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TRANSACTIONS

OF THE

TWENTY-SIXTH AND TWENTY-SEVENTH ANNUAL MEETINGS

OF THE

KANSAS ACADEMY OF SCIENCE.

(1893-1894.)

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VOLUME XIV.

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OFFICERS FOR 1896.

PRESIDENT, ...	D. S. KELLY, . . .	*Emporia.*
VICE-PRESIDENTS, . .	S. W. WILLISTON, . . .	*Lawrence.*
	D. E. LANTZ, . . .	*Manhattan.*
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	G. P. GRIMSLEY, . .	*Topeka.*

THE TWENTY-SIXTH ANNUAL MEETING.

TWENTY-SIXTH ANNUAL MEETING.

The Kansas Academy of Science met in its twenty-sixth annual session at Emporia, Kansas, October 25, 26, and 27, 1893.

The following extracts are made from the minutes of the secretary:

The Academy met in the State Normal School, on the evening of October 25, and listened to the annual address of the president, Dr. E. H. S. Bailey, of the State University, Lawrence.

After the address a short business session was held. B. B. Smyth was appointed vice-president pro tem. and D. S. Kelly secretary pro tem. The following committees were appointed:

On nominations: M. A. Carleton, F. O. Marvin, W. A. Harshbarger.

On new members: T. H. Dinsmore, W. C. Stevens, E. B. Knerr.

On program and press: B. B. Smyth, D. S. Kelly, E. E. Balcomb.

On Thursday, October 26, the following papers were read and discussed:

"Variations in dominant species of plants," by M. A. Carleton.

"An analysis of deposit from a chalybeate water," by E. C. Case.

"The Arkansas river—its past and present," by J. R. Mead.

"Further research on the composition of plants at different seasons," by L. E. Sayre.

"Results of chinch-bug experiments during 1893," by F. H. Snow.

The following committees were appointed by the president:

On place of next meeting: J. R. Mead, S. W. Williston, H. B. Newson.

On resolutions: L. E. Sayre, T. B. Jennings, J. D. Hewitt.

The following were elected to membership: F. B. Dains, Lawrence; G. I. Adams, Emporia; Alva J. Smith, Emporia.

In the evening a lecture was delivered by Prof. Arthur Winslow, State Geologist of Missouri, on "Land Sculpture," illustrated by the stereopticon.

On Friday, October 27, F. O. Marvin was appointed secretary pro tem.

Librarian and treasurer made their annual reports. Treasurer's report showed balance in treasury, $174.45. Referred to committee.

In consequence of $50 paid into the treasury (donated by the Academy as a reward for his valuable services), Prof. James H. Carruth was elected to life membership in the Academy.

The following papers were read and discussed:

"Some tests on the strength of building stones," by F. O. Marvin.

"Figurate series," by B. B. Smyth.

"Some useful botanical apparatus," by W. C. Stevens. He showed a new case for holding test-tubes, a home-made microscope case, a new method of mounting in collodion, and a home-made auxanometer.

"Histology of *Sagittaria variabilis* Eng.," by W. C. Stevens.

"Linear analytic geometry," by H. B. Newson.

"Meteorological observations at Emporia," by T. H. Dinsmore.

"A resumé of the crop-weather season of 1893 in Kansas," by T. B. Jennings.

A new aecidium of peculiar habit," by M. A. Carleton.

"The solvent action of acetic acid as a substitute for alcohol," by L. E. Sayre.

"On the comparative value of the hypobromite and hypochlorite methods in testing for urea," by L. E. Sayre.

"Long-continued blooming of Malvastrum coccineum," by Minnie Reed.

"Our Kansas mosses," by Minnie Reed.

"A freak in Solanum tuberosum," by D. S. Kelly.

"Notes on Kansas plants in the herbarium of the State Agricultural College," by A. S. Hitchcock. (Read by M. A. Carleton.)

The following papers were read by title:

"The Kansas river as a source of city water supply," by E. H. S. Bailey.

"On the composition of mineral water from the vicinity of the Great Spirit Spring," by E. H. S. Bailey and M. A. Rice.

"Telephonic communications between anchored vessels," by L. I. Blake.

"A geologic section along the Neosho river," by Erasmus Haworth.

"On the composition of a natural oil from Wilson county," by F. B. Dains.

"Coal in Atchison county," by E. B. Knerr.

"Some experimental telephonic and induction coils," by E. W. Caldwell.

"A method for producing rain artificially," by L. I. Blake.

"Inverse of conics and conicoids," by M. E. Rice.

"Notes on hypnotic suggestions," by Prof. Marvin and others.

The following new members were elected: Prof. H. S. Harnley, McPherson; Dr. S. Z. Sharp, McPherson; Prof. Erasmus Haworth, Lawrence; Prof. W. V. Ingham, Lecompton.

The following officers were elected for the ensuing year:

President, L. E. Sayre, Lawrence.

First Vice-President, I. D. Graham, Manhattan.

Second Vice-President, J. D. Hewitt, Emporia.

Secretary, E. B. Knerr, Atchison.

Treasurer, Dorman S. Kelly, Emporia.

Librarian, B. B. Smyth, Topeka.

Curators: A. H. Thompson, B. B. Smyth, C. S. Prosser, all of Topeka.

A resolution was passed extending the thanks of the Academy to Prof. Arthur Winslow for his entertaining and instructive lecture.

SMALL THINGS.

Address of the retiring President, PROF. E. H. S. BAILEY, Lawrence.

The Kansas Academy of Science last year celebrated its twenty-fifth anniversary. It is not a young nor a new institution in the state, for it has been identified with its growth and development. It has helped to increase that material wealth that is so important to the prosperity of a state. Its members have been looking into the ground to see what they could find that was of value; they have studied the animals and plants that were above the ground, to see which should be increased for the benefit of man, and which, like the pestiferous chinch-bug and the Canada thistle, should be eliminated and driven from the face of the earth, at least as far as Kansas was concerned. This has been generous work—gratuitous work. The reward has come to the members of the Academy in seeing a more populous state, a more prosperous people, a more fruitful land.

In all the work that you have done you have been animated by the desire to pry into the secrets of nature, to find out her processes, to understand her laws. It is my purpose to recall to your mind one phase only of this work, and to direct your thoughts towards the part that has been played in this work and in the scientific investigation of the world by the so-called "little things."

The work of research has reached the advanced position which it now holds because those who have been most active in the great field of research, those who have been closest to the warm heart of nature, have not been satisfied with superficial observation alone, but have recorded the most minute and seemingly trivial things which they have seen. To do this has required labor, self sacrifice, and patience; patience cultivated to such a stage of perfection that it may almost be classed among the saintly virtues. The chemist and the physicist have pried between the atoms; the naturalist has examined and classified the infinitely minute creatures of earth, air and water, and the physician has followed the pathogenic or disease-producing germs to their original breeding places.

The great strength of scientific investigation then depends on the attention paid to details, and on the ability displayed towards getting at the very bottom fact—to the very smallest factor of the problem. And what are some of these small things that have helped to unravel the tangled web of the great world of nature?

First, in the realm of matter: Do we know anything of the constitution of matter? Matter can be infinitely divided or else there is a definite limit to the division. I may take a piece of chalk, for instance, and cut it into small pieces and each one of those pieces into smaller pieces, and so on forever, or if this it not possible, there will come a time in my division when the small particle obtained cannot be farther divided. This latter is the view now held in regard to matter—that there is a point beyond which its subdivision cannot go. Of course this point is infinitely below any possible mechanical division, and far below what the highest power of the microscope can reveal. That little particle of matter that is incapable of being cut or divided we call the atom. No one ever saw an atom; no one will ever see an atom, for it is infinite in smallness beyond our ken, just as there is an infinite greatness which we cannot comprehend.

Starting then with this atom: If we get two or more of them together, an aggregation of atoms, we call this a molecule. For according to the present theories these atoms are social beings; they seldom go wandering off alone. As Sothern so aptly says in regard to birds of a feather, "Of course they flock together; you don't suppose they would flock all alone, do you?" The atoms then are found in groups. Perhaps they recognize that there is greater safety in traveling in this way; less danger of being "held up."

But how large are these atoms, anyway? I need not perhaps remind you of the investigations that have been made on the size of the atom and of the molecule of which it is a part. From the work of Sir William Thomson on the electricity of contact of different metals, from a study of the surface tension and the thickness of the soap-bubble film, and finally from what is known of the molecular motion of gases, a calculation has been made as to the distance apart of the particles of matter and as to their actual size.

From this we learn that the diameter of a particle is about one 250,000,000th of an inch, and therefore the number of particles in a cubic inch of air is not far from 3 raised to the tenth power, or (to represent this number more accurately to our comprehension) 3 with 20 ciphers annexed, thus: 300,000,000,000,000,000,000. Tait says that to get some understanding of it, we may say that one of the particles that go to make up a drop of water is to the whole drop as an ordinary base ball is to the whole size of the earth.

Perhaps I cannot better illustrate the extreme smallness of these particles than by dissolving a little of this coal-tar color known as fuchsin in some water. In this carboy there are 10 gallons or about 40 liters of water. I have weighed out, on a very delicate scale, four milligrams of this fuchsin. That is one 10,000,000th of the weight of the water in the carboy. I dissolve this dye stuff in alcohol for convenience and pour the solution into this carboy of water. You will notice the beautiful red or magenta color that is produced, and you will see that the whole quantity of water is reddened. This means that one part of the dye will color at least 10,000,000 parts of water. How very small must the molecules or particles be.

The chemical balance is the most important instrument that the analytical chemist or the investigator uses. With it he weighs ponderable matter, and the more accurate and the finer his weighings, the closer his results. Much progress has been made in the construction of balances, so that now the aluminum beam, the agate bearings and agate or steel knife edges, to avoid friction as much as possible, and finally the short arm balance, to facilitate rapid weighing, are common improvements to be found in every laboratory. The balance is inclosed in a glass air-tight case to avoid the inaccuracy that might be caused by draughts of air while weighing, and an artificially dried atmosphere is always present, so as to avoid the errors that might arise from excess of moisture. Moreover it is possible to pump out the air from a balance case and weigh in a vacuum, as is done in many of the finer physical and chemical investigations.

For greater convenience the decimal system of weights is used, and we say that we ordinarily weigh to the one-twentieth of a milligram. The scales are so delicate that they will fluctuate on the addition of a single hair to the load. I may illustrate this by balancing on the two pans of this scale pieces of paper of the same weight. You can see by the spot of light that is reflected on the wall from a mirror on the index that the beam is at rest as the support is lowered, and the beam is free to move up and down. The balance is then at equilibrium. Now I will write a name on this piece of paper with a lead pencil and replace the paper upon the pan. You see the result; the pan having the name written on the paper is heavier than the other. That shows the weight of a great name.

Dr. E. L. Nichols, a former president of this association, exhibited at the Madison meeting of the American Association for the Advancement of Science, this summer, some photographs that he had taken of the intermittent electric spark. For recording what takes place in infinitely small spaces of time, he makes use of the extreme sensibility of the photographic plate, and he makes the assertion that there is thus far no exposure too short to be recorded by it. By the use of this sensitive plate it is possible to photograph the rifle bullet at all stages of its passage through the air. It is possible to observe the condensation of the air that takes place in front of the advancing bullet, and the waves showing the vacuum behind it. We can study also the effect on the bullet at the instant when it strikes the target, or at various stages of its passage through an oak plank.

Wheatstone has isolated by the revolving mirrors the one-millionth of a second, and the photographic plate records the phenomena that take place in these short intervals of time. They are accurately measured. With such delicate apparatus it is possible to record the history of the first three or four millionths of a second at the beginning of a phenomenon and also at the close. In this line what an inviting field for investigation.

What advances in study have become possible since Muybridge has succeeded so admirably in photographing animals in motion.

The waves of sound are considered to be coarse waves. They require air for their propagation. Pump all the air out of this room and you might ring the great bell of Moscow and no sound would be heard. Has it not occurred to all there are sounds both too high and too low for us to recognize with the hearing apparatus with which we are endowed? Our ability in this direction depends on the delicacy of the organs of hearing. We hear some of the sounds that agitate the air, but how many sounds are there so exquisitely fine that they are never heard? You can hear the voice of the mosquito as fine as a cambric needle, but is that not nearly at the end of your scale? What a vast orchestra may be playing about us at this very moment, while their music is as completely lost as the fourteenthly of the pastor's sermon upon the sleeping deacon. These are the little sounds. We may sometime invent instruments suitable to enable us to detect the unheard sounds.

The deep tones of nature can be heard and appreciated by some better than by others. The roar of Niagara and the crash of the avalanche is the sublimest of music if we hear it aright. We must catch the harmonic tones of the cataract's roar and the dying echoes of the crashing ice torrents as they are hurled from the icy walls of the mountain valley.

But we should not call upon the sense of sight and of hearing alone to testify to the capacity of the human body for minute investigation. The sense of smell and the sense of taste have been too long neglected. We have continual evidence of the delicacy of the sense of smell. I need not refer you to the oft quoted assertion that a grain of musk will scent a room for a score of years, and yet not lose appreciably in weight. Still, can we account for the dissemination of this odor on any other theory than that the minute particles have actually left the original grain of musk and are floating about in the air? We cannot catch them nor weigh them, yet the nose will tell us where the sweet or disagreeable odor is, and it is an unfailing monitor. In the present state of development of this sense, however, the lower animals far outdo man. But this greater sensitiveness is without doubt largely due to the more extensive use of the organ of smell by the lower animal. Man has cultivated the sense of sight and of hearing; he has learned to appreciate the beautiful in art and in music, but he has regarded as entirely beneath his notice those senses that contribute so much to his happiness. What will recall the old home kitchen more quickly than a whiff of some long-forgotten odor? Can you ever smell the fragrant hickory-nut shell without being reminded of the tall tree you boys used to climb in the mellow October Saturday afternoons? Can you smell the old-fashioned marigold or four-o'clock without seeing some kitchen garden tended by a spinster aunt of your acquaintance?

There are no senses that are quicker to respond to suggestions than these so intimately associated ones. We express this in common conversation, when we associate the Irishman with his peat fire smoke, the Italian with his macaroni and cheese, and the German with his onions and sour beer. These appeal to our sense of smell and recall the nationality instantly.

The nerves of taste, too, can pick out substances of different quality so delicate that neither chemical nor physical science is acute enough to follow them. From some experiments made in the laboratory of the State University, it has been shown that a normally-endowed person can pick out one part of a bitter substance in about 700,000 parts of water; but one part of sugar in 128 parts of water is the limit of sensibility. There are those, however, who, either from superior training or from natural delicacy of the sense, can detect one part of a bitter substance even if it is dissolved in a million and a quarter parts of water. They can detect one 170,000th part of a grain of strychnin, for instance. That is beyond the delicacy of the chemical test for this poison, but not very much beyond it. And it must be remembered that the chemical test says that the substance is strychnin, while the taste only tells us that the substance is bitter. It may be any bitter principle, as aloin, morphin, or quinin.

In the field of Toxicology, also, as we have a knowledge of poisons, minute quantities of which are fatal, we have also extremely delicate methods for the detection of these poisons. One is reminded in this science of the progress that is made in building huge projectiles and in heavier armor to withstand the force of the projectiles. With the Krupp gun comes the 10-inch chilled steel for it to penetrate. With the increase in projectile power comes the greater ability to withstand these projectiles. We cannot tell why that molecule $C_{21} H_{22} N_2 O_2$, which we call strychnin, has such deadly power, but we can find it even if it is present in very minute quantities in the body. From a mass of organic matter many thousand times the amount, it is possible to separate, after repeated purifications, the pure needle-shaped crystals of strychnin, that may be identified by a dozen distinct and characteristic tests. We can go out of the line of chemical investigation and make physiological tests that will verify our results from another standpoint. I have experimented with a frog, for instance, by injecting less than one 125th of a grain beneath the skin, and seen the peculiar spasms so characteristic of this poison appear in less than a minute, and in three minutes the frog was dead. This was with strychnin that had been taken from the body of a man who had been poisoned by a fatal dose.

There is also another deadly drug, aconite, so poisonous that a still smaller portion than that noticed for strychnin is liable to prove a fatal dose. Here, too, the physiological test can be relied upon with certainty. It is stated that if one 1,000th of a grain of this alkaloid be dissolved in water and placed upon the tongue it will cause a distinct numbness that will last for an hour, while one 100th of a grain dissolved in alcohol and rubbed on the skin will produce loss of feeling that will last for some time. Experiments have shown that one 50th of a grain given to a bird will kill it almost instantly.

