be regarded as resting on the shores of Victoria Land and Barrier, and hence on the submarine flanks of Mount Erebus, an active volcano upwards of

12,000 feet high. Knowing as we do that Infusoria, Diatomaceæ, and other organic constituents, enter into the formation of the pumice and ashes of other volcanoes, and are still recognizable in these minerals, it is perhaps not unreasonable to conjecture, that the subterraneous and subaqueous forces which keep Mount Erebus in activity, may open a direct communication between the diatomaceous deposit and its volcanic fires.

"VI. The diatomaceous deposit flanks the whole length of Victoria Barrier, a glacier of ice 400 miles long, whose seaboard edge floats in the ocean, whilst its landward is extended in one continuous sweep from the crater of Mount Erebus, and other mountains of Victoria Land, to the sea. The progressive motion of such a glacier, and accumulations of snow on its surface, must result in its interference with the deposit in question, which, if ever raised above the surface of the ocean, would present a striped bed of rock which had been subjected to the most violent disturbances."

In 1850 Captain Penny collected in Assistance Bay, in Kinstone Bay, and in Melville Bay (which lies between 73° 45′ and 76° 40′ N.), specimens of the residuum left by melted ice and the sea bottom in these localities. These were sent by Dr. Dickie, of Aberdeen, to Ehrenberg, who examined them and reported upon them in the Berlin *Akadamic Monatsberichte* for 1853. There were figured in it siliceous loricæ of Bacillaria and also spiculæ of sponges. And also some of what he called Polycistinæ, or Radiolaria, as we should call them now, but no Foramenifera apparently occur only in certain strata or regions of the sea bottom.

In the March, 1854, number of the *American Journal of Science*, page 176, Prof. Bailey gave "The Examination of Some Deep Sea Soundings from the Atlantic Ocean," in which he detected this microscopic feature of the soundings and says they were in continuation of some detailed in the *Smithsonian Contributions to Knowledge, Vol. II, Art. 3*, Therein he made known the soundings along the coast from the depth of 51 fathoms southeast of Montauk Point in 90 fathoms southeast of Cape Henlopen, Fire Island Inlet and Little Egg Harbor were chiefly made up of vast amounts of forameniferous shells, rivalling in abundance the deposits of analogous species which he had found to compose the immense beds under the city of Charleston, South Carolina. He examined the soundings brought home by Lieut. Berryman, of the U. S. S. "Dolphin," made by using Lieut. Brooke's lead. There were five soundings made in 1080, 1360, 1580, 1800 and 2000 fathoms. None contained gravel or sand. All contained microscopic forameniferous shells. They all contained Bacillaria, which Bailey referred to *Coscinodiscus lineatus*, *C. excavatus* and *C. radiatus*. They all contained what he called Polycistiniæ, that is to say, Radiolaria, and also *Dictyocha jübulæ* (G. E.), which is now relegated by Haeckel to the Radiolaria also.

He also says that "the Cretaceous deposit of New Jersey presents no resemblance to soundings, and are doubtless littoral, as stated by Prof. H. D. Rogers."* Thus showing how they were produced before the era of "species generation" made certain by the researches of Darwin, who followed Carpenter.

In the year 1856 Prof. Bailey published his remarkable researches on soundings, in which he found Bacillaria, that is to say, Diatoms, and as he gave me the publication I wish to be explicit. It was a remarkable addition to our then knowledge, although Hooker had discovered Bacillaria in the soundings from the south sea. Some years before, Lieut. Brooke, of the United States Navy, had been employed in surveying the Sea of Kamtschatka and Prof. Bailey wrote on the specimens. It was in a letter to Lieut. Maury, of the National Observatory at Washington, D. C., dated at West Point, January 29th, 1856. He details examining three samples, as follows: —

No. 1. Sea bottom, 2700 fathoms (16,200 feet), latitude

* Proc. Bost. Nat. Hist., 1853, p. 297.

56° 46′ N., longitude 168° 53′ E., brought up by Lieut. Brooke, with Brooke's lead.

No. 2. Sea bottom, 1700 fathoms (10,200 feet), latitude 60° 15′ N., longitude 170° 53′ E., brought up as above, July 25th, 1856, and

No. 3. Sea bottom, 900 fathoms, temperature (deep sea) 32° Saxton, latitude 60° 30′ N., longitude 175° E.

He says that "a careful study of the above specimens gave the following results: —

"First — All the specimens contain some mineral matter which diminishes in proportion as the depth increases, and which consists of minute, angular particles of quartz, hornblende, feldspar and mica.

"Second — In the deepest soundings (No. 1 and No. 2) there is least mineral matter, the organic contents (which are the same in all) predominating, while the reverse is true of number three.

"Third — All the specimens are very rich in the siliceous shells of the Bacillaria, which are in an admirable state of preservation, frequently with the valves united, and even retaining the remains of the soft parts.

"Fourth — Among the Bacillaria, the most conspicuous are the large and beautiful species of *Coscinodiscus*. There are also, besides many others, a large number of a new species of *Rhizosolenia*, a new *Syndendrium*, a curious species of *Chætoceros* with furcate horns, and a beautiful species of *Asteromphalus* with from five to thirteen rays, which Bailey proposed to call *Asteromphalus brookeii*, in honor of Lieut. Brooke, to whose ingenious device for obtaining deep soundings, and by whose industry and zeal in using, we are indebted for these and many other treasures of the deep.

"The specimens contain a considerable number of the beautiful, siliceous shells of the Radiolaria. No Foramenifera have been detected."

In November, 1856, I made the personal knowledge of Prof. Bailey when I visited him at West Point and spent several hours working at the microscope. They were delightful hours, for I enjoyed them immensely, and although he was weighted down by the disease which terminated his life soon after, he could not refrain, although warned to do so, from entering enthusiastically into the work in hand. He then gave me a slide from West Point of *Meridion circulare*, and one of Radiolaria from Barbadoes. He also gave me some of the celebrated "Bermuda tripoli," and some of the original deposit of fresh water Bacillaria from West Point. He likewise presented me with a copy of his "Notes of Microscopic Forms Found in the Soundings of the Sea of Kamtschatka," then published in the *American Journal of Science and Arts*, Volume XXII, for 1856, page 1. This has a plate with figures of the various forms found.

COLLECTING AND PRESERVING DELICATE ORGANISMS.

BY CHARLES F. ROUSSELET, F. R. M. S.

(Mr. Charles F. Rousselet, of London, England, at the recent meeting of the International Zoological Congress in Philadelphia, met Mr. Edward Potts, of Media, Pa., by appointment, and procured from him specimens of local Polyzoa of species not native in England. Among these were Pectinatella, Pottsiella and Urnatella. He was desirous of making the attempt to acclimatize these forms in certain canal waters in London, and afterwards wrote Mr. Potts, under date of October 10th, 1907, requesting statoblasts for this purpose; adding that "specimens of these did not exist in England." Accompanying the letter Mr. Rousselet sends the detailed instructions for collecting and preserving Polyzoa and Rotifera, as given below. These directions are so precise that they cannot fail to be of value to students and collectors of these organisms.)

FRESH WATER POLYZOA.

The preparation of Polyzoa fully extended presents no great difficulties, but a little practice and patience are undoubtedly required.

As with Rotifera, these animals require to be narcotized, and cocaine or eucaine 1 per cent. solutions have proved best for this purpose.

Polyzoa are often found in large masses, but no useful purpose is served in preserving a very large colony. It is much better to pick out several small characteristic and clean pieces and after washing these well in water, and removing all branches and weeds that may interfere, place the selected pieces in a fairly large bottle of very clean water and allow the animals to expand. When they are fully expanded transfer each piece into a separate tube bottle (4 to 10 c. c.), and when the animals have again recovered add one drop of the cocaine or eucaine solution and gently mix with a pipette. So little of the narcotic must in the first instance be put in, that the animals do not mind it; they will all retract at first, but soon come out again. After ten minutes add again one drop and mix, and then add again one drop more after every five minutes for twenty minutes to half an hour, when the polypides will appear fairly rigid and will no longer retract when touched with a needle. Then add a pipette full of the narcotic and wait another five minutes, when the animals will probably be ready for killing and fixing.

The killing is best done by adding a large pipette full of formalin 10 per cent. (commercial formalin 10 parts, water 90 parts).

After a quarter of an hour the extended and fixed Polyzoa must be transferred into another bottle containing formalin 5 per cent., in which they are preserved permanently; fill up the bottle to the top and in putting on the cork gently squeeze out the superabundant fluid so as to close the bottle without leaving an air bubble.

Formalin 10 per cent. fixes and 5 per cent. preserves Polyzoa white and transparent; it may bleach the tubes somewhat, but this is no great disadvantage.

Very weak osmic acid may be used for fixing, but it stains the animals more or less.

The different species of Polyzoa vary somewhat in their behavior under the narcotic. Should a specimen not come out after the first drop of cocaine, it will show that it has received too much of it, and the colony must be removed to a bottle of clean water and left there for some time to recover.

I may mention that it is of no use applying a dose of the narcotic and allowing the Polyzoa to die in it; the polypides will simply curl up and become macerated and show no structure when fixed.

When collecting Polyzoa, the statoblasts, which are very characteristic of the various fresh water species, should always be searched for and preserved at the same time.

Polyzoa are found attached to the stems and leaves of aquatic plants in lakes, canals, water reservoirs, backwaters of rivers and slowly moving streams; also on submerged timber, stones and shells, often at considerable depth. A loaded three pronged hook attached to a strong line, for bringing up weeds, etc., from the bottom, is a very good method for discovering Polyzoa.

ROTIFERA.

The following instructions have been drawn up for the use of collectors in distant lands, or away from home, when an examination of the living material is not possible. The Rotifers are thus obtained in bulk and preserved for future study.

A. PELAGIC ROTIFERS.

I. Collect with plankton net, or with small silk straining net with bottle attached, in clear water and amongst aquatic weeds until a large bottle full of the material has been obtained.

II. Transfer the material into a window tank (or large, clear bottle) and allow to stand for an hour or two, and place the tank so that it is illuminated obliquely on one side only. All floating debris and dirt will fall to the bottom and the Rotifera will collect and can be seen like a cloud on the illuminated side of the vessel, mostly near the surface. Here they can be picked up clean with a pipette and transferred to a small tube bottle (2 to 6 c. c.)

III. The narcotizing process is performed in this tube by adding one drop of eucaine (or cocaine) 1 per cent. solution for every 2 c. c. of water it contains, and mixing. After five minutes the same quantity of the narcotic is again added. The Rotifers will continue to swim about, but gradually they will fall to the bottom, so that in say fifteen minutes from the beginning they can be killed and fixed.

IV. The killing and fixing is done by adding one drop of 1 per cent. osmic acid solution for every 4 c. c. of fluid, and mixing rapidly. The tube is then allowed to stand for a quarter of an hour, then the clear fluid is pipetted off, and the bottles filled with 7 per cent. formalin. This is repeated four times to get rid of all traces of osmic acid and also floating particles of dirt, and then the tube is corked as full of fluid as possible, after placing in it a slip of paper with a number and date and place of collection written with pencil. In order to obtain also some of the loricated Rotifera fully contracted, it is advisable to add to the tube a pipette full of the unnarcotized living forms immediately after the osmic acid has been added, as certain characters are better seen in the fully contracted animals.

B. SEMI-PELAGIC ROTIFERS,

that is, forms which are found mostly creeping on, or temporarily attached to aquatic plants, are best obtained by collecting a quantity of these plants (*Ranunculus*, *Myriophyllum*, *Ceratophyllum*, *Anacharis*, moss, etc.) and placing these in a large vessel with just sufficient water to cover the plants. By allowing this to remain (not in the sun) for several hours, or over night if necessary, all the animals will be driven by asphyxiation to near the surface, and towards the light side of the vessel, where they can be picked up with a pipette, and prepared as before.

C. FIXED ROTIFERS.

These are more difficult to prepare, and must be treated individually to obtain satisfactory results. However, small twigs of weeds on which such Rotifers can be perceived with the lens may be fixed and preserved (with or without narcotization) for identification.

D. FINALLY,

it is advisable to dry some of the weeds, particularly aquatic moss (without squeezing out the water). Some Rotifers can be hatched from eggs after a prolonged state of dryness.

RAPID PRESERVATION.

Should want of time or other circumstances prevent the adoption of the above more elaborate narcotizing method, then a rough and rapid collection may be made as follows: —

Collect with the straining net and bottle and transfer material, dirt and all, into a somewhat tall tube bottle and add at once one or two drops of 1 per cent. osmic acid (or some formalin 10 per cent. if osmic acid should be absent). Every living thing will at once be killed and will sink to the bottom; after a quarter to a half hour pipette off the clear fluid, taking care not to disturb the sediment at the bottom, and fill up again with formalin 7 per cent.; repeat this once more, after which the sediment alone can be removed with the pipette into a store bottle, filled up with formalin, and corked with label inside, as before.

SUITABLE PLACES FOR COLLECTING ROTIFERS

are standing waters of all kinds, lakes, canals, ornamental waters, water reservoirs, pools large and small, cattle ponds and roadside ditches (excluding all foul and ill-smelling waters). Flowing waters and rivers as a rule do not yield much, but backwaters of rivers, and bays cut off from the river flow, and very slowly moving streams may be good. In hot countries, when other sources fail, the railway water storage tanks at the stations may prove prolific.

Before proceeding to narcotize and preserve it is as well to examine the condensed water in a flat bottle with a hand lens x 6 or 8 to ascertain if Rotifera are present.

REAGENTS REQUIRED.

I. Eucaine hydrochlorate B. 1 per cent solution. Made with 1 gramme (15 grains) of the powder dissolved in 100 c. c. (3½ ounces) of water. If eucaine is not obtainable, cocaine can be used.

II. Osmic acid. 1 per cent. solution. Best made by obtaining a small sealed tube (Grübler's) containing 1-10th gramme of osmic tetroxide crystals, which, when wanted, is broken in a wide mouthed bottle containing 10 c. c. (⅓ ounce) of preferably distilled water; after the crystals are dissolved, which may take a few hours, the solution is transferred into a small, glass stoppered stock bottle.

III. Formalin 7 per cent., (not formaldehyde 7 per cent). For distant lands it is best to take a bottle of the commercial formalin (40 per cent. formaldehyde) which can be reduced with water as required. (Formalin 7 parts, water 93 parts, or say 1 to 13).

APPARATUS REQUIRED.

Plankton net, or stick with straining ring net, made of bolting silk (or "soft mull" cotton material) with small bottle attached.

Flat bottle.

Glass pipettes, straight, 6 to 7 inches long, provided with India rubber teat.

Bottles of various sizes.

Small tube bottles for collected specimens.

ÆGAGROPILÆ.

Through the kindness of William M. Parker, of Springfield Township, this county, the museum of the Institute has recently had added to it a specimen of ægagropila, or hair ball, taken from the stomach of a cow. The size of the specimen in question and the rather rare occurrence of such curiosities may perhaps warrant a few words on the subject.

Ægagropilæ consist of masses of matted hair, or hair and vegetable matter, found occasionally in the stomachs of certain ruminating animals. The name [derived from Greek *aigagros*, wild goat, and Latin *pila*, a ball (or *pilus*, hair) Cent. Dict.] would indicate them as commoner to the goat than to other animals. This is in keeping with the goat's reputation for gastronomic feats.

The specimen of hair ball presented to the museum was taken from the first stomach of a cow killed for beef in Camden, New Jersey. It subsequently came into the hands of Mr. Parker, who presented it to the Institute. In its present condition, after having a long interval in which to dry out, it is an approximately spherical mass, three and one-fourth inches in diameter, consisting of little else than matted cow's hair. The hair on the surface appears very much the same as hair growing on the skin of a cow.

On sectioning through the middle of the specimen, it is found to consist of the same material throughout. There is no sign of nucleus of any kind and the whole mass seems nothing but matted cow's hair held together by some sort of adhesive material. This material in its dry condition is fragile and easily reduced to powder. The integrity of the mass is preserved almost entirely by the interlocking of the strands of hair composing it. So firmly are these knit together that it is very difficult to tear the ball apart. The specimen does not present layers in its make-up, and the hairs intertwine in all directions. On the surface of the ball, however, the hairs all pointed in one way around the circumference. Whether this was caused by rotation in the cow's stomach or whether it was caused by subsequent handling, is not known.

Microscopically the ball shows little other than hair, grains of ground-up mineral matter (silica, lime salts, etc.), and some little cementing substance. A water solution of this latter responded weakly to the proteid tests, but enough could not be obtained for certain identification without destroying more of the substance of the mass than seemed advisable. Strange to say, the ball has no odor whatever of putrefaction and smells of nothing else than cow's hair.

The manner of formation of these balls is, of course, only conjectural. Probably a few strands of matted hair, stuck together with mucous or albuminous matter, form a nucleus which grows larger and larger as more and more of the indigestible hair is taken into the stomach. The peristaltic motion of the walls of the stomach would keep it in more or less irregular rotation, thus preserving the rounded form. Further, the irritation of the lining of the stomach by the presence of this indigestible mass would produce a catarrhal condition and stimulate the flow of mucus, which would thus keep the ball sticky and ready to catch more hair.

Despite the large size of the ægagropila, it was, as already stated, not this, but the butcher's axe, that caused the death of the animal. The first three stomachs of the cow being more for storage than digestive purposes, its effect was not so great as though the ball had formed in the fourth stomach. It is hardly conceivable, however, that it was not a source of great discomfort to its unfortunate possessor.

LINNÆUS FUSSELL, M. D.

1842--1907

It is with profound regret that the Institute announces the death, on Monday, October 28th, of its Secretary, Linnæus Fussell, M. D.

Dr. Fussell became a member of the Institute in 1872 and from that time until the close of his life was one of its leading members. For the past twenty-four years he served faithfully and continuously as its Secretary. His loss to the Institute and to the community is irreparable.

In the next issue of the PROCEEDINGS a biographical sketch, covering the various incidents of Dr. Fussell's long and useful life, will be published.

MINUTES OF MEETINGS.

August 1, 1907.—Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. In the absence of the Secretary, Walter Palmer acted as Secretary pro tem. The minutes of the previous meeting were read and approved. The Publication Committee announced that the half tones and printing illustrating the article on Sycamore Mill, in the April number of the Proceedings, were the gift of H. H. Battles. The following additions to the library were reported: "Electrons," by Oliver Lodge, and "Miscellaneous Reports of the Smithsonian Institution." After a short discussion on right and left handedness, by C. M. Broomall and other members, the meeting adjourned.

September 5, 1907.—Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. In the absence of the Secretary, Robinson Tyndale acted as Secretary pro tem. The minutes of the previous meeting were read and approved. Judge Isaac Johnson was proposed for membership. The following Smithsonian publications were received: "Bulletins Nos. 50, 53, 57 and 58 of the U. S. National Museum," and "Contributions from the U. S. Herbarium." The President called attention to specimens of fossil coral of the Silurian Age from Lake Superior, collected by W. W. McFarland. A new theory of aurora borealis was mentioned by John Palmer. The President announced the following Committees on Winter Course:—For October, 1907, Mrs. C. M. Broomall and John W. Palmer; for November, Prof. L. H. Watters and Dr. Kenworthy; for December, C. M. Broomall and C. Edgar Ogden; for January, 1908, Dr. T. Pratt and James G. Vail; for February, Robinson Tyndale and Henry L. Broomall; for March, Homer E. Hoopes and Dr. Fitch; for April, T. Chalkley Palmer and Lewis Fussell. After a short discussion the meeting adjourned.

October 3, 1907.—Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. The minutes of the previous meeting were read and approved. Arthur Pusey was proposed for membership. Judge Isaac Johnson was unanimously elected to membership. The Publication Committee reported having completed the issue of two volumes of the Proceedings, and presented a detailed report of receipts and expenditures to date. The report was received and ordered to be spread upon the minutes. The following additions to the library have been received: "Zoological Bulletin, Pennsylvania Department of Agriculture, Insect Collections;" "The Soil Preferences of Certain Alpine and Sub-Alpine Plants," and "Les Observatoires Astronomiques et les Astronomes." Miss Anne Knapp Whitney presented a number of curios, including an assortment of Russian toys, late the property of our deceased member, Jacob B. Brown. On motion a vote of thanks was tendered Miss Whitney. James G. Vail exhibited specimens of calcite penetrated by wires of native silver. Following a brief discussion the meeting adjourned.

INSTITUTE NOTES.

The paper in this issue by Mr. Charles F. Rousselet, on the narcotization and preservation of delicate organisms, is most valuable. Some samples of his method, now in the possession of Mr. Edward Potts, of Media, show the specimens preserved with the finest tentacles and tendrils extended in life-like posture. Indeed, so natural are they that it seems scarcely possible to believe the organisms are dead. The directions given by Mr. Rousselet are so complete that other workers in this line may expect equal success.

Mr. Edward Potts, of Media, whose article on Fresh Water Jelly Fish, published in the PROCEEDINGS of January, 1907 (Volume II, Number 2), will be remembered by our readers, has been busily engaged during the past summer in pursuing further his studies in this branch of science. In a recent lot of material he has had the fortune to find a specimen of three headed Hydra. The three headed form is by no means a common one, the usual Hydra having only two branches. Mr. Potts is studying carefully the process of digestion in this form of the organism and in the next issue of the PROCEEDINGS it is hoped the results of his observations will be published. It is from the Hydra that the asexual larval form of organism, first observed by Mr. Potts, develops and he is hoping to again witness this occurrence.

A subject worthy of note in the Fall issue of the PROCEEDINGS is the scant chestnut crop in this section this year. It may be the phenomenally cool Summer has been the cause of this. On the other hand this scarcity may be only an instance of the more or less regular alternation of periods of plenty and of scarcity often observed in plant life. One of the Institute members, in this connection suggests that next year's crop of chestnuts will contain comparatively few chestnut worms. Why?

Officers of the Institute:

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First Vice President, - -	Charles Potts
Second Vice President, - -	Henry L. Broomall
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Vol. III, No. 2 January, 1908

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

T. Chalkley Palmer, Chairman; Henry L. Broomall, Trimble Pratt, M. D.

Carolus M. Broomall, Editor.

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PROCEEDINGS

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Delaware County Institute of Science

VOL. III, NO. 2 JANUARY, 1908

LINNÆUS FUSSELL, M. D.*

"His life was gentle, and the elements
So mixed in him that Nature might stand up
And say to all the world: 'This was a man!'"

To those of us who love and reverence the memory of the late Dr. Linnæus Fussell, this application of the great dramatist's characterization is not an act of presumption. He was held in such reverent affection by so many of the residents of Media and vicinity that it seems eminently fitting and appropriate.

Linnæus Fussell was born in Pendleton, Indiana, September 2nd, 1842. His parents, Dr. Edwin Fussell and Rebecca Lewis Fussell, were descended from a long line of Friends imbued with a strong opposition to slavery, and had taken an active interest in the anti-slavery agitation then going on over the whole country. In no part of the country was the feeling so high, both for and against, as it was in Indiana. A series of conventions was being held throughout the West. Dr. Edwin Fussell, with "the courage of his convictions," was an active organizer of the anti-slavery element in that part of Indiana where he resided (Pendleton), and in furtherance of the plans of the Anti-Slavery Society had made arrangements for a meeting to be held at Pendleton, to be addressed by Frederick Douglass, James Monroe, Micajah White and others. Years after, in an article on "The Great Agitation," Frederick Douglass penned the following lines:—

*Dr. Fussell's death, October 28th, 1907, was previously announced.

"The roughest handling we received anywhere was in the State of Indiana. Many of its inhabitants were from Virginia and North Carolina, and they felt that in loyalty to their native States they must suppress the anti-slavery agitation. So we were met everywhere with opposition and often with mobs. In Pendleton, Indiana, now a leading anti-slavery town in Indiana, we were attacked and driven off by the fiercest and most determined mob that anywhere confronted us in our five months' campaign. In this mob our friend and co-worker, Micajah White, who kindly piloted us through the country, was severely bruised and beaten, and two of his teeth knocked out. William A. White, one of the speakers, was felled with a heavy bludgeon. I, also, was knocked nearly senseless and had my right hand broken. I believe all who held these conventions, except Professor Monroe, of Oberlin, and myself, have passed away. Yet they all, with the exception of William A. White, lived to see the public mind enlightened, the anti-slavery sentiment take the form of arms, emancipation proclaimed by Abraham Lincoln, the slaves made free, the country redeemed, and its possible future thereby made cloudless."

Upon the platform with other women of Pendleton sat Rebecca Fussell, with her infant son in her arms. Frederick Douglass was speaking when the attack of the mob was made. A large man, wild with excitement, who had forced his way to the platform, with raised club was rushing toward the speaker to strike him down. On the impulse of the moment she held up her child between the two. The man hesitated, looked ashamed, and with a muttered oath said, "We are not here to fight women and babies," and turned aside.

This was the first time in history that the future Dr. Linnæus Fussell was instrumental in saving a human life.

The blow thus warded off fell afterwards, and Frederick Douglass, bleeding and senseless, was taken to the residence of Neal and Elizabeth R. Hardy (who was a sister of Dr. Edwin Fussell), and by skillful nursing brought back to health, strength and usefulness in the anti-slavery cause after an illness of nearly two months.

It may be mentioned in passing that Dr. Linnæus Fussell, during the trip to China in 1867, had the pleasure of meeting Professor James Monroe, and of extending to him his father's greeting for the sake of "Auld Lang Syne." Professor Monroe was then the United States Consul at Rio Janeiro.

The prominent part taken by Dr. Edwin Fussell brought down upon him the enmity of the pro-slavery element, and threats had been made of personal violence, going so far as "to put a price upon his head." Similar threats had been made against others, and some of them had been carried out, notably the murder of Elijah P. Lovejoy, in Illinois. In the Fall of 1843 he reluctantly yielded to the persuasions of relatives and friends and returned to Pennsylvania, arriving at the home of his wife's mother, Esther Lewis, in Vincent, Chester County, as recorded in her diary, 11 mo. 26th, 1843.

A portion of the farm having been set aside for their use, on it in a grove of hickory trees a house was built, to which they removed in the Fall of 1845. The place was duly named "Hickory Grove." About the same time Esther Lewis and her other three daughters built a new house for themselves on the hill, opposite Hickory Grove, and within sight. This was called "Sunnyside," and as within its walls many a pleasant summer vacation was spent by all the Fussell children, it became an important landmark in family history.

It was during their residence at Hickory Grove that the three older children had their first induction to the mysteries of school life, first in "the Hall," and afterward at the Octagon School House, more commonly called the "Eight Square" School House, where under the skillful guidance of their aunt, Elizabeth R. Lewis, they had instilled into their youthful minds that love of learning for learning's sake, which lasted with them through all their school days. This period was largely one of a hearty, free, out-of-door life, and it was as healthy and sturdy a set of children as any one would desire to see that four years later entered the primary schools of Philadelphia far in advance of other children of their age.

In describing a heavy storm on the cruise of the "Unadilla," on her way to the Cape of Good Hope, Dr. Linnæus Fussell relates that a group of the ward room officers, seated around the table were trying to keep up their courage by telling amusing stories, anecdotes, etc., when one of them, rising, said: "Well, gentlemen, I must say this is ill-timed levity." Scarcely had the words been uttered than a great wave carried away the bulwarks and crashing upon the skylight of the ward room a flood of water poured in, wetting them thoroughly.

In view of the recent death of Dr. Fussell, it may appear to some that what is about to be related is also "ill-timed levity." But to the writer of this it is far, very far, from it. It is a tender, reverent record of a pet name that Linnæus Fussell bore for most of the happiest period of his boyhood.

At the Octagon School House there was a small boy of about his own age (five years), who found it impossible to properly pronounce most of the common words, and when it came to the name Linnæus, the nearest he could come to it was "Nierie." Many a ripple of merriment passed round that little school room when a shrill, high young voice would call out: "Tousin 'Izzie, Nierie's dot my penser!" or "Tousin 'Izzie, Nierie's scrougin' me!" These were two of the many complaints that became bywords in the school, repeated so often that the name "stuck." For many years he was chiefly called so by his boy playmates and companions. It is more than probable that John A. Groff, to whose persistent use the name owed its permanence, never to the day of his death spoke or even thought of him by any other name, certainly not in speaking of him to any of these boy playmates. With all our love and reverence for the goodness and accomplishments of the man Linnæus, there will always be left a fond corner for the boy Nierie.

As showing a strong characteristic trait of the young Linnæus, it may be related that in the Fall of 1846 Joseph Fussell (grandfather of Henry M. Fussell, of Media), with his wife and four children, moved to Fall Creek, Indiana. As his brother, William Fussell, three sisters and a host of nephews and nieces lived in Vincent, that place was considered by all as a fitting place for the start to their new home, and their last preparations were made there. The wagon was dismantled in the Hickory Grove yard, the running gears going to the wheelwright's at Norlan Square, some three-quarters of a mile away, the body remaining for some additions for personal comfort that were being put in by Joseph Fussell and his nephew, Joseph Fussell, Jr. During a momentary absence of the workers in the barn, the four year old Linnæus tried his hand at wielding a hatchet, and as a result severely cut his foot. After it was bound up there was no let up in the lad's desire for play — not a bit of it; he played on as long as there was any one to play with. The wounded foot healed all right, and a few days later, when everything was about ready, it was found necessary that some one should go to Norlan Square. A number of boys volunteered to do the errand. Linnæus was eager to be allowed to go, which was permitted on the promise of the bigger boys to take good care of him. The party was climbing the last fence when Linnæus fell, hurting his shoulder, "a little," he said, but as it did not seem to trouble him, and kept on his play, nothing was thought of the hurt. The boys had to wait about two hours for the article needed. All played vigorously, none with more keenness than Linnæus. The final start was to be made next morning and all the folks were assembled at Sunnyside. The boys returned from their errand and had reached the valley at Hickory Grove, when Dr. Edwin Fussell said, "Linn has broken his collar bone," and started down the hill to meet the boys. Linn was tenderly picked up and carried the rest of the way to the house, where, after the bone was set and his arm bound up, he was just as eager to continue his play, to have "lots of fun" seeming to be his controlling desire in those days, and it remained such until his early manhood.