I need not speak of that interesting active substance, atropin, which the oculist will inject into your eye when he examines it. We know that as small a quantity as one 3,000th of a grain will dilate the pupil. Here then we have a delicate and efficient test for this drug.

In the field of organic chemistry the advances that have been made are wonderful. One of the most interesting substances that has been discovered is saccharin. It is made, as are the anilin colors, from coal tar. It is several hundred times as sweet as sugar; so that, if a small particle be placed on the tongue, the impression of sweetness will remain for a long time. If any of you want to go forth as apostles of sweetness and light, you can be fitted out from the chemical laboratory, and can go forth with a bottle of saccharin in one hand and a coil of magnesium ribbon in the other. You can thus sweeten the walks of men and light their paths in a purely physical sense.

It is appropriate that I should speak of some of the most delicate physical and chemical methods used in making tests.

One of the most delicate instruments is the spectroscope, the invention of Kirchoff and Bunsen. Without going into details as to the construction of the instrument, it is only necessary to say that by its use it is possible to analyze the light from a heated metal, from the sun, or from the most remote fixed star or comet, and tell of what it is composed.

One of the commonest substances on the earth is common salt, sodium chloride. We have an immense storehouse of it in the water of the ocean, and it is found deposited in great beds in several favored localities, of which central Kansas is one. When sodium, the metal of salt, burns, it imparts to the flame a yellow tint. This can be seen on a large scale if I light a bowl of alcohol that is saturated with salt. You will notice the peculiar cadaverous effect that the light produces on all objects in the vicinity.

By the use of the spectroscope it is possible to detect an almost infinitely small quantity of this substance. It is estimated that one 195,000,000th of a grain can be detected. A grain is about as much as would lie on the point of a pen-knife. That is considerably less than a "pinch." Lithium, too, has a characteristic flame reaction.

The chemist can avail himself also of very delicate tests for ammonia; and he finds these tests of the greatest use in the determination of the extremely small quantities of ammonia in air and in water. Yet these tests in water are of great importance to the analyst in helping him to decide as to the purity of a water and whether it is fit for use as a domestic supply. One of these tests is by the use of "Nessler's solution," as it is called. By its use we can detect the one 1,000,000th of a grain, or, to be more practical, we can detect one part of ammonia in 100,000,000 parts of water.

In an interesting article on "Next to Nothingness in Chemistry," W. H. Pendlebury speaks of some of the latest discoveries that have been made in the importance of little things. It is wonderful, for instance, what an effect moisture has on the simple process of combustion. Even the ordinary coal or wood fire does not burn well if the fuel and the air are perfectly dry. It has been shown that if oxygen be perfectly dry, such a combustible substance as phosphorus may be warmed, or even distilled in it, and not take fire. Wanklyn has discovered that dry chlorin will not combine with dry oxygen; but, if the least particle of moisture be admitted, the combination takes place immediately with the evolution of light and heat.

It has been shown that copper does not act on nitric acid, if both are pure; but the smallest trace of nitrous acid will bring about the combination with avidity. One part of nitrous acid in 10,000 is sufficient.

What a vast difference the presence of a little impurity can make in commercial copper. It will carry twice as many messages used as a telegraph wire if pure as if adulterated with even one-tenth of 1 per cent. of bismuth.

One 1,000th part of antimony in copper will destroy its value for many commercial purposes.

Steel is perhaps as sensitive to small quantities of carbon as any metal that can be mentioned. Look at that strong boiler plate: it is made of a steel that contains perhaps two-tenths of 1 per cent. of carbon. This kinfe is made of a steel that contains perhaps eight-tenths of 1 per cent. But it would be impracticable to make a boiler plate out of this knife steel.

We are all more or less familiar with the substance known as gold leaf. Gold is the most malleable of metals, so that if I pile up 200,000 leaves of gold one above another the pile will be only one inch high. It is so thin that it floats almost in the air, yet really the metal is 19.5 times as heavy as water. If then I have a vessel of water on this table that weighs 100 pounds the same vessel filled with gold would weigh 1,950 pounds, or almost a ton.

Gold is very susceptible to a small amount of impurity. One part in 2,000 would make it so brittle that a bar of it would be readily broken with a hammer. This is in the face of the fact as I stated that it is when pure the most malleable of metals. Our predecessors, the alchemists, understood the wonderful effect of a small quantity of another metal upon this precious metal, and is it any wonder that they sought to find a philosopher's stone that would change a common metal to gold?

A large amount of work has recently been done on the micro-organisms of the soil; those infinitesimal creatures that have their home and do their work in the darkness below the surface of the earth. Some of these bacteria are very curious in their habits as well as very small. There is one, for instance, that actually needs carbonate of iron in order to keep in good growing condition. It gives off oxygen that it has abstracted from the iron compound. We hear much just now of the great corporations swallowing the railroads, but given an unlimited cycle of years, as our geologists say, and an infinite number of bacteria, and they will also swallow the railroads—at least the rails.

You have perhaps heard also of those wonderful "nitrifying ferments," which have been so successfully studied by Warrington and by Winegrawdski. One of these is an organism which can grow and work in the dark in material that actually contains no organic material. Here it can produce organic bodies, using the ammonia of the soil and the carbon of the carbonates. Another ferment has the power to change the organic nitrogen of the soil to ammonia.

The agricultural chemist will tell you of organisms that actually add nitrogen to the soil. Though there is an abundance of nitrogen in the air, in fact four-fifths of the air in this room is nitrogen, yet most plants have not the ability to use it. The leguminous plants, however, are an exception to this rule; but they cannot do the work without calling to their aid some of those little bacteria that I mentioned. Did you ever notice the knotted root of the clover? It is supposed that these tubercles or knots are produced by exterior infection. In fact this is proved by the simple test of attempting to grow lupines in a soil of pure sand. They will starve; but if the plants are watered with a fresh extract made from lupines, then the little tubercles will be produced and they have the power to assimilate the nitrogen from the air, and the plants will thrive.

It is well known, to those who have kept apace with what is going on in the agricultural world, that not only is the farmer under obligations to the microscopic forms of life for the fertility of his soil, but in the domestic operations of butter and cheese making he must call to his aid these mysterious allies. He is obliged to depend on these minute organisms for the production of the "gilt-edged butter" that always commands the highest price in the market. The Danes, whose exhibit at the World's Fair was a revelation to some of us, have done as much as any people towards the isolation and perpetuation of those particular forms of bacteria that have been found to produce the best, sweetest butter. As a result of their work, "prepared cultures" are now offered to dairies. If they have allowed their stock of bacteria to degenerate; if through lack of care or of cleanliness their particular families of bacteria are not the best that can be had, all that it is necessary to do is to sow in the dairy some of these good, healthy colonies and good, sweet grass butter can again be made. Our grandmothers did not suppose that when they watched so carefully the temperature of the cream, and when they attended so carefully to the cleansing of the milk pans, that they were only producing conditions for the healthful growth of those bacteria that had "blue blood" in their veins, and those that would scorn to aid in the manufacture of anything but the highest grade of butter.

So also in cheese ripening. It makes the greatest difference what colonies of these lower organisms are admitted into the factory. Some will only bring discord and moldy cheese; others sweet, ripe old age .

It would be interesting to illustrate the subject farther by more glances into the under world of bacteriology that has begun to open out so wonderfully within the past few years to the eye of the patient investigator. What immense results may be expected from the work in this field, following the lead of such men as Koch and Pasteur? We have learned to identify with reasonable certainty the germs of consumption, of cholera, and of typhoid fever; and now the next step obviously is to study the conditions of their propagation and growth; and, knowing their life history, we shall be better able to guard against their attacks. But, however seductive this field is, we must leave it with only these few glimpses.

Finally, be it noted that all those who are engaged in the work of scientific investigation are adding to the sum of human knowledge, each in his narrow sphere, it may be, but each just as effectively. We cannot afford to look on anything that can be seen or heard or felt or tasted or smelled or known as too small or too insignificant for our notice. It is only in following out the little clews that we may chance to get hold of that we can hope to solve the labyrinth of nature. The true investigator never despises the "day of small things."

THE INVERSE OF CONICS AND CONICOIDS FROM THE CENTER.

By M. E. RICE, University of Kansas, Lawrence.

For the purposes of this paper it is convenient first to discuss briefly the locus of a point which moves so that the sum, or difference, of its distances from two fixed points bears a constant ratio to its distance from a third point midway between these two.

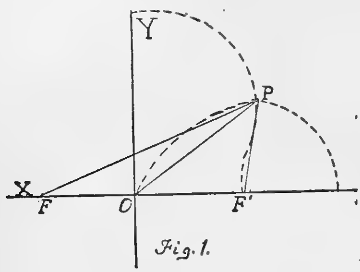


Fig. 1.

In Fig. 1 let P be the moving point, F, F' and O the three fixed points. Take O for origin, and the line FF' for the axis of abscissae; then the condition is

$$\frac{PF \pm PF'}{PO} = \text{a constant.} \qquad (1)$$

This gives the equation,

$$[(x + OF)^2 + y^2]^{\frac{1}{2}} \pm [(OF - x)^2 + y^2]^{\frac{1}{2}} = k\,(x^2 + y^2)^{\frac{1}{2}} \qquad (2)$$

For convenience let $OF = OF' = \frac{a}{e}$, and $k = \frac{2}{e}$; equation (2) becomes, after clearing of radicals:

$$a^2 x^2 + y^2 \frac{a^2}{1 - e^2} = (x^2 + y^2)^2 \qquad (3)$$

It is evident from the form of this equation that the curve is symmetrical about either axis; and that as e varies the shape of the curve will change accordingly. Hence e may conveniently be called the *eccentricity* of the curve; and the fixed points F and F', *foci.*

Denote the numerical value of

$$\frac{a^2}{1 - e^2} \text{ by } b^2, \text{ whence } e^2 = \frac{\pm b^2 - a^2}{\pm b^2} \qquad (4)$$

Equation (3) may now be written in the symmetrical form,

$$a^2 x^2 \pm b^2 y^2 = (x^2 + y^2)^2 \qquad (5)$$

according as $e < 1$ or $e > 1$.

Consider first the case when $e < 1$, and the equation is,

$$a^2 x^2 + b^2 y^2 = (x^2 + y^2)^2 \qquad (6)$$

The curve cuts the axes of coordinates at the points $(\pm a, o)$, $(k, \pm b)$; and as it is a closed curve, a may be called the minor, and b the major semi-axis respectively.

The distance from center to either focus is $\frac{a}{e}$. Since the equation contains no terms of a lower degree than the second, the origin is a conjugate point. Also the equation of imaginary tangents at the origin is

$$a^2 x^2 + b^2 y^2 = 0. \qquad (7)$$

The circular points at infinity are imaginary double points for, making the given equation homogeneous by means of the line at infinity, $0x + 0y + c = 0$, gives

$$(x^2 + y^2)^2 = 0, \qquad (8)$$

which is the equation of the lines through the origin and the points common to the curve and the line at infinity. But this breaks up into

$$(x + iy)^2 (x - iy)^2 = 0; \qquad (9)$$

that is, the four lines reduce to two pairs of coincident lines, showing that the line at infinity cuts the curve in two imaginary double points.

The curve has four foci, two real and two imaginary: for the foci of a curve are determined by the points of intersection of tangents from the circular points at infinity. In the case of a curve of the fourth degree there are in general twelve such tangents; but as the circular points at infinity are also double points, there are in this case but four distinct tangents, which intersect in two real and two imaginary points. The two real points are the foci F, F' mentioned above.

When $e = 0$, $a = b$, and the equation breaks up into the two factors,

$$x^2 + y^2 = a^2, \text{ and } x^2 + y^2 = 0; \tag{10}$$

that is, the curve is a circle of radius a and a point circle at the origin. When $e > 0$ and $< \sqrt{\frac{1}{2}}$, the curve is a smooth oval. When $e = \sqrt{\frac{1}{2}}$, it changes to an indented oval. In order to determine when this change occurs, it is only necessary to express the condition that the curvature at the x axis shall be zero. Using the polar equation

$$r^2 = a^2 \cos^2 k + b^2 \sin^2 k, \tag{11}$$

the initial line being the axis of abscissæ, the condition for zero curvature at a point is:

$$r^2 + 2\frac{dr^2}{dk^2} - r\frac{d^2r}{dk^2} = 0, \tag{12}$$

which becomes, when values are substituted:

$$\begin{aligned} &a^2 \cos^2 k + b^2 \sin^2 k - (b^2 - a^2) \cos 2k \\ &+ \tfrac{3}{4} (b^2 - a^2)^2 \sin^2 2k \, (a^2 \cos^2 k + b^2 \sin^2 k)^{-1} = 0 \end{aligned} \tag{13}$$

When $k = 0$ this reduces to $2a^2 = b^2$, whence $e = \sqrt{\frac{1}{2}}$, the required condition.

When $e > \sqrt{\frac{1}{2}}$ and $e < 1$, the curve is an indented oval, with four real points of inflection. In order to determine these points of inflection, set

$$\frac{d^2u}{dk^2} + u = 0, \tag{14}$$

where $u = \dfrac{1}{r}$ of equation (11).

This gives, after substituting values and reducing,

$$k = \tan^{-1} \pm \frac{a}{b} \left[\frac{b^2 - 2a^2}{2b^2 - a^2}\right]^{\frac{1}{2}} \tag{15}$$

Equation (15) shows that there are four points of inflection symmetrically placed about the origin, as might have been inferred from the form of the curve. Substituting the values of $\sin^2 k$ and $\cos^2 k$ obtained from equation (15), in equation (11), the radius vector to the points of inflection is found to be

$$r = \frac{\pm a b \sqrt{3}}{\sqrt{2}\sqrt{a^2 + b^2}} \tag{16}$$

showing that the four points of inflection lie on a circle concentric with the curve.

When $e = 0$; $b = a$ and $\tan k$ is imaginary; showing that there are no real points of inflection.

When $e = \sqrt{\frac{1}{2}}$; $b^2 = 2a^2$, $\tan k = 0$, and $r = \pm a$, showing that the four points of inflection coincide two and two at the extremities of the minor axis. This is the transition from a smooth to an indented oval. When $e = 1$; $a = 0$, $\tan k = 0$, $r = 0$; that is, the points of inflection are all at the origin.

In this case the equation of the curve breaks up into

$$x^2 + y^2 = by \text{ and } x^2 + y^2 = -by, \tag{17}$$

two circles of radius $\frac{1}{2}b$, tangent to the axis of abscissæ at the origin. They will be finite if e becomes unity by a being zero; infinite, and hence simply two straight lines coincident with the axis of abscissæ, if e is made unity by b assuming a value that is infinite compared with a.

The length, S, of the curve may be represented by the definite integral,

$$\tfrac{1}{4}S = \int_0^{\frac{\pi}{2}} \left[r^2 + \frac{dr^2}{dk^2} \right]^{\frac{1}{2}} dk, \tag{18}$$

which becomes, after values are substituted, $\tfrac{1}{4}S = \int_0^{\frac{\pi}{2}} \left(\frac{a^4 \cos^2 k + b^4 \sin^2 k}{a^2 \cos^2 k + b^2 \sin^2 k} \right)^{\frac{1}{2}} dk.$

The area, A, of the curve may be found by the formula

$$\tfrac{1}{4}A = \int_0^{\frac{\pi}{2}} r^2 \, dk, \tag{19}$$

which gives for the whole area inclosed by the curve the value, $\frac{\pi}{2}(a^2 + b^2)$.

The inverse of the given curve with respect to the center is,

$$a^2 x^2 + b^2 y^2 = 1, \tag{20}$$

an ellipse whose eccentricity is identical with that of the given curve. The polar reciprocal of this ellipse is,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1. \tag{21}$$

If circles be described upon the semi-diameters of this latter ellipse, they will envelop the quartic under discussion. Hence, in general, the inverse of an ellipse from the center is the pedal curve of its polar reciprocal with respect to the center.

The above relations furnish a convenient method of investigating many properties of the curve given at the beginning of this paper.

The curve may be described mechanically by means of its pedal property, thus:

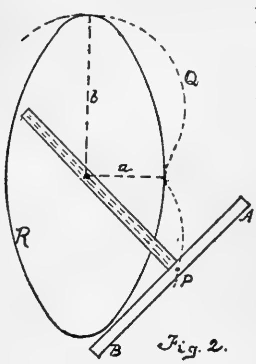


Fig. 2.