In September, 1849, the family moved to Philadelphia, living for a short time at Eighth and Brown streets. The boys were entered in a primary school kept in a church building on Franklin above Green, to be in due time transferred to the Jefferson Primary, on Fifth street above Poplar, a "move" having been made to a house near there in 1850. Three years later another move was made to 910 North Fifth street, three doors above, where the family lived happily until 1867.

After attending the Jefferson Primary School a short time, Linnæus was promoted to the secondary school at Third and Brown, thence to the Jefferson Grammar School, at that time under the charge of Zephaniah Hopper, who shortly before Linnæus was prepared to enter the High School was appointed to a professorship in that institution, a position he still holds at the age of eighty-three. Linnæus Fussell entered the High School in 1858, finished the two years' course, and ended his school days proper on February 14th, 1860. But the following year, spent near the place of his birth, in Pendleton, Indiana, was infinitely more effective in paving the way for his professional career in after life.

During the winter of 1860 Neal Hardy and his wife and daughter had been on a visit East, and on his return took Linnæus and his sister, Emma J. Fussell, home with him. Emma returned in October, 1860, but Linnæus, having been appointed a teacher, remained until March, 1861. He had already decided that he would like to be a physician, and as showing under what sort of guidance his selection was made, a portion of a letter written to him upon his eighteenth birthday will be of more purpose than anything that can be written now.

"Thee is just at the time of life when to many comes the 'tide, which taken at the flood, leads on to fortune.' But to many others, on the other hand, it leads to shipwreck and destruction. Of course, we feel all of parents' solicitude. We have settled down into the following plan as to what seems to us to be the best for thee, and offer it for thy consideration. First, come fully to the conclusion that with a Heavenly Father's assistance and a very little aid from men thee can work out thy own future, whatever it may be! Now, what shall it be? If thee still turns wistfully to the profession of thy father, we will encourage and help thee all we can to be a noble physician. Remember, no half-breeds for us! A high place, or not at all! Now, if this is the conclusion, let me offer the following suggestions as to the best way of its accomplishment — a way for thee to do it thyself. Set out in the beginning with a determination to do everything thee attempts in the best manner of which thee is capable. Then whatever thee does will be so much gained toward professional knowledge, for to be a good doctor requires a man to know something of everything, and the better He knows it the more successful will he be. There is no need for haste in getting a diploma; green sprouts are not often turned into bread; the grain must have time to ripen; the boy must have time to grow into a man. Take time, plenty of time, and work straight along to the end. I know of no way that offers to thee better than teaching, because while thee is teaching others thee can be educating as well as sustaining thyself. and slowly accumulating the means to enable thee to go to the University. This can be done a part of each year, and the other part can be devoted to more special preparation. Part of the time thee can spend in studying materia medica and pharmacy in a drug store, and thee can besides devote at least three winters to attending lectures and hospitals. Take time, plenty of time. If thee graduates in five years, or six or seven years even, it will be soon enough. Make the way, and every step is an important gain for all time, for as exercise strengthens the muscle, so exercise strengthens the mind. The tree grows broader, stronger and taller for the storm as well as the sunshine. For all created things, work is an end as well as a mean. It brings at once its own exceeding great reward—free work, right work, of course, and none other. Whatever, therefore, that time offers for thee to do, do it, and do it well."

This visit to Indiana had much to do with broadening the character of Linnæus Fussell. He had no end of "fun," but it was not all fun by any means. He had his initiation into the harder parts of farm life and work. He had the experience of teaching a rather rough school, including the necessary "thrashing" of an unruly pupil larger than himself, but the job was done in his usual thorough manner. The bad boy humbly came back, promising to behave himself, which promise he kept as well as he could, to the betterment of himself and the school.

Then there were numerous spelling bees, attendance at debating societies, the excitement of an active political campaign, resulting in the election of Lincoln and Hamlin. There were special arithmetic schools, where mathematics were taught to music, but in which he records he learned many short cuts and quick methods of computation that he found of much use in after life.

After his return East he was for some time in Sleeper's drug store, on Fifth street above George. The confinement proving trying on his strength, it was followed by a Summer at Sunnyside. There, in conjunction with George L. Maris, he took charge of the yearly harvest home of the Royal Spring Temperance Society, holding one of the most successful meetings that the Society ever had. During the Summer he took and passed several teachers' examinations, and in the Winter of 1861-2 taught a school on the main line of the Pennsylvania Railroad, near where Devon now is.

Most of the year 1862 was spent in the store of Isaac Haldeman, at Newtown Square, Delaware County, Pa. In the Winter of 1863 he was at home at 910 North Fifth street, working for the greater part of the time in Vansciver's photographic gallery, at Tenth and Poplar.

In the latter part of the Spring of 1863 came the call for the "Emergency Men," and Linnæus Fussell enlisted in Co. K, Twentieth Regiment, P. M., Colonel William B. Thomas commanding. Their service was mainly in guarding points near Harrisburg, the bridge on the Conowingo, in camp near Shippensburg, at Camp Curtin and Camp Yates, and near Chambersburg, where (the officers having heard that he had had some experience in a drug store) he was transferred to a hospital as apothecary's clerk. After a short service the regiment was honorably discharged, and he was at home in time to matriculate for the University lectures for the term of 1863-64.

Emma J. Fussell, the eldest daughter of Dr. Edwin Fussell, had been an earnest nurse in the soldiers' hospital at Fourth and George streets, near her father's home. Since he feared that her zeal would undermine her strength, he insisted in the Summer of 1862 that she should take a rest. Reluctantly she started for Milton Fussell's home, at Reeseville, for a short stay, but the severe strain had already told. Shortly after arriving she was taken with a severe sickness that defied all that the best medical skill of the times could do. On 7th mo. 30th, 1862, she departed this life, leaving behind the memory of devoted service in a good cause. Her loss was severely felt by all who knew her, and by none more than by her brother, Linnæus, who since their visit to the West, two years before, had been closer united in brotherly and sisterly affection. It had a very noticeable effect upon his character. From the fun loving boy he grew at once into the mature, hard working man — a close student, interested in matters scientific and medical, with some attention to the natural sciences — paving the way for the serious work of his college life, which commenced with the Fall term of 1863.

How well he applied himself to his medical studies is attested by the fact that before he had half finished his college course he had passed an examination for a position in the United States Navy, a severer test than even the strict examination of the strictest medical college of that day and this. Upon receiving his first commission in the Navy he asked the privilege of standing an examination for his diploma, which was denied him because he had not yet taken the prescribed course of lectures. But two years later, after two sea trips and a partial course of lectures, he was allowed to come up, and passed. "Tell your son," said Professor Rogers, dean of the faculty, "that he not only passed, but passed remarkably well." This remark was made just before the starting on his third period of sea service, a voyage to China, a trip of three years. The diploma conferred on him by proxy on March 14th, 1867, he never saw until after his return in 1870.

Linnæus Fussell's first assignment to duty in the U. S. Navy was on the U. S. Steamer "Sagamore," which left the Philadelphia Navy Yard on March 18th, 1865, for the Gulf Blockading Squadron, with its destination off St. Marks Light House, on a small island off the port of St. Marks. At that time all of the northwestern coast of Florida was in the hands of the Confederates, and St. Marks was one of the principal points upon which they depended to get their supplies from the Gulf. But the work of blockading was nearly over, as within a month after the arrival of the vessel Lee surrendered, and the end of the war followed. The town of St. Marks surrendered, and thereafter the principal duty of the blockading squadron was the transferring of the prisoners, guns and ammunition to the government store houses at Key West.

These duties performed, the blockading squadron was disbanded and on October 2nd Linnæus was in Philadelphia, matriculating for the class of '65 and '66 at the University. His attendance was cut short in the early part of December, 1865, when he was ordered to the U. S. Steamer "Massachusetts," stationed at the Brooklyn Navy Yard, which left on January 6th, 1866, for the Gulf Squadron, carrying supplies. They were kept plying between New York and the Florida ports, New Orleans, Mobile, etc., until August, when the vessel was laid up for repairs at the Brooklyn Navy Yard and ordered out of commission.

Linnæus Fussell, then on shore leave, matriculated for his third course of lectures at the University in the class of '66-'67, but was destined not to finish that class either, as he was again ordered to the Brooklyn Navy Yard, to the "Unadilla," for a three years cruise to China and the Far East. They left New York on January 12th, 1867, and stopping on the way at Barbadoes, Rio Janeiro, Cape Town, Madagascar, Singapore and various other ports, finally reached Hong Kong, which was their headquarters until the Fall of 1869. Then the "Unadilla," being found unseaworthy, was sold, and the officers sent home by way of the Pacific Mail steamers, via Yokohama to San Francisco, and thence across the continent by the Union Pacific R. R. to New York, reaching that city early in 1870. His "waiting orders" were of short duration, as in February, 1870, he was again ordered to the Brooklyn Navy Yard, on the Receiving Ship "Vermont" and remained in that position for the most of that year.

On December 5th, 1870, he was "at sea" again, having left the Brooklyn Navy Yard on the 3rd, in the U. S. Steamer "Guard," of the Darien Exploring Expedition, and after a quick passage to Cartagena commenced at once the survey of the Atrato River and its branches. They found, in the opinion of the leader of the expedition, Capt. Thomas O. Selfridge (now Admiral), that the route was a perfectly practicable one and he so reported to the Secretary of the Navy. They then crossed the Isthmus by the Panama R. R. and surveyed the route from the Pacific side, St. Miguel Gulf, Tuyra and Para Rivers, returning to Philadelphia early in the Summer of 1871.

In the Fall of 1871 the family removed to Media, and he having been assigned to shore duty at League Island Navy Yard, the next and last assignment was to the iron clad monitor "Ajax," which left Philadelphia in January, 1874, for Key West and vicinity.

Dr. Fussell resigned from the Navy early in the Summer of 1874 and returned to Media, which continued to be his place of residence to the time of his death, October 28th, 1907.

He married, 6th mo. 4th, 1877, Edith Johnson, daughter of Oliver H. and Ellen Sellers Johnson. He leaves a widow and daughter — a son, Charles Johnson Fussell, dying in infancy.

By inheritance from both his parents, Linnæus Fussell had received the tendencies which made the natural history studies congenial to his mind. His mother, as early as 1835, had entered Kimberton Boarding School, only two miles distant from her home, and there, under the guidance of her friend and teacher, Abigail Kimber, had become an enthusiastic student of botany. Miss Kimber was herself a distinguished botanist, and had the pleasure of co-operating with her friend, William Darlington, M. D., author of "Flora Cestrica," by sending to him any new specimens of plants she might discover in her neighborhood. She also possessed a remarkable power over her pupils, in awakening a profound love of study.

Dr. Edwin Fussell studied medicine with his uncle, Dr. Bartholomew Fussell, at Kennett Square, Chester County, Pa., and there had the opportunity of hearing the frequent lectures of Joshua Hoopes, one of the prominent botanists of the time, and also of listening to the private conversation of the lecturer, who was one of a number including such men as

Dr. George Smith of Delaware County, who had been influenced by John Bartram and John Evans, of an earlier generation. These men had left their influence on the eastern counties of Pennsylvania, not only by the trees they had planted, but by the botanical tendencies they had inspired.

Linnæus Fussell, M. D., removed from Philadelphia to Media with his parents, in October of 1871. He became a member of the Delaware County Institute of Science in 1872, and eleven years later, on June 6th, 1883, was elected Secretary. Later he became a Curator, and for the twenty-four years preceding his death served the Institute with characteristic faithfulness and efficiency.

During this long period the herbarium of the Institute had claimed much of his attention. In conjunction with several other members of the Institute, its more complete condition was determined upon, and he entered upon the study which later led to the publication of one of his most important papers. The classification of the specimens needed revision to meet the demands of the newer nomenclature, and injured or lost specimens required to be replaced. The task of placing and maintaining the herbarium in its present remarkably fine condition is largely owing to his indefatigable labors.

In Volume I, Number 2, of these PROCEEDINGS, in conjunction with his associate, Sanford Omensetter, Dr. Fussell published a "List of Winter Birds," comprising forty-six species, which during several years of field observation they had met in the vicinity of Media, between the first days of November and March; in other words, those species which remained after the Fall migration, or which were seen earlier than the coming of the Spring birds. This list includes a number of interesting species, among which is our common blue bird, which has been seen in Media every month of the year, although its habit is to go further south.

In Volume I, Number 3, of the PROCEEDINGS, Dr. Fussell published his "List of Delaware County Plants," including something less than fourteen hundred species.

In explanation of the necessity for this list the author says:

"Dr. George Smith prepared and published, in his 'History of Delaware County,' a very complete list of the plants within our borders. Since the issue of that work, forty-four years ago, many other species have been found — so many that it was thought well to arrange a new catalogue. The revised list includes the names of all plants known in the county, and to be seen in the herbarium of the Institute. Others have been added, many of which have been taken from Dr. Ida Kellar and Stewardson Brown's lately published work, 'Handbook of the Flora of Philadelphia and its Vicinity.' That admirable manual includes nearly all the plants discovered in the county, with localities of the species and authorities for the same.

"A few plants not included in the work, but specimens of which are in the herbarium, have been noted. The entire catalogue has been arranged in accordance with the classification found in Britton's 'Manual of the Flora of the Northern States and Canada.'"

The preparation of this paper could have been undertaken only by a botanist as skilled as himself.

Volume II, Number 2, of the PROCEEDINGS, contains an article by Dr. Fussell on "Botanical Names," the purpose of which is to show the real value of scientific names, and to interest the student in the study of them. His liking for common names, where they are accurate and descriptive, and are confined to one species only, is manifest. At the same time he sees the necessity of a common language for scientists of all nations, and understands the value of Latin and Greek for this purpose. The article is a scholarly production of great value to less advanced students.

All of these papers are not only highly valued for their intrinsic worth, but also because they are the later efforts of one whose services during so many years have been so greatly appreciated. They are monuments of his extreme patience, carefulness of statement and love of scientific truth.

As a physician, he was implicitly trusted and dearly beloved, his patients becoming his devoted personal friends. By his compeers of the medical profession he was always held in profound respect for his ability and accurate judgment, and at his funeral they appeared in a body, having sent a beautiful floral offering in token of their estimation. At the time of his death he was Secretary of the Delaware County Medical Society, and Secretary of the Board of Health of Media Borough.

As a citizen, he was manly, courageous, dignified and respectful to all, without distinction of rank or standing, and in return he was honored by all as a high minded gentleman, worthy of all the respect which could be offered him.

Of his domestic life, it may be said that it reached very near perfection. In him a pillar of support has been removed from those he best loved, and who drew their chief happiness from him. Did all men approach him in consideration for others, in earnest affection, in devotion to those dependent upon him, the world would not wait indefinitely for the realization of many of its highest ideals.

CARBON AND SILICON.

BY JAMES G. VAIL.

Widely different as are our physical relations to carbon and silicon, the tendency is to forget the close relationship that exists between them. Certain it is that both are vital factors in the great economy of which we are a part, and a brief review of some points of comparison may be not unprofitable.

Carbon is the one element that occurs throughout the animal and vegetable kingdoms; and, in comparison, it is interesting to note that silicon occurs in nearly all geologic formations. Following the suggestion that silicon is to the inanimate world what carbon is to the animate, we should remember that in the periodic system, by which the elements are grouped into families by arranging them in the order of their atomic weights, carbon stands next to silicon in the family of elements which combine with two atoms of oxygen. The oxides, in each case the most familiar occurrence of the element, are exceedingly unlike physically — carbonic acid gas, on the one hand, and quartz or sand on the other. This probably accounts for our small tendency to consider how close is their relation.

But when we come to the consideration of the free elements the similarity is more apparent. The various forms of amorphous carbon, such as bone black, lamp black, charcoal, coke, etc., have their counterpart in amorphous silicon, which is usually seen as a brown powder. This powder burns in the air to the dioxide. Like carbon, it is non-volatile and infusible. Graphitoidal silicon is very similar in appearance to graphite. It melts at a temperature between the melting points of pig iron and steel (1100°-1300° C.), but is less active chemically than the amorphous variety. Graphite and graphitoidal silicon bear much the same relations to their amorphous varieties. A great commercial application of graphite lies in the making of crucibles for melting metals, notably brass. Vessels of almost identical appearance have been made of silicon, which would serve the purpose even better, but the present cost of reducing silica is too great to admit of their use. Carbon and silicon both combine with many metals directly, to form carbides and silicides respectively. These have been much studied in their relation to the properties of iron and steel, in which they almost invariably occur. Notable among commercial carbides is that of calcium, the source of acetylene for lighting purposes; while carborundum, the great abrasive, is a silicide.

As yet no form of silicon comparable to the diamond has been discovered.

In October, 1907, Mr. E. G. Acheson delivered a lecture before the Franklin Institute on the subject of "Deflocculated Graphite," in which he explained how graphite may be suspended in water in a state of division much finer than mechanical means could produce. This is accomplished by means of a small amount of tannic acid digested with the finely divided graphite, and the product will pass through the finest filter. He stated that the effect may be obtained with many non-metallic, amorphous bodies. In this connection it is interesting to note that graphitoidal silicon shows almost identical action with graphite under this treatment. It is suspended in the water so as to pass the finest filter, and is thrown out from the state of suspension on acidifying with hydrochloric acid. When the water containing the suspended silicon is evaporated we get, not the graphitoidal form with which we started, but amorphous silicon, which can be burned in the air. Graphitoidal silicon cannot be burned in air or oxygen.

Chemically, carbon is the most interesting of all the elements on account of the vast number of compounds which it is capable of forming. We are told that this is explained by the ability of the carbon atoms to combine with each other to form chains. It is by studying the structure of the molecule that we can classify and investigate organic compounds. Beside analysis, which reveals only the percentage composition of a compound, we have several methods of studying the character of the compounds of carbon, most important of which are the determination of their molecular weights, boiling and melting points.

Like carbon, silicon forms a large number of compounds, as any mineral collection will bear witness. Many minerals of which silicon is a component occur in differing crystalline forms, although their chemical composition is the same, indicating a different molecular structure. The methods used to identify different carbon compounds of the same percentage composition cannot be applied in the case of these mineral substances. As an example, molecular weights are mostly determined by finding the vapor density of the substance. But as we cannot get the silicon substance into the state of vapor, this means is shut off. The methods depending on the raising of the boiling point and the depression of the freezing point are unsuitable, because any known liquid that will bring a silicate rock into solution will also decompose it.

Thus our knowledge of the isomeric silicon compounds ends with the strong probability that they do exist in great numbers, and that if we had at hand the means thoroughly to investigate them, they would prove exceedingly interesting, forming as they do a very large percentage of the earth's crust.

In view of the wonderful discoveries continually being made in chemistry, it seems not beyond possibility that the problem of the chemical structure of silicon compounds may some day be solved. Neither would it be surprising if some one should succeed at last in producing the crystalline form of the element silicon, and show us a jewel of rare beauty, which may exceed the diamond itself in lustre and in hardness.

ECLIPSES.

BY JACOB B. BROWN.

The calculation of eclipses is a difficult and recondite matter which the present article has no intention of attacking. From the known intricacy of the calculations it is generally supposed, by those who have not much occasion to think about it, that the physical explanation of an eclipse is in like manner involved and difficult. The contrary is the fact, and an attempt will be made to show as much.

When the earth and the sun are both in the plane of the ecliptic, the opaque and spherical earth intercepts the rays of the sun and casts a conical shadow — conical because the sun is so much larger than the earth.

There may be those who do not know, or, at all events, have not reflected that the plane of the ecliptic means neither more nor less than the plane where eclipses take place. It is obvious that in order that one body be eclipsed by another for a third, the three must be in the same straight line, or nearly so. If two of the bodies be in a given plane, the third must be in the same plane. The moon can eclipse the sun when she is "in her nodes" or passing through the plane of the ecliptic, and at no other time; for the sun and the earth are there already as matter of course. There can be a transit of Venus when Venus is in her nodes, or crosses the plane of the ecliptic, and only then; for the transit is a kind of eclipse. And the conical shadow cast by the earth is always on the surface of the ecliptic plane, and at intervals exactly calculable, catches and more or less completely darkens the slow revolving moon.

This does not mean that all eclipses take place in the ecliptic plane. There are those seen from the earth with which the sun and moon have no connection.

* Through the kindness of Miss Anne Knapp Whitney, the Institute is enabled to publish this article from the pen of its deceased member, Jacob B. Brown.

The conical shadow cast by the sun has a length calculable by Rule of Three, because we know the distance of the earth from the sun and the diameter of the sun and of the earth.

From the extremities of the solar diameter draw straight lines tangent to the earth. They will meet and form an isosceles triangle, the base of which is the diameter of the sun, 882,000 miles. This triangle is cut proportionally by the diameter of the earth, 8000 miles, at a distance of 93,000,000 miles from the sun; round numbers being given for the sake of simplicity. Setting as x, unknown, the long side of the isosceles triangle, it is clear enough that the side of the conical shadow cast by the earth will be x — 93,000,000 miles. Solving the proportion, we get 93,851,258 miles for the long side, and taking from this the distance of the sun, 93,000,000 miles, we have 851,258 for the length of the shadow.

This shadow "lies floating on the floor," as it were, of the ecliptic plane, always, of course, turned away from the sun. The moon revolves about the earth, and supposing her always to be in the ecliptic, she would be, every time she came round, caught by this shadow and eclipsed; that is, would find her light, which is derived wholly from the sun, screened off from her. She falls into the shadow at a distance from the earth varying greatly, but averaging 240,000 miles; and, using the same triangles as before, 8000 miles at 851,258 miles is 5744 miles at 611,258 miles. For this distance of 5744 miles, then, the moon is in "solid" shadow.

If the eclipse be central, that is, if she pass through the axis of the shadow, it will be two hours from the time of complete immersion before she begin to emerge on the eastern side. For though the moon moves eastward about her own diameter in an hour, and the shadow diameter is 2.6 of the moon diameter (the latter being 2160 miles) — yet, as a moment's pondering will show, her centre at first internal contact will be at half her diameter within the shadow, and at second internal contact still half a diameter within the shadow. Her centre, therefore, will be moving by the space of two diameters while she is wholly in a state of immersion.

If the moon moved in the ecliptic she would come into the earth's shadow once in every lunation, and would also come directly between the sun and the earth once in every lunation.

She does not, however, move in the ecliptic, but is in it, and below it, and above it at irregular intervals and at irregular distances. Sometimes, therefore, she avoids the shadow altogether, sometimes she skirts it lightly, and sometimes plunges wholly into it.

It should be clear from the above that eclipses of the moon are confined not only to the nodal epochs, but also to the times of opposition.

An eclipsed moon is always a full moon.

It rarely happens more than twice in the year that the moon is at one and the same time in opposition and near her node. Occasionally the unusual supervenes. In 1898, for example, there were three eclipses of the moon — two partial and one total.

The moon is visible to a whole hemisphere (nearly) at one time, and it is the hemisphere bounded by the line in which a cone with apex at the moon is tangent to the earth. The pole of this hemisphere will be a point somewhere on the parallel denoted by the moon's declination, and on the meridian of the observer; in short, where the moon can be seen in the zenith. This, as we already know, may be at any point within a zone lying equally on both sides of the ecliptic and 10° 18′ wide.

Suppose, now, the moon in her node at the first of Cancer, and full. This will place her on the meridian about midnight of the December Solstice, and she will necessarily be totally eclipsed. Her centre shall pass the axis of the shadow cone at midnight precisely on the meridian of Greenwich. And she will be 23° 30′ north of the equator.

Those living on the Tropic of Cancer will see her in the zenith, and the hemisphere will, at the moment chosen, be bounded by a circle whose plane is inclined 66° 30′ to the plane of the equator and is parallel to the horizon — which passes on the equator through 90° east (Bay of Bengal) and 90° west (Galapagos Islands, coast of Ecuador), and which touches the polar circles north (head of the Gulf of Anadir, eastern end of Siberia) and south (in the unknown Antarctic Continent). For those 90° east of Greenwich the moon will be just setting in the west; for those 90° west of Greenwich she will be just rising in the east. The others intermediate. All within the hemisphere described will see her at the point of centrality at the same instant of absolute time, which is recorded as one thing at one place and another thing at another. And it is only this hemisphere in question that can see the eclipse at the moment when it is central. For all the rest of the world the moon will at that moment be either not yet risen in the east or already gone down in the west.

It is clear from this that if the time of all the phases of an eclipse be accurately calculated for the meridian of Greenwich, or indeed for any other meridian, the hours and minutes of the calculation can be turned into the hours and minutes of any other meridian for which she may be above the horizon by adding or subtracting the known difference of longitude, which is time. And such, in fact, is the practice; since the Greenwich Nautical Almanac sets forth, amongst other things, the "elements" of every eclipse down to the hundredth part of a second.

Now when the centre of the moon is on the axis of the shadow the moon has been wholly immersed one hour, and will so remain for another hour. It follows that those living 105° to the eastward and to the westward of Greenwich (let us still say) can see the moon totally immersed.

Generally, therefore, when circumstances are favorable, a zone of 210° of longitude is so favored.

If, now, we take into account the hour which the moon requires to get wholly into the dark and the hour which she requires to get wholly out again, it will appear that 240° of longitude can see some part at least of the same total eclipse.

There are many circumstances which modify these statements to a small extent, but the general working of the system is correctly set forth.

We have supposed our conical shadow formed, as it were, by rays drawn tangent to sun and earth on the "same" side, upper side, so to speak, of both, western side of both, and so on. Now suppose rays drawn from upper side of sun to lower side of earth, from western side of sun to eastern side of earth, and so on. These rays will meet at a point between sun and earth — nearer to the latter. They will form a cone pointed in the direction exactly opposite to that of the *umbra*, or shadow, previously described. The portion of the cone on the far side of the earth will be in shadow, but shadow necessarily much less dense than the other.

Penumbra, almost shadow, therefore, —

The moon must traverse the penumbra before reaching the umbra, and may be seen to do so, the effect being that of a light smoke slowly spreading over her surface.

The moon when eclipsed in summer time appears pretty low down in the south; when in winter time, high up and nearly overhead.

If an observer were stationed at the apex of the earth's shadow he would see the sun not at all. The earth would eclipse the sun exactly — no more and no less. The dark side of the earth would be seen as a black disk with lighter edges. If the moon entered the earth's shadow she might perhaps be faintly made out.

The physical explanation of a lunar eclipse would thus seem to be an elementary matter enough, and that of a solar eclipse is not less so.

Once more for simplicity's sake supposing the moon to be moving in the ecliptic — she comes of necessity, once in a lunation, directly between the sun and the earth and her little conical shadow falls in the direction of the earth. Its dimensions are dealt with precisely as those of the earth's shadow, with simple change of data ; and its average length is readily found to be 232,000 miles. As the moon's distance from the earth varies, the shadow is sometimes just long enough to reach the earth, and sometimes more than this, sometimes less.

Supposing as before an observer at the apex of this conical shadow ; he would see the sun not at all — for the moon would blot out that luminary exactly, no more and no less.

If he went nearer to the moon, it is clear that he would go farther into the cone of the shadow, and that the moon would more than cover the sun. If, on the contrary, he went farther away, he would be clear of the shadow apex. The moon would not suffice to blot out the sun. A portion of the sun's disk would be visible around the black circle of the moon. All this is realized in fact ; the only difference in the working being, that in consequence of the moon's varying distance from the sun, the point of the shadow cone falls short of the observer on the earth's surface, reaches him exactly, or passes beyond him several thousand miles into the body of the earth (as it were) and even beyond it on the other side. It must be clear that in the first case the observer sees an annular eclipse ; in the second a total eclipse, lasting but for an instant, and in the last case a total eclipse lasting some little time.

We have now but to remember that the moon is sometimes in the ecliptic, sometimes above it, and sometimes below it. Hence the irregularly recurring solar eclipse. The moon comes to her nodes at periods irregular, but entirely calculable. Her shadow points at, reaches or more than reaches the earth at periods irregular, but entirely calculable. Whoever wishes to have the "figures" of an eclipse may find them in the almanac. The physical explanation of a solar eclipse is so readily set out by a little orderly thought that it is not easily lost when once acquired.

It is not usually realized that we see, to all intents and purposes, a total eclipse of the sun every time a cloud passes fairly across his face. The sun is obscured, and we see the moving shadow. And, indeed, the moon's shadow may be seen by those suitably raised above a level, far extended horizon. Its edge is plainly enough defined and it advances eastward with a very impressive velocity.

The moon's shadow, then, if it reach so far, is cut by the earth's surface at varying distances from the apex. It may be circular, if the shadow strikes the earth vertically, and may be from 160 to 170 miles in diameter at the intersection. Observers within the shadow see a total eclipse, with optical effects well calculated to terrify those who in old times beheld, but did not understand. The path of the shadow and the day, hour and minute of its passing are calculated beforehand, and though the number of conditions to be taken into account makes the computation intricate, it is perfectly within the scope of ordinary mathematics.

If what was said just above regarding penumbra be remembered, it will suffice to say here, that the moon's shadow is precisely like the earth's in this respect, and that those within the penumbra see a partial eclipse instead of a total eclipse.

There are few that have not seen an eclipse of the sun, but very few that have seen a total eclipse. And yet there are those who will hear a new fact when they are told that about four solar eclipses happen for every three lunar eclipses. More than half the earth sees every lunar eclipse. But the track of the moon's shadow has a small width and length, which under favorable circumstances may make up about one two-hundredth part of the earth's surface. And even this does not mean that one man in two hundred sees the phenomenon of a total eclipse when it occurs; for the track may pass in great part over desert land or over the open ocean.

We have seen that the moon's diameter is 2163 miles (nearly) and that she moves eastward about her own diameter in an hour. This, then, would be the rate at which the moon's shadow would pass the observer eastwardly. But the earth also is rolling eastward, and it is the difference in the two velocities which is observed. On the equator, therefore, $2163 - 1000 = 1163$ miles in an hour. In higher latitudes, where the surface of the earth moves with less velocity, the difference is greater. At 40° north, for example, the velocity of the earth's surface is 766 miles in the hour and the shadow would pass it at 1397 miles per hour — 2049 feet in a second, the velocity of a cannon shot.

Now, supposing the sun in Cancer when he is eclipsed, the shadow of the moon will fall upon the earth vertically at latitude 23° 30′ north. And we will suppose the shadow spot to have a diameter of 160 miles. Totality begins as soon as the shadow spot covers the observer and ends when it leaves him.

The earth turns eastward in 23° 30′ north at 923 miles per hour (nearly), so the shadow passes the observer at 1240 miles per hour, and by Rule of Three will be about seven minutes and three-quarters in getting by. For so long the eclipse is total. It is easy to see that these results are modified in various ways by the time of day, the season of the year, by the latitude and by other causes, all of which have to be taken into account in calculating the elements of a solar eclipse. The above is by no means the way in which the duration of a solar eclipse at a particular point is computed, but it is on the whole, perhaps, the best way of getting a general idea of the phenomenon.

The Nautical Almanac gives the several elements of a solar eclipse and a chart of its path. From these and his own observations the computer at one station and at another can work out local results for himself.

DOES THE DIATOM MOVE IN DARKNESS?

BY T. CHALKLEY PALMER.

In a previous paper in these PROCEEDINGS* certain experiments on moving naviculoid diatoms were described. The conclusion drawn from these experiments was adverse to the notion that light (at least such light as was used in the tests described) exerts any necessary attractive force upon the motile diatom, since all the diatoms studied moved in total disregard of a lighted area in the midst of a semi-dark field. Moreover, doubt was expressed as to the correctness of the further notion — somewhat prevalent with theorists — that diatoms are unable to move in darkness. This doubt is not the fruit of a disbelief in the "osmotic" hypothesis. On the contrary, the writer believes that hypothesis to be unnecessary, erroneous, and worse than valueless because of facts already known. But it may not be out of place to slay the slain once more by a demonstration that diatoms do move in a darkness that is to all intents complete.

The observations now to be described were made at night with the aid of the following simple arrangements: —

A small Beck binocular stand was fitted with a revolving diaphragm in a substage tube, the arrangement being such that light coming from below the stage could be admitted or entirely excluded at will, and with rapidity. Cuplike caps, impervious to light, were provided for the eye-pieces, and these, when in place, cut off any faint illumination from above. A silk cloth was folded into several thicknesses, until no light could be seen through it when looking directly toward a bright Welsbach lamp. This was passed around the tube of the objective and secured there, the edges being brought down around the circumference of the circular stage. No light from any direction could now reach the stage except as

* "Some Observations on Diatom Motion," Vol. II, No. 4, July, 1907.

it was permitted to enter through the substage diaphragm. The objective of one inch focal distance was used, with short eye-pieces, and the apparent diameter of the field was 16 centimeters. The amplication was found to be approximately 80 diameters. The source of light, as in previous experiments, was a Welsbach mantle, the volume of light being minimized by the interposition of a screen pierced with a rectangular hole. This screen left only a narrow beam of light to fall upon the mirror of the microscope, and at the same time greatly lessened the general illumination of the room.

A fresh gathering of naviculoid forms was made in the afternoon and during the evening these were examined and found to be in active motion. The water in which they were seemed highly impregnated with oxygen, and a nearly colorless, freshly made, aqueous solution of hæmatoxylin, when mixed with it, turned a deep blood red in three minutes. There was, therefore, no fear of the diatoms coming to rest for want of oxygen.

Experiment I. — A few of the diatoms were put into a shallow, rectangular cell, open at the ends, and a thin cover superposed. The slip was then put upon the stage of the microscope, which had been arranged as described for exclusion of light. The diaphragm having been opened slightly, it was seen that the *Naviculæ* were moving normally in every direction.

INTERVALS OF OBSCURITY	EXPOSURES TO LIGHT
9.05 — 9.10 o'clock	15 seconds
9.10¼ — 9.20 "	15 "
9.20¼ — 9.50 "	

At all three exposures the activity of the moving diatoms was seen to be undiminished, and new groupings were visible each time. From 9.05 to 9.50 o'clock, therefore, they continued their motions in darkness, with only 30 seconds of exposure to a feeble light.

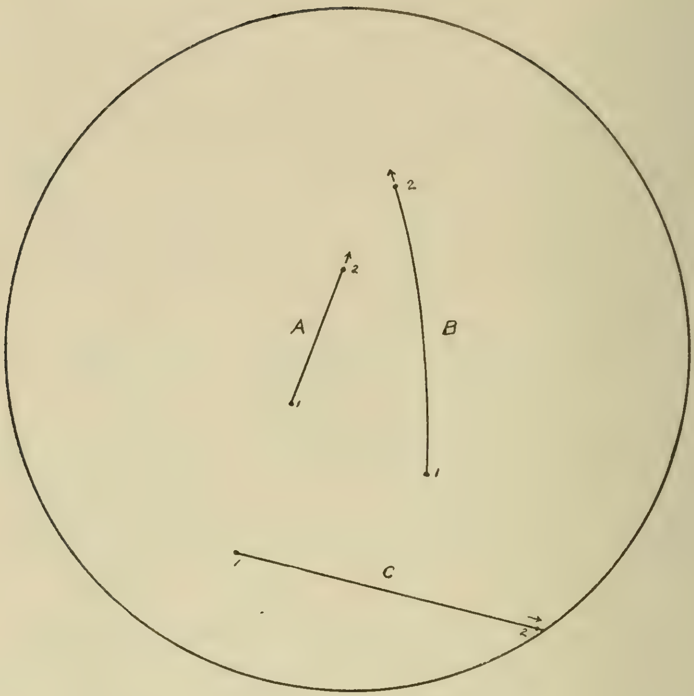

FIGURE I.

Experiment II. — A fresh mount was made from the same gathering and left in darkness upon the stage for two hours, with momentary and slight exposure to light every half hour. At the end of that time the movements of the *Naviculæ* and some small forms of *Nitzschia* were as vigorous as ever. The slide, with the diatoms in it, was now put into a dark box for twenty hours, or until the next evening. It was then arranged on the stage with practically no exposure to light. After an interval of half an hour of darkness, the diaphragm was opened slightly. The *Naviculæ* had all come to rest, but the numerous minute *Nitzschiæ* were moving with vigor. The slide was now strongly illuminated for an hour, but not a single *Navicula* moved. A careful examination showed that every *Navicula* in the slide was dead and the endoplasm much contracted. Whatever the cause of the catastrophe, it had not harmed the *Nitzschiæ*, neither had the long continued darkness influenced their motile activity to a perceptible degree.

At this point it was thought best, for the sake of definiteness, to map the further observations, as in a former paper, and a number of diagrams of the field, drawn to scale, were prepared. On these were dotted the positions of the diatoms observed, and the directions of motion at times of observation were indicated by arrows.

Experiment III. — A few of the diatoms (perhaps not more than 100) were put into a Holman life slide, and kept in dense obscurity 24 hours. The slide was then momentarily illuminated, and showed (See Figure 1) three diatoms at locations 1, A, B and C. After three minutes of total darkness the diatoms had all moved to 2, A, B and C. These were all *Navicula gibba*. The distance moved in three minutes was approximately measured and found to agree very well with the speed for this species as given in the former paper.

Experiment IV. — (See Figure 2). Another mount of the diatoms was made, but of such a sparseness that it was possible to find a field showing not a single frustule. The slide was kept in darkness on the stage one hour. At the end of this time it was observed at intervals of three minutes, with an exposure of not more than 15 seconds each time, as follows :—

8.47	No diatoms.
8.50	" "
8.53	" "
8.56	" "
8.59	" "

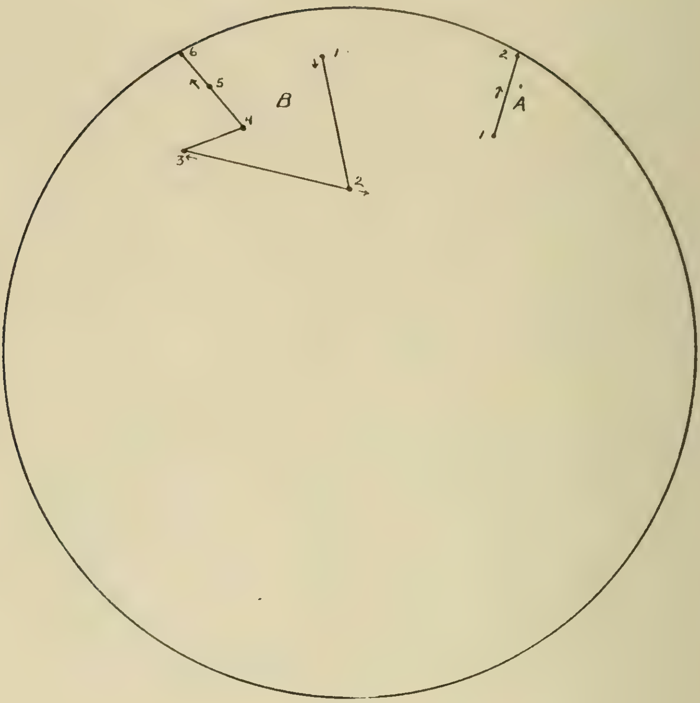

FIGURE 2.

9.02 *Navicula gibba* at 1 A.
9.05 " " " 2 A.
9.08 Another *Navicula* at 1 B.
9.11 The same at 2 B.
9.14 " " " 3 B.
9.17 " " " 4 B.
9.20 " " " 4 B. Rested three minutes.
9.23 " " " 5 B.
9.26 Disappeared Did not return by 9.30.

Experiment V. — (Figure 3). A mount having been in darkness about one half hour, a *Navicula gibba* was observed

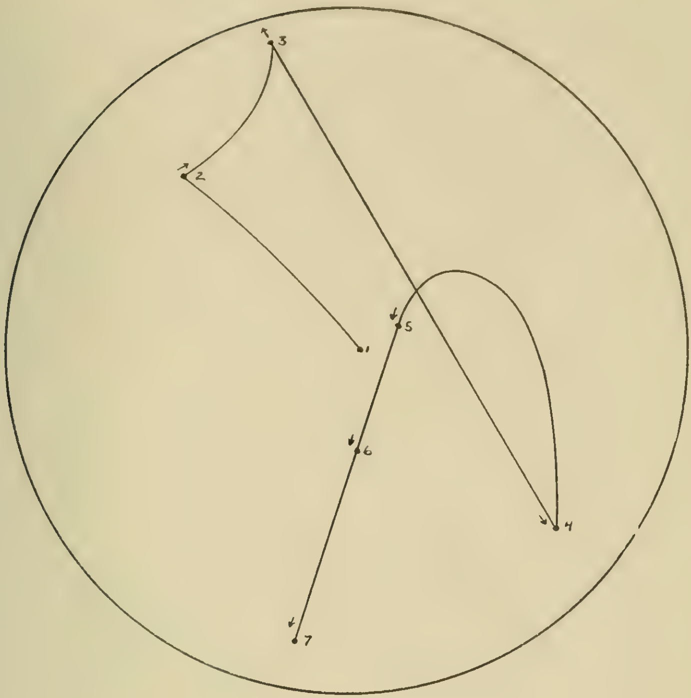

FIGURE 3.

in motion. Its devious track was followed and mapped by three minute intervals, with intermediate exposures, as follows :

LOCATION	TIME	EXPOSURE
1	7.37	
2	7.40	15 seconds
3	7.43	10 "
4	7.46	15 "
5	7.49	20 "
6	7.52	10 "
7	7.55	10 "
8	7.58	Disappearing.

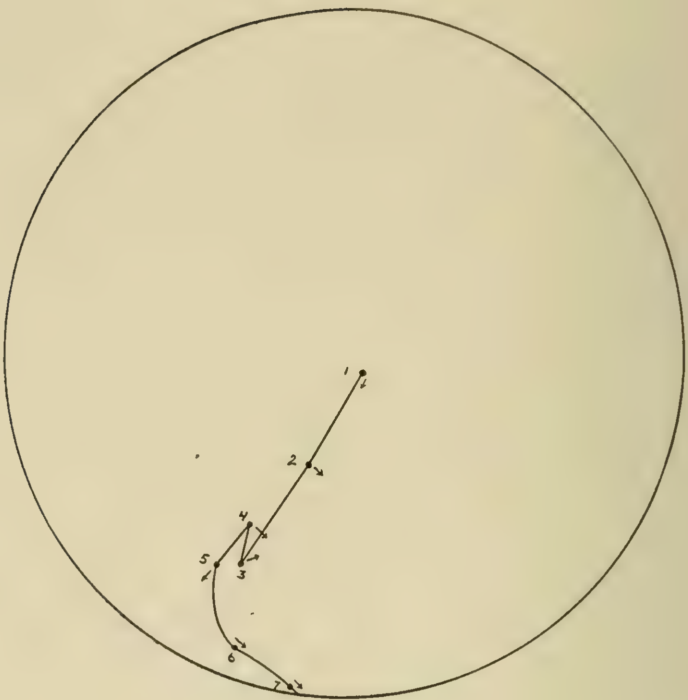

FIGURE 4.

Experiment VI. — (Figure 4). The same mount as in the last preceding. The diatom followed was *Navicula Bacillum*.

LOCATION	TIME	EXPOSURE
1	8.11	15 seconds
2	8.13	10 "
3	8.15	8 "
4	8.18	5 "
5	8.20	5 "
6	8.22	10 "
7	8.24	8 "
8	Disappeared.	

In view of all the above, it would indeed be of interest to learn what supposed basis there could have been for the assertion that diatoms do not move except in fairly strong light. This claim continues periodically to be made, and wild theories as to the nature of diatom motion take root and grow therefrom. But why base any theory on mere supposition, when experimental facts are within easy reach? For, as happens in this case, the facts may turn out fatally in opposition to the theory.

THE EVOLUTION OF THE MUSICAL SCALE.

BY C. M. BROOMALL.

To the musician the thought of science in connection with his art is distasteful. He refuses to admit in its make-up other than the divine inspiration of the Muse and claims that everything he produces or renders is untrammeled by cold, scientific laws.

In this he is wrong and modern harmony, existing in its present form and developed from the music of the past, is an unanswerable argument in support of the allegation that music is to some extent at least the child of science. The development of the modern system of harmony, as evidenced in the present orchestral combinations, from the old Greek scale of two thousand years ago, shows, as we shall see, how the musician of to-day has been forced unconsciously to obey these laws. In other words, it is impossible that the music of to-day could have developed from the ancient melodic music except in the one direction in which it has. Indeed, had the old Greek with his scale of melody possessed to-day's knowledge of acoustics and had he been seized with a desire to predict the scale which could be the basis of a system of harmony, he would have chosen unquestionably the intervals of the modern scale.

It is interesting to examine this more in detail. History tells us that a couple of centuries ago music consisted only of the melody sung in unison and there appears little reason why one scale should have been preferable to another. The scale as used by the Greeks, for instance, was that which, in terms of the first note, can be represented by the following ratios :—

$$1 \quad 9:8 \quad 81:64 \quad 4:3 \quad 3:2 \quad 27:16 \quad 243:128 \quad 2$$

This is known as the Pythagorean scale and is one of the scales of which a complete record has come down to us. There were probably many others, but this will suffice for comparison. So much for the ancient music.

But as time went on artistic yearnings were not satisfied with this simple form of music. There arose a desire for more complicated music in which the performers made use of other relations than unison and the octave. They began to try various simultaneous combinations of the notes of their scale and harmony began to develop. But along with this the intervals of the scale changed. Unconsciously the musician was changing the intervals of his scale under the domination of scientific laws of which he had no knowledge. After two centuries of slow change and when harmony has reached its full development in the music of to-day, the ratios of the scale are found as follows: —

1 9:8 5:4 4:3 3:2 5:3 15:8 2

Its intervals are evidently much simpler than those of the Pythagorean scale.

This scale is a product of evolution and illustrates the survival of the fittest, or rather the survival of that which is most agreeable and acceptable to the ear of the musician. No matter what form the original scale of melody might have had, no other possible evolution product than the present form could have resulted, now that harmony has become the basis of music.

It is most interesting to study out the reason for this evolution. Before doing this it may be well to recall to mind a few of the fundamentals of sound. To begin with, sound has three characteristics, namely, pitch, intensity and quality. The first two are determined by the number and amplitude of the vibrations. The third characteristic, quality, that property by which we are enabled to distinguish the note of one instrument from another, is determined by the number and intensity of the overtones or harmonics accompanying the fundamental. These harmonics are produced by a secondary vibration of the string or reed or pipe superimposed upon the fundamental. Thus, for instance, a vibrating string, in addition to vibrating as a whole, vibrates faintly in 2, 3, 4, 5, etc., segments, these vibrations being superimposed upon the original vibration. By the relative number and intensity of these is the quality of the note determined.

Another phenomenon to be referred to is that of "beats." If two notes of different pitch are sounded together the waves of one continually gain upon the other, producing alternate reënforcement and weakening of the sound. If these beats become rapid enough, a new note, called a "resultant tone," is produced, which is faintly heard together with the two primaries. Without going into the theory of beats we may note that there are always theoretically two sets of beats and that it may be possible to have two resultant tones. These resultant tones in turn may form beats with other resultant tones or with the primaries and so on, theoretically, *ad infinitum*. Practically, however, the resultants soon become too weak to be heard. The rule for calculating the number of beats is as follows: The lower vibration number is divided into the higher the nearest number of whole times and the remainder gives the number of beats. There are two sets of beats depending upon whether this remainder is counted from the next highest or next lowest multiple of the low note.

With an apology for this reference to elementary principles let us turn to the question of the evolution of the modern scale. The adoption of the present scale may be briefly stated to have been brought about by a process of unconscious selection on the part of the musician. The presence of beats being extremely unpleasant even to the untrained ear, it has been the effort to avoid this which has led to the unconscious evolution of the modern scale. There has thus resulted a scale which, when used in harmonical composition, will produce on one hand the fewest instances of and weakest beats, and on the other hand the greatest number of resultant tones in consonance with primaries and harmonics. No matter what the original melodic scale might have been, harmony required its evolution into the modern form.

An analysis of the ordinary major chord will serve as a good example of what we have tried to illustrate. We will assume that the first three harmonics only are prominent enough to require consideration. Let us assume 240 vibrations per second for the low note (a very low note indeed) for the sake of avoiding large figures. The modern major chord, corresponding to C, E, G, C, would then have vibration periods as follows: —

C, 240 E, 300 G, 360 C, 480

Accompanying each of these are the three faint overtones according to the above assumption, so that the number of notes to be taken into account is twelve. In addition every one of these notes will form beats or resultant tones with every other, so that the total number of combinations is large. We will consider only a few of them, however, and for illustration may form the following table. The primary notes are printed in large type, the harmonics in medium size and the resultants in small type. Practically only the first, second and third lines amount to much, except as regards the timbre of the chord.

MAJOR CHORD

Primaries	**240**	60 180	**300**	60 240	**360**	120 240	**480**
Resultants*			120 120		120 180		
Harmonics	**480**	120 360	**600**	120 480	**720**	240 480	**960**
Resultants	240 240		300 300		360 360		480 480
Harmonics	**720**	180 540	**900**	180 720	**1080**	360 720	**1440**
Resultants	240 480		300 600		360 720		480 960
Harmonics	**960**	240 720	**1200**	240 960	**1440**	480 960	**1920**

* The resultants in this line are derived from the primaries 240, 360, and 300, 480, respectively.

It must be borne in mind that this table represents only a small proportion of the total number of resultants, and that only the resultants of the primaries are of much importance.

Considering the preceding table it is seen how many are the points of coincidence and how it must result that the major chord is so perfect. It would be impossible to take any other intervals of approximately the same size which would present so many cases of unison, octaves, etc. Any variation from these intervals would produce utter confusion.

The table shows another thing, that the chord can be made more perfect by adding to it the lower octave and double octave of the fundamental, as in several cases at least will these reënforce the resultant tones between the primaries. Piano players will recognize how important these tones are in making the major chord agreeable.

When it is considered that no other intervals than these can produce so many unisons, octaves, etc., we see at once what necessity there is that the modern scale of harmony should be exactly as it is. It is evident how, side by side with the growth of harmony, artists were inevitably pushed toward the adoption of these intervals in their search for agreeable combinations of notes. Of the multitudinous combinations of ratios that have been tested, those of this scale and this only were able to survive.

Indeed, the harmony and sweetness of music based upon the major chord only is so perfect as to become often monotonous and dull. The musician feels the necessity of introducing an occasionally less perfect chord in order that the contrast thus afforded may add additional charm to the music. An instance of this is the well known chord of the dominant seventh, which alone is decidedly rough, but which most agreeably resolves itself into the tonic major chord. The minor scale is another instance of the same tendency.

The musical system is hence perfect as far as theory goes. But the artist has another difficulty to contend with due to the mechanical imperfection of the majority of musical instruments, which has forced him to deviate somewhat from this perfect scale, and to use one slightly different, called the "tempered scale." The necessity for this has arisen from the fact that instruments with fixed tones are unable to make all the notes necessary to form the perfect scale in all keys. That is, in order to run a perfect scale commencing on any note at random it would be necessary to have the ability to make more notes than most instruments are capable of making. It is only with such instruments as the violin, slide trombone, etc., and with the voice, that perfect harmony can be obtained. The result is that in most musical instruments those notes which are very close together are represented by a sort of average note which does the duty of both. The difference, while not great, is readily perceptible to the musical ear. The theoretical scale has therefore to be "tempered," as it is called; that is, the intervals must be slightly altered. The result is that the instrument does not play exactly in tune in any one key, but a very little out of tune in all keys. On instruments of short or unsustained notes, like the piano, the difference is not very noticeable. On the other hand, in an instrument like the organ, with sustained notes, the beats often become very disagreeable. It is said that violinists and singers, when not influenced by the presence of tempered instruments, are apt to revert to the true scale in rendering harmonically arranged music.

In conclusion, we may summarize the history of the musical scale as follows: There is (1) to begin with the period when all music was melody, when perhaps many scales existed and any one was practically as good as another. Following this comes the long period (2) during which harmony was growing and the various scales were being tried. The outcome of this was the evolution of the scale into its modern form (3) this being the only form suitable for music based on harmony. Lastly there comes the degradation of this perfect scale into the tempered scale (4), a change brought about by the mechanical imperfection of fixed tone instruments.

MINUTES OF MEETINGS.

NOVEMBER 7, 1907.—Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. Reading of Minutes and Reports of Officers and Curators. Arthur N. Pusey, of Media, was elected to membership. Miss Anne Knapp Whitney presented to the Institute a scrap book of Japanese papers, letters, etc., collected by our deceased member, Jacob B. Brown, during his foreign travels. William M. Parker, of Springfield, presented to the museum a "hair ball" taken from the stomach of a cow. The question of its mode of formation was discussed by Dr. Underhill, Charles Potts, C. M. Broomall and others. A description of this specimen was published in the PROCEEDINGS, Volume III, Number 1. T. Chalkley Palmer presented a specimen of tourmaline in quartz, from a quarry near Morgan Station, on Chester Creek, exhibiting "slickensides."

The announcement of the death of Dr. Linnæus Fussell, Secretary of the Institute, on October 28th, 1907, was made. Dr. Trimble Pratt and T. Chalkley Palmer were appointed a committee to prepare a minute expressing the profound regret of the Institute. A biographical sketch of Dr. Fussell appears in this issue of the PROCEEDINGS.

Under the head of scientific business, attention was called to a recent U. S. Geological Report, wherein it was stated that a very pure form of titanium was to be found in Chester County, Pa. The occurrence and use of titanium were discussed by James G. Vail, Charles Potts and T. Chalkley Palmer. C. M. Broomall gave an account of a long series of experiments on flower pigments pointing toward certain interesting physiological conclusions. A detailed account of these will be given in a subsequent number of the PROCEEDINGS. Attention was called to the very scanty chestnut crop of this year as a fact worthy of record in the minutes. An experiment was reported in which a fresh egg yolk, after immersion in alcohol for some weeks, was found to have assumed the consistency of a hard boiled egg and which, dried and exposed to the atmosphere for months, showed no signs of decay.

NOVEMBER 14, 1907. — Adjourned meeting. Lecture on "Blood," by Dr. Ernest L. Clark.

NOVEMBER 21, 1907. — Adjourned meeting. Illustrated lecture, "Nansen's Farthest North," by Prof. George A. Hoadley, of Swarthmore College.

NOVEMBER 28, 1907. — Adjourned meeting. Illustrated lecture, "Over the Trossachs to Edinburgh," Dr. E. D. Fitch.

DECEMBER 5, 1907. — Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. Reading of the Minutes and Reports of Officers and Curators. William S. Ellis, of Moylan, Pa., was elected to membership. The matter of providing fire escapes for the building was discussed and referred to the Board of Curators.

The following minute in memory of Dr. Linnæus Fussell, late Secretary of the Institute, was read and adopted: —

For thirty-five years Dr. Linnæus Fussell was a prominent member of the Institute, and for more than twenty years he performed with conspicuous ability the important duties of a Secretary and a Curator.

He was a botanist of note, and his unusually extensive and accurate knowledge of plants was of especial value to the Institute. Beyond this, his broad-minded culture had made him conversant with all the sciences, and his unaffected sympathies were at the command of all students and lovers of nature with whom he came in contact.

As a member and officer of the Institute, he at all times gave his support to measures designed to promote its welfare or calculated to advance the high purpose for which it exists.

As a physician, Dr. Fussell was held in honor by his fellows for his learning in the science of medicine. Long a resident in this community, he was from first to last a good and useful citizen.

As a man among men, and in all the relations of life, he was alike remarkable beyond most men for high principles of thought and conduct unalloyed with consciousness, for broad and unobtrusive kindness and sympathy, for native and ineradicable modesty. His was a type of humanity rare in any society, and his death brings to the Institute and to the community a sense of distinct and irreparable loss.

The following additions to the library were announced: "Torrey Bulletin" and "Torreya" for two years, presented by Mrs. Hannah B. Trainor; "Smithsonian Annual Report for 1906." Following the business of the meeting a general scientific discussion took place. James G. Vail described the new metallic filament incandescent electric lamps. The question of the illumination of a snow-covered landscape on a dark night, apparently greater than all the light the snow could collect and reflect, was discussed. It was suggested that there might be some phosphorescent action connected with it. T. Chalkley Palmer described some experiments concerning the motion of diatoms in darkness. A full account of these investigations is published in this number of the PROCEEDINGS.

DECEMBER 12, 1907.—Adjourned meeting. Illustrated lecture, "The Genesis and Development of Christian Church Architecture," by Prof. William G. Casner, of the Central High School, Philadelphia.

DECEMBER 19, 1907.—Adjourned meeting. Illustrated lecture on "Brittany," by Elise Whitlock Rose and Vida Hunt Francis.

INSTITUTE NOTES.

This Winter's Course of Lectures before the Institute promises to be a most interesting one. The programme for the year is practically filled, and the lectures so far given have been very successful.

The library of the Institute has been receiving for some time past, through the kindness of William R. Newbold, Jr., copies of the *Canal Record*, a weekly paper published under the authority of the Isthmian Canal Commission. Mr. Newbold is employed in the construction department of the Canal and frequently remembers the Institute in this and other ways.

The donation of Russian peasant toys, presented to the Institute by Miss Anne Knapp Whitney, of which note has previously been made, has proven a most interesting addition to the museum. These toys were collected by the late Jacob B. Brown while travelling in Russia. They are of wood, hand-carved and colored, and apparently represent peasants occupied in their various crafts, with tools, etc. There is also a model of a Russian wagon, with horses and all complete.

In Volume II, Number 3, of the PROCEEDINGS, was published, under the pen of Sanford Omensetter, a description of the "Indian Rock," near Bishop's Mills, this county. It has been reported that there is another rock of similar origin in the neighborhood. If any of our readers have information on this point they will confer a favor by communicating with the Institute.

The Publication Committee is greatly pleased with the reception accorded to the PROCEEDINGS by the scientific world. Its articles have been noted, abstracted or published in full by other journals, all of which goes to show that it fills its little niche in scientific literature quite creditably.

The year 1907 has been most remarkable meteorologically. The late Spring, short Summer and early Winter which we have experienced are worthy of record.

A. Lewis Smith, Esq., of Media, has presented to the Institute a very fine portrait of his father, the late Dr. George Smith. Dr. Smith was one of the five founders of the Institute, who, on September 21st, 1833, signed their names to the constitution. The other four signers were George Miller, Jr., Minshall Painter, John Miller and John Cassin. Dr. Smith was the first President of the Institute, and served continuously in that position until his death in 1882.

Homer E. Hoopes, member of the Board of Curators, has recently left Media for a tour through the West. The members of the Institute are hoping he will have the opportunity to take further photographs of El Morro or Inscription Rock. It will be remembered by our readers that Mr. Hoopes in 1904 took a number of photographs of these inscriptions, copies of which, with translations by Henry L. Broomall, were published in the PROCEEDINGS, Volume I, Number 1. At that time, however, Mr. Hoopes could not finish the work for lack of time, and it is hoped that he will be able to complete the series of photographs now. The article referred to above was recognized by the Bureau of Ethnology at Washington as a valuable contribution to the literature touching upon this historic old landmark and was quite fully noted by it in its publications.