Let R be an elliptical board with semi-axis a and b, a "T" square is held by a pivot at O working in a slot, while the arm AB slides against the board; a pencil or crayon at P will describe the required curve Q.

Following is a partial list of theorems relating to the curve. They were obtained by inverting those properties only of the ellipse which in some way were dependent upon the center of the curve. The first paragraph contains the original theorem in the conic; the second paragraph, that relating to the quartic.

From the fact that straight lines invert into circles passing through the origin, it is convenient to call all such circles "central" circles. The quartic will be called an oval.

1. Two tangents can be drawn to an ellipse from any point, which will be real, coincident, or imaginary, according as the point is outside, upon or within the curve.

2. Two "central" tangent circles can be drawn to an oval from any point, which will be real, coincident, or imaginary, according as the point is within, upon, or outside the curve.

1. If the polar of a point P with respect to an ellipse pass through the point Q, then will the polar of Q pass through P.

2. If the "central" polar circle of a point P with respect to an oval pass through the point Q, then will the "central" polar circle of Q pass through P. [By "central" polar circle is meant the circle passing through the origin and the points of contact of "central" tangent circles from the point to the oval.]

1. The locus of the point of intersection of two tangents to an ellipse, which are at right angles to one another, is the director circle of radius equal to $(a^2 + b^2)^{\frac{1}{2}}$ when a and b are the semi-axes respectively.

2. The locus of the point of intersection of two "central" tangent circles to an oval which cut one another orthogonally is a circle of radius $\frac{a\,b}{(a^2+b^2)^{\frac{1}{2}}}$ when a and b are the semi-axes of the oval respectively.

1. The equation of the locus of the foot of the perpendicular from the center of an ellipse on a tangent is $r^2 = a^2 \cos^2 k + b^2 \sin^2 k$, the equation of the ellipse being $1 = \frac{r^2 \cos^2 k}{a^2} + \frac{r^2 \sin^2 k}{b^2}$.

2. The equation of the locus of the extremity of the diameter through the origin of a "central" tangent circle to the oval given by the equation $r^2 = a^2 \cos^2 k + b^2 \sin^2 k$ is an ellipse whose equation is $1 = \frac{r^2 \cos^2 k}{a^2} + \frac{r^2 \sin^2 k}{b^2}$.

1. The sum of the reciprocals of the squares of any two diameters of an ellipse which are at right angles to one another is constant.

2. The sum of the squares of any two diameters of an oval which are at right angles to one another is constant.

1. The line joining the extremities of any two diameters of an ellipse which are at right angles to one another will always touch a fixed circle.

2. The "central" circle joining the extremities of any two diameters of an oval which are at right angles to one another will always touch a fixed circle.

1. The tangent at a point P of an ellipse meets the tangent at A, one extremity of the axis ACA', in the point Y; then is CY parallel to $A'P$, C being the center of the curve.

2. The "central" tangent circle at a point P of an oval cuts the "central" tangent circle at A, one extremity of the axis ACA', in the point Y; then is C Y tangent at C to the "central" circle through P and A', C being the center of the curve.

1. If three of the sides of a quadrilateral inscribed in an ellipse are parallel respectively to three given straight lines, then will the fourth side also be parallel to a fixed straight line.

2. Four points are taken on an oval: if three of the four "central" circles through the consecutive pairs of these points have their "central diameters" perpendicular to three given lines respectively, then will the "central diameter" of the fourth "central" circle be perpendicular to a given line. [By "central diameter" of a "central" circle is meant that diameter which passes through the origin.]

1. A parallelogram circumscribes a circle, and two of the angular points are on fixed straight lines parallel to one another and equidistant from the center; then are the other two on an ellipse of which the circle is the minor auxiliary circle.

2. Four "central" circles are inscribed in a circle so that the two opposite ones have a common "central diameter"; two of the four points of intersection

lie on equal fixed "central" circles having a common "central diameter" and on opposite sides of the center; then are the other two points of intersection on an oval to which the circle is tangent at the extremities of the major axis.

1. Three points, A, P, B, are taken on an ellipse whose center is C. Parallels to the tangents at A and B drawn through P meet CB and CA respectively in the points Q and R. Then is QR parallel to the tangent at P.

2. Three points, A, P, B, are taken on an oval whose center is C. "Central" circles drawn through P and having common "central diameters" with the "central" tangent circles at A and B respectively, meet the lines CB and CA respectively in the points Q and R. Then the "central" circle through Q and R has a common "central diameter" with the "central" tangent circle at P.

1. The sum of the distances from any point on an ellipse to the two foci is constant. The ellipse may be described mechanically by the use of this property.

2. The sum of the distances from any point on an oval to the two foci bears a constant ratio to its distance from the center. The oval, also, may be described mechanically by the use of this property.

1. To draw a tangent at any point of an ellipse, bisect the external angle between the focal radii: to draw a normal, bisect the interior angle.

2. To draw a tangent line to an oval, bisect the external angle formed by the two "central" circles through the point and the two foci respectively: to draw a normal, bisect the interior angle.

1. The subtangent of an ellipse is equal to the corresponding subtangent of the circle described upon the major axis.

2. Given an oval and a circle described upon its minor axis. "Central" tangent circles are drawn at the points where the oval and circle are cut by a "central" circle that intersects the major axis at right angles. Then will the two "central" tangent circles cut the transverse axis at the same point.

Consider now the case where $e > 1$, and the equation of the curve is

$$a^2 x^2 - b^2 y^2 = (x^2 + y^2)^2 \qquad (6')$$

The development of the properties of this curve is much the same as for the quartic first considered. Analytically, it is only necessary to change b^2 to $-b^2$ in the equations of the former to obtain the corresponding equations in the latter.

The curve cuts the axis of coördinates at the points $(\pm a, 0)$ $(0, 0)$; and a and b may be called the minor and major semi-axis respectively.

The distance from center to either focus is $\frac{a}{e}$.

The origin is a real double point. The equation of real tangents at the origin is,

$$a^2x^2 - b^2y^2 = 0. \qquad (7')$$

The circular points at infinity are imaginary double points.

The curve has four foci, two real and two imaginary.

The origin is a point of inflection.

When $e = 1$; $a = 0$; and the equation breaks up into two imaginary circles,

$$x^2 + y^2 = \pm b y \sqrt{-1}. \qquad (17')$$

When $e > 1$, the shape of the curve is that of a figure 8 extending along the axis of abscissæ.

When $e = \sqrt{2}$; $a = b$, and the curve is identical with the lemniscate of Bernouilli.

When $e = \infty$; $b = 0$, and the equation breaks up into

$$x^2 + y^2 = \pm ax; \qquad (17'')$$

that is, two circles of radius $\frac{1}{2}a$, tangent to the axis of ordinates at the origin.

The length S of the curve may be represented by the definite integral,

$$\tfrac{1}{2} S=\int_0^{\tan^{-1}\frac{a}{b}}\left(\frac{a^4 \cos^2 k - b^4 \sin^2 k}{a^2 \cos^2 k - b^2 \sin^2 k}\right)^{\frac{1}{2}} dk.$$

The whole area inclosed by the curve is given by the value of $a\,b + (a^2 - b^2) \tan^{-1}\frac{a}{b}$. The entire area of the lemniscate of Bernouilli is found by putting $a = b$ in the preceding expression, which gives the value a^2. The inverse of the curve from the center is the hyperbola

$$a^2\,x^2 - b^2\,y^2 = 1, \qquad (20')$$

which has the same eccentricity as the quartic. The polar reciprocal of this hyperbola is

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1, \qquad (21')$$

showing that the inverse of an hyperbola from the center is the pedal of its polar reciprocal with respect to the center, as in the corresponding case of the ellipse.

The curve may be described mechanically by means of its pedal properties, very much as in the preceding case of the ellipse.

Many of the inverse theorems relating to the ellipse and oval are equally true when applied to the hyperbola and this curve, which may be called a lemniscate. Following are a few additional theorems relating more especially to the hyperbola and the lemniscate:

1. The difference of the two lines drawn from any point of an hyperbola to the foci is equal to the transverse axis.

2. The difference of the two lines drawn from any point on a lemniscate to the foci bears a constant ratio to the radius vector of the point.

1. PN is the ordinate of a point P on an hyperbola, PG is the normal meeting the axis in G; if NP be produced to meet the asymptote in Q, then is QG at right angles to the asymptote.

2. PN is a "central" circle through the point P on a lemniscate and whose "central diameter" is the axis of abscissæ, PG is a "central" circle cutting the curve orthogonally at P and meeting the axis of abscissæ at G; if the "central" circle NP cut the tangent at the origin at Q, then is the "central" circle QR cut orthogonally by this tangent.

The lemniscate may be said to have a "conjugate" lemniscate, just as the hyperbola has a conjugate hyperbola.

1. The equation of an hyperbola is $a^2x^2 - b^2y^2 = 1$. The equation of its conjugate is $a^2x^2 - b^2y^2 = -1$. The equation of its asymptote is $a^2x^2 - b^2y^2 = 0$. The equation of an hyperbola referred to its asymptotes is $xy = \frac{b^2 + a^2}{4a^2b^2}$. That of its conjugate is $xy = -\frac{b^2 + a^2}{4a^2b^2}$.

2. The equation of a lemniscate is $a^2x^2 - b^2y^2 = (x^2 + y^2)^2$. The equation of its conjugate is $a^2x^2 - b^2y^2 = -(x^2 + y^2)^2$. The equation of tangents at the origin is $a^2x^2 - b^2y^2 = 0$. The equation of a lemniscate referred to tangents at the origin is $xy = \frac{a^2 + b^2}{4a^2b^2}(x^2 + y^2)^2$. That of its conjugate is $xy = -\frac{a^2 + b^2}{4a^2b^2}(x^2 + y^2)^2$.

1. The two lines joining the points in which any two tangents to an hyperbola meet the asymptotes are parallel to the chord of contact of the tangents and are equidistant from it.

2. The two "central" circles joining the points in which any two "central"

tangent circles to a lemniscate meet the tangents at the origin are in directum with the "central" circle joining the points of contact of the two "central" tangent circles.

1. The asymptotes of an hyperbola coincide with the diagonals of the rectangle contained by the transverse and conjugate axes.

2. The tangents to a lemniscate through the origin coincide with the diagonals of the rectangle formed by the intersections of four "central" circles whose diameters are the four semi-axes of the curve respectively.

And in general, the inverse, with respect to the center, of a system of conics given by the equation,

$$a^2 x^2 + y^2 \frac{a^2}{1 - e^2} = 1, \qquad (22)$$

is the system of pedal curves, whose equation is,

$$a^2 x^2 + y^2 \frac{a^2}{1 - e^2} = (x^2 + y^2)^2 \qquad (3)$$

These curves belong in the general class of curves designated by the name of *bicircular quartics.*

1. The condition that the line whose equation is $y = mx + c$ shall touch the conic given by equation (22) is $c^2 = \frac{m^2}{a^2} + \frac{1 - e^2}{a^2}$

2. The condition that a "central" circle whose equation is $y = mx + c\,(x^2 + y^2)$ shall touch the pedal curve given by equation (3), is $c^2 = \frac{m^2 + 1 - e^2}{a^2}$

1. The equation of a tangent line at any point of the conic is $a^2 xx' + b^2 yy' = 1$.

2. The equation of the "central" tangent circle at any point of the pedal is $a^2 xx' + b^2 yy' = (x^2 + y^2)$.

In this manner many more sets of corresponding equations in the two systems of curves might be given; but the above examples are sufficient to show their general relations.

Following is a list of theorems relating to confocal conics and confocal pedal curves:

1. The equation of a system of confocal conics is

$$\frac{x^2}{a^2 + h} + \frac{y^2}{b^2 + h} = 1.$$

2. The equation of a system of confocal pedal curves is

$$\frac{x^2}{a^2 + h} + \frac{y^2}{b^2 + h} = (x^2 + y^2)^2.$$

1. Two conics of a confocal system pass through a point. One of these conics is an ellipse and the other an hyperbola.

2. Two pedal curves of a confocal system pass through a point. One of these curves is an oval and the other is a lemniscate.

1. One conic of a confocal system and only one will touch a given straight line.

2. One pedal curve of a confocal system and only one will touch a given "central" circle.

1. Two confocal conics cut one another at right angles at all their common points.

2. Two confocal pedal curves cut one another at right angles at all their common points.

1. The difference of the squares of the perpendiculars drawn from the center on any two parallel tangents to two given confocal conics is constant.

2. The difference of the squares of the reciprocals of the diameters of any two "central" tangent circles in directum with one another, to two given confocal pedal curves is constant.

1. If a tangent to one of two confocal conics be perpendicular to a tangent to the other, the locus of their point of intersection is a circle.

2. If a "central" circle tangent to one of two confocal pedal curves cut orthogonally a "central" tangent circle to the other, the locus of their point of intersection is a circle.

1. From any point T the two tangents TP, TP' are drawn to one conic, and the two tangents TQ, TQ' to a confocal conic; then will the straight lines QP, $Q'P$ make equal angles with the tangent at P.

2. From any point T the two "central" tangent circles TP, TP' are drawn to one pedal curve, and the two "central" tangent circles TQ, TQ' to a confocal pedal curve; then will the "central" circles QP, $Q'P$ cut the tangent at P at equal angles.

1. TP, TQ are tangents one to each of two fixed confocal conics; then, if the tangents are at right angles to one another the line PQ will always touch a third confocal conic.

2. TP, TQ are two "central" tangent circles one to each of two confocal pedal curves; then, if these circles cut one another orthogonally, the "central" circle PQ will always be tangent to a third confocal pedal curve.

1. If an ellipse have double contact with each of two confocal conics, the tangents at the points of contact will form a rectangle.

2. If an oval (concentric) have double contact with each of two confocal ovals, the "central" tangent circles at the points of contact will cut one another orthogonally.

1. A triangle circumscribes an ellipse and two of its angular points lie on a confocal ellipse; then will the third vertex lie on another confocal ellipse.

2. Three "central" circles are tangent internally to an oval, and two of their points of intersection lie on a confocal oval; then will the third point of intersection lie on another confocal oval.

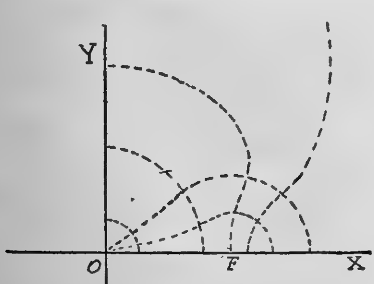


Fig. 3.

In figure 3 is shown the general appearance of a system of confocal pedal curves, consisting of ovals and lemniscates.

If the foregoing method of inversion be applied to a system of central conicoids, it gives rise to a system of surfaces of the fourth degree. These surfaces bear to the plane pedal curves just considered many of the relations that conicoids bear to plane conics They have three general forms according as the sections made by the coördinate planes are ovals or lemniscates, just as the central conicoids have the three forms of ellipsoid, hyperboloid of one sheet and hyperboloid of two sheets.

Let the general equation of a system of central conicoids be

$$\frac{x^2}{a^2} \pm \frac{y^2}{b^2} \pm \frac{z^2}{c^2} = 1, \tag{23}$$

where $a > b > c$, then that of the system of inverse surfaces will be

$$\frac{x^2}{a^2} \pm \frac{y^2}{b^2} \pm \frac{z^2}{c^2} = (x^2 + y^2 + z^2)^2. \tag{24}$$

This is the first pedal surface from the center of the conicoid given by the equation

$$a^2 x^2 \pm b^2 y^2 \pm c^2 z^2 = 1, \tag{25}$$

which in turn is the polar reciprocal with respect to the center, of the original conicoid. Hence, in general, the inverse of a conicoid from the center is the pedal surface of its polar reciprocal with respect to the center.

Resuming equation (24), it is evident that the three semi-axes of the surface are $\frac{1}{a}$, $\frac{\sqrt{\pm 1}}{b}$ and $\frac{\sqrt{\pm 1}}{c}$; and that the surface is symmetrical about any coordinate plane. The eccentricities of the sections made by the xy, xz, yz planes respectively are

$$e_z{}^2 = \frac{a^2 \mp b^2}{a^2}, \quad e_y{}^2 = \frac{a^2 \mp c^2}{a^2}, \quad e_x{}^2 = \frac{\pm b^2 \mp c^2}{\pm b^2} \tag{26}$$

When the signs in equation (24) are taken all positive, the surface is the pedal of an ellipsoid, and so far as this paper is concerned, may conveniently be called a pedal surface of the "first kind." It varies from a smooth to an indented surface, the transition occurring when either e_z or e_y or each becomes equal to $\sqrt{\frac{1}{2}}$. The two limiting forms are, a sphere when $e_z = e_y = e_x = 0$, and two spheres tangent at the origin to the xy plane when $e_y = e_x = 1$.