The January programme of lectures promises to be an interesting one. The committee has arranged for a series of four lectures on foods and food adulteration, covering the various aspects of the subject. Four prominent men engaged in pure food work have signified their willingness to speak. In view of the importance of this subject to everyone, the lectures will certainly be opportune.

ERRATUM:

Page 81, line 10 from top — "twelve" should read "sixteen."

OFFICERS OF THE INSTITUTE:

President, - - - -	T. Chalkley Palmer
First Vice President, - -	Charles Potts
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Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

Contents:

PROCEEDINGS

OF THE

Delaware County Institute of Science

Vol. III, No. 3 April, 1908

MICROHYDRA DURING 1907.

BY EDWARD POTTS.

Observations during the year 1907 directed toward the determination of the obvious life history of the most recently discovered and least familiar species of North American Fresh Water Hydroids, *Microhydra ryderi*; — recently discovered, although it was found twenty-four years ago; least familiar; for, excepting Dr. John A. Ryder, no competent scientist, within the knowledge of the present writer, has collected or described it.

FIRST NOTICE.

At the date of the preparation of his first and only published article (*American Naturalist*, Extra, December, 1885, page 1232) Dr. Ryder had not seen the living *Microhydra ryderi*. Later, a full stock was placed in his hands and carefully studied; resulting in the preparation of several valuable drawings, many of which have been used in illustration of other articles; but his lamented death prevented the preparation of such a history and description as the novelty of the animal seems to demand. His only textual reference to *Microhydra* now in my possession forms part of a lecture upon some abstruse subject and says: "The lowest and simplest hydroid yet discovered, the *Microhydra ryderi*, Potts, may throw some light on the question. It is, in reality, the nearest approach to a realization of the typical *gastrula* that has yet been found;" and continues in some detail as to the peculiarities of its internal structure. This was written several months after he had carefully watched the living forms and made excellent sections of prepared specimens. Had he lived, my present and previous attempts in this direction would not have been required.

In the *American Naturalist*, December, 1885, page 1232 (above); same journal, December, 1897, page 1032; in the *Quarterly Journal of Microscopic Science*, Volume 50, Part 4, November, 1906, page 623, and in the *Proceedings of the Delaware County Institute of Science*, Volume II, Number 2, 1907, page 77, a brief history of its discovery, appearance and habits at their respective dates, was given. The writer will endeavor to avoid undue repetition by relating in this only such facts as may seem necessary to make clear the more particular life history noticed during the past year.

HYDRA VIRIDIS, ETC.

The now familiar first Hydra, under its several indifferent specific names, had been known at least since the year 1703—but in 1744, under the name of the "Zoophyte of Trembley," an interest was created in it among zoologists, only, perhaps, exceeded by that excited amongst natural philosophers, a few years later, by Dr. Franklin's discovery of the identity of lightning and electricity, and in the many experiments devised by him and his correspondents.

P. H. Gosse writes: "When in 1744 Abraham Trembley, of Geneva, declared what he had seen of this little fresh water animal, this little ball of green jelly, it was regarded as a thing incredible and even impossible." He quotes from "Johnston's British Zoophytes": The facts "were so contrary to all former experience, and so repugnant to every established notion of animal life, that the scientific world was amazed; and while the more cautious among naturalists set themselves to verify what it was difficult to believe, there were many who looked upon the alleged facts as impossible fancies. The discoveries of Trembley were, however, speedily confirmed; and we are now so familiar with the outlines of the history of the fresh water polyp and its marvelous reproductive powers, that we can scarcely appreciate the vividness of the sensation felt when it was all novel and strange; when the leading men of our learned societies were daily experimenting on these poor worms, and transmitting them to one another from distant countries by careful posts and as most precious gifts; and when even ambassadors interested themselves in sending early intelligence of the engrossing theme to their respective courts."

The discoveries, however, communicated by Trembley that excited most astonishment were hardly such as will appeal to the modern scientist as most important, or even as any parts of the life history of an animal. It may be very wonderful to learn that the Hydra can be chopped into many pieces, longitudinal, transverse or diagonal, and that each will, or may, reconstitute itself an entire worm; or that parts of different individuals can be grafted together, or turned inside out, like the fingers of a glove, and live happily ever after. Such accidents can happen very seldom in real life, and I, for one, am not ambitious that any person shall try such experiments upon the subjects of this memoir. Suffice it that we may learn under what circumstances it lives; how its daily meat is provided; what methods of reproduction are given to it; and the wonderfully true story of the Alternations of its Generations under favorable circumstances; enabling it, without passing through the gateway of a pseudo-death, to break away from its earlier groveling state and assume for a time the free, wandering life of a rover of the waters.

It can hardly be necessary to describe that Hydra, familiar to almost everyone, with its six or more tentacles and its almost infinite powers of extension and retraction, in order to contrast with it the one which is to be my present subject.*

DISCOVERY AND DESCRIPTION.

In January, 1885, *Microhydra ryderi* was discovered under similar conditions to those in which the writer has ever since seen it growing, viz.: lying *perdu* on the surface of rough stones, under the protection of several species of polyzoa — in Tacony Creek, near Cheltenham, Pa. It was found later in a more favored locality — in the Schuylkill Canal near Flat Rock dam, not far from Shawmont station, on the Schuylkill River. When single headed its cylindrical length was about one-fiftieth of an inch; its thickness about one-fifth of its length. It was entirely without tentacles, but the free or head end was crowned with a *capitulum* bristling with from twenty to fifty lasso or thread cells and terminating in a mouth, with difficulty detected (See Plate I, Figure 1). More frequently two branches, terminated by *capitulæ*, were observed connected near the base; occasionally there were three branches, and once or twice colonies of four have been doubtfully noted. It is mortifying to have to acknowledge that in all these twenty-four years I have never once seen the budding or growth of this second or third stem from near the base of the first, although bicapitate forms are much more frequent than single ones. A branch bearing a head will, however, be mentioned a little later.

TWO LOCALITIES DESCRIBED.

Tacony Creek is a shallow mill stream with its shifting bed composed of riffs and shallows, and but few have recently been collected there. Singularly favorable conditions, however, are found at Flat Rock dam, at a place where a continuous influx of water is made to feed several mills further

* Before the latter appeared there had been found one other hydroid in fresh water (Cordylophora lacustris), but its great dissimilarity from either of the others and its striking general resemblance to many of the marine forms, seem to place it in a quite different class.

down the canal. Here, at a depth of six feet or more, a violent current prevents the accumulation of much silt upon the stones and at the same time supplies the favored tenants with an abundance of food.

COLLECTING.

It is no trifling labor to dredge up and recover these stones from the depths mentioned, working from an unstable boat in the last named violent current. The one consoling fact is that we may be positively certain of our game. Seldom indeed is a stone brought up that is not literally covered with life in various forms, Polyzoa, Annelids, Hydroids, Rotifers, etc. I should be "de-lighted," as somebody says, to have other localities of equal promise pointed out to me, for there also, I think, might be found *M. ryderi*. It is desirable to gather many small, thin stones that may be examined in shallow dishes with just sufficient water to cover them, and to pay particular attention to their margins, where the *capitulæ* are often stretched out so as to be illuminated by transmitted light from the mirror below. By an occasional syringing of the surface we may see many other forms by direct light; but it is difficult to reach them with high powers without undue risk to our lenses.

DESCRIPTION OF A-SEXUAL MULTIPLICATION.

The difficulty, or one great difficulty, in studying the life history of this organism seems to lie right here: —As it is not a free swimmer (in its early condition) it cannot follow its prey; and without tentacles it cannot even reach after it effectively and control its victim, without establishing a firm base of support. This, under natural circumstances, is found upon rough stones as described, where it is protected and somewhat hidden from sight of the animals it would catch; who thus crawl over it, unsuspicious of danger, and are paralyzed and caught unawares. From these rough places it cannot be removed without violence, and it remains yet undetermined whether or not it is possible for it even to reattach its pedal disc after removal. We are, therefore, limited to observation by direct light only, unless the larvæ, to be presently described, can be induced to plant themselves upon some transparent support that may either be removed to the stage of our microscope or to which the microscope may be applied.

The initial condition of this larva may be described as follows (See Plate I, Figure 2): A slightly swollen place may be seen at the side of one of the older hydroids involving about one-third of its length, marked at its upper end by a pronounced notch or depression and at the other extremity, less conspicuously, by another, about the same distance from the end of the branch or the point of attachment. The upper notch deepens very rapidly into an evident constriction that progresses sublongitudinally downward, the wound healing as the cells separate, tapering at the lower end, but finally rounding out to become nearly as large at one end as at the other. The gemmation or asexual reproduction of this larva has taken about eight hours.

Agreeing with Dr. Ryder's excellent drawing (Plate I, Figure 2) from a median longitudinal section, and with my own diagram (PROCEEDINGS OF THE DELAWARE COUNTY INSTITUTE OF SCIENCE, Volume II, Number 2, Figure 7), it must be noticed that though the position of the larval bud is, from the first, well marked at *both* extremities, as limited to the middle third of the hydroid body, the actual constriction begins at the frontal end of the larva; destined, Dr. Ryder says, to become the *capitulum* of the new hydroid; that the larva increases in length during segmentation, and, near the proximal end, tapers gradually in a somewhat ragged fashion, the parental tie continuing as a hair-like thread, until the last cells have parted, when this extremity becomes rounded out, leaving also the wounded side of the parent as perfect as ever (See Plate I, Figures 3—7).

If its birthplace has been upon the upper surface of a stone it may, when liberated, become entangled in, or protected by, the overgrowth of Polyzoa, etc., during the time required to perfect its organism, while forming a *capitulum* and terminal mouth at one end and attaching the other by a pedal disc to the same surface that has supported the parent. If, however, its starting point in life has been upon the overhanging edge of a stone, we may often see the liberated larva hanging from it by an invisible thread, probably of mucus, until a momentary current in the water of our culture jar drifts it against the glass, where by the same suffusion it is held slightly, while traveling *evidently but invisibly*, if the expression may be allowed, during its larval growth into a state of ability to feed and nourish itself; when a pedal disc becomes requisite.

AS SEEN UPON THE SIDES OF A JAR.

We here have it in one of the positions suggested for examination — not ideal, of course; — the glass is curved and of uneven thickness; reflected light must come through another curved surface with six or more inches of impure water intervening; the supporting base of the hydroid also intervenes between our lenses and the branches, whose structure and contents we want to examine; these are, of course, frequently turned directly inward and away from our lenses; and, worse perhaps than any other, impurities may lodge upon the mucous coatings of the hydroid and hide what we might otherwise see; but it is the best we can contrive until some one designs small aquaria with flat, smooth sides, with which we can replace our culture jars. If these could be secured of such dimensions that they could be used upon the stage of our microscopes or in front of them, we should be content. At present we have to study our friends where they place themselves, in common jars, not fruit jars, but what are far better, candy or confectioners' jars (often called specie jars), — and then build up a "microscopic observatory." A description of this may be allowed. Removing the mirror bar with its substage fixtures from our instrument we bring down the tube into a horizontal position and run the objective in use through the opening in the stage. A series of solid blocks must now raise the eye piece to the level of the eye of the observer, and another "Eiffel tower" must be built up, on which the particular jar wanted must stand, and must be laboriously adjusted with blocks and books to suit the exact height of the selected atom that is to be examined.

THE EARLY MOVEMENTS OF THE LARVA BEFORE ATTACHMENT

My recent journal reads: "July 3rd, 1907. The microscope was last evening directed toward a bicapitate microhydra, and we were surprised to find this morning in close proximity with it, a larva that had undoubtedly been liberated at some time during the night, although no hint of it had been noticed the evening before. As there was now no interfering debris I watched this larva for a long time with the highest powers I could use, trying to discern its mode of motion, but without success. Yet it was easy to see that it had moved, and that with considerable speed, in a comparative sense, as was shown when an eyepiece micrometer was used. The minor divisions of the scale were passed much faster than I had expected, and while I did not succeed in determining any certain line of progress, the changing curvatures of its extremities conveyed the impression that it was following a simple wave line, controlled by a very deliberate bending of one end and then the other, that had an effect like that of *pseudopodia* in dragging or pushing the only half animate body in *some way* to *some where*. Certainly there were no cilia, flagella or other external organs, and the supporting surface of the glass was never abandoned."

The time during which they remain in this immature, larval condition is quite uncertain. I have generally placed it between one and two weeks, having made many efforts to determine this, with its several points, by stenciling their positions upon the sides of my jars and measuring the distances moved during definite periods, but have failed to discover any certain rule or fact except that they do move out of any given optical field with some rapidity, but by the use of what machinery I have not determined. My earliest observations of twenty-four years ago, as recorded in a note book, frequently refer to the crenulations of the ectodermal surface near the extremities. One note in particular reads: "Numerous cell outlines appeared and disappeared, swelling and contracting like the lobose *pseudopodia* of amœboids;" another entry runs, "there is a constant amœboid change of shape in the surface cells of the ectoderm, as well as a slight writhing, expansion and contraction of the whole, so that their change of position is quite obvious from one night to the next."

A FEW SIGHTS WORTH RECORDING.

In describing a marine hydroid, also without tentacles, found off the coast near Ostend by Dr. Greef, of Bonn, he speaks of a "homogeneous cuticula" covering the basal part of the ectoderm of *Protohydra*; and something similar may been seen in the drawings made by Messrs. Bourne, Parsons and Fowler of the fresh water hydroids examined by them in London, supposed to be the antecedent of the medusa, *Limnocodium sowerbii*; but I am far from convinced that anything of the nature of a "tubular habitat" can be properly associated with the structure of *Microhydra ryderi*. In common with snails and many worm-like forms there is a mucous excretion from their bodies, and while fixed in position upon stones, etc., this necessarily gathers about it particles of silt and other refuse matter that come in contact with it. This, in time, may accumulate to some depth around *M. ryderi*, but it is altogether adventitious, and the tube or mass is not utilized as a place of retraction, for protection, as is the case with many worms, rotifers, etc. Here, on the glass, the larvæ and young hydroids are for a long time quite clear and transparent; but after feeding a while in the same place, it would seem that the rejected matter thrown out through the mouth is apt to find lodgment upon this excretion around the place of support, and there to attract many of the lower Protozoa, Rhizopods, Trachelomonads, etc., to enjoy this "predigested food," and, adding to it their own remains, they together form quite a serious obstruction to a perfect view through a microscope.

To the presence of minute living Protozoa, *Microhydra* seems entirely indifferent, but when Rotifers of a rather larger size begin to browse over their bodies, we notice the first evidence of sensibility, at least in the upper third of its length. As soon as that height is reached, it has been observed that the *capitulum* is deliberately curved toward the enemy (or the desired victim) and, if it happens to be particularly stupid, the trespasser is caught and swallowed; but if, alarmed, it turns away, the *capitulum* is also returned to its former position of watching. The point I make is this, and it is a first step towards explaining the mystery, heretofore felt, as to its ability to catch its prey. It has not been actually seen, but is clearly inferred, that the moistened, everted lips, shown in one of Dr. Ryder's drawings, lick up, as it were, the small prey and draw it into the beginning of its downward course.

AS TO ITS FOOD.

It is now found necessary to change entirely the description heretofore given of the nature of this hydroid's food supply and the method by which it is captured. I have generally compared it to a starveling dog with open mouth catching at any crumbs that might fall from the rich table spread above it by its abler-bodied neighbors. That must all be taken back, and you may now picture it, not as snapping at crumbs, but, as a Scriptural passage says of a very different animal, "The young lions do roar after their prey, and seek their meat from God." I have never actually heard it roar, to be sure, but have no doubt the source of its supply is the same as is the others'. It is no longer hungry and snarling, as a dog over a just discovered bone, but vigilant and watchful; lying *perdu*, perhaps, but with head erect and fearless, where we have now placed it ready to catch a gnat and at least attempt to "swallow a camel."

On a former occasion a hydroid had been seen in the act of swallowing one of the largest class of *Anguillulidæ*, probably much longer than itself, that slipped down its gullet, dissolving as it went, suggesting the similar disappearance of a stick of candy in the mouth of a small boy. On June 29th, 1907, while glancing over some mature hydroids that had fixed themselves upon the side of a jar, attention was drawn to a *something* drawn into, or exuding from, the mouth or *a* mouth of a bicapitate form, that at once claimed closer study. Removing the jar to the "microscopic observatory," I discovered that my hero had actually captured one of the setigerous worms that had been frequently seen crawling or swimming around it, and that was now disappearing *descensus averni*. A movement in one of the lower sections of the captured worm proved to be a little turtle-backed rotifer, still living. It had been swallowed by the worm before its own capture, and was now being pushed backward by the narrowing gorge it was approaching until it was eventually forced out through the vent of its first captor with life and strength enough to go on its way rejoicing.

June 30th. The microscope and jar were left in position over night, and the first peep through them this morning showed the two heads in a condition of quiet watchfulness, soon to be rewarded by the capture and deglutition by the *same* branch of a similar chætopodal worm; the whole of which action I watched until its completion, one and a half hours later. This worm, like the other, had been, in its extended condition, much longer than the branch of the hydroid that "took it in," and about one-half its diameter. When first seen it lay in front of the hydroid, reaching toward it with extended head, and, immediately upon touching one or more of its palpocils, the spasmodic jerks that followed the injection of poison were not successful in liberating it, although I could not see that it was then held by anything stronger than the lasso threads of the poison darts that had pierced it.* In a few moments, however, the everted lips had grasped the projected head of the worm; then more energetic struggles were again ineffective to release it, and its doom was evidently sealed.

In about fifteen minutes the stomach proper was reached, and as I continued to watch, group after group of the *podal setæ* disappeared from view, although life was manifested by a squirming motion, more particularly of those portions of the worm not yet absorbed, but now shrunken to one-half or less of its formerly extended length, bringing the groups of *setæ* into close proximity to each other. In this case, as before, an imprisoned rotifer, still living, was forced backward by the narrowing orifice and liberated in the same way, but without then showing any signs of life.

The interposed pedal disc, supplemented by a mass of accumulated debris, precluded the possibility of determining with certainty whether the stomach passage is continuous throughout the two branches of a bifid hydroid. This is presumable, however, from our observation of the change in shape and opacity of the inactive half during engorgement by the other; and was almost, if not fully, confirmed the next morning by the sight of quantities of indigestible *setæ* that had been disgorged through *both* mouths of the hydroid, accompanied by other rejected matter, more or less granular. Their position and appearance are shown in Plate I, Figures 3 and 4.

July 1st. The opacity of both branches of this *Microhydra* very gradually diminished as digestion proceeded, with the exception that at one place, near the attachment of the more active branch, it was noticed to continue and for a while even to deepen, indicating a coming change. The inauguration, at that place, of the growth and final liberation of a larval bud,

* Query — Do they have any tensile or retentive power?

during a period of about eight hours, I have attempted to show by a dozen drawings, from which the following have been selected: Plate II, Figures 3 to 7.*

July 4th. After searching for a colony enjoying better light and exposure, I selected a bicapitate pair rather favorably placed and so transparent that I feared they were suffering from lack of nourishment, so endeavored to supply fresh meat by transferring to this jar some of the setigerous worms seen in another. Returning after a short absence, I found the head at my left hand busily engaged in swallowing one of the largest of these worms, whose free end writhed in vigorous efforts to escape. I need not dwell upon the disasters of this campaign. Its final result was determined when a line of transverse fission was reached and the latter end of that worm, too large for the hydroid to swallow and more fortunate than the first, broke off and crept away to renew, if needed, the part it had lost. (See Plate II).

July 5th. On examining the hydroid this morning, I find *both* branches gorged with food particles, and have clearly seen at *each* everted mouth the slender *setæ* known to have been swallowed by but *one* of them, as appurtenances of the above described worm, now disgorged (Plate I, Figures 3-4).

July 7th. A new subject was placed before the microscope, selected on account of the unusually bloated appearance of both branches of the hydroid. The constant discharge of digested matter from both mouths convinced me that the creature had been overfed and was suffering from surfeit; and the further appearance of *setæ* at both mouths made it probable that this colony, also, had like Luther, been entertained at the "Diet of Worms." At 7 o'clock a. m. I saw the early condition of another larva which has, at 1 p. m., been fully separated from the hydroid.

Another observation recorded late in October presents our

*My attention has been called to the fact that this mode of reproduction seems often to follow closely after excessive feeding.

subject as a victim where before he has been a victor in many combats. Desiring to supply nourishment to a tricapitate form, I injected into his jar some slimy deposit from a piece of board floating on my lily pond, and was rewarded almost immediately by seeing that two of the *capitulæ* had each captured a *Rotifer vulgaris*. The third branch seemed indifferent about food; perhaps it was sufficiently nourished through a common digestive tract uniting the whole. While the feast of rotifers was going on, a swarm of their late companions, introduced with them into this new locality, crowded around the *Microhydra*, darkening its middle portions, to taste of the predigested food that there adhered. These proved to be an undetermined species of *Trachelomonas*, that, though intruders, were not dangerous. Then a third rotifer was so imprudent as to allow himself to be trapped by the third *capitulum* and held. Another "Richmond" now "appeared upon the field," a dozen — fifty or more, crowded around the helpless rotifer like so many ravening wolves or hyenas, from whom, if he had been himself free, he could have easily escaped. The fierce determination of these, and their barrel-like markings, left no doubt in the minds of the observers that they were *Coleps hirtus* (?), the only protozoan I know, so vindictively personal in its attacks, which evidently express, "We have come to devour you, and to do it now." Well, they quickly reduced the rotifer to a mass of pulp, and began upon his late captor, who was as powerless to resist them as the other had been. One, two, three heads succumbed and soon lost their characteristic outlines, when I felt called upon to lend a hand to my friends. I first scattered them by a few puffs from a ball pipette; but seeing them again gathering to continue their feast I began a war of extermination which, I am happy to say, was more effective than that which has been waged by this community against the English sparrows. Wherever a trace was seen of the material in which they were introduced, it was drawn up and discharged; and I have not seen a *Coleps* since. I am pleased to be able to state that

M. ryderi has "saved its face," all three of them, in fact, and seems now as able to "roar after its prey" as ever. I am happy to be able to state that the hydra recovered.

ONE SINGLE MEDUSA DURING 1907.

Still another extract from my note book, though of earlier date than that which has been already recorded, seems to have its appropriate place here. I have told what I have seen this year of the life history of *Microhydra* and its asexual multiplication by means of larval hydroids. The single opportunity of the year, of witnessing the growth of a true *sexual* bud and the liberation of a free swimming *medusa* remains.

In the *Quarterly Journal of Microscopical Science*, Volume 50, November, 1906, Plate 46, Figures 15 and 16; and in the *Proceedings of the Delaware County Institute of Science*, Volume II, Number 2, Figure 5, is shown all that has already been illustrated of the initial stages of these buds. Under date of September 16th, 1897, I find the following remarks, written in my note book *apropos* of the observations that had been made ten days earlier: —

"Several points remain to be observed — such as the first appearance of the medusoid bud; its gradual enlargement, including the prolongation of its pedicle; its condition at the first opening of the distal extremity; the relation of the first pulsating movement to that opening; the formation and development of its eight tentacles and its final separation from the hydroid body." It continues: "The distal surface of the unopened bud, at least above the line of the future marginal canal, appears closely covered with thread cells. When first seen, a single tentacle is found at the junction of each radial canal with the marginal canal, and four more at points midway between these pairs. These eight tentacles appear nearly or quite of equal lengths, and to be developed, not by longitudinal growth or prolongation, but by radial segmentation from the surface of the disc. A close examination will, I think, show this distal surface to consist of two distinct membranes, of which the inner becomes the *velum*, and the outer, dividing from the marginal canal towards the centre into eight portions, gathers into these the thread cells, that are, afterward, found so abundantly upon the tentacles."

It is possible that a few medusæ were seen after their first discovery in 1897, say in 1898 or 1899, but no opportunity was found for such observation as was above suggested until May 16th of last year. On that morning a bud was doubtfully suspected, watched during that day and the next, and by 9 p. m. of the 17th the evidence of a coming medusa became convincing. Yet its position on the side of a jar, and in relation to the other members of the group was not such as made possible the determination of the first two points named above. The "microscopical observatory" had not, at that date, been devised, and the best we could do was to stand the jar upon a pile of books before a Welsbach gas light and examine it with a Coddington lens or, later, through the tube removed from a compound microscope and laid across another pile of books.

This was the situation when, at 9.30 p. m., five of us determined not to lose sight of it during the night; wherefore one or more were continuously on the watch until 6.30 a. m, of May 18th. The first differentiation of parts had appeared about 9.30 p. m., May 17th, and all hands took part, though without artistic skill or scientific training, in recording what we saw, by drawings, the most characteristic features of which I have here preserved. (See Plate III, Figures 1 to 8). An examination of them will show the first recognizable feature to have been the *manubrium* at the proximal extremity of the bud — bearing upon its summit a circular or spherical figure more or less complete in every figure, though variable in size; whose meaning must be left to elucidation through other specimens. Above or beyond this there was always a light-cavity of varying size and shape; and, almost from the beginning, transverse lines were to be seen at the distal end of the bud, suggestive of two membranes; and, still more faintly *longitudinal* lines that *ultimately* resulted in becoming the radial canals. From 12.45 a. m. of May 18th, and persistently thereafter, the innermost of the transverse lines mentioned gave convincing proof that it was to be the *velum*, including the marginal canal and circular aperture; and a few minutes later every observer noticed more or less distinctly, upon the outer membrane or surface, radial lines diverging from the apex or crown toward the position of the marginal canal, adjoining the *velum*. From 2.15 a. m. the approximately circular outline of the medusa changed to a pear shape, widening, with nearly straight sides, from the proximal to the distal end; and the faint lines of the radial canals became more marked. About 4.30 a. m. pulsation or throbbing of the *velum* was observed; at first a pair, one, two; then, say a half minute later, *one;* a pause, then, one, two — one, two, and so on, very irregularly; and thus continued, perhaps increasing in force until 5.30, when the *velum* with its aperture could easily be seen distended, pressing up against and separating, at 6.20, the segmented tentacles as shown in two excellent drawings by Miss C. W. Beekley, *as she saw them*, parted, as when an orange is peeled from any central point down to an equatorial line, and then forced upward by internal pressure.

I know not what other observers may have written as to the formation of the earliest tentacles in marine medusa; but all our night watchers unhesitatingly agreed that my impressions of ten years ago had been proved correct, in relation to this species of fresh water forms. Of course, my theory assumes that the wider portions of these wedge-shaped segments contract or, as it were, roll up upon themselves so as to form the nearly cylindrical tentacles. I place great weight upon the simultaneous appearance of the whole eight, without the slightest suggestion of longitudinal growth.

The throbbings of the *velum* continued irregularly after the last drawing was made, finally liberating the medusa about 9 a. m. of the same day (May 18th). Two days had passed since the first determination of the bud, and the liberated medusa lived but two days longer, so that this specimen did not secure us any better sight of possible sense organs than had those seen ten years before.

While I am far from presuming that a complete life history of this interesting organism, in its hydroid phase, has been supplied by our observations during the past year, I think that much has been learned as to its larval gemmation and mode of feeding; and some progress has been made towards a full discovery of the development of the medusa bud and the liberation of the free-swimming medusa of this genus.

It is no cause of astonishment that announcements are frequently made of the discovery of fresh water medusa in new localities, as Africa, Japan, Washington, D. C., etc., but so far as I am aware none other have been traced back to their derivation from a hydroid phase — which should give this paper additional importance.

EXPLANATION OF PLATES.

The subjects of these plates have been greatly but very variously magnified, and of course nothing can be learned by comparing them.

PLATE I.

Figure 1. As drawn this represents a mature, bicapitate Microhydra. Either end with the base may be understood as representing its single upright condition when first attached, when it measures about one-half a millimetre, or one-fiftieth of an inch, in height; (b.) is the base or pedal disc; (c.) the capitulum crowned with lasso or thread cells. When mature it most frequently branches near the base, becoming about one millimeter, or one-twenty-fifth of an inch, from end to end. A third or fourth branch is sometimes seen.

Figure 2. A highly magnified median section (by Dr. J. A. Ryder) showing the initial condition of the larval bud, or asexual larva, (l.b.) of this hydroid occupying about the middle third of its length.

Figures 3 to 7. Show the serial changes in size and position of the larval bud (l.b.), as seen during seven or eight hours, until the helpless larva (l.) drops off and drifts away as described.

Figures 3 and 4. Show at both the oral extremities where they have been disgorged, and in groups over other surfaces, the indigestible setæ (bristles) of worms, the hydroid has recently been seen to swallow.

PLATE II.

Shows the Microhydra, as it has frequently been seen, swallowing or attempting to swallow, worms (w.) far larger than itself;—in both these cases failing to "stomach" the whole worm, it broke off at a natural line of transverse segmentation, when the unburied "remains" escaped alive, or dead.

Figure 4. A very small hydroid had captured by the head a worm apparently a dozen times its own length and nearly its own diameter: how much had "gone down" when first seen we could only guess, but probably a full meal for both branches; but the remainder of the worm wriggled around until its tail was caught by the other head, after which a long battle was waged, whose result remained problematical until a transverse segmentation, as in the former case, released the hinder part of the body, which ultimately broke loose near the tail, and the headless and tailless worm "lapsed into obscurity."

PLATE III.

Consists of a series of Figures, 1 to 8, representing the gradual development of a sexual medusa bud, observed by a party of five persons during the night of May 17th-18th, 1907, as sketched by them at the hours marked. Attention is called to the pendant manubrium (m.) running through the whole series;—the somewhat diagrammatic radial canals (r.c.) connecting with the marginal canals (m.c.), 3 to 8,—and particularly to the radial segmentation of the distal surface (d.); also visible throughout the series from 3 to 8, and eventually forming the "eight tentacles (t.) simultaneously," as a result of the throbbing pressure against them of the velum (v.) connected with the marginal canal.