When the sign of $\frac{z^2}{c^2}$ in equation (24) is taken negative, the surface is the first pedal from the center of an hyperboloid of one sheet; and may be called a pedal surface of the "second kind."

The general form of the surface is represented by fig. 4.

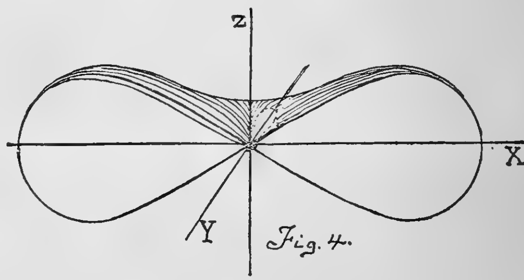


Fig. 4.

When the signs of $\frac{z^2}{c^2}$ and $\frac{y^2}{b^2}$, in equation (24) are taken both negative, the surface is the pedal from the center of an hyperboloid of two sheets; and may be called a pedal surface of the "third kind." The general form of the surface is shown in fig. 5; it is much the shape of two tops placed point to point.

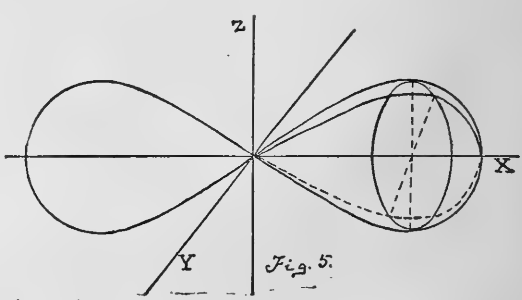


Fig. 5.

Following is a list of some of the more important theorems on the above pedal surfaces. They were obtained by inverting the properties of conicoids, the center of the conicoid being taken as the center of inversion. As in the case of plane pedal curves, only those properties were used which may be denominated "central properties"; that is, are dependent upon the center of the conicoid. The term "central sphere," analogous to "central circle," will be used to denote the inverse of a plane; it is a sphere passing through the origin or center of inversion.

1. All plane sections of a conicoid are conics.
2. All central plane sections of a pedal surface are plane pedal curves.

1. The equation of the tangent plane at any point of the conicoid,

$$ax^2 + by^2 + cz^2 + d = 0, \text{ is}$$
$$axx' + byy' + czz' + d = 0.$$

2. The equation of a central tangent sphere at any point of the pedal surface,

$$ax^2 + by^2 + cz^2 + d\,(x^2 + y^2 + z^2)^2 = 0, \text{ is}$$
$$axx' + byy' + czz' + d\,(x^2 + y^2 + z^2) = 0.$$

1. The condition that the plane $lx + my + nz + p = 0$ shall touch the above conicoid is $\frac{l^2}{a} + \frac{m^2}{b} + \frac{n^2}{c} + \frac{p^2}{d} = 0.$

2. The condition that the central tangent sphere $lx + my + nz + p\,(x^2 + y^2 + z^2) = 0$ shall touch the above pedal surface is,

$$\frac{l^2}{a} + \frac{m^2}{b} + \frac{n^2}{c} + \frac{p^2}{d} = 0.$$

1. The asymptotic cone to the conicoid given by equation (23) is

$$\frac{x^2}{a^2} \pm \frac{y^2}{b^2} \pm \frac{z^2}{c^2} = 0.$$

2. The tangent cone at the origin to the pedal surface given by equation (24) is

$$\frac{x^2}{a^2} \pm \frac{y^2}{b^2} \pm \frac{z^2}{c^2} = 0.$$

1. The condition that the conicoid shall be one of revolution is $(b - a)\,(c - a) = 0$.

2. The condition that the pedal surface shall be one of revolution is $(b - a)\,(c - a) = 0$.

1. The sum of the squares of the reciprocals of any three diameters of an ellipsoid which are mutually at right angles is constant.

2. The sum of the squares of any three diameters of a pedal surface of the "first kind" which are mutually at right angles is constant.

1. The locus of the point of intersection of three tangent planes to the conicoid given by equation (23) which are mutually at right angles is $x^2 + y^2 + z^2 = a^2 \pm b^2 \pm c^2$. This is the director sphere of the conicoid, and is real in the case of an ellipsoid; in the other cases it depends upon the values of a, b, and c.

2. The locus of the point of intersection of three central tangent spheres to the pedal surface given by equation (24) which cut one another orthogonally is $x^2 + y^2 + z^2 = \frac{1}{a^2 \pm b^2 \pm c^2}$. This may be called the director sphere of the pedal surface, and is always real in the case of a pedal surface of the "first kind."

1. The locus of the foot of a perpendicular from the center upon any tangent plane to a conicoid is a pedal surface.

2. The locus of the extremity of the "central" diameter of any "central" sphere tangent to a pedal surface is a conicoid. [By "central diameter" is meant the diameter which passes through the origin.]

1. Any tangent plane to the asymptotic cone of a conicoid meets the conicoid in two parallel straight lines, equidistant from the center.

2. Any tangent plane to the cone tangent at the origin to a pedal surface meets the surface in two equal circles in directum.

1. The area of any central plane section of an ellipsoid given by $\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1$, is $\frac{\pi a b c}{(a^2 l^2+b^2 m^2+c^2 n^2)^{\frac{1}{2}}}$, the cutting plane being given by the equation $lx+my+nz=0$.

2. The area of any central plane section of a pedal surface of the "first kind" given by $\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=(x^2+y^2+z^2)^2$, is $\frac{\pi}{2}(abc)^{-2}[(b^2+c^2)a^2 l^2+(a^2+c^2)b^2 m^2+(a^2+b^2)c^2 n^2]$, the cutting plane being given by the equation $lx+my+nz=0$.

1. If central plane sections of an ellipsoid be of constant area, their planes touch a cone of the second degree.

2. If central plane sections of a pedal surface of the "first kind" be of constant area, their planes touch a cone of the second degree.

The six central planes cutting circular sections from the conicoid given by equation (23) are given by the three pairs of equations

$$y^2\left[\frac{1}{b^2}-\frac{1}{a^2}\right]+z^2\left[\frac{1}{c^2}-\frac{1}{a^2}\right]=0. \quad (i)$$

$$z^2\left[\frac{1}{c^2}-\frac{1}{b^2}\right]+x^2\left[\frac{1}{a^2}-\frac{1}{b^2}\right]=0. \quad (ii)$$

$$x^2\left[\frac{1}{a^2}-\frac{1}{c^2}\right]+y^2\left[\frac{1}{b^2}-\frac{1}{c^2}\right]=0. \quad (iii) \qquad (27)$$

Taking the case of the ellipsoid, the two systems of real circular sections are given by the equations

$$x\left[\frac{1}{b^2}-\frac{1}{a^2}\right]^{\frac{1}{2}}\pm z\left[\frac{1}{c^2}-\frac{1}{b^2}\right]^{\frac{1}{2}}=p\left[\frac{1}{c^2}-\frac{1}{b^2}\right]^{\frac{1}{2}} \qquad (28)$$

where p is the perpendicular distance from the origin upon the cutting plane. Since a circle in space may always be considered as the intersection of a sphere by a plane, it follows that the inverse of a circle from any point is also a circle. Hence, the inverse of a system of circular sections of a conicoid is a system of circular sections of a pedal surface. And it is seen from equations (27) and (28) above, that there are two such systems of real circular sections in each of the three pedal surfaces. In the case of a pedal surface of the "first kind," these sections all lie on the system of central spheres which are bisected by the xz plane in the circles,

$$x\left[\frac{1}{b^2}-\frac{1}{a^2}\right]^{\frac{1}{2}}\pm z\left[\frac{1}{c^2}-\frac{1}{b^2}\right]^{\frac{1}{2}}=p\left[\frac{1}{c^2}-\frac{1}{a^2}\right]^{\frac{1}{2}}(x^2+z^2). \qquad (29)$$

When the sphere given by equation (29) is tangent to the surface, the point of tangency may properly be called an umbilicus, corresponding to an umbilicus in the conicoid. Hence the pedal surface has four umbilici, that is, points at which tangent planes will cut out infinitely small circles.

Following are a few additional theorems on circular sections:

1. In a conicoid, any two circular sections of opposite systems are on a sphere.

2. In the pedal surface, any two circular sections of opposite systems are on a sphere.

1. If the squares of the axes of an ellipsoid are in arithmetical progression the umbilici lie on the central circular sections: if they are in harmonic progres-

sion, the circular sections are at right angles: if they are in geometrical progression the tangent planes at the umbilici touch the sphere through the central circular sections.

2. If the squares of the axes of a pedal surface of the "first kind" are in harmonical progression, the umbilici lie on the central circular sections: if they are in arithmetical progression, the two systems of spheres cutting the circular sections have their "central diameters" at right angles: if they are in geometrical progression, the central tangent spheres at the umbilici touch the sphere through the central circular sections.

1. The angle made by the two systems of planes cutting circular sections from an ellipsoid is $k = 2 \tan^{-1} \frac{c}{a} \left\{ \frac{b^2-a^2}{c^2-b^2} \right\}^{\frac{1}{2}}$.

2. The angle between the "central diameters" of the two systems of central spheres cutting circular sections from a pedal surface of the "first kind" is $k = 2 \cot^{-1} \frac{c}{a} \left\{ \frac{b^2-a^2}{c^2-b^2} \right\}^{\frac{1}{2}}$.

Since a straight line in space inverts into a circle through the origin, the straight-line generators of a conicoid invert into circle generators of a pedal surface. Hence the properties of ruled conicoids, when inverted, give rise to corresponding properties of circularly ruled pedal surfaces. This circular generator lies entirely in the surface and passes through the origin. And since the hyperboloid of one sheet is the only central conicoid having straight-line generators, the pedal surface of the "second kind" is the only one of the three surfaces under discussion having circular generators. Also, corresponding to the two systems of straight-line generators of the hyperboloid are two systems of circular generators of the pedal surface. Following are a few theorems on the pedal surface of the "second kind" obtained by inverting those properties of the hyperboloid of one sheet which relate to straight-line generators:

1. The tangent plane to an hyperboloid of one sheet at a point through which a generating line passes will contain that generating line.

2. The central tangent sphere to a pedal surface of the "second kind" at a point through which a generating circle passes will contain that circle.

1. Through any point on a generating line of an hyperboloid of one sheet another generating line passes, and they are both in the tangent plane at the point.

2. Through any point on a generating circle of a pedal surface of the "second kind" another generating circle passes, and they are both in the central tangent sphere at the point.

1. Any plane through a generating line of a conicoid touches the surface, its point of contact being the point of intersection of the two generating lines which lie upon it.

2. Any central sphere through a generating circle of a pedal surface touches the surface, its point of contact being the point of intersection of the two generating circles which lie upon it.

1. Three non-intersecting generators are sufficient to determine the conicoid on which they lie.

2. Three non-intersecting (except, of course, at the origin) circular generators are sufficient to determine the pedal surface on which they lie.

1. The straight lines which intersect three fixed non-intersecting straight lines are generators of the same system of a conicoid, and the three fixed lines are generators of the opposite system of the same conicoid.

2. The central circles which intersect three fixed non-intersecting central circles are generating circles of the same system of a pedal surface, and the three fixed circles are generating circles of the opposite system of the same pedal surface.

1. Two straight lines, and two only, will, in general, meet each of four given non-intersecting straight lines; but if the four given straight lines are all generators of the same system of a conicoid, then an infinite number of straight lines will meet the four, which will all be generators of the opposite system of the same conicoid.

2. Two central circles, and two only, will, in general, meet each of four given non-intersecting central circles; but if the four given circles are all generating circles of the same system of a pedal surface, then an infinite number of central circles will meet the four, which will all be generating circles of the opposite system of the same pedal surface.

1. Two planes are drawn, one through each of two intersecting generating lines of a conicoid; these planes meet the surface in two other intersecting generating lines.

2. Two central spheres are drawn, one through each of two intersecting generating circles of a pedal surface; these spheres meet the surface in two other intersecting generating circles.

1. The plane through the center of a conicoid and any generating line will cut the surface in a parallel generating line, and will touch the asymptotic cone.

2. The plane through the center of a pedal surface and any generating circle will cut the surface in another generating circle equal to the first, and having a common diameter with it, and will touch the tangent cone at the origin.

1. The locus of the point of intersection of perpendicular generators of an hyperboloid of one sheet is a sphere $x^2+y^2+z^2=a^2+b^2-c^2$.

2. The locus of the point of intersection of generating circles of a pedal surface of the "second kind" that cut orthogonally is a sphere given by the equation $x^2+y^2+z^2=(a^2+b^2-c^2)^{-1}$.

This and the following theorem depend upon the fact that an angle in space inverts into an equal angle.

1. The angle between the generating lines through the point (x, y, z) of the quadric, $\frac{x^2}{a}+\frac{y^2}{b}+\frac{z^2}{c}=1$, is $\cos^{-1}\frac{\kappa_1+\kappa_2}{\kappa_1-\kappa_2}$, where κ_1, κ_2, are the roots of the equation, $\frac{x^2}{a(a-\kappa)}+\frac{y^2}{b(b+\kappa)}+\frac{z^2}{c(c+\kappa)}=0$.

2. The angle between the generating circles through the point (x, y, z) of the quartic, $\frac{x^2}{a}+\frac{y^2}{b}+\frac{z^2}{c}=(x^2+y^2+z^2)^2$, is $\cos^{-1}\frac{\kappa_1-\kappa_2}{\kappa_1-\kappa_2}$, where κ_1, κ_2, are roots of the equation $\frac{x^2}{a(a-\kappa)}+\frac{y^2}{b(b+\kappa)}+\frac{z^2}{c(c+\kappa)}=0$.

If a system of confocal conicoids be inverted from the center, a system of confocal pedal surfaces is obtained. The general equation of such a system is

$$\frac{x^2}{a^2+\kappa}+\frac{y^2}{b^2+\kappa}+\frac{z^2}{c^2+\kappa}=(x^2+y^2+z^2)^2 \qquad (30)$$

If κ is positive, the surface is a pedal of the "first kind," whose axes decrease as h increases: so that the limiting form of the surface when $h = \infty$ is a point sphere at the origin.

If h is negative and less than c^2, the surface is a pedal of the "first kind," which recedes more and more from the spherical form, like an hour-glass, until, when $h = -c^2$, it folds over on itself, as it were, and embraces all of the xy plane exterior to the oval whose equations are

$$\frac{x^2}{a^2 - c^2} + \frac{y^2}{b^2 - c^2} = (x^2 + y^2)^2,\ z = 0. \qquad (31)$$

When h is between $-c^2$ and $-b^2$, the surface is a pedal of the "second kind" which approaches as a limit, when h is very nearly equal to $-c^2$ that portion of the xy plane inclosed by the oval given by equation (31); and when h is very nearly equal to $-b^2$, the surface is very nearly coincident with that part of the xz plane which is exterior to the lemniscate whose equations are

$$\frac{x^2}{a^2 - b^2} + \frac{z^2}{c^2 - b^2} = (x^2 + y^2)^2,\ y = 0. \qquad (32)$$

If h is between $-b^2$ and $-a^2$, the surface is a pedal of the "third kind." When h is very nearly equal to $-b^2$, the surface is very nearly coincident with that portion of the $x\,z$ plane which is inclosed by the lemniscate given by equation (32). When $y = -a^2$, the surface becomes imaginary; but analytically it is all that portion of the $y\,z$ plane exterior to the imaginary curve

$$\frac{y^2}{b^2 - a^2} + \frac{z^2}{c^2 - a^2} = (y^2 + z^2)^2,\ x = 0. \qquad (33)$$

And when h is between $-a^2$ and $-\infty$ the surface continues imaginary. The two pedal curves given by equations (31) and (32) may be called the focal pedal curves of the system, corresponding in their properties to the focal conics of a system of confocal conicoids. Following is a list of corresponding theorems on confocal conicoids and confocal pedal surfaces:

1. Three conicoids of a confocal system pass through any given point: one of them is an ellipsoid, one an hyperboloid of one sheet, and one an hyperboloid of two sheets.

2. Three pedal surfaces of a confocal system pass through any given point: one of them is a pedal surface of the "first kind," one is of the "second kind," and one is of the "third kind."

1. One conicoid of a given confocal system will touch any plane.
2. One pedal surface of a confocal system will touch any central sphere.

1. Two conicoids of a confocal system will touch any straight line.
2. Two pedal surfaces of a confocal system will touch any central circle.

1. Two confocal conicoids cut one another at right angles at all their common points.

2. Two confocal pedal surfaces cut one another orthogonally at all their common points.

1. If a straight line touch two confocal conicoids, the tangent planes at the points of contact will be at right angles.

2. If a central circle touch two confocal pedal surfaces, the central tangent spheres at the points of contact will cut one another orthogonally.

1. The difference of the squares of the perpendiculars from the center on any two parallel tangent planes to two given confocal conicoids is constant.

2. The difference of the squares of the reciprocals of the diameters of any two

central tangent spheres in directum to two given confocal pedal surfaces is constant.

1. The locus of the point of intersection of three planes mutually at right angles, each of which touches one of three given confocal conicoids, is a sphere.

2. The locus of the point of intersection of three central spheres cutting one another orthogonally, each of which touches one of three given confocal pedal surfaces, is a sphere.

1. The locus of the umbilici of a system of confocal ellipsoids is the focal hyperbola.

2. The locus of the umbilici of a system of confocal surfaces of the "first kind" is the focal lemniscate.

1. If two concentric and co-axial conicoids cut one another everywhere at right angles they must be confocal.

2. If two concentric and co-axial pedal surfaces cut one another everywhere at right angles they must be confocal.

1. Three confocal conicoids meet in a point, and a central plane of each is drawn parallel to its tangent plane at that point, then, one of the three sections will be an ellipse, one an hyperbola, and one imaginary.

2. Three confocal pedal surfaces meet in a point, and a central plane of each is drawn tangent at the origin to the central sphere tangent at that point, then, one of the three sections will be an oval, one a lemniscate, and one imaginary.

1. If three lines at right angles to one another touch a conicoid, the plane through the points of contact envelop a confocal conicoid.

2. If three central circles at right angles to one another touch a pedal surface, the central sphere through the points of contact will always touch a confocal pedal surface.

Many other theorems relating to the curves and surfaces under discussion might be obtained; but those already given show their principal properties, and more would merely add comparatively uninteresting details.

FIGURATE SERIES.

By B. B. Smyth, Topeka.

Between arithmetical and geometrical series are to be found many series known as figurate series, based upon the fact that they represent geometrical figures, such as triangles, squares, pentagons, hexagons, octagons, tetrahedrons, hexahedrons, cubes, parallelopipeds, pyramids, cones, cylinders, spheres, and frustums of pyramids and cones.

Figurate series are produced by addition, to each of the successive terms, of a constantly increasing number, usually the preceding term, the last preceding term but one, the same term of another series, or some other definite term, as the case may require.

Figurate series are of two kinds—planimetric and volumetric, the former secondary, the latter tertiary. Arithmetical series are primary and linear.

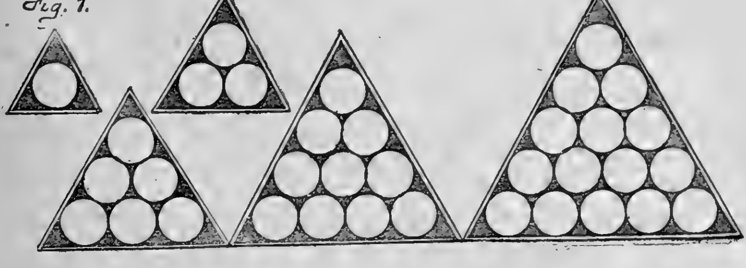
In most of the following series each term is found by adding to the same term of the preceding series the preceding term of the same series. It is equivalent to the sum of all the terms of the preceding series up to and including the same term. Thus the seventh term (84) of the tetrahedral series is equal to the sum of the first seven terms of the trigonal series; the eighth term (64) of the square series is equal to the first eight terms of the alternate series. In the following examples linear series are marked (1), planimetric series are marked (2), and volumetric series are marked (3).

TRIGONAL SERIES.

Terms:	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th,	etc.
		1	1	1	1	1	1	1	1	1	
(1)	1	2	3	4	5	6	7	8	9	10	.... Numeral Series.
(2)	1	3	6	10	15	21	28	36	45	55	.... Trigonal Series.
(3)	1	4	10	20	35	56	84	120	165	220	.... Tetrahedral Series.
Add		1	4	10	20	35	56	84	120	165	.... " "
(3)	1	5	14	30	55	91	140	204	285	385	.... Hexahedral Series.

This tetrahedron is, of course, a regular equilateral triangular pyramid. The hexahedron is not a cube but a double triangular pyramid. Any term in the hexahedral series is obtained by addition of two terms of the tetrahedral series—a similar term with the preceding term.

Fig. 1.



SQUARE SERIES.

Terms:	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th, etc.	
		2	2	2	2	2	2	2	2	2	
(1)	1	3	5	7	9	11	13	15	17	19	Alternate Series.
(2)	1	4	9	16	25	36	49	64	81	100	Square Series.
(3)	1	5	14	30	55	91	140	204	285	385	Pyramidal Series.
		1	5	14	30	55	91	140	204	285	" "
(3)	1	6	19	44	85	146	231	344	489	670	Octahedral Series.

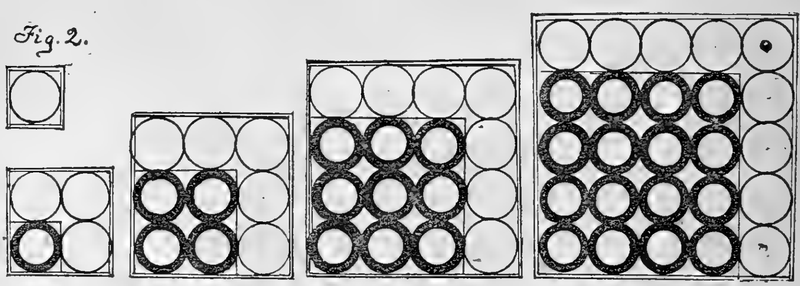
The units of the hexahedral and pyramidal series, though the same, are differently arranged. For example: In the fifth pyramid the lower tier contains $5 \times 5 = 25$ units. The second tier, laid in the interstices on top of this, contains $4 \times 4 = 16$ units; the third tier, 9; the fourth, 4; and on top, 1; making in all, 55 units.

Now compare the fifth hexahedron. At the bottom there is 1 unit. Just above it there are 3 in a triangle. The next layer or tier has 6 in a triangle; the fourth tier has 10; and the fifth, 15. Then they decrease to the top. The sixth tier has 10, as has the fourth; the seventh has 6, like the third; the eighth has 3, the same as the second; and on top is 1, as at the bottom. Thus there are 55 in all, the same as in the pyramid.

These forms, for school work, may be cut out of cardboard, potatoes, etc., or molded from wax, clay, or other plastic substance, or built up of marbles or wooden balls. A very good series may be made in outline by using wooden toothpicks, fastening together at the tips with small cubes of potato. In a few days the bits of potato dry hard and hold the sticks firmly in position.

The method of obtaining the square series from the alternate series, as above, may be represented to the eye thus, in which the light circles show the successive additions:

Fig. 2.



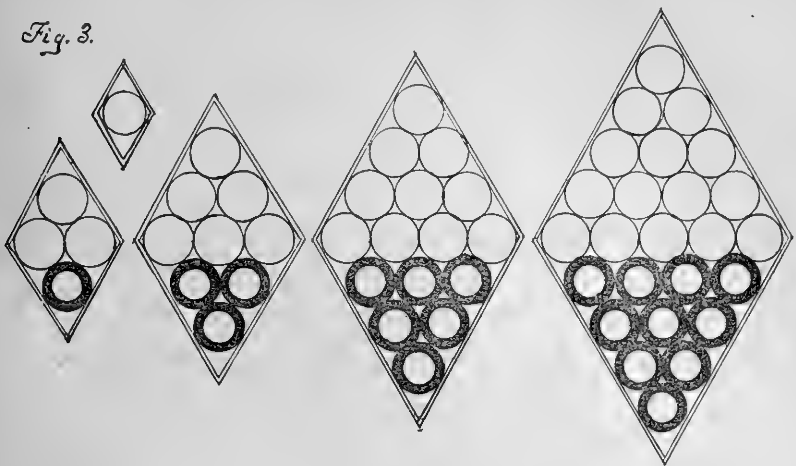
There are several other methods of obtaining the square series by addition, thus:

Secondly. By adding to each term of the trigonal series the preceding term, as:

	0	1	3	6	10	15	21	28	36	45	55	66 ....
Add		0	1	3	6	10	15	21	28	36	45	55 ....
	0	1	4	9	16	25	36	49	64	81	100	121 ....

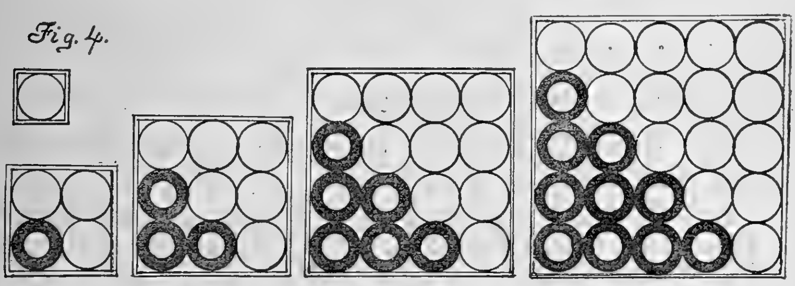
This would appear to the eye as rhombs, thus:

Fig. 3.



These, by a simple readjustment of the units, become squares, thus:

Fig. 4.



Thirdly. By subtracting from the tetrahedral series the second preceding term, thus:

	0	1	4	10	20	35	56	84	120	165	220	286	364 . . .
Subtract			0	1	4	10	20	35	56	84	120	165	220 . .
	0	1	4	9	16	25	36	49	64	81	100	121	144 . . .

Fourthly. By subtracting from the hexahedral series the preceding term, thus:

	0	1	5	14	30	55	91	140	204	285	385	506	650 . . . .
Subtract		0	1	5	14	30	55	91	140	204	285	385	506 . . . .
	0	1	4	9	16	25	36	49	64	81	100	121	144 . . . .

Remembering that the units in the pyramidal series are the same as in the hexahedral series, if we consider that the above series is a pyramidal series, the apparent strangeness of the performance disappears.

The square series seems to be indestructible by addition to it (or subtraction from it) of alternate, quartate, sextate, octate, or any regular arithmetical series, in which the common difference is 2 or any multiple of 2.

CASE I. EVEN SERIES.

Common difference of series, 4.

....	16	9	4	1	0	1	4	9	16	25	36	49	64	81	100	....
....	–12	–8	–4	0	4	8	12	16	20	24	28	32	36	40	44	....
....	4	1	0	1	4	9	16	25	36	49	64	81	100	121	144	....

Common difference, 8.

....	36	25	16	9	4	1	0	1	4	9	16	25	36	49	64	....
....	–32	–24	–16	–8	0	8	16	24	32	40	48	56	64	72	80	....
....	4	1	0	1	4	9	16	25	36	49	64	81	100	121	144	....

Common difference, 12.

....	64	49	36	25	16	9	4	1	0	1	4	9	16	25	36	....
....	–60	–48	–36	–24	–12	0	12	24	36	48	60	72	84	96	108	....
....	4	1	0	1	4	9	16	25	36	49	64	81	100	121	144	....

Common difference, 20.

....	144	121	100	81	64	49	36	25	16	9	4	1	0	1	4	....
....	–140	–120	–100	–80	–60	–40	–20	0	20	40	60	80	100	120	140	....
....	4	1	0	1	4	9	16	25	36	49	64	81	100	121	144	....

Common difference, 32.

....	100	81	64	49	36	25	16	9	4	1	0	1	4	....
....	–64	–32	0	32	64	96	128	160	192	224	256	288	320	....
....	36	49	64	81	100	121	144	169	196	225	256	289	324	....

Common difference, 60.

....	400	361	324	289	256	225	196	169	144	121	100	81	....
....	–300	–240	–180	–120	–60	0	60	120	180	240	300	360	....
....	100	121	144	169	196	225	256	289	324	361	400	441	....

Common difference, 100.

....	900	841	784	729	676	625	576	529	484	441	400	361	....
....	–500	–400	–300	–200	–100	0	100	200	300	400	500	600	....
....	400	441	484	529	576	625	676	729	784	841	900	961	....

CASE II. ODD SERIES.

Common difference, 2.

....	9	4	1	0	1	4	9	16	25	36	49	64	81	100	121	144	....
....	–5	–3	–1	1	3	5	7	9	11	13	15	17	19	21	23	25	....
....	4	1	0	1	4	9	16	25	36	49	64	81	100	121	144	169	....

Common difference, 6.

....	9	4	1	0	1	4	9	16	25	36	49	64	81	100	121	....
....	–9	–3	3	9	15	21	27	33	39	45	51	57	63	69	75	....
....	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	....

Common difference, 10.

....	25	16	9	4	1	0	1	4	9	16	25	36	49	64	81	....
....	–25	–15	–5	5	15	25	35	45	55	65	75	85	95	105	115	....
....	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	....

Common difference, 14.

....	49	36	25	16	9	4	1	0	1	4	9	16	25	36	49	....
....	–49	–35	–21	–7	7	21	35	49	63	77	91	105	119	133	147	....
....	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	....

From these examples we may deduce the following formula:

Let *cd* be the common difference of the series to be added; then, having arranged the square series as far as desired in either direction from *0*, $\left(\frac{cd}{2}\right)^2$ is to be added to *0*, and $-\left(\frac{cd}{2}\right)^2$ to be added to the term in the square series equal to $\left(\frac{cd}{2}\right)^2$, so as to make the sum of the two *0*. The other terms of the series to be added will be $\left(\frac{cd}{2}\right)^2 \pm cd$, $\left(\frac{cd}{2}\right)^2 \pm 2cd$, $\left(\frac{cd}{2}\right)^2 \pm 3\,cd$, etc.

In the even series *0* of the series to be added falls under $\left(\frac{cd}{4}\right)^2$ of the square series. In the odd series *0* in the series to be added does not occur; because, of course, *0* is not an odd number.

To show the harmonies that exist between the arithmetical series and the square series we will inspect a few of them. Take, for instance, the first example given, having a common difference of 4:

Squares...........	36	25	16	9	4	1	0	1	4	9	16	25	36	49
Quartate series.....	–20	–16	–12	–8	–4	0	4	8	12	16	20	24	28	32
Sums..............	16	9	4	1	0	1	4	9	16	25	36	49	64	81
Remainders.........	56	41	28	17	8	1	–4	–7	–8	–7	–4	1	8	17
Difference...........	–40	–32	–24	–16	–8	0	8	16	24	32	40	48	56	64
Common difference.	8	8	8	8	8	8	8	8	8	8	8	8	8	
Difference of rem...	15	13	11	9	7	5	3	1	–1	–3	–5	–7	–9	
Difference of sums..	7	5	3	1	–1	–3	–5	–7	–9	–11	–13	–15	–17	
Differences.........	8	8	8	8	8	8	8	8	8	8	8	8	8	

Take another example, with a common difference of 2:

Squares.........	25	16	9	4	1	0	1	4	9	16	25	36	49	64
Alternate series,	–9	–7	–5	–3	–1	1	3	5	7	9	11	13	15	17
Sums............	16	9	4	1	0	1	4	9	16	25	36	49	64	81
Remainders......	34	23	14	7	2	–1	–2	–1	2	7	14	23	34	47
Difference.......	–18	–14	–10	–6	–2	2	6	10	14	18	22	26	30	34
Common diff....	4	4	4	4	4	4	4	4	4	4	4	4	4	
Diff. of rem.....	11	9	7	5	3	1	–1	–3	–5	–7	–9	–11	–13	
Diff. of sums....	7	5	3	1	–1	–3	–5	–7	–9	–11	–13	–15	–17	
Differences......	4	4	4	4	4	4	4	4	4	4	4	4	4	

PENTAGONAL SERIES.

		5	5	5	5	5	5	5	Constant.
	0	5	10	15	20	25	30	35	Pentate series.
	1	6	16	31	51	76	106	141	Pentagonal series.
Add	0	1	2	3	4	5	6	7	
	1	7	18	34	55	81	112	148	
× 40 =	40	280	720	1360	2200	3240	4480	5920	
+ 9 =	49	289	729	1369	2209	3249	4489	5929	Square series.
√ =	7	17	27	37	47	57	67	77	

Thus even the pentagonal series, under certain manipulation, is resolved into the squares of a certain series regulated by the constant 5.