PLATE IV.

Figure 1. Is a copy of the drawing made of the medusa (m.) seen at about the same age attained by the last described, about ten years ago.

Figure 2. Is a copy of the medusa bud (m.b.) at an early stage of its development at the same date.

Figure 3. Is a sketch of another Fresh Water Hydroid (h.), probably the fourth in order of discovery, found (three or four of them) upon one of the stones from Flat Rock dam; parasite upon a rhizome of the polyzoan, Pottsiella (Paludicella) erecta, and strongly suggestive of a marine form described by Sars (Rhizorgium roseum), found on the Baltic coast of Denmark.

Figures 4 and 5. Progressive stages of the development of the summer ovum of the same Pottsiella erecta, Kraepelin.

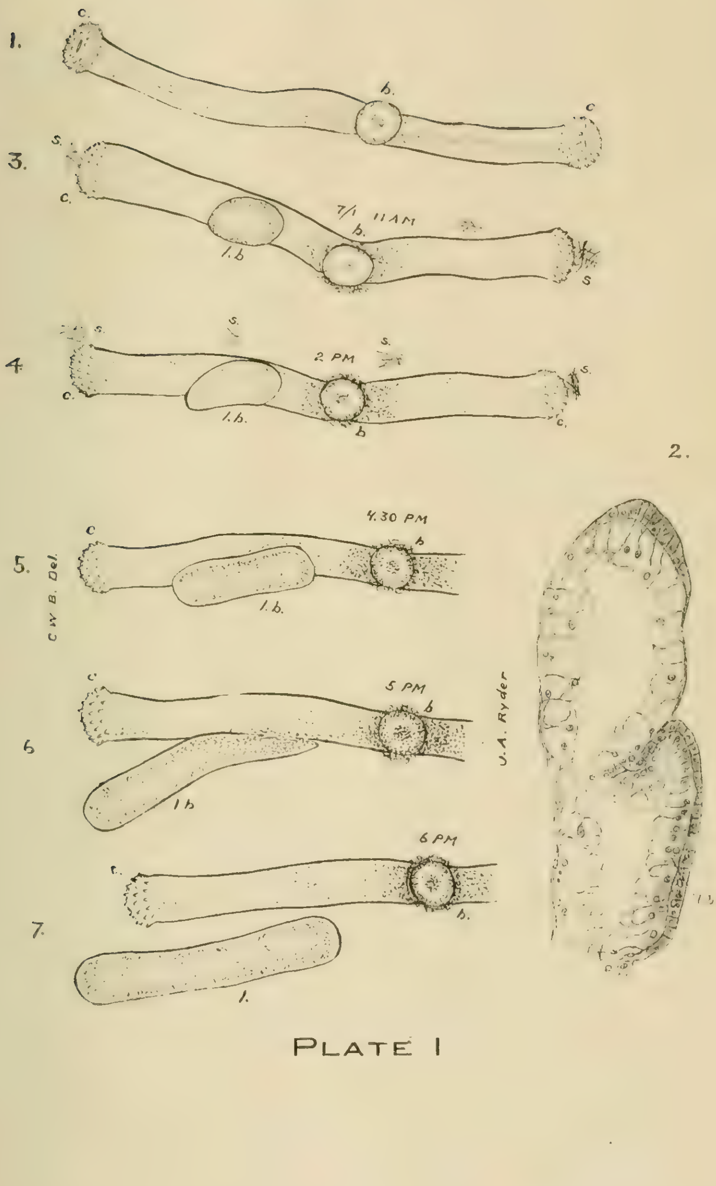
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PLATE I

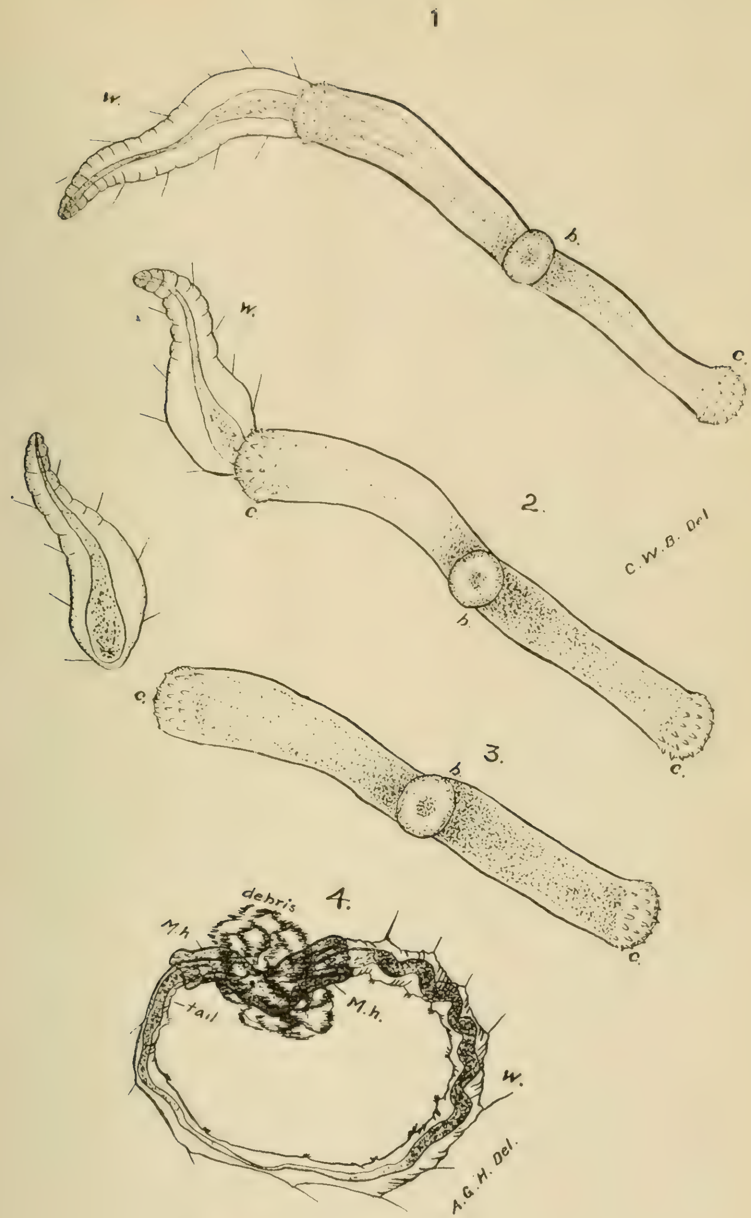
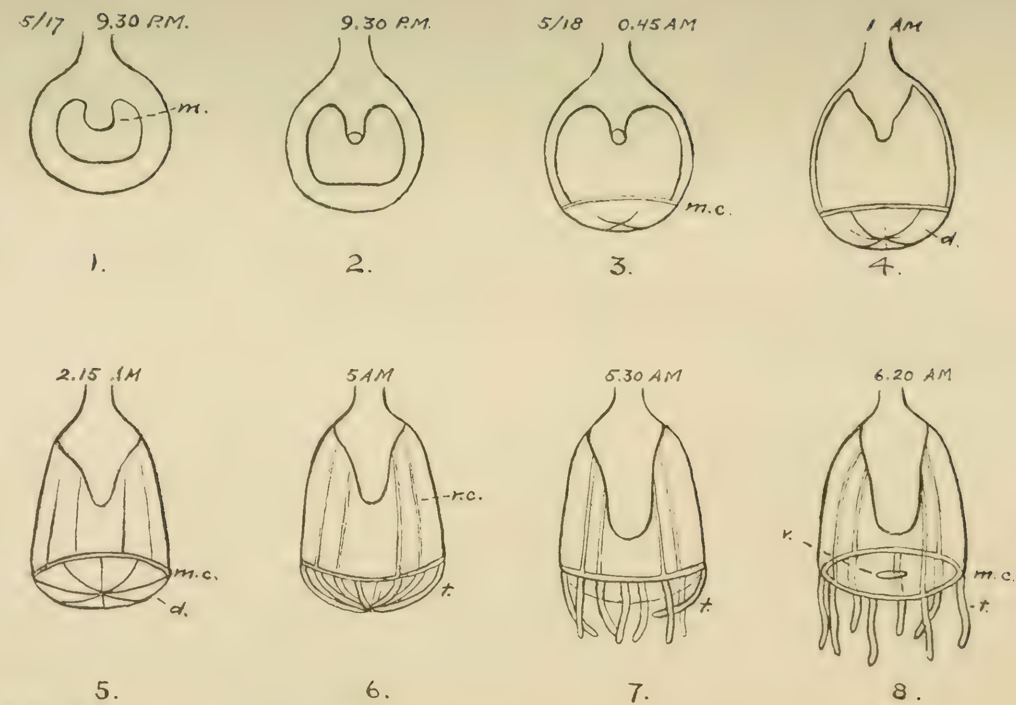


PLATE II



C.W.B. Del.

PLATE III

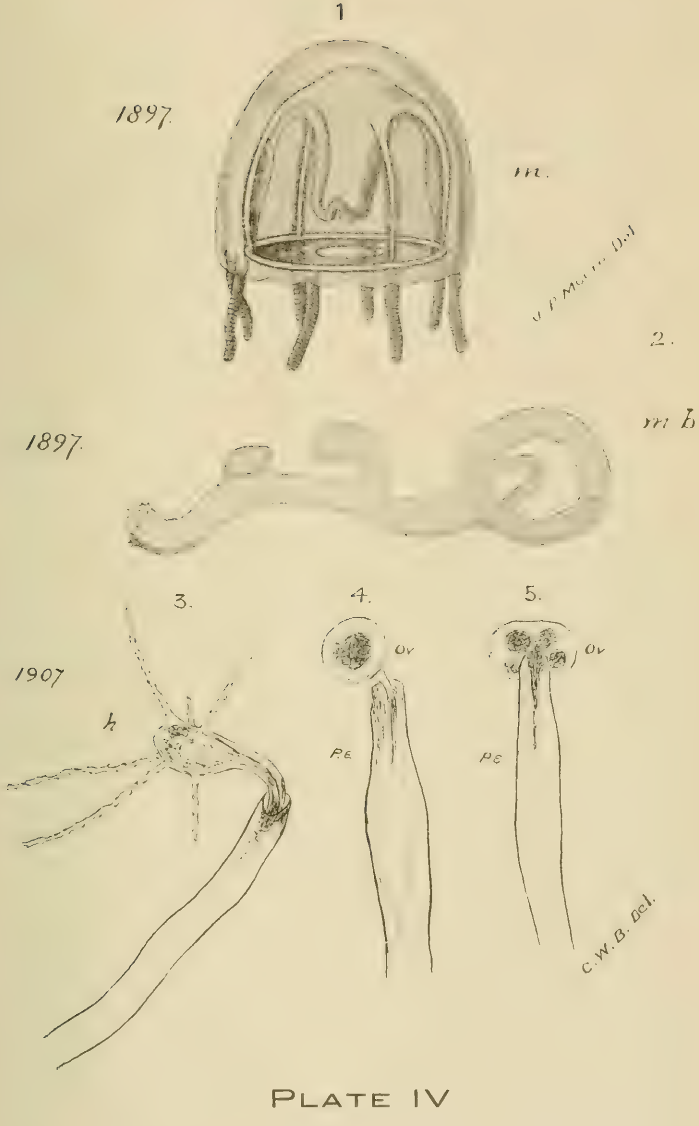


PLATE IV

SOME PHENOMENA OF COMPRESSED AIR IN RELATION TO ORGANIC LIFE.

BY THOMAS B. WHITNEY.*

The purpose of this paper is to describe some of the phenomena of air under high pressure, in relation to animal and plant life.

There is some question as to the date when compressed air was first employed in submarine work, and in sinking caissons through water bearing strata for foundations, etc., but in 1839 it was used in France, on a considerable scale, to reach a seam of coal under the River Loire, a caisson being sunk through the river bed. It has long been used in operations of divers working in suits and in diving bells, though the latter appliance is now but little used.

Of recent years it has been employed upon a very extensive scale, on three great works of construction in the United States — the St. Louis Bridge, the Brooklyn Bridge, and the system of subaqueous tunnels now approaching completion under the waters of New York harbor. While engaged upon the latter work, the writer passed some thousands of hours under varying degrees of atmospheric pressure, and had an opportunity to note some phenomena which may be of interest to the Institute.

The gauges used upon caissons and tunnel locks read zero in normal air, so that all pressure is recorded in pounds to the square inch, above normal. Thus a reading of 20 pounds means 20 pounds above normal air pressure. The number of atmospheres in the caisson or tunnel heading therefore = one atmosphere + gauge reading.

In laying the pier foundations of the St. Louis Bridge the pressure under which work was carried on exceeded + 50 pounds to the square inch, or somewhat more than four atmos-

* Mr. Whitney was an inspector of shield driving and work on the Penna. R. R. tunnels under the Hudson River for one and a half years.

pheres. On the work of the Brooklyn Bridge, the pressure exceeded + 36 pounds to the inch, and on much of the subaqueous tunnel system of New York it has ranged from three to four atmospheres. The time during which men can be safely subjected to such pressure is very limited.

Air being a gas composed as follows:

	Nitrogen	Oxygen	Argon
By Weight,	75.5 per cent.	23.2 per cent.	1.3 per cent.
By Volume,	78.06 "	21.0 "	.94 "

and the rate of respiration being little if at all changed in compressed air, it is evident that the lungs take in three to four times the normal amount of nitrogen, oxygen and argon, and we have as a result a peculiar and little understood disease, known as "caisson disease," or more commonly, "the bends." Many men are subjected daily to compressed air and enjoy entire immunity for months, or years; others experience it whenever subjected to pressure for any length of time, while the majority of workers have it slightly at considerable intervals of time.

It is caused largely by emerging too rapidly from compressed into normal air. The attack usually begins a few hours after coming out, though there are many cases in which it comes on almost at the moment when all pressure is removed.

The symptoms are confined almost entirely to the nervous system, beginning with neuralgic pains in the knees and arms in mild cases, and in the trunk in severe ones. In the latter case, paralysis of the motor nerves is likely to follow if the patient is not promptly treated. The most efficacious method of relief is to at once put the subject in air of about the same pressure as that from which he has emerged, and then withdraw the pressure at the rate of about one atmosphere per hour. For this treatment an iron room is provided, furnished with sofas, electric light, clock and pressure gauges. The door closes upon a rubber gasket, and a thick bull's eye of glass serves as a window. This room is connected with the compressors in the engine room, and can be flooded with air as desired.

The pathology of this disease is very obscure, and there are a number of theories as to the way in which the air acts upon the system. One theory is that it is caused by excess of oxygen in the tissues; another that it is excess of nitrogen, and one French physician claims to have demonstrated the presence of bubbles of nitrogen in the blood of a caisson worker.

Another theory is that owing to the great waste of tissue from the active oxygen, the system is unable to eliminate this waste and a poisoned condition is induced. It is well known that the specific gravity of the urine is very high in cases of "bends."

Still another idea is that congestion of blood in the internal organs is the prime cause, and in this connection it may be said that a *post mortem* examination of a patient has disclosed a necrosed and crumbly condition of the spinal cord.

Full blooded and fleshy men are much more readily attacked by this disease than those having little adipose tissue.

In spite of the strain upon the lungs, there is a case on record of a man with a large cavity in one lung, who improved under caisson work, and the writer has heard of cases of asthma which improved under it; also of men prone to rheumatism who never suffered while in compressed air; and who were in time cured by long continued work in it. It may be said, however, that most diseases are greatly aggravated by compressed air, but a strong constitution can be safely exposed to it daily for months or years, if great care is taken to put no strain upon the system while in normal air, and to considerably increase the time given to sleep.

Baldness is greatly benefitted by compressed air. The writer has in mind two young men, who upon beginning work were almost bald, but after about a year of regular work in high pressure had quite a thick growth of hair.

The activity of the oxygen is strikingly shown when smoking in high pressure, flames often spurting from a cigar or pipe, which is consumed with great rapidity. Fire in a caisson or tunnel heading where there is timbering, is a very serious accident, as if once started it is almost impossible to extinguish it.

The acoustic effect is to deaden sound, the waves not vibrating freely in highly compressed air. This effect begins to be noticeable at about two and a half atmospheres.

In survey work, involving sighting from normal into compressed air, or from one pressure into another, through the plate glass portholes of the locks, a marked degree of refraction is experienced.

Among other phenomena, is the very rapid growth of fungi, and other forms of vegetable life, upon wood, or on wet mud. It is probable that a crop of mushrooms could be raised with great rapidity under three or four atmospheres.

Rats from time to time get into the empty cars sent from the surface of the earth and are shot through the car-locks with great rapidity. In the tunnels they breed and so long as they can get food from portions of dinners left by the workers, they seem as active as upon the surface. After living a few weeks or months in the pressure, they are found to die, when the "air" is lowered to normal pressure. Formerly mules were worked in caissons and tunnels under "air," but the more economical application of electric and pneumatic power has superseded them. On removing animals from a pressure in which they had lived for days or weeks, it was customary to take from 12 to 24 hours to bring them out, and to give them oats soaked in whiskey, before entering the lock.

The human eye takes on a remarkable brilliancy in highly compressed air, the pupil and iris suggesting the glitter of polished metal. This may be due to conditions of circulation.

As the intensity of pressure is increased, the worker's time in it must be decreased. In extreme pressure, from forty-five minutes to two hours at a time is as much as can be safely allowed, with some hours of rest before again entering.

Care is taken nowadays that pure air is drawn into the compressors to be discharged below. Formerly there was great carelessness in this respect, the air being drawn from the engine room frequently, and containing dust and impurities. The air should be taken from out of doors and at some height above the streets.

Among the many nationalities working upon the New York tunnels, the Negro and Slav are most frequently to be found, and they show great physical stamina and adaptability to the work. The Italian is very rarely found working in compressed air. This may be owing to the fact that the life necessitates the consumption of much nutritious food and increased expense of living, which he is unwilling to incur, even for the increased pay, or it may be that his livelier imagination invests the mysterious medium with exaggerated terrors.

Through the many tunnels under New York waters there will be passing daily and nightly an enormous stream of travel, for within a radius of twenty-five miles of the City Hall the population is now between five and six millions, and growing at a rate which no other great city has ever equalled. In affording transit facilities to this focus of the United States, the machinery and material would have availed nothing, had not "the air" served as a dam and wall of defence against the undermined rivers, to the workers beneath the river bed.

THE PINE LANDS—THEIR FLORA AND FAUNA.

BY SARAH C. HILLMAN.*

The expression, "Down in the Pines," to many simply implies far-off, desolate regions, insignificant, unproductive—except for discomfort, and hence unworthy of a second thought. What a pitiable misconception! The innocent ignorance of such a conclusion challenges one's sympathy. Admitting the variety of tastes, certainly, among the pines, the most fastidious person would not lack objects of interest, both numerous and instructive, far more than enough to remunerate him for a journey of a few miles to their habitation.

One need go no further than Clementon to be in the edge of the great pine belt of southeastern New Jersey, which, in Camden County, includes Winslow, Atco, Jackson, Blue Anchor, etc.

In the pine belt are the uplands, the light, dry, sandy soil of which is adapted to the growth of the pine; the savannas, which will not produce timber; and the swamps. Most of the streams of the pine belt are fringed with cedar swamp, varying from a few feet to miles in width. There are also thousands of acres of mixed pine and deciduous swamp.

The pine family belongs to the order *Coniferæ*, and comprises some of the most important timber trees, and the principal evergreen trees of northern climates.

Surprises constantly await the traveller among the pines. The variety, the abundance, and the *négligé* arrangement, as it were, charm by their harmony and naturalness. Here are brooks, pools of uncertain depth, and great lagoons of inky water. Here, too, is the delicious spring, to animate the sight-seer's drooping aspirations. Half-hidden by the tangled undergrowth, and silently wending its secluded path, is the quiet stream. Fed and expanded by springs and tricklings from the porous sand and gravel, the streamlet finally emerges

* Of the Haddonfield Natural Science Club.

from its solitude, and to the wonderment of the observer presents a broad and beautiful river.

Scattered throughout the pines are the remains of a once famous industry, the manufacture of iron from bog ore, or limonite. These ruins are seen in the vicinity of streams and bogs. Much charcoal was consumed by these forges. With their failure the manufacture of charcoal faded, and with it the value of coal wood. But coal pits in active operation are still in the pine belt. At Florence, in Camden County, a large tract has recently been cleared, and the wood is being used for charcoal purposes.

Among the pines, then, we have not only swamps and cranberry bogs, but villages, towns and farms. Cedar Brook is a clearing among the pines; so are Hammonton and Vineland. In Chemung Township, Burlington County, there is a tract of a thousand acres, cleared and cultivated, right among the pines. The soil is as noted for its fine agricultural products, as the surrounding forests are for the abundance and variety of first class game.

The genus *Pinus* belongs to the gymnospermous, or naked seeded family, the less abundant class of the exogens. The true pines are readily distinguished by their leaves and their cones. Their branches are whorled at regular intervals, and bear needle-like leaves, united in groups of two, three or five by a short sheath enclosing their base. The leaves remain on the stem two or three years before falling. The flowers of the pine are monœcious; that is, male and female flowers are found in separate catkins, but on the same tree. The males occur in spikes at the base of the new shoots of the season, and the females are solitary or in clusters at the ends of the boughs. The fruit is not matured until the second year after the flowers. The cone takes a year to ripen; it is composed of woody scales, thickening toward the top. Each scale of a pine cone is an open pistil, bearing, on the inner side of its base, two naked seeds, furnished with membranous wings, which aid in their dissemination. The wind is the agent by which fertilization is effected, for it conveys the pollen directly from the stamen-bearing flowers to the ovules. The new annual shoots of the pine continue to grow for a second year, if not longer, to contribute to the growths in length as well as thickness. The leaves, being evergreen, absorb throughout the year the carbonic acid from the atmosphere and assimilating the carbon, return to the air pure oxygen.

The pines are found mainly in cold and temperate regions, and mostly make compact forest growths. In size they range from a few feet to three hundred feet in height. The pines of New Jersey, however, range from low bushes to about seventy feet in height. Owing to deterioration by forest fires, the pine timber in New Jersey is often small and stunted, as in the Jersey or scrub pine, *Pinus virginiana* or *inops*.

Southeastern New Jersey was originally covered with pine, the inferior soil being occupied by pitch pine, *Pinus rigida*.* The leaves of this species are dark green and grouped in threes. The resinous wood is reddish yellow, covered with rough, blackish bark, and the cones have stout, prickly points.

The short leaf, or yellow pine, *Pinus echinata*, occupies the better soil, in partnership with various hardwood species. Owing to the prevalence of destructive fires in the pines, but few original forests remain. The most noted of these in Camden County is at Winslow, where the pine is in patches

* During the Civil War the North was unable to obtain the necessary naval stores, for which ship chandlers were willing to pay immense sums. The natives of Southern New Jersey took advantage of this and collected great quantities of fat pine knots, from which they made tar. This was quite a profitable industry in the vicinity of Tuckerton. An old timer from that section recently described the modus operandi: — A large basin was constructed, from which a small trough or channel led into another receptacle, and the whole affair was carefully cemented with a composition of sand, loam and clay. The pine knots were piled in the large basin in a cone-shaped stack and covered with soil, sod, etc., similar to the preparation of a charcoal pit, and then lighted at the top. The tar oozing out passed into the bottom of the basin, thence through the channel into the receiver, from which it was collected.

and scattered over the tract. Trees here reach the height of 85 feet, and are from 120 to 200 years old.

There is also another tract of 18 acres at Blue Anchor, belonging to Mr. Duble, of Cedar Brook, who owns several hundred acres of swamp and clearings in this section. This is a forest of dense growth, "a silent sea of pines," the trees varying from 50 to 70 feet in height. There is considerable of pitch pine, but the yellow variety predominates. Here are also the red, black, white, chestnut and pin oaks.

The large timber is being cut and hauled to Cedar Brook, where the owner's saw mill is kept busy with orders more numerous than can be filled. Here, as by magic, the tall, straight cedars and pines, one by one, are transformed into bundles of smooth shingles and enviable piles of charming, golden lumber.*

Pausing to think, the question arises, Why are the pines where they are? The science of paleobotany helps to solve the problem. The paleobotanists draw their conclusions from fragments of wood, impressions of leaves, flowers and fruits imbedded in rocks, and beds of coal. Ernest Bruncken, in "North American Forests," remarks that, during Tertiary times, vast forests composed of trees similar to those now growing in the United States, existed in high northern latitudes where now nearly everything is covered with ice and snow. The warm climate of the Tertiary age was succeeded by the Glacial period of the Quaternary epoch. The great glacier, joined by those flowing down from the mountains of the West, moved southward till it reached the latitude of Cincinnati, and beyond was covered with an immense thickness of ice. Before the ice and the cold temperature the forests succumbed, and many species were either extinguished

* In New Jersey there are 2,424,931 acres of cleared upland, 2,069,819 acres of which are in forest. In Camden County there are 66,588 acres of forest, which is about 48 per cent. of the upland area of the county, the coniferous occupying the eastern and the deciduous the western part.

or restricted to more northern latitudes. After thousands of years the ice melted, and as the land was laid bare, vegetation recovered the lost territory. On the barren ground left by the ice, at first only mosses and sedges appeared, and gradually these were supplanted by the forest spruce and poplar, slowly coming up from the South. Then followed the pines, and these were succeeded by maples, oaks and others. While the forests were advancing northward, the different species struggled with each other for particular localities.

Certain conditions are necessary for the life and growth of all trees alike. They must have moisture and they must have light. Light is essential to enable the leaves to elaborate the inorganic substances brought by the roots from the subsoil, which are deposited on the surface in the leaves or twigs.

The fact that a certain species is always found in one locality does not prove that it will not flourish elsewhere. If given a chance, the magnolia, golden rod and others, are only too glad to adorn one's garden.

In every pine wood are suppressed trees of some kind, whose presence is due to birds or squirrels. Just as soon as the pines are cut, and they receive more light and room, they grow rapidly. Trees are driven into environments by their competitors; they compete, not only with their own kind, but with different species. Interesting instances of this were seen at Blue Anchor. In one case, four pitch pines about 40 feet high had come up from sprouts around the huge stump of the parent tree. Each seemed to claim the place of the old landmark, and we left them all standing straight up for their rights. In another place a mammoth black oak and a pine were in close proximity. Evidences of a prolonged strife were here visible. By more rapid growth, doubtless, the broad leaves of the oak had sheltered the seedling pine till it became established, when the latter, claiming absolute ownership, had spread its lateral branches in the endeavor to crowd out this early friend. Failing in this, it had divested itself of all unnecessary covering, and shot upward, till towering many feet above its rival, it spread out waving branches far and wide from the summit.

One meets many eccentricities in the pine forest. The conifers are generally contented among themselves, and never seem too thick to thrive. Like a well-regulated family, their aspirations are high, and each one seems disposed to make the best of its opportunity. But the pines are exclusive, and they have a music of their own. "The soft and soul-like sounds," of which Coleridge loved to sing, render their groves enchanting, and naturally, any element foreign to their own, disturbs the melody.

In the northwestern part of New Jersey is what is known as the deciduous zone; in the southeastern, the coniferous; while in an irregular line between them, extending from Long Branch to Salem, is the tension zone. In the tension zone the flora of the other two meet and overlap, and a constant strife is waging for the ascendency. Although favorably situated by environment, the deciduous species show a tendency to travel southward, while the coniferous, equally well situated, tend to move northward.

Where a hardwood forest has been cleared, pines and cedars have been known immediately to occupy the ground. Under the changed condition of a heavier soil and freedom from competition, they flourish, until driven out by the reëstablished angiosperms, whose numbers far exceed their own. For the same reason, when the pine lands are cut off or burned, deciduous trees spring up, regardless of the sandy soil, which, however, is never too barren for the scrub oak.

The area of the pine is constantly decreasing, while that of the deciduous tree is increasing. Away back in the closing scenes of the Triassic period, when the vegetation included immense forests of ferns, conifers and palms, great physical changes occurred along the eastern coast of North America. There was a slow subsidence of the southeastern area of New Jersey, during which large quantities of land vegetation disappeared, of which the pines constituted the greater part. A changed condition of the soil of later formations seemed favorable to the growth of the angiosperms which, at the present day, exist in the ratio of five to one, as compared with the gymnosperms. This subsidence seems to have been the first great set-back to the pines in New Jersey.

The pine has a lower position in the biologic scale than the deciduous trees, and not only has been crowded out by them, but, by more aggressive varieties, has been driven into environments unsuited to its proper development. There are many reasons for the disappearance of the pine. Fifty years ago it was largely used in the iron industry of New Jersey, over 6000 acres being cut annually for this alone; then the amount used for sawed lumber, as well as for charcoal, was equally great. In more recent years, repeated forest fires have well-nigh completed the work of destruction among the pines.*

The white oak, *Quercus alba*, so common among the pines, is known by its light-colored bark. The leaves are deeply

*According to the Annual Report of the State Geologist, between April and September of 1902, sixty-five fires occurred in fourteen counties, in which 98,850 acres of timber land were burned over, with a total damage estimated at $168,323. But one of these fires was, however, in Camden County, and that was near Winslow Junction in April of the above year. Locomotive sparks set fire to 400 acres of pine timber, 50 years old, the average loss being $15 per acre — total, $6000.

Throughout the pines there are German, Italian, Russian and other foreign colonies, and many of the most destructive fires have been caused by these people in clearing their farms. Where fire frequently burns the surface litter and hinders the growth of forests, the soil finally becomes sterile and lifeless, from the fact that the organisms in the soil, causing decomposition of humus and the preservation of nitrogen, are killed.