HEXAGONAL SERIES.

The method of obtaining this series is shown under "cubic series."

CUBIC SERIES.

Terms:	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th, etc.	
		6	6	6	6	6	6	6	6	6	.....Constant.
(1)	0	6	12	18	24	30	36	42	48	54	.....Sextate Series.
(2)	1	7	19	37	61	91	127	169	217	271	.....Hexagonal Series.
(3)	1	8	27	64	125	216	343	512	729	1000	.....Cubic Series.
(3)	1	9	36	100	225	441	784	1296	2025	3025	.....Tower Series.

The cubic series is regular hexahedral, and differs from the hexahedral series before given, as explained under the head of "trigonal series."

The "tower" series represents piles of cubes of successively decreasing sizes. The tower series is equal to the square of the trigonal series.

To show how much the formation of squares and cubes depends on the trigonal and tetrahedral series, we will analyze a few of each:

SQUARES.

		$0^2 = (0 \times 8) + (0 \times 4) = 0$		
$1 = (0 \times 8) + 1 = 1^2$			0	$4 = (0 \times 8) + 4$
$1 \times 8 = 8$	1	$2^2 = (0 \times 8) + (1 \times 4) = 4$		
$9 = (1 \times 8) + 1 = 3^2$			1	$12 = (1 \times 8) + 4$
$2 \times 8 = 16$	2	$4^2 = (1 \times 8) + (2 \times 4) = 16$		
$25 = (3 \times 8) + 1 = 5^2$			2	$20 = (2 \times 8) + 4$
$3 \times 8 = 24$	3	$6^2 = (3 \times 8) + (3 \times 4) = 36$		
$49 = (6 \times 8) + 1 = 7^2$			3	$28 = (3 \times 8) + 4$
$4 \times 8 = 32$	4	$8^2 = (6 \times 8) + (4 \times 4) = 64$		
$81 = (10 \times 8) + 1 = 9^2$			4	$36 = (4 \times 8) + 4$
$5 \times 8 = 40$	5	$10^2 = (10 \times 8) + (5 \times 4) = 100$		
$121 = (15 \times 8) + 1 = 11^2$			5	$44 = (5 \times 8) + 4$
$6 \times 8 = 48$	6	$12^2 = (15 \times 8) + (6 \times 4) = 144$		
$169 = (21 \times 8) + 1 = 13^2$			6	$52 = (6 \times 8) + 4$
$7 \times 8 = 56$	7	$14^2 = (21 \times 8) + (7 \times 4) = 196$		
$225 = (28 \times 8) + 1 = 15^2$			7	$60 = (7 \times 8) + 4$
$8 \times 8 = 64$	8	$16^2 = (28 \times 8) + (8 \times 4) = 256$		
$289 = (36 \times 8) + 1 = 17^2$			8	$68 = (8 \times 8) + 4$
$9 \times 8 = 72$	9	$18^2 = (36 \times 8) + (9 \times 4) = 324$		
$361 = (45 \times 8) + 1 = 19^2$			9	$76 = (9 \times 8) + 4$
$10 \times 8 = 80$	10	$20^2 = (45 \times 8) + (10 \times 4) = 400$		
$441 = (55 \times 8) + 1 = 21^2$			10	$84 = (10 \times 8) + 4$
$11 \times 8 = 88$	11	$22^2 = (55 \times 8) + (11 \times 4) = 484$		
$529 = (66 \times 8) + 1 = 23^2$			11	$92 = (11 \times 8) + 4$
$12 \times 8 = 96$	12	$24^2 = (66 \times 8) + (12 \times 4) = 576$		
$625 = (78 \times 8) + 1 = 25^2$			12	$100 = (12 \times 8) + 4$
$13 \times 8 = 104$	13	$26^2 = (78 \times 8) + (13 \times 4) = 676$		
$729 = (91 \times 8) + 1 = 27^2$			13	$108 = (13 \times 8) + 4$
$14 \times 8 = 112$	14	$28^2 = (91 \times 8) + (14 \times 4) = 784$		
$841 = (105 \times 8) + 1 = 29^2$			14	$116 = (14 \times 8) + 4$
$15 \times 8 = 120$	15	$30^2 = (105 \times 8) + (15 \times 4) = 900$		
$961 = (120 \times 8) + 1 = 31^2$			15	$124 = (15 \times 8) + 4$
$16 \times 8 = 128$		$32^2 = (120 \times 8) + (16 \times 4) = 1024$		

Here we see the constant 8 multiplied by the successive terms of the trigonal series, plus a certain number which is either constant (1 in the odd squares) or bears a constant relation to the root.

CUBES.

$0^3 = (0 \times 6) + 0 = 0$			
(Add) 0		(Add) $1 = (0 \times 6) + 1$	
$1^3 = (0 \times 6) + 1 = 1$			(Add) 1
(Add) 1		(Add) $7 = (1 \times 6) + 1$	
$2^3 = (1 \times 6) + 2 = 8$			(Add) 2
3		(Add) $19 = (3 \times 6) + 1$	
$3^3 = (4 \times 6) + 3 = 27$			(Add) 3
6		$37 = (6 \times 6) + 1$	
$4^3 = (10 \times 6) + 4 = 64$			4
10		$61 = (10 \times 6) + 1$	
$5^3 = (20 \times 6) + 5 = 125$			5
15		$91 = (15 \times 6) + 1$	
$6^3 = (35 \times 6) + 6 = 216$			6
21		$127 = (21 \times 6) + 1$	
$7^3 = (56 \times 6) + 7 = 343$			7
28		$169 = (28 \times 6) + 1$	
$8^3 = (84 \times 6) + 8 = 512$			8
36		$217 = (36 \times 6) + 1$	
$9^3 = (120 \times 6) + 9 = 729$			9
45		$271 = (45 \times 6) + 1$	
$10^3 = (165 \times 6) + 10 = 1000$			10
55		$331 = (55 \times 6) + 1$	
$11^3 = (220 \times 6) + 11 = 1331$			11
66		$397 = (66 \times 6) + 1$	
$12^3 = (286 \times 6) + 12 = 1728$			

Thus we find that the cubes are equal to the successive terms of the tetrahedral series multiplied by the constant factor 6, plus the root. The differences between the cubes are equal to the successive terms of the trigonal series multiplied by 6, plus the constant 1. The differences themselves are the successive terms of the hexagonal series.

I cannot do better in closing this paper than to produce the beautiful

PHYLLOTACTIC SERIES.

										0	1
								0	1	1	2
						0	1	1	2	3	5
				0	1	1	2	3	5	8	13
		0	1	1	2	3	5	8	13	21	34
0	1	1	2	3	5	8	13	21	34	55	89
1	2	3	5	8	13	21	34	55	89	144	233

I have carried this to the twelfth term; and that is about as high and complex as our observations on phyllotaxy have gone. A more frequent method of arranging these numbers is to place them in the form of fractions, thus:

$$\frac{0}{1} \quad \frac{1}{2} \quad \frac{1}{3} \quad \frac{2}{5} \quad \frac{3}{8} \quad \frac{5}{13} \quad \frac{8}{21} \quad \frac{13}{34} \quad \frac{21}{55} \quad \frac{34}{89} \quad \frac{55}{144} \quad \frac{89}{233}$$

In which either term of any fraction is obtained by addition of the two preceding terms of the same denomination. This may not be considered exactly a figurate series; but in nature it expresses the most beautiful and symmetrical arrangement of leaves, scales, bracts, seeds, etc., on stem, branch, or fruit, as the leaves on a house-leek, the florets on a spike of petalostemon, the scales on the cup of an acorn or a cone of pine or spruce, the seeds of a magnolia cone or a strawberry, the florets and seeds on the head of a sunflower, etc. These numbers show two things—how leaves, etc., have the greatest possible distribution to sunlight and air, and how the greatest number of leaves, seeds, etc., may be packed into the smallest and most economical space, in bud and fruit. The fractions express the distance around a stem, cone, or capitulum, from one leaf or seed to the next above.

ON THE ANALYSIS OF THE DEPOSIT FROM A CHALYBEATE WATER.

By E. C. CASE.

During the past year there have been carried on in the chemical laboratory of the State University a series of very careful analyses of the river water which furnishes the commercial supply for the city of Lawrence. A portion of the water supplied was taken from a well situated a few hundred feet from the bank of the river, and this water presents marked differences from the river supply, and is in many respects different from that of the surrounding wells. In cleaning the well, during the above-mentioned investigations, a deposit was found in the bottom, consisting mainly of oxide of iron. This deposit was some two feet thick and of a homogenous character. It was thought that an examination of this sediment might be useful as giving some clue to the dissolved matters of the underground waters of this region, and as to the part that would be deposited when the water stood where there would be little opportunity for aeration.

The well stands near the bank of the river and is sunk in a bed of gravel, part of the moraines of the earlier glacial epoch. These drift pits are full of limonite in nodules and scattered masses, so that any water filtering through them would easily take up iron, especially with the aid of any carbonic acid gas that might be in solution in the water. An analysis of the water gave the following composition, in parts per 100,000:

Silica and insoluble matter	4.50
Oxides of iron and alumina	3.45
Calcium oxide	12.25
Magnesium oxide	3.20
Sulfuric anhydride	5.48
Chlorin	8.64

The above constituents are probably combined in the following order:

Silica and insoluble matter	4.50
Peroxide of iron and alumina	3.45
Calcium sulfate	9.31
Calcium carbonate	15.03
Magnesium carbonate	6.72
Sodium chlorid	14.43
Total	53.44

This water contained 35.15 parts of carbonic anhydride per 100,000 parts of water. Of this amount 10.14 parts would be required to combine with the lime and magnesia, as above computed, leaving 25.01 parts of carbonic anhydride free, or to keep the bicarbonates in solution.

On standing in the air the water, which is as clear as distilled water when first drawn, becomes first milky then turbid within an hour, but does not deposit all the iron under 36 hours. Then the water again becomes clear by settling. Below is the analysis of an air-dried sample of the sediment found in the well, this being the deposit from the water when it has not a full opportunity for aeration:

Silica and insoluble matter	19.30
Peroxide of iron and alumina	46.95
Calcium oxide	4.20
Magnesium oxide	.34
Sulfuric anhydride	.15
Water, driven off below 100 degrees C	9.15
Water, driven off above 100 degrees C	14.40
Chlorin	.31
Carbonic anhydride	3.12
Sodium oxide (calculated)	.39

The most probable combination is the following:

Silica and insoluble matter	19.30
Iron and alumina oxides	*46.95
Calcium sulfate	.25
Calcium carbonate	7.32
Magnesium carbonate	.75
Sodium chlorid	.60
Water, driven off at 100 degrees C	9.15
Water, driven off at 230 degrees C	14.40
Organic matter (undetermined)	1.28
Total	100.00

From an examination of these analyses it can be seen that the silica is retained in solution to a much larger extent than the iron; the part of the silica retained, however, being only a portion of that dissolved in the original water, as is shown by the character of the deposit.

The copious deposit of iron is a very instructive illustration of how much of this substance the underground water, saturated with carbon dioxide, can hold in solution, and the ease with which it is deposited on the slightest contact with air. The sulfates and the sodium chlorid are deposited only to a limited extent, while carbonates of calcium and magnesium are deposited freely. This latter deposition would be expected, since the excess of carbon dioxide has had an opportunity to escape, thus precipitating the carbonates. This is then a process of softening, as far as those substances that make up what is known as the temporary hardness of the waters is concerned.

The presence of a large quantity of water, and especially the characteristic amount given off at 230 degrees C., shows that the deposit is practically an ore of iron, in fact, limonite. This might be considered as transported from the surrounding gravel as such, were it not that the water is so clear when it first runs into the well, so it is more rational to believe that the iron is first dissolved in the highly carbonated water, for in the freshly drawn water it is always present in the ferrous state, and is later oxidized to ferric iron and at the same time deposited. Upon heating the deposit a dark reddish paint is obtained. It might be supposed that there would be a large amount of organic matter in this deposit, since there is no doubt that the organic substances in the soil have played a very important part in the changes that the water has undergone, but on examination with the microscope no organized organic remains can be discovered.

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*Nearly all oxide of iron.

ON THE COMPOSITION OF A NATURAL OIL FROM WILSON COUNTY, KANSAS.

By F. B. DAINS, State University.

During the last few months some very successful experiments have been made in the vicinity of Neodesha in boring for oil and gas. Nine wells have been drilled in Wilson county, and the work of prospecting is still going on. A wealthy capitalist of Pittsburg, Pa., has become interested in this new field, and already at least $30,000 have been expended in the work. Of the nine wells bored, one about 16 miles north of Neodesha and another about six miles southwest have proved worthless. Five of the seven productive wells are oil wells and two are gas wells.

The Norman well is about 800 feet deep; has yielded as much as two barrels of oil per hour, and with constant pumping for several days at the rate of 18 to 24 barrels per day.

The Demoss well, 842 feet in depth, had about the same capacity as the above, but the oil gushed at intervals of 30 minutes.

In the Pierce well, an oil rock was struck at about the same depth as in the others, but the boring was continued to a depth of 1,000 feet in order to find a thicker oil-bearing stratum. At this depth the so-called flint was struck.

In the Haag well gas was struck in great quantities, so that it was pronounced by experts to be the greatest gas well west of the Mississippi.

The Hopkins well struck a different kind of oil. It is much thicker and heavier. After shooting the well an abundance of salt water came up, so that now it is a salt-water artesian well.

The Shoemaker well is a good gas well.

The Moulton well seems to strike the same rock-bearing stratum as the first three mentioned.

There are three wells now in the process of boring. Much of the work that has been done has been with the object of finding definitely what the limits of the oil-field are. The rock is from 10 to 25 feet in thickness and of finer structure than the Pennsylvania rock. Some prospecting has been done at Thayer, where a well 1,000 feet in depth was abandoned after proving that nothing of value could be obtained. Further down the valley, in the vicinity of Pasons and of Cherryvale, and also at Liberty, considerable interest is manifested, and the land is being used for boring puposes. At Cherryvale, as is well known, the gas that is obtained is used in the streets, stores, and residences. It is a cheap fuel, and with the Welsbach, or some other incandescent lamp, it produces a beautiful, clear, steady light. I am indebted to Mr. Wm. Hill, of Neodesha, for many of the facts above stated.

A sample of the oil from well No. 1, the Norman well, situated near the Verdigris bridge, has been received at the chemical laboratory of the state university, and has been examined by fractional distillation.

The crude oil is of a greenish-brown color, and has a specific gravity of .850.

The oil was fractionated, with the following result:

50 to 140	90cc,	8.1 per cent.
140 to 160	70cc,	6.37 per cent.
160 to 205	167cc,	15.18 per cent.
205 to 250	125cc,	11.36 per cent.
250 to 300	153cc,	1.4 per cent.
300 to 350	66cc,	6 per cent.
350 and above:		
1 frac.	120cc,	11 per cent.
2 frac.	70cc,	6.36 per cent.
3 frac.		15.45 per cent.

Several specific gravity determinations, made on the different distillates, gave the following results:

Temperature 50 to 120	0.8082
Temperature 120 to 160	0.8282
Temperature 160 to 185	0.8542
Temperature 185 to 205	0.8763
Temperature 205 to 250	0.8944
Temperature 250 to 275	0.9144
Temperature 275 to 300	0.9220
Temperature 300 to 350	0.9249
Temperature above 350:	
1 at	0.9424
2 at	0.9518
3 at	0.9140

The quantity of light oils is small—about 9 per cent., while the distillates between 150 and 300, usually considered as burning oils, form nearly 50 per cent. of the whole. Above 300 there distill over products suitable for lubricating purposes. From the higher portions above 375, paraffin solidifies out on cooling in a freezing mixture.

The high heat "cracked" or split up into lighter oils the last portion that passed over. This was shown in the way it distilled and in its specific gravity, 0.9140. This cracking increases the amount of illuminating oils. Below 275 the amount of unsaturated hydrocarbons is unusually small for petroleum, while above that temperature the percentage of unsaturated bodies increases.

ON THE COMPOSITION OF THE WATER FROM A MINERAL SPRING IN THE VICINITY OF "THE GREAT SPIRIT SPRING," MITCHELL COUNTY, KANSAS.

By E. H. S. BAILEY and MARY A. RICE.