Fires also destroy the game and its food supply as well as cause an increase of insects and produce general unhealthfulness, aside from the loss of wood and the crippling of industries depending on it. Pitch pine can resist fire to a great extent and recover after severe injury. The short leaf pine is also able to resist fires, but recovers less readily. It is the thick, corky bark that protects these trees; it may be burned till fairly charred, and yet the living part of the tree will not be injured. Young trees suffer most, however, on account of their thinner bark.

The chestnut oak flourishes luxuriantly in the shade of the pine.

divided, the straight veins extending from the midrib to the margin. Like the pine, the oak puts forth two kinds of flowers, the pistillate and the staminate. In the pistillate flowers, each ovary has three stigmas and three cells, with two ovules in each; but in ripening only one of the six ovules becomes a seed. The fruit of the oak is the acorn, a one-seeded nut, fixed in a woody cup or involucre. Under the oak at the time of flowering are found acorns of the preceding year in different stages of germination. The two cotyledons, to extricate themselves, burst the shell, thrust forth their petioles, with the plumule to grow upward and the radicle to grow downward. The acorn ripens the autumn following its flower; the seed is well-flavored and eaten by both man and beast. They are abundant, always yielding a fair crop, and sometimes an immense one. The wood of the oak, when split into thin slivers, is an excellent basket material. Baskets made of oak are noted for their strength and durability.

Nut galls are produced on the leaves and twigs of oaks, by the puncture of insects depositing their eggs. On the leaves they are usually spherical or marble-like, but they differ in size and texture; sometimes they are quite solid, with thick walls, and again they have paper-like coverings, and are filled with loose tissue. Through the outer covering, in time a series of pointed processes appears, each of which is a larval cell, and from fifty to a hundred larvæ sometimes form a large gall. Galls also occur on the roots. Most of the orders of insects contain gall makers. The Hymenoptera, or wasp family, do a great deal of injury.

One theory for the growth of the gall is that there may be some virus deposited with the egg, or that the irritation caused by the larva, which lives in the gall till it is developed into an insect, causes it.

Leaving the bitter galls, let us turn to the sweet flora of the pines. On the edges of the uplands, we find almost the same variety prevails as in the swamp; the hickory, sassafras, gum, birch, maple, wild cherry, cedar, magnolia, spruce poplar and others are seen. But in the interior, where the trees are all pine, the flora is more limited. In the Blue Anchor tract, the writer saw four varieties of the huckleberry, the blueberry, the blue and black seedy berries and the dainty sugar clusters, all at home among the pines. The teaberry and the arbutus were half hidden by the pine chats, while the pipsissewa, both green and striped, was more obvious.

Chicken grapes were numerous; one vine had clambered to the top of the highest pine, at whose base, in a bed of velvety moss, close by a famous mushroom, was a whip-poor-will's shoe. Sweet fern lost its charm, when, too late, alas! it was discovered to be the habitat of a species of the *acaridan arachnids*, which to us, in simpler language, meant legions of seed ticks.

Everywhere the cow wheat seemed to welcome us; it is a low branching plant, with small, greenish-yellow, solitary flowers in the axils of the upper leaves. The calyx is bell-shaped and the corolla is two-lipped. It is exceedingly common among the pines, seeming as much at home there as the trees themselves. In the mixed portions of this forest was the kill-calf, noted for its fantastic roots; also the laurel, holly and wild plum.

In a small, cleared area were lichens, sedges, Indian grass, wood violets and daisies of every size and hue.

Among the birds of the pines are the pheasant, flicker, woodpecker, jays, warblers, finches, quail, owls and crows. The chewink was abundant. The blue heron and other water birds are in the vicinity of streams, where the angler enjoys a chance at the famous pickerel. The raccoon, squirrel, mink, opossum, weasel, toad, turtle and mice are here; also lizards and snakes without number, especially the water snake and the pine snake, well known tenants of the pine lands.

Among the insects is the moth, which kills the growing twigs; the scale insect, that sucks the plants' juices; the weevil, whose larvæ bore into the wood of pine trees, and others far too numerous to mention.

Since pines are more easily affected by these enemies than hardwoods, mixed forests have been found an advantage.

In considering the pines, it might, perhaps, appear like an oversight to omit the mosquito. Conscientiously unable to say anything in its favor, we think it best to add nothing to increase the prejudice already existing against this truly impressive creature.

WEIGHTS AND MEASURES.

BY JACOB B. BROWN.*

The question of weights and measures is more closely allied to the study of astronomy than is generally supposed, and the object of what is to follow is to set forth the connection between the two.

Without going into the long and most interesting history of the matter in other parts of the world it will suffice to say that the systems of measure best known are the French and the English — the metre and the yard.

The French reduced their confused and varying system to order by getting the length of the earth's quadrant — the quadrant of the meridian of Paris — and taking the ten millioneth part of the same as the metre. The metre is divided and multiplied decimally; and from it all measures, linear, superficial and cubic, are derived. So likewise weights: — by weighing under certain carefully recorded conditions and circumstances the distilled water contained in a cubic centimetre, calling that weight a gramme, and making it the unit.

But the quadrant could not have been measured without a knowledge of astronomy, while the details of the operation fall under the head of measurements.

The original earliest English standards of length were the barley corn, or grain of dried barley, three of which laid lengthwise were an inch; and the cubit or elbow, that is, the distance from the elbow to the shoulder. This varied in different places and at different times, the average being about eighteen inches. The "King's foot," Henry I, his foot, if Blackstone say truly, was called twelve inches, and his arm from breast bone to tip of middle finger was called thirty-six inches or one yard.

We must suppose that in course of time a standard yard

*Paper read before the Physical Section of the Institute by our deceased member, Jacob B. Brown.

was manufactured with every possible care and skill, and without regard to cost, so that it should, under certain recorded and easily reproduced circumstances, measure what was to be called a yard. In short, a standard yard. One-third of this was to be called a foot; and one-twelfth of this was to be called an inch.

But the standard might be lost in the vicissitudes of things. So to make it recoverable the length of a pendulum vibrating seconds *in vacuo* — 62° Fahrenheit — latitude of London — at the sea level — was determined. The standard inch was contained in this pendulum thirty-nine times and thirteen hundred and ninety-three ten thousandths of a time (nearly). That is to say, the pendulum was 39.1393 (nearly) inches long. Now set a sum in Rule of Three: —

$$39.1393 : 1 = 1 : \text{Ans. } .02555$$

That is to say, further, that the pendulum length was divided into one hundred thousand equal parts, and two thousand five hundred and fifty-five such parts were taken for an inch.

Twelve times the inch is the foot, three thousand and sixty-six ten thousandths of the pendulum length; and three times the foot is the yard, or nine thousand one hundred and ninety-eight ten thousandths of the pendulum length.

And thus the original unit is recoverable.

It requires fairly good eyesight to read the hundredth part of an inch on the scale, and the hundredth part is divided into ten thousand parts again to get the millionth part. But the magnifying power of optics and the excessively minute subdivision obtainable by delicate machinery, together with the appliance called the vernier, are made substitutes for increased power of perception. Accordingly I am informed, generally, that the Board of Trade has instruments which deal readily with the ten thousandth of an inch, and which can read off the one hundred thousandth. There are also, it is said, instruments — requiring, however, special precautions and great skill in the using — which will take account of the millionth of an inch. These statements the writer accepts in childlike confidence, but of his own knowledge he knows nothing of them.

The standard of length, then, being a known portion of a length which beats seconds, depends upon the standard of time.

The old, original standard of weight was, as in the case of length, the grain of dried barley. It varied, of course, but gradually took a value.

To get a fixed, recoverable standard, a cubic inch of rain water was weighed under recorded circumstances — latitude of London — sea level — *in vacuo* — 62° Fahrenheit. In short, precisely the same as in the matter of the pendulum. The weight was 252.722 times that of the grain in use.

Which means that when the weight of a cubic inch of water, as above, is divided into two hundred and fifty-two thousand seven hundred and twenty-two equal parts, one thousand such parts is a grain.

Seven thousand grains, that is, seven million such parts, were called an Avoirdupois pound, and the pound was suitably subdivided. The standard thus fixed is recoverable if lost in the vicissitudes of things.

The measure of weight depends upon the measure of length, which depends upon the measure of time, whose unit is one second.

Now, what is a second ?

Everything else left out of the question, the earth revolves once on its axis in an invariable space of time, marked by the return of a star to the meridian. This is called a mean sidereal revolution of the earth. The word is "invariable," and there is as yet nothing to show that we may not understand the word in its fullest sense. This space of time is divided into twenty-four hours, each hour into sixty minutes, each minute into sixty seconds ; in all, 86,400 seconds. The second, then, is the eighty-six thousand four hundredth part of the earth's mean diurnal, sidereal revolution, and it is an immutable unit. But it is not the unit that is used, for it is not convenient.

Owing to the movement of earth in orbit it comes to pass that supposing the sun and a star to be on the meridian together on a given day, the sun will, on the next day, come to the meridian some time behind the star. The difference is rather less than four minutes and varies according to various circumstances. For convenience it is imagined constant, and a "mean solar day," in reality 86,635.96 mean solar seconds long, is called an even twenty-four hours, and the 86,400th part of this is taken as the second of common life. It is one sidereal second and two hundred and seventy-two one hundred thousandths of a sidereal second (1.00272).

This second is told off by one beat of the pendulum spoken of above. It is the second of common life, of clocks and watches—the standard second, permanent, invariable, because it bears a known proportion to a quantity which is permanent and invariable.

The original unit, then, is the mean sidereal second, or 86,400th part of a mean sidereal revolution of the earth on its axis. From this is derived the mean solar second, the invariable standard unit of time; which gives us through the pendulum the standard of length, and through length the standard of weight.

The existence, moreover, of any record, however rude, of the lapse of time, implies some knowledge of the heavenly bodies and their motions, since by them only can time be measured.

In view of this, it seems not too much to say that human transactions are regulated by the stars in their courses.

But the stars move in their courses as God bids them.

THE SPELLING OF CLASSICAL NAMES.

BY HENRY L. BROOMALL.

For some years past writers on classical names have exhibited a tendency to ignore the established Latin spelling of Greek names and to attempt a closer literal representation of the Greek spelling. Hence we have *Hektor*, *Isokrates* and *Lukourgos*. These changes seem to play mainly upon *k* for *c*, *ou* for *u*, *os* for *us*, and *ai* for *ae*. In these days of universal reading and writing, the written form of a word is a matter of practical importance. Many words have no other life. The average citizen reads and understands many words that he cannot pronounce correctly. It behooves those who make sweeping changes in familiar forms of words, thereby rendering them less promptly apprehended by the mind, to show good reasons therefor.

All reasons for this orthographical reversion, so far given, are one at bottom, namely, that thereby these names are more correctly spelled.

But if correct spelling consists in writing the names of men and things as the men themselves and the men who use these things spell or spelled them, then there is a deal of spelling in need of reform. Without undertaking to formulate what shall determine correct spelling, we may still adduce some objections to this particular reform.

And first, it is historically incorrect. Our letters are Latin letters. In the course of time, from their first introduction into English use, Latin methods of spelling have more and more predominated. For instance, the long surviving Runic sign Thorn at last gave way to *th*, *cw* (as in *cwean*) to *qu* (as in *queen*), and *hw*, a phonetically correct digraph, gave way to *wh* in analogy with and under the influence of the Latin forms *th*, *ch* and *ph*. That part of the English vocabulary which is of Greek origin, introduced mainly by the Church, the scholiasts and the scientists, comes to us in Latin dress—spelled with Roman letters and pronounced by Roman rules of accent. Are we to go back now and change all these words, or are we to write *Hektor*, the proper noun, and *to hector*, the verb?

Again, this reform cannot be consistently carried out. Call Hector again! Would Ἕκτωρ recognize himself in *Hektor*, and yet know not *Hector?* Is it consistent, is it worth while, to substitute a *k*, in semblance of the Greek, for a *c* which has been sanctioned by English literature so long, and yet leave untouched the Latin-English *H?* Are we to give up the digraphs *ph*, *th*, *ch* and *ps* in Greek words and go back to ϕ, θ, χ and ψ? Must we vary the form of *e* so that some belated Greek shade may be able to discriminate between η and ϵ? Are we to give up *Bacchus*, which everybody knows, and lay ourselves open to an appearance of being too intimately acquainted with the jolly god's ways by writing him down as *Bakchus*, *Bakchos* or *Bakχos* — or how?

In fine, the Latin representation of Classical Greek names is sanctioned by the uses of good literature, by the consistency of its process, by its conformity to our own methods of spelling Anglicized words of Greek origin, and by the spelling and consequent pronunciation of so many such names already a part of our modern literary culture.

MINUTES OF MEETINGS.

JANUARY 2, 1908. — Regular Monthly Meeting. Reports of committees and curators. Additions to the Library were announced as follows: "Annals of the Royal Observatory of Belgium," "Annual Report of the Missouri Botanical Gardens." Announcement was made of the Mid-Winter Meeting of the Delaware Valley Naturalists' Union to be held on January 25th, 1908. At the close of the business portion of the meeting discussion of general scientific topics took place. Lewis Kirk gave some interesting statistics concerning the weather. T. Chalkley Palmer gave an account of certain frauds in connection with the transmutation of metals and described the production of an allotropic form of silver that had the appearance of gold. Dr. Underhill presented a very perfect specimen of trilobite. Mention was also made of a supposed Indian Rock in this neighborhood, and it was suggested that the Institute investigate the matter.

JANUARY 9, 1908. — Adjourned Meeting. Dr. George H. Woolfolk, of the local office of the United States Bureau of Animal Industry, at Chester, presented a paper on "Some Facts Regarding Tuberculosis of Food Producing Animals and Practical Meat Inspection." This was illustrated by specimens, and was the first of a series of four meetings on pure food.

JANUARY 16, 1908. — Adjourned Meeting. Lecture on "Patent Medicines in the Light of the Pure Food Law," by Dr. I. V. Stanley Stanislaus, Professor of Pharmaceutical Chemistry in the Medico-Chirurgical College of Philadelphia.

JANUARY 23, 1908.—Adjourned Meeting. Lecture, "The Question of Pure Milk," by Dr. J. Clinton Starbuck, Media.

JANUARY 30, 1908. — Adjourned Meeting. Lecture, "The Administration of the Pure Food Law," by Prof. C. B. Cochran, of the West Chester State Normal School. Specimens illustrating adulteration were exhibited.

FEBRUARY 6, 1908. — Regular Monthly Meeting. Reports of committees and curators and routine business. A motion was passed directing the curators to take up the matter of providing the hall with fire escapes that would comply with the requirements of the law. The following additions to the Library were announced: "Report of Smithsonian Institution for 1907," "Smithsonian Quarterly Miscellaneous Collections." Sanford Omensetter presented to the Institute two salamanders that had been caught in the cellar of the hall. The subject of the occurrence of coal clinkers in stoves and the conditions governing their formation was discussed by Robinson Tyndale, T. Chalkley Palmer, James G. Vail and others. The question of the resistance of the air to flying bodies, such as rifle balls, was discussed, and attention called to the wave of compressed air preceding the projectile in its flight. Report was made of a recent explosion of powder mills at Gibbstown, New Jersey, and T. Chalkley Palmer and others discussed the question of high explosives and their peculiarities. C. M. Broomall called attention to a peculiar rustling sound that followed the first shock in the case of the Gibbstown explosion, which, it was thought, might be in some way due to the summation of little echoes as the great sound wave rushed across country. Sanford Omensetter called attention to a recent motor, which, its exploiters claimed, was operated by carbon dioxide.

FEBRUARY 13, 1908. — Adjourned Meeting. Illustrated lecture, "Sicily," by Dr. Alice Rogers Easby.

FEBRUARY 20, 1908. — Adjourned Meeting. Lecture on "Esperanto, the International Language," by Prof. A. M. Grillon, of the Central M. T. High School, Philadelphia.

FEBRUARY 27th, 1908. — Adjourned Meeting. Lecture, "A Study in English," by Prof. L. H. Watters, Principal of the Media Public Schools.

MARCH 5, 1908. — Regular Monthly Meeting. Usual routine business and reports of committees and curators. The curators reported progress in regard to the matter of fire escapes for the building. Additions to the Library were announced as follows: Three bulletins from the New York Botanical Gardens, "U. S. National Herbarium Report, Volume X, Part 6." Following the business session the usual scientific discussion took place. A specimen of broken ballast stone, picked up along the railroad track, was exhibited, showing most interestingly the process of weathering which the stone had undergone previous to being broken open. For the depth of some half an inch from the surface the stone was reddish brown, while the inner portion was black, the line of contrast between the two colors being very clearly marked. The question of the glowing of the eyes of certain animals in the dark, for instance, the eyes of the cat, was mentioned, and the question of whether it might be due to phosphorescence suggested. The prevailing opinion seemed to be, however, that it was due to reflection entirely. Mention was made of the appearance of prismatic colors obtained by looking at bright stars through an opera glass kept in rapid motion up and down. These colors were supposed to be caused by chromatic aberration of the lenses. Photographs were exhibited of a luxuriant growth of fungi occurring accidentally on the gelatine pad of a hektograph. The meeting closed with a lengthy talk by Henry L. Broomall on "Esperanto," given in response to a question as regards the possibilities of this and other artificial languages.

MARCH 12, 1908. — Adjourned Meeting. Illustrated lecture, "An Evening with Burns," by Dr. E. D. Fitch.

MARCH 19, 1908. — Adjourned Meeting. Illustrated lecture, "The Sensitive Movements of Plants," by Dr. J. M. Macfarlane, of the University of Pennsylvania.

MARCH 26, 1908. — Adjourned Meeting. Lecture, "Citizenship," by Hon. Isaac Johnson.

APRIL 2, 1908. — Regular Monthly Meeting. Usual routine business, reports of committees, officers and curators. On motion the curators were authorized to erect steps at the back of the building so as to provide the hall with another exit. This being the meeting designated for the nomination of officers, the following members were respectively put in nomination : —

President, T. Chalkley Palmer;

First Vice President, Henry L. Broomall;

Second Vice President, Charles Potts;

Secretary, Dr. B. M. Underhill and Prof. L. H. Watters;

Treasurer, C. M. Broomall;

Librarian, Henrietta K. Broomall;

Curators, Edgar T. Miller and Homer E. Hoopes.

Under the head of scientific communications report was made of the occurrence of an aurora borealis visible on the evenings of the 26th and 27th of March. These displays were of short duration and occurred about the same time on the respective evenings. Dr. Pratt called attention to the recent rather unusual occurrence of a thunder storn in winter prevailing off and on all one day accompanied by an easterly wind.

APRIL 9, 1908. — Adjourned Meeting. Illustrated lecture, "Consciousness in Micro-organisms," by John G. Rothermel, of the Wagner Free Institute of Science, Philadelphia.

APRIL 16, 1908. — Adjourned Meeting. Lecture, "The Meaning of Evolution," by Dr. Jesse H. Holmes, of Swarthmore College.

APRIL 23, 1908. — Adjourned Meeting. Lecture, "My Little People and Their Work," by E. L. Pratt, bee keeper, of Swarthmore, illustrated with bees and appliances.

INSTITUTE NOTES.

The Institute is fortunate in this number of the PROCEEDINGS in being able to publish another article on Fresh Water Jelly Fish, by Mr. Edward Potts. In Volume II, Number 2 of the PROCEEDINGS a previous article by the same writer appeared, and the two together make a most valuable contribution to the literature of the subject. The paper in the present number is devoted especially to observations of the life history of the organisms made during the year 1907. The results of Mr. Potts' work during this past year are of great importance, and despite the technical character of the subject will be read with interest by all. Most of the drawings are original and are now published for the first time.

On the evenings of March 26th and 27th there were visible in this locality displays of aurora borealis, of which note should be made. These lights appeared for about the same length of time, say fifteen minutes, and at about the same time in the early evening of the days in question. The displays exhibited practically the same phenomena: — vertical or slightly radiating shafts or rays of light, constantly changing, and with more or less rapid motion from east to west; color of the light white; brightest centre of illumination to the west of the rays, which latter seemed to originate to the eastward and moved westward until lost in the uniform stronger centre of light. A peculiarity in both instances was the presence of low-lying dark clouds to the north, from behind which the rays of light could be seen to dart upward. The two days in question were typical of auroral conditions, the sky during the day being hazy and more or less streaked with cirrus clouds. A relation between cirrus clouds and the aurora seems to be well recognized, although what its nature may be is not known. That the black clouds referred to above had any relation other than accidental to the displays, however, seems doubtful.

With this month, the Winter's Course of Lectures before the Institute comes to a close. The meetings have been well attended and much appreciated by those present. The Institute takes this opportunity of extending its cordial thanks to those lecturers who have, at no small trouble to themselves, aided it in its work during the past year. The complete list of formal lectures delivered before the Institute, in addition to those cited on previous pages of this issue, includes:

"Blood," Dr. Ernest L. Clark;

"Nansen's Farthest North," illustrated, Prof. George A. Hoadley;

"Over the Trossachs to Edinburgh," illustrated, Dr. E. D. Fitch;

"Christian Church Architecture," illustrated, Prof. William G. Casner;

"Brittany," illustrated, Miss Vida Hunt Francis.

One of the naturalists of the Institute calls to mind a method of trapping bumble bees which was much in vogue in his boyhood days. This consisted in placing an ordinary stone jug, partly filled with water in the vicinity of the nest. Of special value was this device while mowing grass in swampy situations. The passing bees, perhaps taking the unoffending jug for an enemy, would dart into its open mouth and drown themselves. This may not be the proper explanation of the phenomenon, but as to its success as a bee catcher there is little doubt. Perhaps some of our readers have a better explanation to offer.

Mr. William R. Newbold, Jr., of Ancon, Canal Zone, has recently sent to the Institute a number of very fine photographs of the customs and manners of the people in Panama. The pictures show phases of life now rapidly disappearing, and later on will become valuable from a historical standpoint.

In the Institute Minutes of January mention is made of a so-called Indian Rock located on the property of Casper S. Garrett, on Crum Creek, in Newtown Township, Delaware County. In this connection, a self-appointed committee of the Institute investigated the matter in pursuance of the suggestion of the meeting. The committee ascertained that the rock was originally found in Crum Creek and was afterwards removed to the lawn surrounding Mr. Garrett's residence. The rock is in the shape of the frustum of a cone, about three feet high, with a hole vertically through the middle of it, and is unquestionably of artificial workmanship. It is said by old millers, however, that somewhat similar stones were used in the mills of olden time, a fact which points to the conclusion that the stone was not fashioned by the Indian, but by some early settler of this locality. This conclusion is supported by the fact that in the creek near where the stone was found there are certain remains which might well be those of an old mill.

Dr. J. Miller Kenworthy, a member of the Institute, has just returned from a tour through Italy, Sicily, France and England. He spent considerable time in Italy and has many interesting things to recount of that country. In speaking of Venice he says that the Campanile of St. Mark is being reconstructed and at present has reached the elevation of about the second story of an ordinary house. In Volume I, Number 3 of the PROCEEDINGS there was published an article by our deceased member, Jacob B. Brown, treating upon this most interesting historical landmark. The Campanile is supposed to have been built some time in the tenth century. It fell on July 14th, 1902. Its height was 98 metres. It is intended that the new structure shall duplicate the old as nearly as possible.

Homer E. Hoopes, Curator of the Institute, has recently returned from a Winter spent in California and the West. No doubt he comes back with a fund of information with which to enliven the meetings of the Institute.

Officers of the Institute:

President, - - - -	T. Chalkley Palmer
First Vice President, - -	Charles Potts
Second Vice President, - -	Henry L. Broomall
Secretary, - - -	
Treasurer, - - - -	Carolus M. Broomall
Librarian, - - -	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

Vol. III, No. 4 July, 1908

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OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

T. Chalkley Palmer, Chairman; Henry L. Broomall, Trimble Pratt, M. D.

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OF THE

Delaware County Institute of Science

VOL. III, NO. 4 JULY, 1908

NAPLES.

BY JACOB B. BROWN.*

The unit of arc of the 40th parallel is decimal seven-six-six.

This compact statement is for those whose way of life has brought them to an understanding of it. The little explanation which follows is for whom it may concern.

What is meant is that the degree of longitude on the equator is to the degree of longitude on the fortieth parallel as one thousand is to seven hundred and sixty-six; from which it results that if one travel on the equator from the meridian of Media, 75° west of Greenwich, to the meridian 14° east of Greenwich, he will traverse 6148.12 statute miles; but if he make the crossing on the fortieth parallel he will have only .766 of this distance to go.

Accordingly, if I could rub yonder lamp and summon Aladdin's djinn or genie, I might bid him instantly transport our building and all us with it due east 4709 miles and then north sixty-nine miles and eight one-hundredths of a mile, and we should find ourselves right in the midst of some of the loveliest scenery in the whole world — namely, in the Bay of Naples, just between Capri and Ischia.

The time which is now here (say) eight o'clock in the evening would be then and there one fifty-six of to-morrow morning. If we were really there we would be glad enough

* Deceased.

to wait for morning to reveal the sight of Capri — the Siren Rocks, Sorrento, Vesuvius, with Herculaneum and Pompeii at its foot — the hills to the northward and eastward, crowned with St. Elmo and all fringed with white Naples, and so around to Cape Misenum and tall Ischia in the order named.

Now, I have set out this common place stuff, not as you may well suppose, for the sake of being witty, but in order to have something by which to remember the exceedingly useful little fact with which I began a moment ago ; namely, that the degree of longitude on parallel 40 is to the degree of longitude on the equator as 766 is to 1000 ; or, more simply, and quite near enough for all practical purposes, the degree of longitude at forty is in actual length four-fifths of what it is at the equator.

Just as a man ties a great, big, blundering, lumbering tag to his little key, lest he lose it.

Naples accordingly bears, nearly enough, due east from where we are, distant in round numbers 4700 miles.

But it will not do to imagine any such climate as there is here.

The isothermals do not follow the parallels at all.

The place and neighborhood are warmed by the sea round about it ; and the sea in turn tempers and moistens the hot blasts that blow from the Great Sahara — not so very far away. And well for the Neapolitans ; for the scirocco, or southwest wind that blows directly in between Sardinia and Sicily, though it has 400 miles of water to cross, brings down the average of briskness and vigor among that noisy cityful in a way that is instantly noticeable. And even if there be any so strong as to resist, these have but to look at the west end of Capri to know how the wind is ; for the scirocco causes a mirage which tilts that island up so that men can see under its seaward extremity.

I have seen the cone of Vesuvius, 4000 feet or so, covered with plenteous snow, but do not remember ever to have seen snow in the streets of the city — though at times the cold was annoying enough, owing to insufficient preparation for it.

The shores of the "Regno," as the Kingdom of Naples is called, have been described by one who lived there, Massimo d' Azeglio, in his novel of "Ettore Fieramosca:"

"Era l'indomani della cena: il primo chiarore dell'alba faceva appena all'orizzonte distinguere dal cielo la bruna linea del mare, quando il giovane Fieramosca, lasciato il letto ove non sempre trovava sonni tranquilli, uscì su un terrazo, a piedi del quale venivano a batter l'onde leggermente agitate dal fresco venticello della mattina.

"Poveri abitanti del settentrione! Non sapete quanto valga quest' ora sotto un bel cielo del mezzogiorno, in riva al mare, mentre la natura è ancora tutta nel sonno, e questo silenzio viene appena interrotto dal sordo gorgoglio dell'onda che, al pari del pensiero, non ebbe mai riposo dal dì che fu creata, nè l'avrà finchè più non sia. Chi non s' è trovato solo a quest' ora, chi non ha sentito sventolarsi presso il viso l'ultimo batter d' ala della nottola mattutina nel principiar del caldo sulle belle coste del regno, non sa sin dove giunga la divina bellezza delle cose create."

The very dogs and cats in Italy know the passage in the original; but take the English: —

"It was the morrow of the supper. The first faint gleam of dawn had hardly begun to mark the sombre line of the horizon on the sea when young Fieramosca, quitting a couch where he did not always find tranquil sleep, came out upon a terrace at whose base the tiny waves, moved by the cool, soft breeze, were beating.

"Unhappy dwellers in the North, that cannot know what this hour is under a southern sky, and on the sea shore, while all nature is as yet in slumber, and the silence is hardly broken by the dull murmur of the waves, which, like our thoughts, have never been an instant still since the day they were created, nor ever will be until they are no more! He who has never been alone at such a moment to feel his cheek fanned by the last morning flutter of the bat, when early summer heat is setting in upon the lovely shores of the Regno, knows not how divinely beautiful can be the features of creation."

Now hear a description of the Bay of Naples by one who, if we may believe it, never saw the place: —

My soul to-day
Is far away,
Sailing the Vesuvian Bay;

My wingéd boat,
A bird afloat,
Swims round the purple peaks remote:—

Round purple peaks
It sails, and seeks
Blue inlets and their crystal creeks,
Where high rocks throw,
Through depths below,
A duplicated golden glow.

Far, vague and dim,
The mountains swim;
While on Vesuvius' misty brim,
With outstretched hands
The gray smoke stands
O'erlooking the volcanic lands.

Here Ischia smiles
O'er liquid miles;
And yonder, bluest of the isles,
Calm Capri waits,
Her sapphire gates
Beguiling to her bright estates.

I heed not, if
My rippling skiff
Float swift or slow from cliff to cliff;—
With dreamful eyes
My spirit lies
Under the walls of Paradise.

Now if it be true, as stated, that Buchanan Read had not seen the Bay of Naples when he wrote this, it is a real creation — true poetry according to the derivation of the word.

Leaving Point Palinuro — and there are not many more renowned men than Palinurus, the pilot of Æneas. He was drowned, deprived of the rites of sepulture, and so could not cross the river Styx. And when Æneas found the poor fellow mourning on the hither shore of that dreadful stream he could console him with the declaration that the cape where he vainly tried to land should bear his name forever.

Leaving, then, Point Palinuro on the right and sailing northwest we come to Salerno, and then to Amalfi, where the compass was not invented, but to which it may have been brought by the Crusaders; for the Chinese knew it, but knew little about it, 4000 years ago.

And so at last to the true Bay of Naples, with the Rocks of the Sirens on the right. Still moving on — against the hands of the watch — we pass Sorrento, Pompeii, Herculaneum, the foot of Vesuvius. By this time we are in Naples proper and must drive for many a mile through scenes renowned, but not greatly renowned in history, before we reach the Grotto of Posilippo, where the Tomb of Virgil is said to be. It did not flash conviction on me, somehow, and I never went to see it.

If there be one thing that I respect, it is an undoubted landmark. If there be one that I neglect with fury, it is a doubtful one.

But I passed the place, nevertheless, all the time. For, first, the "Grotto," as it is called, is a great work, an ample tunnel through a quarter of a mile of solid tufa. Second, it is due east and west — so due that at the equinoxes, morning and evening, the sun shines right through it; as I saw with my own eyes. And, third, because it is the way to the mouth of hell.

I mean, of course, that a little farther on, and to the westward, are Cape Misenum, the Sibyl's Cave, the birdless Lake Avernus, and the huge opening through which Æneas was conducted by his stately and little talking, but much saying guide, down to the City of Dis and the Elysian Fields.

I did not stop on the way to speak of the Temple of Diana — or if not of Diana of some other heathen diety — which stands near the road along the sea for everyone to look on. It has been repeatedly submerged by the sea and raised again by the throes of geology. Its columns are honeycombed by marine animals to prove the fact. The interest attaching to it is scientific wholly.

The Dog Cave near the Lake Avernus, where a poor beast kept for the purpose is half stifled by the mephitic vapor and then hauled out to be ready for another turn, our party scorned.

And here I must stop a half an instant to contrast the hell of Virgil with the hell of Homer. That is a mere exaggeration of what may be seen above. It is made as terrible as possible, of course, but it strikes no awe. This, the "abode of the silent," is vague, dark, cold, dreary, sordid, soundless horror; that, to read of, leaves the soul aghast and sickened.

Why I never went to Ischia I cannot tell you, unless it be that I could have done so at any moment. And then, it is a high island, like any other high island in a summer sea. Why should one go there?

But Capri is a different matter. Its top is 1500 feet from the water, and from that top I one day looked down into a sea so clear and still that the larger fish were visible as they swam about in it. If I were under cross examination, and the lawyer asked me, sternly, "Will you swear that you saw those fish?" I should answer: "An oath is a serious thing, but I declare to the best of my honest recollection that I saw them. They were large, they moved swiftly, and their white sides glanced."

Moreover I was told that there were old men up there (the little village is called Ana Capri) who had never been down to the sea in their lives. I say I was told so, and that a two roomed stone house, weather-tight and fit to live in, could be had for two dollars and fifty cents a year. This was in 1855, when the only communication with above was by the then well known Ana Capri stairs, up and down which men and asses carried burdens. And a poor fellow, whose name I have forgotten and who went to the island to die of consumption, had the nerve to make that ride both up and down rather than not see the place. I have been told that there is at present a broad carriage way to go up by.

Now you shall know that in those days I was rather by way of risking my bones. So I resolved to get up to Ana Capri without troubling the stairs — taking with me, as usual, Parry, a small Spitz dog — a prick eared cur of Iceland, belonging to Ross, the hotel keeper. This little beast was always so frantic with delight at being taken for a walk that he would seize me by the boot heel, discreetly confining himself to the solid part of it, and be dragged all the way to the door, yelling as best he might under those unfavorable circumstances. At the cliff we got on fairly enough until near the top, and then there came a place where I could not climb and carry Parry. I left him behind, therefore, and disappeared round a corner. But he howled and wailed so dolefully that it could not be borne. I went back, took him by the scruff and placed him in a cleft above, bidding him stay still. He heeded, and no Christian could have behaved more steadily or more intelligently. Then getting above and reaching down, I placed him in another cleft above with like injunction and like result. A third turn brought us to the level top, and that animal was fit to turn inside out for joy of his deliverance. Judge if I were fond of him or not. It is fifty years, and I have not forgotten Parry — no, not one little bit.

I saw a good deal of the Bay of Naples boatmen, and though they are good natured fellows enough, their skill and force did not impress me greatly. In Narragansett Bay, and as I take it for granted, elsewhere, one man manages a three ton cat boat with perfect ease. In fact, I have seen a single mariner dredging for oysters in a twenty ton sloop. When the cat boat is to go about it is — full for stays, helm down, boat comes into the wind, leash of the sail rattles a little, sheet block traverses on the iron traveler, sheet belayed to leeward, helm steadied — and the thing is done. Not a word said, no fuss made, no notice taken — matter of course. But here in Italian waters the four or five picturesque fellows that man a vessel not so big, gabble and scream when the boat head is to be got round the other way — the yard dipped and hoisted again. There is no denying, however, that the lateen rig is out of sight more graceful and pretty. In fact, our scenery is dwarfed by the high spars which our vessels carry.

I lived with my mother and sisters in Capri a whole long summer, and enjoyed that whole long summer wholly. It was like being at sea in a huge ship that did not roll or pitch. For the island is only about four miles and a half long and two miles or so wide.

The Emperor Tiberius was no better than a brute beast, but he knew where to go to pass his leisure, and his whole time was devoted to the neglect of his duties.

I wish very much that I could claim that twist as my own. It belongs of right to the Great Porson.

The island is covered with the remains of palaces built by Tiberius, and I have heard of, but never seen, records of wonderful structures down under the sea, built perhaps for coolness, perhaps merely to amuse the wretch's jaded soul.

Everyone has heard of the Blue Grotto. It was my good fortune to go into it for the first time on a day when the sky had no cloud and the sea no ripple. While we were enjoying the color and the sight and the air and the quiet, a boatman coolly undressed and hopped overboard. No one was taken by surprise, for it was an understood thing. Some extraordinary refraction, which I do not in the least care about understanding, made the fellow's body look more ridiculous than words can picture. He was wider than he was long — as if, as the expression is, he would have been taller lying down than standing up. And to see him tread water!

The next time I tried it I was alone with the boatman. The swell kept covering the opening which is at the water's edge, and only four feet or so wide and high. We missed our tip and got a ducking. The boatman said it was a "combinazione," which was of course a great consolation.

There is a green grotto which I clambered into without discovering anything but cold, gray stone. There is a natural arch which I was reviled for successfully attempting to reach the top of. There are Farralones — pointed rocks rising right out of the water and wholly unclimable — and on the eastern end of the island is a little, abandoned watch tower, where long before an unclaimed body had been deposited and left a good while. I need not say that the peasants avoided the place altogether after dark. So I went at Hallowe'en midnight without any results whatever.

All this is tame and stupid enough in the telling. But there were three families of us there that year, and we were always together. The enjoyment was something intense, and the remembrance of it as vivid as if it did not need nearly fifty years to carry me back to it. In these later years I hear the place is modernized and improved, but I do not believe it is half as pleasant.

Now cross over to Sorrento on the mainland and four miles to the southward and eastward. Stay there, if you like ; I am not going to. The memory is not pleasant. Wrong season, various annoyances. Lovely road along the cliffs towards Castellamare, past Pompeii. Your books will tell you all about it. What I principally remember about Pompeii is that there I for the first time in my life plucked a live orange off the tree, and that my good friend, Frank Abbott, rest his soul, and I desecrated the ampitheatre by engaging in a shrieking, yelling, retiarius and secator fight, using a Scotch plaid and an umbrella for Niger's net and trident, and a walking stick and Murray for Sporus' sword and shield.

Herculaneum I never saw. Same reason as Ischia.

So now at last we have on our second round reached Naples. We pass through renowned Santa Lucia and through the fishy smelling Basso Porto — Bash' Poort, as the Neapolitan calls it. Even in my day the lazzaroni had all disappeared, being converted into sensible fishermen. But they wore their red caps. I longed to see a man swallow an unbroken yard of maccheroni, but it was not given me. My pockets, as I went about, were attempted several times with such amazing coolness and audacity that I fairly laughed.

Naples is the most densely populated city in Europe, a distinction by no means to be envied. In my time drain fever was a perfectly well recognized local type of disease, and very dangerous. It is not so now.

The building material is the volcanic tufa, which comes out so soft as to be worked like wood with saw and hatchet; and with time and exposure becomes nearly as hard as a brick. It is admirably cheap and suitable as used in its own home, but I vehemently suspect that our high buildings would crush it. The houses are all stuccoed; the party walls are tiles, not lath and plaster. A new building takes a long time to dry out, and the saying is: "Let your enemy live in your house the first year, your friend the second, and you may live in it the third if you choose."

San Gennaro — St. Januarius is the patron saint of the city. Some of his blood is kept in a small bottle at the Cathedral, I believe, and once or twice a year it is liquefacted. All Naples goes to see the miracle, and there is some confusion. It may be that what is in the bottle, blood or whatever else, is stiffish in its natural condition, and being much handled by warm hands relents a little. I did not go to the function. One scrambling crowd in a church is just like another and such things may be seen anywhere, almost. But at all events, go all the faithful do, and swear, every one of them does, that the miracle comes to pass.

There is one act of worship which, as far as I know, is altogether peculiar to this city. I say, as usual, as far as I know. A line of a hundred and fifty or two hundred little, cast iron mortars — more or less, according to the sanctity of what is to be adored—is set in order. The mortars are loaded with something excessively noisy when fired off, and from every touch hole there hangs a very wide awake little fuse. One carrying a torch passes along and touches these diabolical implements off at the rate of say sixty to the minute. When the bangs begin to grow gradually louder you know that meeting is nearly out. The matter is so arranged on purpose. A salvo of this kind was rarely to lack on the piazza in front of the English church of a Sunday for the benefit of us accursed heretics. At the first bang Mr. Pugh would stop right in the middle of his sentence, contemplate the visible horizon with a countenance from which every particle of expression was discharged, and, when all was over, when

> " * * silence like a poultice came
> To heal the blows of sound,"

would go on right where he left off.

I am afraid — sadly afraid — that we enjoyed this sight with a delight that was far from reverent.

Now Naples is a sure Paradise. And here it suddenly occurs to me what an admirable thing it was for humanity that Adam and Eve were driven from the Garden of Eden out into the world to get their living and face things. The cold plunge braced them, made useful creatures of them, fitted them to be parents of a true human race. I should like to enlarge, but neither time nor place agrees. A sure Paradise. When all is done and all searched through, but little is to be found of broad world interest. Shall I give you an idea when I say the place is local — due, I think, to the climate?

Naples — Neapolis — the New City — is one of the oldest living settlements in Europe. So is Novogorod, in Russia — name has the same meaning. And Newport, in my colossal native State of Rhode Island, is a senior in this country; but alas! neither potent, grave nor reverend.

I am not here to attempt giving you any connected notion of the city and its history. That has all been done. But one or two matters may be touched upon.

I played a cartino in the lottery nearly every week and in all that time, as I remember, not even once did one of my numbers come up. For those who do not happen to know, the lottery is a source of revenue and a source of considerable revenue to the government. And for one I do not see any great harm in it. Ninety numbers, the drawing weekly, in public, with some ceremony. I saw it. In one of the old time, long ago halls of the city, the officials dressed in the clothes of time long ago both as to fancy and as to fact. I explain myself. No one has, as I believe, ever questioned the entire fairness and straightforwardness of the performance. Up in a gallery, plain for all folk to see, sit the queerly clothed magnates. Before the eyes of all, ninety things supposed, and doubtless correctly, to be the numbers are one by one put into something like a small keg. When all are in — and those reasonably near may count if they see fit — the keg is screwed up tight by one magnate, who then hands it to another who shakes violently, and hands it to another who shakes furiously, and hands it to another who shakes thoroughly, and hands it to another who courteously waives his right to shake in order to cut short a series of shakes which might become tedious. The keg is then set on a table and another magnate solemnly opens the keg. Meanwhile an exiguous boy, known like Alp, by the right arm bare, has been got ready. The boy thrusts the bare arm into the keg, pulls out a number and hands it to still another magnate, who partially unrolls it and hands it to a final magnate, who completely unrolls it, displays emotion and hands it over to the capo lazzarone, who is in waiting and has several thousand pairs of eyes and ears intent upon him. There are no lazzaroni, have not been for many years, as hinted above, but he is called capo lazzarone all the same. The title is titular. He has, you see, by my little device had time to take in upon himself the awful significance of what is on the slip of paper, and he screams it out with all his might, to the dismay or delight, according to circumstances, of those who hear him.

This is repeated five times.

One number is nothing. Two, as I think I remember, is nothing. Three is several thousand per cent. profit. Four is a small fortune, and five lowers the price of government securities. I used always to buy the same numbers — 3–11–37 — and though I did not always go to the same place (there are branch offices at every furlong) the men got to know me, and would snigger and whisper, "Same old numbers."

For fun about the lottery read Dickens' pictures from Italy.

One terrible summer day, I hardly know why, a mighty, morbid yearning seized me to go and see the public burying place of the poor, high up on the hill and well away from the habitations of the living. So far, so good. I was shown a large, stone paved, high walled court, into which the sun's rays were striking, and striking with a vengeance. In this pavement were 366 stone slabs that covered the openings to as many pits about fifteen feet deep, a pit to a day the year round. They were all mortared tight. The one of the day before, freshly. I should not do so now, but at that time of my life I asked to have the pit of the day before opened. The custode very sensibly refused. The heat was tremendous and — all the rest of it. So the slab of the day was wrenched out of its place by a suitable contrivance and I had the satisfaction of looking down upon a mass of corruption and a number of peering rats. How they got into those tightly walled pits is their own lookout. The bodies are brought up by public conveyance and await the hour. One was lying coverless under the wall, festering in the sun, and several hundred thousand flies were in close attendance. I was told that at the proper time service is held over the bodies and they are lowered into the pit. As to the service, no doubt. But as to the rest — there is no one to see or to tell. And I do not believe that much rope is worn out. There is a story told how the public cartman in the service of the cemetery went to the authorities and complained that his one horse could not draw so much up the hill. The officer in charge sternly twisted his mustaches. "How is this, sir? Is there not a one horse omnibus that goes that way every day and takes a greater number than you do?" "Excellenza," said the man, "what you say is quite true, but when that omnibus reaches the foot of that hill that driver courteously suggests to those passengers that they get out and walk. 'E la vada dire a questi signori miei di scendere.' And just go tell those gentlemen in my omnibus to get out and walk, will you?"

I wish rather than hope that I may have given you without putting it into words the idea of Naples of which my mind has always been full. A hint of it appeared a moment ago when the place was spoken of as Paradise. Now Paradise and the Happy Valley of Rasselas, which is Paradise and water, are both delightful, but most uninteresting. There is so little of the work of man to see and speak about. What would be, what has been written of Florence, for instance, is altogether different. The hills about Florence are all very well, very fine, indeed, if you choose; the climate is not good and not agreeable, however much people may try to deceive themselves. But what matter! It is the men and their works. Look at the stones in the Cyclopean walls of Fiesole! The Tower of Giotto is, architecturally speaking, worth all Naples put together. I did not visit Naples. I lived there; but I have only a vague remembrance of the streets and public buildings. The Cathedral has passed out of my mind altogether, except for the crypts. They are very old, indeed. Older, as I seem to recollect, than the edifice. In their open niches are lying bodies put there many centuries ago. I dare not say how many. When I went there in '55 or thereabouts they were by some extraordinary combination of circumstances almost at the discretion of the public. What one saw in its niche was a single mound of damp, lightest colored matter, between five and six feet long and eight or ten inches wide. At both ends and in the middle was a little, raised heap. Some few, strangely enough, were intact, wholly undisturbed. My friend, whose profession made him more indifferent than I could possibly be, coolly groped in the pile at one end of one of the longish heaps, until he brought out a white and shining tooth, which he carried away, "to remember the man by," as he remarked. I never have been able to account to myself for the amazing neglect which exposed these bodies in this way. After all, the care of them was in the hands of the priests, and not of the government, which was the king, and that King Bombino, as he was nicknamed. I have forgotten his other name. His father was nicknamed Bomba, and was as poor and troublesome a thing in kings as they make. But the son could beat him and give him long odds. A circumstance floats back to me: — It was at the time of the Crimean War, and Bomba or Bombino, easy enough to determine which, but it really does not matter, wrote to the Emperor of Austria to ask him what attitude he had better assume with regard to that conflict. This came to the ears of the London *Times*, at that epoch a far more influential journal than now. "Well!" it said. "We wonder what next! How long is it since this person has professed apprehension? We advise his Neapolitan majesty to bestir himself and creep under the bed or anywhere else, so only he get out of the way!" The monarchy in my time was feebly propped by Swiss Guards, just as was that of poor Louis XVI.

And Naples has the finest aquarium in Europe.

The beggars, though not first rate as compared with their colleagues farther East, are nevertheless high class beggars. One showed a hideous sore on his afflicted arm. I do not think the worse of him that turned away, sickened, but another member of the party, the tooth man of a few paragraphs ago and the Sporus of the ampitheatre combat, looked more closely, and shouted with delight on seeing a real work of art worthy of place in the gallery of wax work — a horrid, festering, mortal ulcer, made with lard and apple seeds.

The corribolo deserves to be immortalized in this writing. A one horse cart, with wheels between seven and eight feet in diameter, as I remember. At all events enormously large — and they had need be. On this vehicle is piled a mass of humanity, the constituent individuals of which are in number fourteen or fifteen. The driver sits on the shaft and a bag hangs underneath, into which (as is said) a small boy who must go and can find no place elsewhere, is occasionally inserted. Once (it is said) the bag dropped off and the boy, nearly choked with dust, was rescued by the next corribolo that passed. This is not physically impossible. But Neapolis two thousand years ago was called "otiosa," which means, being fully interpreted, "having so much leisure as naturally to take to gossip," and the boy bag story must go for what it will fetch. A few hours spent in Naples in 1875 left no impression of corribolo, and the strong probability is that the last wheel of the kind has echoed away.

When we need ice we have nothing to do but to get it in any quantity by squabbling a little with the ice man and paying the bill. In Naples, when I lived there, ice, especially for invalids, was a question full of poise and difficulty. It is probable that since then a great change for the better has supervened, but fifty years ago or so the chief dependence of the Neapolitan cafe haunter for his "mezzetta" was on snow brought down from the far side of Vesuvius on men's backs. There is in winter time no lack of snow at 4000 feet or so and on one occasion it seems there was a specially heavy fall which drifted into a gorge and filled the same completely up. If we may believe it, a timely eruption covered this gorge entirely over with a thick stratum of ashes and then lava, which had preserved the snow up to my time and presumably until long since then. A treasure better worth than a gold mine. I do not know this of my own knowledge, and have never seen it mentioned in any book. But it was a matter of common talk, and after all there is no natural reason why it should not be perfectly true. Think of Pompeii — and find the snow story by no means difficult of belief.

I remember the Museum, full of the displaced landmarks hinted at above, some more interesting than others. At the head of the list I venture to place a bit of water main which was unearthed in Pompeii. It was, I assure you, nearly five inches in diameter, an ordinary bronze, three-way pipe. The unhappy water which was in there when Vesuvius broke loose never got out. It was sealed up somehow by the forces of nature. And if the bit of pipe be picked up by a couple of men and shaken, the water may be heard to splash and gurgle within. I do not know by direct evidence about the sealing up so long ago, the shaking and the splashing; but there is no particular reason to doubt the facts as stated, and there the bit of water main is for any man to see.

One exceedingly interesting monument of the past I must mention, though it did not reach its present place until recently. The important question of whether people before the Christian Era wore trousers under their tunics has been settled. It is possible, though not probable, that some may be reading this who do not know how volcanic ashes filtered in around such bodies as were left in overwhelmed Pompeii, were dampened by rain and hardened by heat or time or whatever it may have been, so as to form a solid casing. When discovered, what was within was dust. It was carefully shaken out and liquid plaster poured in instead. So when the case of ashes was taken off, in pieces, a cast was found of what had been within. And one of these casts was that of a man in trousers. Q. E. D.

Whoever has not read the "Last Days of Pompeii" had better do so at once. I can think of no higher praise to give that book than to say that it reminds me of Ezekiel xxxvii — the Valley of Dry Bones. For the dry bones of Pompeii live, and one half expects in walking through her streets, to see Arbaces, the wise Magian, the Hermes of the Burning Girdle, majestic with his retinue; or immortal Nydia, swiftly and surely threading her blind way where the seeing could not see for outer darkness.

But Pompeii! What is Pompeii? A thing of yesterday, a pleasant summer resort on Sarnus' banks at the foot of Vesuvius, overwhelmed by dust and ashes and boiling mud in the 80th year or so of the Christian Era — and dug up the other day.

Go to Pæstum — Poseidonia, the City of Neptune — which was antiquity in ruins when Rome was founded, and looked then exactly as it does now. There is standing a small bit of wall and three Doric temples — two near together, one haughtily aloof. Nothing beside remains. And I have no imagination to conceive anything more impressive. A flat plain, the scenery utterly meaningless. The work of man, pure and simple, what it can be and what it must come to. There is not a traveling recollection of my life that I would not sooner part with.

And when we think of it, there are so many places that owe their interest altogether to the work of man. Scotland is a pottering, little, pocket edition, but the work of man, bloody or kindly, destructive or productive, as the case may be, has made that of it which takes people there from every point of the compass. What is the River Rhine to our Hudson, and yet who cares for the Hudson when the Rhine is in question? It is the castled crag of Drachenfels. It is Ehrenbreitstein, the "broad rock of honor," the banks that bear the vine and then the scattered cities crowning these, whose far, white walls along them shine, which turn what we should be half inclined to call a creek into a world landmark.

Think of the Thames at London, not so big as the Schuylkill; but with its docks! And so of a hundred other places.

It seems to me that Browning never was more a poet than when he wrote "Love Among the Ruins"—

> "But he looked upon the city, every side,
> Far and wide,
> All the mountains topped with temples, all the glades'
> Colonnades,
> All the causeys, bridges, aqueducts,—and then,
> All the men!"

I venture to say that there is only one thing which awes one like the glorified work of man, and that is something that is wholly out of the reach of man. Something visible, but inaccessible, unapproachable, majestic—a Chimborazo from far out at sea, or a Dwalaghiri from down among the deodars—the sea itself—a sailing planet, if you like.

Do me the justice to realize that while making the well known "pezzo di cielo caduto in terra," this piece of heaven fallen to earth, as the people call it, a subject of discourse, I have not detained you overmuch in mere uninteresting Naples.

SOME FACTS REGARDING TUBERCULOSIS OF FOOD PRODUCING ANIMALS AND PRACTICAL MEAT INSPECTION.

BY DR. GEORGE H. WOOLFOLK.*

Tuberculosis, commonly called consumption in the human, is at the present time the most extensive, menacing and loathsome disease of the human race, and I may say it is rapidly becoming equally as common amongst our meat producing animals; practically all animals, as well as all races of men, being subject to its ravaging powers. It is commanding the attention of scientific authorities throughout the medical world, and I am proud to say that some of them are representatives of the veterinary branch.

It is a subject, therefore, in which we are all vitally interested, and one possessing a wide field for research and discussion, but I shall only attempt to give some facts regarding the disease as found in the domesticated animals.

To discuss the subject in a logical manner, I will first give you something of its bacteriology and pathogenesis.

What is tuberculosis? Tuberculosis is a chronic, infective disease, caused and disseminated by a specific micro-organism, the tubercle bacillus. This fact was first discovered by the eminent scientist, Prof. Koch, of Germany, in about the year 1882. Previous to that time it was generally believed that tuberculosis was an inherited disease. This belief, much to be lamented, is still held by many not thoroughly acquainted with the manner in which it is produced.

The tubercle bacillus (the little micro-organism producing the disease) is a single celled, microscopic, non-motile, non-chlorophylic organism of vegetable origin, that reproduces by division of the cell, and so far as is known does not grow outside of the body except in artificial media, although it may remain an indefinite period in a dormant state.

Owing to the peculiarity of the tubercle bacillus after

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having once taken a stain, it fixes it very firmly, being called an acid-fast bacteria. Mineral acids will not discolor it like most other bacteria or animal substances, hence the absolute surety of distinguishing it when prepared rightly by the microscopist.

The tubercle bacillus grows within a wide range of temperature; the human bacillus in temperature limits of 85° to 104° F.; bovine bacilli in practically the same temperature; the bacillus from birds, 75° to 114° F., and in cold blooded animals, such as turtles, they multiply at a temperature anywhere from the freezing point up to 110° F. It appears that the tubercle bacillus is one which is able to adapt itself to a wide range of temperature, and is believed now to be one and the same organism wherever found, but modified somewhat by conditions of environment.

In form it appears under the microscope in the shape of little rods, whose length is usually four or five times its diameter, and measuring from two to four microns — a micron being 1-25,000 of an inch. So, if it is possible for you to imagine anything rod shaped so small as 1-12,000 to 1-6000 of an inch in length, you have an idea of the tubercle producing organism.

The name tuberculosis comes simply from the form or microscopical appearance of the disease, it appearing usually in shape of little tubers or elevations upon the surface of the part affected.

The difference between the microscopic appearance of human and bovine tubercle bacilli is very slight. (I use the bovine bacillus in making comparison, as that is now conceded to be the one from which all other animal tuberculosis emanates). The bovine variety usually is shorter, thicker and without a beaded appearance, while the human variety is usually longer, more pointed and showing a beaded appearance. Yet, exhaustive experiments as to morphology or form of the tubercle bacillus have failed to establish any reliable or constant difference. It has been found that no character is possessed by one in one host, but what may be produced in another entirely different host under favorable circumstances.

In living tissue the tubercle bacilli exercise a slow but progressively destructive action through their constant proliferation. Inoculation experiments on lower animals show a wide degree of virulence in the bacilli, and the susceptibility of different animals varies greatly, some being easy to infect and others showing great resisting powers.

Not wishing to go into extensive and exhaustive discussion pro and con, but believing firmly that Prof. Koch was mistaken in his statement that animal tuberculosis was not transmissible to man, I will quote some authority and experiments that go to show that he was at least a little hasty in making such a statement. After the discovery of the tubercle producing organism many scientists set to work to study its nature and habits. One of the most noted of these to make the study in a comparative way was Theobald Smith, who after an elaborate, well planned and scientifically executed research, which included not only the full description of the morphology and cultural characteristics of the human and bovine tubercle bacilli, but also parallel inoculation of five species of animals, reached the conclusion that the disease was not only transmissible from animal to animal, but also from man to animal.

Some years having elapsed during these experiments, in about 1901 Prof. Koch made the startling announcement that there was but little danger of man becoming infected from tubercle bacilli of bovine origin, because the two were of different source and were not transmissible. He also stated that the transmissibility of tuberculosis from man to animal was exceedingly improbable, if not impossible. These statements coming from so good an authority created quite a stir, but Koch's assertions were apparently the result of a comparison of only the pathogenic effects of these bacilli on two species of animals, while Smith's — as stated — were on numerous specimens and five species of animals.

The demands made by Smith can be performed and met by other investigators, and were, but the demands of Koch are only practicable in so far as they relate to the inoculation of cattle with tubercle bacilli of human origin, since direct proof that would be forthcoming by inoculating man with bovine bacilli cannot be obtained.

The practical importance of having exact knowledge of the intertransmissibility of human and bovine tuberculosis has long been realized by the sanitarian, and was immediately recognized by the public when it became acquainted with the statements made by Koch. As a result of Koch's opinions, health officers in the enforcement of their regulations at once met with opposition from the people who are always willing to grasp at a new thought or idea. But the results obtained by a majority of those who immediately undertook to solve this problem were in opposition to Koch, and they almost unanimously recommended that it would be unsafe to relinquish or modify the present sanitary police regulations with reference to bovine tuberculosis.

Since human and bovine bacilli comprise the most important type known, much of the comparative work has been centred around them.

In the intervening years many instances have been cited of the infection of man through cuts and injuries received while slaughtering tubercular cattle. Numerous attempts have been made to infect cattle through various methods of inoculation with human sputum or with cultures derived from human cadavers. The results have been varied, but the conclusion of the majority of investigators is strikingly uniform, and proof conclusive that the two forms of bacilli are interchangeable.

While it has been shown conclusively that a greater pathogenic power is the most distinguishing character between bovine and human tubercule bacilli, even this is not constant. The pathogenic action of the bovine bacillus for man is seen where a careful study of wound infection is made. A comparison with similar infections with human tuberculous material shows that the bovine bacillus grows well in the human body, under the most favorable circumstances producing typical lesions, and that it shows for man at least as great pathogenic power as the human bacillus under identical circumstances.

The most direct and positive proof that bovine tuberculosis is responsible for a certain amount of human tuberculosis is given by the finding of bovine bacilli in lesions of man.

In June, 1901, Ravenel succeeded in isolating from the mesenteric glands of a child, sent him by Dr. Alfred Hand from the Children's Hospital in Philadelphia, a culture which has been designated B. B. This culture showed most intense virulence for cattle, killing two calves in seventeen and twenty-seven days respectively, and a six year old cow in seventeen days. Later, other cultures were isolated from glands of children, which had unusual virulence, one killing a calf in forty-six days.

As further proof, I will quote some experiments of Drs. Mohler and Washburn, of the Pathological Division of the Bureau of Animal Industry, under date of January 8th, 1907, who report numerous cases of infection of cattle, calves, sheep, guinea pigs, rabbits and monkeys from bacilli taken from human sputum and cultures made from human bacilli. Tuberculosis was also produced in sheep, pigs, dogs, rabbits and monkeys from tubercle bacilli of bovine origin and bovine culture. Guinea pigs were inoculated with tubercle bacilli from birds, which also produced tuberculosis in a severe form. It was previously considered that tuberculosis of the avian or bird type would not affect the mammalian tribe.