The analysis of the water of "The Great Spirit Spring" was published by G. E. Patrick in volume VII of the Transactions of the Kansas Academy of Science, and an analysis of the rock in the vicinity and of the scum deposited by the water was published in the Kansas University Quarterly, volume I, page 85. Through the kindness of a student of the university I have obtained a sample of water from a spring in the immediate vicinity of this celebrated spring, and have thought that the results of the analysis were of sufficient interest to warrant publication.

This spring is situated something over two miles east of Cawker City, and about one-half a mile southeast of the Great Spirit spring. It is surrounded on three sides by the bend of the river, and the water does not seem to come up through rock, but through the soil and deposited alluvium of the valley. There is another spring a short distance south of the spring under discussion, directly in the bed of the river, and at high water covered up by the river. Both these springs furnish an abundant supply of clear water.

Calculating the results in parts per 100,000 the composition of the water is as follows:

Silica and insoluble matter	1.53
Iron and aluminum oxides	1.66
Calcium oxide	38.66
Magnesium oxide	61.48
Sulfuric anhydride	269.50
Potassium oxide	21.20
Sodium oxide	753.30
Chlorin	740.00
Boric anhydride	a trace.
Carbonic anhydride (calculated)	35.69

For the sake of comparison, and in order to show the probable combination of the different constituents in the waters, below is given the result of the above analysis, calculated to grains per United States gallon of 231 cubic inches, and the analysis of the Great Spirit spring, calculated in the same manner, from the publication noted above:

	South spring.	Great Spirit spring.
Silica and insoluble matter	0.892	0.874
Iron and aluminum oxides	0.969	....
Calcium carbonate	40.263	31.398
Magnesium carbonate	5.915	41.023
Magnesium sulfate	99.093	66.050
Sodium sulfate	143.065	206.357
Potassium sulfate	22.860	....
Sodium chloride	711.147	775.703
Sodium biborate	a trace.	....
Total solids	1,024.204	1,120.765

From an examination of these two analyses it can be readily seen that the waters are much alike, the Great Spirit spring being a little stronger than the other. This difference is noticed mostly in the sulfates and in the salt; yet, for all this, there is a remarkable similarity in the mineral salts and in their relative proportions.

A spring situated in the valley, where the water flowed off with little fall into the river, and where there was a frequent opportunity for erosion at high water, would not show the same tendency to build up a solid mound about it that a spring would that issued from the rocks on high ground. At any rate the analysis of this water may throw a little light on the method by which the mound of the Great Spirit spring was built up, as the two are in the same vicinity.

FURTHER EXPERIMENTS ON TARAXACUM ROOT, WITH A VIEW OF ASCERTAINING ITS VARIED CHEMICAL COMPOSITION AT DIFFERENT SEASONS.

By L. E. SAYRE, University of Kansas.

It will be remembered that at the last meeting of the Academy of Science a paper was read on the above subject which endeavored to show that taraxacum root varied at different seasons of the year, not only in the amount of moisture it contained but also in the amount of other important constituents. In the last report special attention was given to the percentage of solids and reducible sugars. During the past year I have given the subject further attention, and have been able to extract other principles from the root. While I have advanced the investigation to a slight extent, I do not as yet consider the work completed by any means, and have not to my entire satisfaction been able to devise a process of analysis which shall fully and satisfactorily answer the questions which arise in connection with the subject. The method of examination has been as follows:

1. Treatment of the Fresh Root for Moisture and Extractive.—(a) Moisture: A known weight of the fresh root, chopped fine and spread in thin layer, was heated in a hot-air oven until it ceased to lose weight. The loss in weight was then computed. (b) Extractive: Another weighed portion was extracted with water 9 and alcohol 1 part. The dregs were then washed with warm water. The resulting mixed solutions were evaporated, and finally heated in a hot-air oven until the extract ceased to lose weight.

2. Treatment of Air-Dry Root for Taraxacin, Inulin, Reducing Sugars, and Levulin.—(a) Taraxacin: Ten grammes of the very finely powdered air-dry root was introduced into an extraction apparatus and percolated by continuous displacement with chloroform for eight hours. This chloroformic extractive, after the evaporation of the chloroform, was treated with distilled water and filtered. The precipitated resin was well washed upon the filter; the aqueous solution evaporated to dryness and the residue weighed and estimated as taraxacin. (b) Reducing sugars: The residue (dregs) from (a) were treated with alcohol in a continuous extraction apparatus for eight hours; the alcoholic extractive treated with water and the solution quantitatively estimated for sugar by Fehling's solution. (c) Inulin: The residue from (b) was treated with warm water until exhausted; the aqueous solution was concentrated and to the resulting evaporate was added three volumes of alcohol. The crude inulin was collected on a filter, dried at 100 degrees C., and weighed. (d) Levulin: The alcoholic filtrate from the inulin was evaporated to drive off the alcohol, and the dense residue dissolved in water. The solution, acidulated with HC_1, was boiled for six hours, thus converting the levulin into reducing sugar. The sugar was estimated by Fehling's solution, and calculated into levulin.

The result of this examination of dandelion root collected at different seasons may be tabulated as follows:

With the exception of the month of January, the root was collected in each month from March to February inclusive, and analyses of each sample were made. I shall not give the result of each analysis here, as it would be going beyond the limits of this paper, but I wish to call attention to a peculiar fact which was observed during this investigation; I have found, to my surprise, that different roots collected in the same month may vary immensely in composition. My attention was called to this fact in this way: In the course of this work it became necessary for me to use a root collected in June of the two years 1892 and 1893. The quantity collected of the former having been insufficient for the analysis, the root of 1893 was necessary for the completion of the work. The root of the first year had been collected and dried for me in the sun, and the root of this year was collected, washed, chopped fine and dried in thin layers in a hot-air oven at a temperature of 60 degrees C. The former had been collected from low, and the latter from very high ground. The following table shows the difference in the composition of the two specimens:

Roots collected in	1892	1893
Moisture (in the dry root).............	9.79	9.48
Taraxacin (in the dry root).............	.612	.720
Inulin (in the dry root).................	9.34	4.83
Reducing sugars (in the dry root)......	12.50	2.60
Levulin (in the dry root)................	1.728	16.00

DILUTED ACETIC ACID AS A SOLVENT FOR EXTRACTIVE SUBSTANCES.

By L. E. SAYRE, University of Kansas.

It is well known, perhaps, that alcohol and water in different proportions is the common solvent for the extraction of various medicinal substances. Its solvent action and range of application is also familiar. On account of its antiseptic qualities it is perhaps all that can be desired for holding in solution organic matter very prone to decomposition. But for many reasons it would be desirable to supplant this solvent in many cases. The stimulant quality of the alcohol in many medicinal tinctures and the enormous price which the pharmacist and physician has to pay for the spirit—the excessive cost being largely due to our internal-revenue tax, which does not discriminate between the common liquor dealer and the physician or scientist—is also a drawback to its universal application. If, therefore, an inert and inexpensive solvent could be substituted for alcohol, even if that substitute be very limited in its application, it would be exceedingly desirable. I have accordingly made several experiments, using acetic acid and water, of various proportions, to ascertain whether a number of medicinal preparations could not be advantageously made equal in quality to that of alcohol and water. While I have not completed the work, I feel safe in saying that in very many cases the pharmacist and physician may well use in his laboratory the solvent I have named as a substitute. Especially is this true in the manufacture of medicinal extracts, such as belladonna, hyoscyamus, aconite, etc. (Specimen of extract of belladonna exhibited, and comments made thereon.)

A NEW AECIDIUM OF PECULIAR HABIT.

By M. A. CARLETON.

During two summers I have collected specimens of an aecidium on *Ruellia ciliosa*, which, so far as I can discover, is yet undescribed. The uredo and teleutospores of *Puccinia lateripes*, B. & Rav., on the same host, is well known. This species may prove to be the aecidium stage of *Puccinia lateripes*. The species is of very peculiar habit, being found on the stem (or root) almost invariably, at or below the surface of the ground. Hence it is easily overlooked. I discovered it on dead stems of the previous year's growth while digging for root-stalks to be transplanted in the greenhouse for experiments with the *Puccinia lateripes* above mentioned. Even at that date, the cups could be easily distinguished. Further examination will probably reveal the presence of perennial mycelium in the root-stalk of the host, and thus add another one to the list of perennial uredinae.

VARIATIONS IN DOMINANT SPECIES OF PLANTS.—II.

By M. A. CARLETON.

At a previous meeting of the Kansas Academy of Science I presented a paper on this same subject, having reference to phanerogams only. I wish here to extend the discussion, considering at this time the group of parasitic fungi.

Of the elements of environment that tend to the modification of flowering plants, only two—heat and moisture—affect parasitic fungi to any material degree. Others do so, if at all, only indirectly, through their action upon the host plants. But there is an element more effective, probably, than any or all these in modifying the structure of parasitic plants, and that is the structure of the host plants themselves. Parasites become greatly modified often in passing from one host to another. *Puccinia graminis* becomes more narrowed, or shorter, or more rounded, according to the host on which it is found. The formation of mesospores is an excellent example of modification, and these are particularly more apt to occur on some hosts than on others. *Puccinia rubigo-vera* almost invariably produces only one-celled spores on *Hordeum pratense*. *Macrosporium*, *Helminthosporium*, *Cladosporium*, *Cercospora*, etc., have all probably varied from a common parent.

HARMONIC FORMS.—THEIR CONSTRUCTION REDUCED TO A SCIENCE.

By Bernard B. Smyth, Topeka.

PART I. PLANIMETRIC FORMS.

1. It is possible to so arrange arithmetical series, either regular or varying, in any regular form that, upon addition of the numbers in any stated direction, equal or proportional sums will be obtained.

2. Trigonal, square, and other figurate series may be arranged in circles, hexagons, and other forms so that addition in various directions will give equal or proportional sums.

3. Geometric series may be arranged, like arithmetical series, so that continued products in any direction will equal continued products of an equal number of factors in any other direction.

In arithmetical series, among the forms that have been successfully tried are squares, rectangles, triangles, hexagons, octagons, four-, five-, six-, and eight-pointed stars, circles, ellipses, cubes, parallelopipeds, prisms, pyramids, cylinders, ellipsoids, and spheres.

The principles of construction, so far as relate to plane forms, are here shown:

SECTION I. SQUARES.

Square of Two.

The smallest square that may be attempted is one of four places. It gives equal sums only twice—either vertically, horizontally, or diagonally, according to arrangement, thus:

1	2
4	3

1	4
2	3

1	2
3	4

As to differences, there are three differences of one unit each between two contiguous numbers, namely: between 1 and 2, between 2 and 3, and between 3 and 4; two differences of two units each, namely, between 1 and 3, and between 2 and 4; and one difference of three units, namely, between 1 and 4. These differences perform an important part in the formation of higher squares, as of 6, 10, etc.

As to laying the four numbers, there are twenty-four different ways of laying them, thus: When 1 is placed in the upper left-hand corner, there is a choice of *three* squares in which 2 may be laid; 1 and 2 being laid, there is a choice of two squares in which 3 may be placed, and then there is but *one* place for 4. Multiplying these (3, 2, and 1) together gives 6 as the possible arrangements when 1 is placed in a certain corner; but there are four corners: Hence there are twenty-four different arrangements by which these four numbers may be laid.

This square is not harmonic, and is introduced here because it is a factor in the construction of harmonic squares of six, ten, fourteen, etc., places on a side

Square of Three.

The smallest square that can be constructed that will sum up equally in all its lines, columns, and diagonals, is one of nine places, thus:

(1)

8	1	6
3	5	7
4	9	2

(2)

6	1	8
7	5	3
2	9	4

(3)

4	9	2
3	5	7
8	1	6

(4)

2	9	4
7	5	3
6	1	8

(5)

8	3	4
1	5	9
6	7	2

(6)

6	7	2
1	5	9
8	3	4

(7)

4	3	8
9	5	1
2	7	6

(8)

2	7	6
9	5	1
4	3	8

This, though apparently eight different squares, is really only one square presented in eight different aspects by transposition.

These schemes show the mode of arrangement:

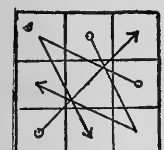


Fig. 1.

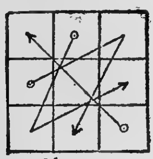


Fig. 2.

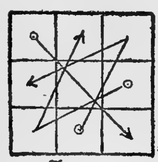


Fig. 3.

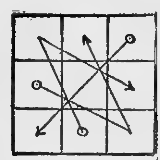


Fig. 4.

This scheme presupposes that the nine numbers are arranged in three sets; and that the initial and final sets are arranged along the broken arrows, and the medial set along the diagonal straight arrow. Figure 1, in the scheme above, answers for squares 1 and 8; fig. 2 answers for squares 2 and 6; fig. 3 for squares 3 and 7; and fig. 4 for squares 4 and 5. It matters not on which side a beginning be made, nor whether the three numbers of a set increase in the direction of an arrow point or the reverse (though in the scheme above, the numbers are supposed to increase toward the arrow points); but whatever arrangement be made for one set must be observed for all sets in the same square.

That no more than eight sums of 15 from three numbers each can be obtained from these nine numbers may be determined by arranging the numbers in a circle and connecting by lines any three numbers that will add 15, thus:

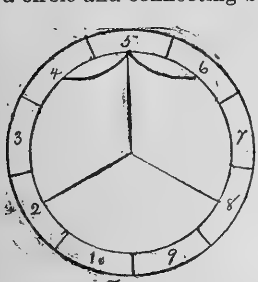


Fig. 5.

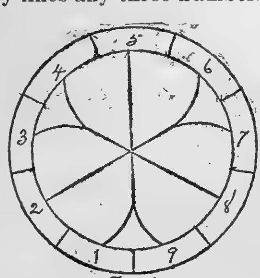


Fig. 6.

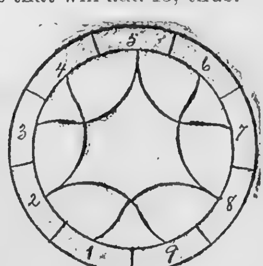


Fig. 7.

On arranging the numbers in a circle, the first thing most apparent is that the circle may be divided into three equal parts by the equidistant numbers, 2, 5, and 8, the sum of which equals 15; also, that the sum of the three adjacent numbers at the top of the circle equals 15. (See fig. 5.) If we try the other equidistant numbers we find they will not make 15. We learn then, that the numbers are divided into three sets of three numbers each, and that both sets and numbers have an initial, a medial, and a final.

Next, we find that each of the medial numbers may be connected with a pair directly opposite—that is: with the initial of the preceding set, and the final of the following set. (See fig. 6.)

And, finally, we find that each medial number may be connected with the final of the preceding set and the initial of the following set. (See fig. 7.)

This makes eight possible sums of 15. The circle complete, which is shown above as three separate circles in order to exhibit the successive steps in the possible additions, is here shown in its entirety:

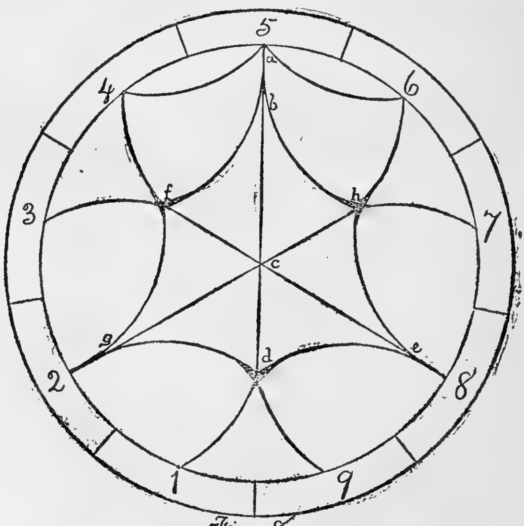


Fig. 8.

Each of the forks (a, b, c, etc.) in the above circle connects three numbers in the margin either by a straight or a curved line. The sum of these three numbers is in all cases 15. There are eight of these forks. It will readily be seen that to connect the numbers by threes in other ways than as shown, and still have the three numbers add 15, is impossible.

It may be noticed as a peculiarity that the three medial numbers (4, 5, 6,) form one of the diagonals in the square; and the three numbers of the medial set (2, 5, 8,) form the other diagonal. The lines and columns have each an initial, a medial, and a final.

Again, in an apparently simpler method, it may be seen by simply arranging the numbers in a square, in regular order, thus:

(9)

1	2	3
4	5	6
7	8	9

Here we see that the two diagonals, the central line, and the central column, add each 15. It may also be seen that each of the four corners, with the two numbers diagonally across the opposite corner, as indicated in the scheme above (figs. 1 and 2) separately foot up 15. For example: $1 + 6 + 8 = 15$, $3 + 4 + 8 = 15$, etc. This gives the clue for the scheme (figs. 1 to 4).

Square of Four.

Squares of 16 places have long been considered very difficult, and if by chance a "magic" square were constructed it was heralded as a great accomplishment. Yet, when the principles of their construction are fully understood, the making of these squares by the hundred or the thousand becomes a comparatively easy matter.

I will first construct a square, and we will then proceed to analyze it and study the principles. Take this as a model:

No. 1.

1	14	12	7
15	4	6	9
8	11	13	2
10	5	3	16

Is this square harmonic? Let us see:

Equal sums are obtained by adding together four numbers in each of the following regular ways:

1st.—By lines—

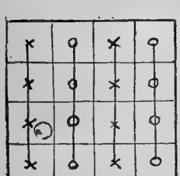


Fig. 9.

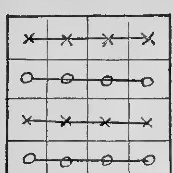


Fig. 10.

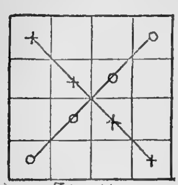


Fig. 11.

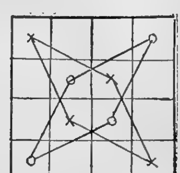


Fig. 12.

	Ways.
Each of the columns (fig. 9)	4
Each of the lines (fig. 10)	4
Each of the diagonals (fig. 11)	2

2d.—By squares—

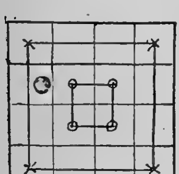


Fig. 13.

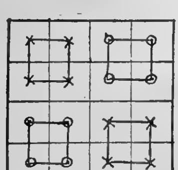


Fig. 14.

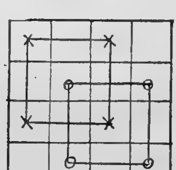


Fig. 15.

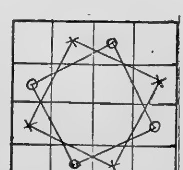


Fig. 16.

The four corners and the four centrals (fig. 13)	2
The four of each quarter (fig. 14)	4
Corresponding corners of quarters (fig. 15)	4
Knight-spring numbers in the margin (fig. 16)	2

3d.—By rectangles—

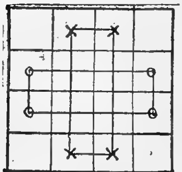


Fig. 17.

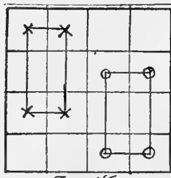


Fig. 18.

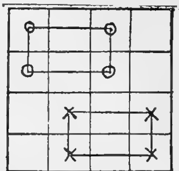


Fig. 19.

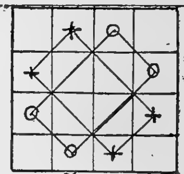


Fig. 20.

Extremes of medial columns and lines (fig. 17)	2
Alternate linear pairs (fig. 18)	4
Alternate columnar pairs (fig. 19)	4
Transverse diagonals of opposite quarters (fig. 20)	2

4th.—*By rhombs and rhomboids*—

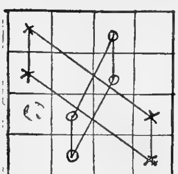


Fig. 21.

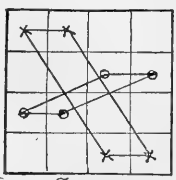


Fig. 22

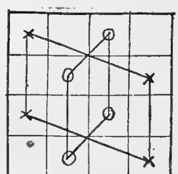


Fig. 23.

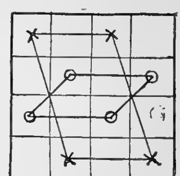


Fig. 24.

Extremes of one diagonal and means of the other (fig. 12)	2
Opposite columnar pairs (fig. 21)	4
Opposite linear pairs (fig. 22)	4
Alternating numbers in opposite columns (fig. 23)	4
Alternating numbers in opposite lines (fig. 24)	4
Total ways of adding 34	52

Here, then, are 52 *regular* ways of adding equal sums (in this case 34). There are many other ways, more or less irregular, of obtaining the same result, as 12, 15, 4, 3, etc.; but the only notice taken of them is that, whatever order be taken in obtaining the sum of 34, the sum can be obtained from four numbers in corresponding positions diametrically opposite.

We may readily concede, then, that this square is perfectly harmonic in all its parts. All parts of the square are evenly balanced and corresponding with every other part.

Transpositions.

Taking this square as a primary, 15 other squares may be derived from this by regular transpositions. All of these *derived* squares will have the same attributes as the primary square; will add equal sums in all the different ways, and in the same order, as the primary square; will, in short, be as perfectly harmonic.

In order to express the different transpositions, the most expressive words will be used; and, where the language does not furnish a properly expressive word, a word suiting the purpose will be invented from an arbitrary syllable.

Square No. 1 is here reproduced for the purpose of comparison with the 15 derived squares.

No. 1. Primary.

1	14	12	7
15	4	6	9
8	11	13	2
10	5	3	16

No. 2. By Troversion.

14	1	7	12
4	15	9	6
11	8	2	13
5	10	16	3

No. 3. By Diversion.

12	7	1	14
6	9	15	4
13	2	8	11
3	16	10	5

No. 4. By Reversion.

7	12	14	1
9	6	4	15
2	13	11	8
16	3	5	10

No. 2 is obtained by transposing adjacent columns, as the second with the first and the fourth with the third. To express this change the syllable *tro*, with the meaning of *around*, will be used. Hence, this will be called transposing by *troversion.* This puts the number 14 in the upper-left-hand corner—the key corner.

No. 3 is formed by *di*viding No. 1 *ver*tically and placing the last half before the first half. Mnemonically, we take the first syllables of the two expressive words, as above, and call this transposing by *diversion.* This puts 12 in the initial or key corner.

No. 4 is obtained by *reversing* the lines and placing 7 in the key corner. It is called transposing by *reversion.*

No. 5. By Conversion.

15	4	6	9
1	14	12	7
10	5	3	16
8	11	13	2

No. 6. By Controversion.

4	15	9	6
14	1	7	12
5	10	16	3
11	8	2	13

No. 7. By Condiversion.

6	9	15	4
12	7	1	14
3	16	10	5
13	2	8	11

No. 8. By Reconversion.

9	6	4	15
7	12	14	1
16	3	5	10
2	13	11	8

No. 5 is obtained by transposing adjacent lines of No. 1, the second with the first and the fourth with the third; as the columns were transposed to form No. 2. For this, the syllable *con*, with the sense of *over*, will be used. This, then, is transposing by *conversion*, and places 15 in the key corner.

No. 6 is derived from No. 1 by *converting* the *troverted* square No. 2 or by *troverting* the *converted* square No. 5. This is transposing by *controversion*, and puts 4 in the upper left-hand corner.

No. 7 is obtained from No. 1 by *converting* the *diverted* square No. 3, or by *diverting* the *converted* square No. 5. This is called transposing by *condiversion*, and brings 6 into the upper left-hand corner.

No. 8 is obtained by reversing the lines of No. 5 or by converting No. 4. This is called *reconversion* and brings 9 into the key corner.

No. 9. By Subversion.

8	11	13	2
10	5	3	16
1	14	12	7
15	4	6	9

No. 10 By Subtroversion.

11	8	2	13
5	10	16	3
14	1	7	12
4	15	9	6

No. 11 By Subdiversion.

13	2	8	11
3	16	10	5
12	7	1	14
6	9	15	4

No. 12. By Resubversion.

2	13	11	8
16	3	5	10
7	12	14	1
9	6	4	15

No. 9 is obtained by superimposing the lower half of No. 1 above the upper half. This is called *subversion.* It places 8 in the key corner.

No. 10 is obtained by *troverting* No. 9, or by *subverting* No. 2. It is called transposing by *subtroversion.* It brings 11 into the key corner.

No. 11 comes by *subverting* No. 3 or by *diverting* No. 9. It is called transposing by *subdiversion.* It brings 13 into the key corner.

No. 12 is made by *reversing* No. 9. This is known as *resubversion.* In this square, 2 comes to the key corner.

No. 13.
By Inversion.

10	5	3	16
8	11	13	2
15	4	6	9
1	14	12	7

No. 14.
By Introversion.

5	10	16	3
11	8	2	13
4	15	9	6
14	1	7	12

No. 15.
By Indiversion.

3	16	10	5
13	2	8	11
6	9	15	4
12	7	1	14

No. 16.
By Reinversion.

16	3	5	10
2	13	11	8
9	6	4	15
7	12	14	1

No. 13 is obtained by *inverting* No. 1; No. 14 by *troverting* No. 13; No. 15 by *diverting* No. 13; and No. 16 by *reversing* No. 13. These squares have respectively the numbers 10, 5, 3, and 16 in the key corners.

Each of these fifteen derived squares adds 34 in all the regular ways enumerated for No. 1.

In the sixteen transposed squares above, each of the successive numbers is brought in succession into the key position, and in the exact order in which the same numbers occur in square No. 1. Now, by placing the respective syllables that express the mode of transposition in the square, letting each occupy the position occupied by its key number in square No. 1, we have a sort of *key* to the name of a square after it is formed, and to the number that should occupy the upper left-hand corner when the square is formed:

KEY.

1	tro-	di-	re-	-version.
con-	contro-	condi-	recon-	-version.
sub-	subtro-	subdi-	resub-	-version.
in-	intro-	indi-	rein-	-version.

Plan of Construction.

The sixteen numbers of the square are considered as consisting of four quaterniads or "sets" of four consecutive numbers each.

Additional Definitions.

By the term "couplet" is meant the two consecutive numbers, an odd and an even, constituting the anterior or the posterior half of a quaterniad, as 1 and 2, 5 and 6, 11 and 12, etc. Numbers falling *adjacently* in the square, as 1 and 15 or 2 and 11 in the squares above, are *columnar pairs* or *linear pairs,* according to whether they fall in the same column or same line. A pair in one square is a pair in all sixteen. Indeed that is the key to retaining the harmony of a square throughout all transpositions — the four numbers of any quarter are two separated; but, however the numbers of one quarter are shifted about, the numbers of all the other quarters are shifted about in a similar manner.

Let it be fully understood that, whether applying to lines, columns, pairs, single numbers, couplets, or quaterniads, the first and second, also the third and fourth, are *adjacent;* the second and third (though contiguous), also the first and fourth (or those which are complementary to each other in any other positions), are *opposite;* the first and third, also the second and fourth (or any occurring with an intervening one), are *alternate.* Adjacent quarters are those on the same side of a square, whether vertical or horizontal; opposite quarters are those diametrically opposite.

General Rules.

The arrangement of numbers in a square is largely optional; yet the following restrictions must be observed:

1. Two odd numbers, and no more, must be placed in each line, each column, and each central diagonal.
2. The position of the odd and even numbers in the square must be determined beforehand according to a certain *scheme* to be agreed upon.
3. The number 1 must always be placed in the upper left-hand corner.
4. The number 2 will be placed at the opposite end of a certain "coupling line" to be seen in the predetermined scheme.
5. The adjacent couplet (3 and 4) may have an arrangement the reverse or crosswise of, or parallel to, the first couplet, in other columns and lines. (The best arrangement is when the four numbers of a quaterniad are so placed that no two occupy the same line, column, or diagonal.)
6. Regarding the quaterniad already laid as having a "dexter" (or sinister) arrangement, the adjacent quaterniad (5, 6, 7, 8) must have a "sinister" (or dexter) arrangement, the couplets in reversed order, in the opposite half of the square (whether horizontal, vertical, exterior or interior) as indicated by the coupling lines of the scheme.
7. The opposite quaterniads must have a similar arrangement, the couplets in reversed order (though some other order will answer to a degree), in the opposite quarters of the square.
8. Thus arranged, numbers diametrically opposite will add together 17. This, though best, is not strictly essential.

Now we will consider the scheme by which our square "No. 1" is constructed:

Scheme I (47 of Schedule).

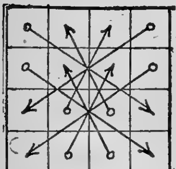


Fig. 25.

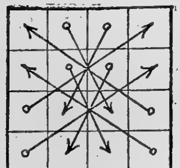


Fig. 26.

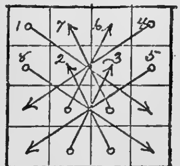


Fig. 27.

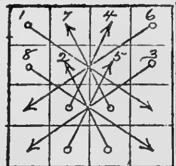


Fig. 28.

The scheme has two forms—a regular (fig. 25) and an inverted (fig. 26). The original or primary square is constructed according to fig. 25. Seven of the derived squares will be like fig. 25; eight of them like fig. 26.

In the above figures (and in all other schemes) the lines connect couplets of adjacent numbers of the series; the second couplet of a quaterniad is to be in the opposite half of the square. Thus, in the scheme above and our square No. 1, the first couplet occupies the upper alternate and exterior columnar half; the second couplet occupies the lower alternate and interior columnar half. The next quaterniad is just the reverse, the first couplet occupying the lower alternate interior half; the second couplet, the upper alternate exterior half.

Now, after having constructed the scheme — which is the first thing necessary to do in forming any harmonic square — the next step to take is to determine the *arrangement* of the numbers in the square. To do this, the coupling lines are to be numbered from 1 to 8 at their uppermost end. These numbers will then be in two rows or lines, with number 1 in the upper left-hand corner.

Numerous arrangements of these eight numbers may be made; and when made under certain laws a harmonic square may always be produced. Such arrangements may be divided into three series.

Series 1.— Harmonic Squares.

To produce perfectly harmonic squares, so arrange these eight numbers with 1 in the upper left-hand corner that they shall add 18 in each line and 9 in each column. These may be called *trial arrangements*.

Under these restrictions, only six arrangements can be made, which, with their corresponding primary squares, are here produced:

1st Arr.

1	7	6	4
8	2	3	5

No. 1.

1	14	12	7
15	4	6	9
8	11	13	2
10	5	3	16

2d Arr.

1	7	4	6
8	2	5	3

No. 17.

1	14	8	11
15	4	10	5
12	7	13	2
6	9	3	16

3d Arr.

1	6	7	4
8	3	2	5

No. 18.

1	12	14	7
15	6	4	9
8	13	11	2
10	3	5	16

The first (see fig. 27) is our square No. 1, from which Nos. 2 to 16 were produced.

The second arrangement (fig. 28) gives square No. 17, from which 15 other squares are derived in the same manner as the first 16 from No. 1. These are all different from the first 16.

From the third arrangement (fig. 29) another set of 16 squares can be constructed by transposition the same as the first 16 were from the first arrangement.

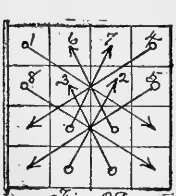


Fig. 27.

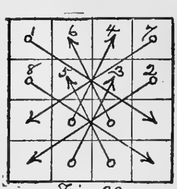


Fig. 30.

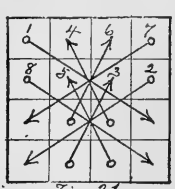


Fig. 31.

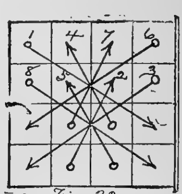


Fig. 32.

4th Arr.

1	6	4	7
8	3	5	2

No. 19.

1	12	8	13
15	6	10	3
14	7	11	2
4	9	5	16

5th Arr.

1	4	6	7
8	5	3	2

No. 20.

1	8	12	13
15	10	6	3
14	11	7	2
4	5	9	16

6th Arr.

1	4	7	6
8	5	2	3

No. 21.

1	8	14	11
15	10	4	5
12	13	7	2
6	3	9	16

From the 4th, 5th and 6th arrangements (figs. 30, 31, and 32, respectively,) 48 more squares may be constructed, making in all so far 96 harmonic squares.

Series 2.—Subharmonic Squares.

In this series the squares add equally, vertically, horizontally, diagonally, and many other ways, but not quite so many as in the first series; yet they will undoubtedly give perfect satisfaction.

In this series of trial arrangements, the lines add 18 each; the four extremes add 18; the four means 18; the first four 18; and the last four 18. The resulting squares will be very harmonic, but rather less perfectly so than in series 1.

First Group.

7th Arr.

1	