So, I might go on and give case after case of many different scientists of the intertransmissibility of human and bovine types. But, to sum it all up, the more recent investigators practically all agree that it is only the degree of *virulence* and the *susceptibility* of different animals that varies, and not the particular form or type of tubercle bacilli, in producing the disease. I trust I have cited authority and experiments enough to convince the most sceptical of the danger of contracting tuberculosis from animal source regardless of whatever difference of opinion may exist in the minds of some investigators. It is certainly more reasonable to guard against exposure to infectious material scattered by both persons and animals than only against that scattered by persons. Protective measures that take into account the clearly defined menace and neglect the highly probable danger are insufficient, especially where the probable danger is, as in this case, believed to be actual by many men such as I have named, and who are competent to judge.

Under head of frequency in different food producing animals and source of infection, I will say that the frequency of tuberculosis in domestic animals varies according to species, and also according to the origin of the animals. It is rare in the horse and sheep, but a frequent disease in hogs and almost a regular plague in cattle of a certain locality. The per centage varies according to locality and environment — cattle from 1 to 45 per cent.; hogs, .2 to 20 per cent. I will not go into a regular statistical account by States, but will say that from tests made with tuberculin and the number found at time of slaughter to be infected with tuberculosis, the per centage in the Eastern States is very much higher than in the Western, and Pennsylvania stands pretty well up in the list of infection, dairy tests showing 15 to 100 per cent.

As to source and manner of infection, before we enter into the minute description of these, I wish to advert to a little anatomy and physiology, in order that I may better convey my subject. No doubt most of you are perfectly familiar with the circulatory system of the body, particularly the blood, but I will hurriedly run over it to freshen us up. The blood is pumped into the arteries from the left side of the heart, from the arteries into the minute capillaries, there nourishing the body, and is again taken up by the capillaries of the veins, which carry the waste material and gases that are the by-products after the different organs or parts composing the body have used up the nourishment and oxygen contained in the arterial blood. These in turn flow into the veins which unite to form the great vein, or vena cava, which empties into the right side of the heart. From here it is pumped to to the lungs to be purified and aerated again, coming into the minute capillary network of the lungs, where the interchange of gases takes place. From here it is taken up by the pulmonary veins and carried to the left side of the heart, to be pumped again to the different parts of the body.

But along with and more minutely constructed than the vessels carrying the circulation of the blood, is another circulatory system which is highly important to understand, called the *lymphatic system*. This system, while it nourishes the body by taking up or absorbing nutriment from the alimentary tract and pouring it into the blood, and also directly nourishes the body and certain non-vascular tissues, such as the cornea, cartilage, etc., seems to have for its principal function that of a drainage or sewerage system for the body. The tissues are bathed in lymph which is contained in the lymphatic spaces existing between the capillary blood vessels and capillary lymph vessels. There is a constant passage of material from the blood into the tissues, and from the tissues through the capillary lymphatics into the main lymphatics, and from there to the lymphatic duct and then into the venous system. Along this lymphatic or sewage system, just before each vessel leaves an organ of the body, are situated little receptacles, or catch basins, called lymph glands. Into these lymph glands are poured the contents of the surrounding organ or parts. Here the fluid is strained and worked over. If the tissues that drain into this gland have been injured or have within them any poisonous or effete material, it is deposited in this gland, causing it to enlarge, become inflamed, or broken down, according to the degree of injury or infection surrounding the part. Thus it is that these little glands are the barometers or danger signals of the body, and it is these and their condition that we consult most freely in looking for bacteriological diseases, particularly in the earlier stages of infection.

To come back to our subject again. The source of infection may vary widely, but as stated in the beginning, always comes from direct contact with the tubercle bacilli. The bacilli are distributed about them from some previously affected animal or man. They may have been expectorated from the lungs or may pass out from the body in some form of secretion or excretion, as through the milk, if the mammary glands are affected; the urine, if the kidneys are affected; or in the feces, if any of the digestive organs are affected; or in meat, if the animal from which the meat was taken was affected with generalized tuberculosis.

From these sources the bacillus may enter the body through numerous channels and thus cause infection. With cattle it is frequently drawn into the air tubes in form of dust floating in the atmosphere of the stable, but in *most cases* it is *now believed* to enter through the alimentary canal, with food that has been soiled with saliva or other secretions of diseased animals. It may also gain entrance through a milk duct or through the vaginal opening or by means of a wound.

The bacillus appears to be able to penetrate the mucous membrane, at least in certain places, even where there is no wound or abrasion, and it may pass through the membrane without leaving any tubercular material or other sign to show where it gained entrance. However, in its progress through the tissue it is usually soon arrested by a lymphatic gland or in some other manner, and then it multiplies and causes the formation of a tubercle.

To go into a minute detail as to the exact manner in which this tubercle is now formed would be rather tedious, but a little may be said. When the tubercle bacilli have lodged in or invaded an organ, their irritating effect upon the tissue surrounding them sets up changes similar to those seen in ordinary inflammation. The fixed connective cells and cells of the endothelium of the capillaries begin to multiply and produce a large number of new cells which form a hollow sphere around the bacilli. After the tubercle has made some progress in its development by the process just described, it becomes barely visible to the naked eye. Numerous small lymphoid cells begin to gather around it and may become so numerous as to obscure the little tubercle and cause a breaking down or liquefying of the centre. As the tubercle is thus increased in size or is joined by other similar ones, a mass is formed which is surrounded by fibrous tissue (this fibrous tissue formation being common to animals, but not seen in human tuberculosis). The centre of infection now undergoes the different forms of liquefaction necrosis, followed by caseation, the depositing of lime salts and calcification, giving us the typical tubercle showing all the stages found in post mortem examination; namely, caseation, calcification and encapsulation.

If the efforts of the little, scavenging leucocytes of the blood and lymph vessels are sufficiently strong they may break down and carry away the little tubercle, or build a wall of connective tissue around it and smother it. But if there are too many tubercle bacilli for the action of these little scavengers to destroy, the tubercle breaks out and multiplies, thus reaching the blood and surrounding lymphatic glands, causing a *generalized* case of tuberculosis, that may be carried to any part of the body by means of the circulation.

Just here I will pause for a moment to say, that as proof of the arresting and overcoming of the disease of tuberculosis in its incipient stages, we find many of these calcified and encapsulated foci in the post mortem examination of food producing animals, and I am firmly of the belief that it is more often overcome in the human being than is commonly supposed.

Of the most common media for carrying the tubercle bacilli from animal to animal (or animal to man, for that matter), the milk and feces are regarded the most frequent and menacing. For while every cow affected with the disease does not secrete milk contaminated with the bacilli, there are frequently one or more cows in an infected herd whose milk is infected, and this in turn infects all milk with which it is mixed. A difference of opinion exists as to the proportion of affected cattle which yield milk containing the tubercle bacilli. Some have held that the udder must necessarily be diseased before the bacilli can find their way into the milk ducts, and as only a small proportion of the affected cows have the disease of the udder, the danger from this source was thought to be slight. It seems likely, however, that the udder is affected in a larger number of cases than has usually been admitted. It requires a very long and careful examination to determine positively that the udder is free from disease. Pearson, in the examination of 1200 cows affected with tuberculosis in Pennsylvania, found the udder affected in about 10 per cent.

Numerous investigations have also shown that milk may contain tubercle bacilli when there are no appreciable signs of tubercular disease in the udder.

The combined results of the ingestion and inoculation experiments showed that the milk of 12 out of 56 reacting cows, or 21 per cent., at one time or another during the experment contained virulent tubercle bacilli. The milk from tubercular herds is a frequent source of tuberculosis in calves and pigs. The calves born in tubercular herds are fed upon the milk produced by such herds during their early life, and a considerable portion of them are infected in that way. In dairies where butter or cream is sold the skim milk is commonly fed to pigs and calves, and these animals are infected to an enormous extent, records showing as high as 75 per cent. of calves or pigs fed skim milk or centrifugal milk, affected with tuberculosis. So well is the extent of this known that packers in purchasing calves and pigs from dairy districts, not only discriminate against them, but in many instances will not buy them only subject to the inspector's post mortem examination, or in other words will only pay full price for the calves and hogs that pass as good, and a dirty-grease price for the condemned ones.

There is another way in which milk plays a prominent part in transmitting tuberculosis. It has been found that cattle or other animals affected with tuberculosis more often distribute the disease through feces from the intestinal tract than in any other way. Even if the digestive tract should not be the location or seat of the trouble, it acts as a carrier, for, as is well known, but few animals do or can expectorate from the mouth. If their lungs or respiratory tract are affected with any disease, they cough the mucus into the mouth and swallow it, and such amount of the bacilli as do not find lodgment again are passed out to the ground, as digestive processes have little or no effect upon them. In this manner they are distributed to pigs and lower animals. Cows located in the same environment become contaminated with the dirt and filth upon their udders and coats of hair, and when the milking is done this in turn to a greater or less degree contaminates the milk, and hence we have the bacilli in the milk of perfectly healthy cows. We have seen large quantities of milk strained in many dairies, but have not found the dairy in which the milk was removed from the cows with a degree of cleanliness so perfect that the cloth or screen through which it was strained did not show the presence of some cattle hairs and fragments of a substance suspiciously like feces.

When we know how completely cattle feces may be charged with tubercle bacilli and how easily milk may be affected from this source, and contemplate this fact, keeping in mind the wide distribution that dairy products have, and add to our knowledge some of the results obtained and published by competent investigators, we must conclude that the eradication of tuberculosis amongst cattle cannot be too vigorously urged or pursued.

Numerous investigators have shown that pulmonary or lung tuberculosis is the most common form of the disease in animals, irrespective of the point at which the tubercular infection enters the body, and that tubercle bacilli may pass through the wall of the intestine and reach the lung without visible disease of the intestinal mucosa.

Nichols, Descos and Ravenel proved by feeding healthy dogs on tuberculous fluids and examining the chyle in the thoracic duct a few hours later that tubercle bacilli may readily pass through the intestinal wall and infect the animal without causing lesions in the intestines.

The reason the bacilli more often lodge in the lungs and affect those organs than any other part is simply because of the bacilli being brought there by the circulation of the lymphatic and blood systems, all of which is strained through these minute capillaries, and also because of the infection brought about by the inspired air. Nowhere else in the body does so minute a sieve and natural field exist for aerobic bacteria as in the lungs, and they may be called the natural habitat of the tubercle bacilli, for it is here they flourish most easily and rapidly.

The theory or supposition that the lungs of persons are *most frequently* affected by sputum which has become dried and pulverized after being expectorated by persons affected with tuberculosis, is generally becoming accepted as erroneous — first, because sputum does not pulverize easily and loses its infectious character in a short time, and secondly, because the frequency of infection of the lung is accounted for, as I have just stated, by way of the digestive tract through the taking in of food and drink contaminated with the tubercle producing micro-organisms.

As a corallary to what I have attempted to bring before you in regard to animal tuberculosis and the exceeding probability of its being transmitted to man through meat and milk, and its manner of transmission, I will now give you a few ideas of what we are doing in way of practical meat inspection — what we look for, how we conduct it, and what it means to the public health.

Federal meat inspection laws governing the interstate and export transportation of meats and animals intended for food have been in existence for a number of years, but not until about 1891 was any great effort made to have inspection at time of slaughter of *all* animals intended for interstate and export shipment. On June 30th, 1906, this law was amended to take in not only the inspection of animals before and at the time of slaughter of all houses doing an interstate or export business, but to include along with inspection, re-inspection, examination, supervision, disposition and the method and manner of handling live cattle, sheep, swine and goats and the carcasses and meat food products thereof; also, the sanitation of establishments doing business outside of their own States.

Establishments doing interstate business in meats or meat food products are required to maintain their houses in a sanitary condition. All floors, tables, trucks, knives, saws, cleavers, machines and implements used in the slaughter of animals or preparation of meats must be cleansed daily. Frocks and clothing of employes handling meats must be of suitable material, easily cleaned; sanitary toilet, wash basins, towels, soap, etc., must be provided. Meats must be prepared in a cleanly way and in compartments free from foul odors. Persons who are known to be infected with tuberculosis are forbidden employment in departments where meat or meat foods are dressed or handled.

No preservatives, coloring matter or chemicals of any sort beyond the simpler forms of salt, saltpetre, vinegar, sugar and wood smoke can be used, and the composition of the products leaving an inspected house must be stated upon the can, tin, canvas, or other receptacle or covering containing the meat or meat food product. For instance, if the receptacle says pork sausage, the contents must be pork only, and not beef and pork mixed; or if branded lard it must be made from hog fat, and so on. No deceptive name or weight is allowed, and upon each receptacle or part of meat or meat food product must be placed the words "U. S. inspected and passed according to Act of Congress of June 30th, 1906," or abbreviation thereof, and the official number of the establishment preparing the article.

Practical meat men are employed by the Department, after a competitive examination, to supervise the preparation and examine the products of all departments, at any and all times.

Houses having inspection are subject to heavy fines, imprisonment and forfeiture of right to do interstate business by failing to comply with any of these regulations regarding sanitation or adulteration, and any article of food found to be dirty, diseased, decayed or adulterated is immediately seized by the inspector and destroyed, either by being tanked or soaked with kerosene.

No meat or meat food product can come into an establishment having inspection without the same bears the inspection legend and is at the time of entrance in a sound, wholesome and clean condition.

All animals intended for slaughter are examined before being killed, and any showing signs of disease or injury are tagged with a metal tag bearing a serial number, and killed under special examination. An examination is made at time of slaughter of every animal killed, the entire carcass, including head, lungs, liver, intestines and all visceral organs, are handled by the inspector. And not only do we look for tuberculosis, but for any and all diseases and conditions that are not normal, such as hog cholera, swine plague, septicæmia, pyæmia, anthrax, tetanus, Texas fever, pleurisy, pneumonia, peritonitis, enteritis, actinomycosis, bruises, abscesses, liver flukes, emaciation, anemia, immaturity, etc.

Carcasses found affected with any of these, or any other disease, are handled according to degree of severity and kind of infection. If the disease is a contagious one, or one capable of being transmitted to man, the entire carcass is destroyed by tanking with a quantity of offal in an air-tight receptacle that has been sealed at its bottom opening with a lead and wire seal bearing a "U. S. Condemned" legend. The carcass is then dropped in from above, a quantity of offal or coloring matter placed upon it, the top sealed as below and the contents subjected to a live steam temperature of not less than 220° F. for at least four hours. The seals are then broken by a Government man and the grease resulting is drawn off into barrels marked non-edible grease and allowed shipment to soap factories or other dirty-grease concerns, the residue going into fertilizer.

The cost of inspection falls on both the United States Government and the owners of packing establishments. The Government pays the hire of its employes and the packer loses the animals and products condemned by the inspectors and is placed at considerable expense in preparing and maintaining his house in a sanitary condition.

Accurate records of meats and animals prepared and shipped by each establishment are kept on file in both local and Washington offices, daily records being rendered, and by means of the brand or stamp placed upon each carcass or part or receptacle, anything found wrong with any of those in any place within the United States or foreign countries can be traced to its point of origin, and in this way the disease or blame located and handled in a proper manner.

A NOTE ON COLLOQUIAL SHIP NAMES.

BY HENRY L. BROOMALL.

The sailor uses some very striking appellatives to describe vessels according to peculiarities of movement, condition or management. A typical domestic animal is referred to in *hen-frigate*, a vessel in which the captain's wife has a hand in the regulations; and an animal of no less decided characteristics gave the name *donkey-frigates* to English men-of-war commanded by officers who had seen little or no service in lower grades — who had come on board "through the cabin windows," and not "over the bows," as it is nautically described. Any one who has seen from a distance a number of small vessels lying close together will recognize the appropriateness of *mosquito fleet*, the blue-water sailor's term for them. Perhaps only those who have experienced the tyranny possible on shipboard can appreciate the name of *hell-afloat* given a vessel notorious for such government. Another ominous term is *floating-coffin* for a vessel that may be apparently sea-worthy, but which in fact only awaits an occasion to vindicate its name. In contrast to this, English sealers and whalers are known as *lime-juicers* because they are required by the British Admiralty to carry lime-juice as an anti-scorbutic. Again, referring to the health of the soul, what could be better than *floating Bethel* for an old ship in port used for religious services?

As opposed to *cutter* and *clipper*, legitimate class names of vessels, from their cutting and clipping the water, the title of *bruise-water* is applied to a bluff-bowed vessel, one that bruises or breaks the water; with which compare French *briser*, to dash or break as waves, *brisants*, breakers. This action upon the water recalls the suggested connection between *sloop* and *slip*, and between *schooner* and *scoon*, *scud* and *skoot*. Wet vessels, that take much water on deck, are known as *diving-bells*, from their plunging into the waves instead of riding over them. A vessel that pitches heavily is called a *pile-*

driver — another term that can be appreciated only by those who have felt such pounding, well described in German as *stampfreiten*, to pitch when riding at anchor. A lighter degree of somewhat the same kind of movement seems to be the source of the legitimate terms *skip-jack* and *dandy*, applied to light, speedy vessels.

Tea-wagon, formerly applied to the ships of the East India Company from their usual cargo, is a colloquial example of the large class of ship names referring to cargo and trade. The wagon idea appears again in *wheelbarrow*, applied to steamboats having a large stern paddle-wheel, which gives them a general appearance fully justifying the name. In allusion to their characteristic shape the canal-boatman calls his boat a *chunker* and the sections of it *boxes*. Under the same idea *butter-box* was formerly applied in England to a beamy trading-vessel. The ship as a box is regularly exemplified by German *Buse*, Dutch *buyse*, Spanish *bucha* and English *buss*, a kind of fishing-boat.

The transfer of the title of the commander of the fleet to his own vessel is an old custom still in vogue. Milton speaks of

> "The tallest pine
> Hewn on Norwegian hills, to be the mast
> Of some great ammiral."

It is interesting to note the change of gender when the officers' names, Spanish *el almirante*, *el capitán*, *el sultán*, French *le capitaine*, are applied to their ships as *la almiranta*, *la capitana*, *la sultana* and *la capitaine*. *Commodore* is frequently applied to the largest or first-arrived vessel in a fleet of fishermen, where, as in the poet's use of admiral, the reference is directly to the superiority of the vessel itself.

The English sailor's nickname for a vessel of the Royal Navy is *Geordie*, which I take to be in memory of the "Royal George" and the English kings of that name. Burns has the same form and reference in describing the British gold coins as "the sweet, yellow darlings wi' *Geordie* imprest." So *monitor* and *una-boat*, originally proper names, are now names of kinds of vessels.

In nautical nomenclature *ship* and *bark* have particular technical meanings, though their almost indiscriminate use ashore, and such compounds as *shipmate*, *embark* and the like, perhaps indicate that formerly their meanings were more general. *Bark*, however, is used for any kind of vessel by the poets, doubtless owing to its convenience for rhyme, and the sailor, familiarly, affectionately, and perhaps no less poetically, applies the diminutive *barkie* to a favorite vessel or that to which he belongs. Indeed, vessels, though too comprehensive, is the only term strictly applicable to any kind of craft —except the very term just slipped from the pen. Anything intended to float and move by pole, oar, sail or steam, is known to the sailor as *craft*. Resorting again to analogy, as French *bâtiment* is a building and particularly a vessel, and if *craft* is from Anglo-Saxon *cræftan*, to build, the "guess" that *frigate* is from Latin *fabricata* (sc. *navis*) is worthy of consideration. Tacitus uses the Latin word in reference to shipbuilding in Annales 14, 29: "Paullinus Seutonius . . . . naves fabricatur."

THE GLYCOGENIC FUNCTION.

BY C. M. BROOMALL.

The function of sugar in the animal economy is recognized to be that of an energy producer. Its round of action briefly stated is as follows: The carbohydrates taken in as food are transformed in the intestines into glucose. This is absorbed and taken by the portal vein to the liver. Here the glucose is converted into glycogen and kept in store in that shape. When energy for heat or muscular effort is needed, the glycogen is reconverted into glucose, transported to the tissues, and there "burned" to supply the required energy. Such of this sugar as is not oxidized is stored away as glycogen in the muscles, to be subsequently reconverted into sugar for fuel at the proper time. It is seen, therefore, that both the liver and muscles act as storehouses of potential energy.

If in the food there is an excess of carbohydrates, more than the liver and muscles can store away as glycogen, a portion of the glucose will appear in the blood. This sugar will be excreted by the kidneys, constituting physiological diabetes. There is nothing abnormal in this, and it is simply the result of overloading the system with carbohydrate foodstuff.

If, on the other hand, sugar appears in the urine under normal food supply, then we may rightly suspect some pathological process. Under such circumstances it is usual to consider the liver at fault. In a large number of cases of pathological diabetes mellitus, however, there is found an accompanying disease of the pancreas. It is concluded, therefore, that the pancreas may also have something to do with diabetes and there seems to be a general trend of opinion to the effect that the pancreas produces an internal secretion in some way intimately associated with the metabolism of sugar in the body.

The foregoing outlines, in few words, practically all that is known concerning the function of glycogen in the human economy. The facts, however, do not appear to have been correlated with other branches of science in such a way as to establish a satisfactory theory. In view of this, therefore, it may not be altogether presumptuous on the part of the lay student to venture a few suggestions looking toward some such correlation.

A theory such as is needed is one that explains — first, the conversion of sugar into glycogen ; second, the reconversion of glycogen into sugar, and third, the oxidation of the sugar. In considering the subject it will be well to take up these various branches one by one and endeavor to see what aid kindred lines of research can offer toward the explanation of the phenomena, and especially let us inquire into the part which may be played by enzymes in the process.

Let us take up, in the first place, the conversion and storage of the sugar as glycogen. The principal localities where this occurs, as stated above, are the liver and the muscles. There seems no way of accounting for the conversion of glucose into glycogen other than to attribute it to the direct action of the living cells. The change being a synthetic one, we cannot appeal to any theory of simple chemical reactions or theory of unorganized ferments to aid us, as such reactions and ferments tend to produce analytic or catabolic processes. In the present state of knowledge, therefore, this change from glucose to glycogen in the liver and muscles can only be explained as a direct result of the activity of the living cells.

Consider now the reconversion of glycogen into glucose. It has been found by a number of observers that there can be obtained by extraction from the liver and also from the muscles an unorganized ferment or enzyme, which has the power of transforming glycogen into glucose. Observations by Von Wittich, Claud Bernard, Kaufman, Pavy and many others have established without question the existence of such a ferment in the liver. This ferment exists in that organ in the form of a zymogen always ready to release the active ferment under proper stimulus. Likewise Nasse, Halliburton and others have obtained from the muscles a similar glycogenic ferment, which probably (in common with most such ferments) exists in the tissues as a zymogen. It may be considered, therefore, a well established fact that the conversion of glycogen into glucose in the liver and muscles is due to the presence of an enzyme in their tissues.

Turn now to the mechanism of the oxidation of the sugar. The way to an understanding of the process is paved for us by the knowledge that in various forms of plant and animal life there exist certain unorganized ferments known as oxidases. These have the power of producing certain oxidations that would otherwise not take place under ordinary conditions. A number of observations have been made showing that a body of this class can be extracted from the pancreas and that this body has the property of oxidizing sugar. Lepine seems to have been the first experimenter to have obtained such a ferment from the pancreas and other observers have confirmed his results. The fact that blood when drawn and exposed to the air has the property of causing the disappearance of sugar corroborates the existence of an oxidizing ferment in the circulation. Taking all in all, therefore, there seems ample proof for the statement that the pancreas produces an internal secretion and that this secretion contains an enzyme capable of oxidizing glucose.

The theory of the glycogenic function may now be formulated as follows: The carbohydrates in the alimentary canal are transformed by the digestive juices into glucose, which is then absorbed and transported to the liver. Here the glucose is transformed by the direct activity of the living cells into glycogen and stored away in that form for future use. When energy is required for heat or muscular effort the ferment of the liver is released from its zymogen and acting upon the glycogen converts it into sugar ready for transportation and subsequent oxidation. This glucose is now oxidized by the aid of the internal secretion which the pancreas pours into the circulation. In order to account for the selective oxidation which occurs by which the glucose is oxidized principally at those points where energy is needed, we may assume that the ferment is secreted by the pancreas as a zymogen and that the active oxidase is only released where the conditions are suitable — in other words, where such energy is needed. As remarked above, any sugar in the circulation that is not completely oxidized, or that has passed the liver without conversion, is transformed into glycogen by the living cells of the muscular tissue and stored away in that form until needed.

In conclusion, if the above theory is sound, there ought to exist, aside from the mixed types, three distinct kinds of diabetes mellitus: (1) Physiological, due to overloading the system with carbohydrate food; (2) That due to inability of the cells to convert and store away the sugar as glycogen, and (3) That due to deficiency of the oxidase in the internal secretion of the pancreas. The first two types are well known and the fact that extirpation of the pancreas is followed by the appearance of sugar in the circulation certainly indicates the possibility of the existence of the third type.

MINUTES OF MEETINGS.

MAY 7, 1908.—Regular Monthly Meeting. In the absence of the President and Vice Presidents, the Treasurer, C. M. Broomall, occupied the chair. A short business session was held, with the usual reports of committees and Curators, approval of bills, etc. Additions to Library were announced as follows: Twenty-four numbers of the Bulletins and Water Supply Papers of the United States Geological Survey; the Annual Report of the United States Ethnological Bureau. Following the business of the meeting a short discussion on general scientific topics took place.

JUNE 4, 1908.—Regular Monthly Meeting, President T. Chalkley Palmer in the chair. Reports of committees and Curators, approval of bills, etc. Dr. B. M. Underhill was elected Secretary of the Institute, to fill the office left vacant by the death of Dr. Linnæus Fussell. President T. Chalkley Palmer and Treasurer C. M. Broomall were appointed a committee to have rear steps erected at the Hall for use in case of fire. Following the business meeting general scientific matters were discussed. President Palmer, who had just returned from a trip to Jamaica, West Indies, mentioned a number of matters of scientific interest which he had noticed on his trip.

JULY 2, 1908.—Regular Monthly Meeting. In the absence of the President, Vice President Henry L. Broomall occupied the chair. Reports of committees and Curators were received and the usual bills approved. The committee on fire escape reported progress. Additions to the Library were announced as follows: Annual Reports of the Michigan Academy of Science from 1894 to 1907, received in exchange for the Institute PROCEEDINGS. Under the head of scientific communications, the chairman called attention to the recent partial eclipse of the sun, visible in this locality, on June 28th last, mentioning the crescent shaped patches of light cast by small apertures, such as the leaves of trees, etc. A discussion of the geometrical theory of eclipses followed, and mention was made of the reversal of the spectrum lines during a total eclipse, a phenomenon predicted and first observed by the late Professor Young. C. M. Broomall called attention to the statement going the round of the papers that wireless telegraphy stations were never struck by lightning. He ventured the idea that, if this statement were true, it might be due in some way to the alternating strain to which the dielectric was subjected by the electric waves causing the medium to break down and the flash of lightning to occur long before the electric tension becomes dangerously high. The Secretary called attention to the Tuberculosis Congress to be held in Washington this Fall and on motion of the meeting he was directed to obtain the publications for the Institute Library.

INSTITUTE NOTES.

With this number the Institute completes the publication of the third volume of its PROCEEDINGS. Our endeavor has been to make the contents of the journal as interesting and instructive as possible in a publication of this class, and we think we have succeeded. The PROCEEDINGS have been very favorably received by the scientific world, notes from our articles have been abstracted in various periodicals, and four of our longest articles have been quoted in full in one of the leading scientific journals of the country. Considering everything, the Institute is well pleased with its venture, and hopes the subscribers to the PROCEEDINGS have been equally so. The Title Page and Index to Volume III, bound in with this number, are for use of those who wish to have the PROCEEDINGS put into book form. The three volumes now issued make a very convenient size for binding into one book.

Mexican Jumping Beans, a few samples of which recently came into the possession of the Institute, have been attracting the attention of the members. These beans have the faculty in some cases of moving themselves with considerable force, especially under the stimulus of slight heat. The movement is due to the fact that within each bean is a small, parasitic worm, the larva of a genus of moth, *Carpocapsa*, which worm, in climbing around the inside of the bean, causes it to turn over or shake. The larva is very destructive to various fruits, as the name of the genus implies (καρπός, fruit; κάπτειν, devour). The worm consumes the inside of the bean to sustain itself; it then passes into the pupa state, and later, under normal conditions, the full-fledged moth comes out of the bean through a hole previously cut by the larva. Under artificial conditions it is scarcely likely this will occur, although the future of the beans will be watched with interest.

James G. Vail, a member of the Institute and chemist of the Philadelphia Quartz Company, is about going abroad to spend a year in the Zurich (Switzerland) University, taking a special course in the chemistry of the silicates. Mr. Vail speaks German fluently, and will have little difficulty in getting along in a strange land.

The Hall of the Institute has recently been provided with rear steps, so that there are now two exits from the lecture room. There was considerable criticism last year concerning the matter of fire escapes for the Hall, and we are glad to announce now that all fears in this direction may be allayed.

The paper on Tuberculosis and Food Inspection, by Dr. George H. Woolfolk, in this number of the PROCEEDINGS, was one of a series of four lectures delivered by different scientific authorities before the Institute at its meetings in January last, relative to the new Pure Food Laws. The present paper is a valuable one, and the Institute regrets that it could not obtain the other three papers also for publication.

Officers of the Institute:

President, - - - -	T. Chalkley Palmer
First Vice President, - -	Charles Potts
Second Vice President, - -	Henry L. Broomall
Secretary, - - -	Dr. B. M. Underhill
Treasurer, - - - -	Carolus M. Broomall
Librarian, - - -	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers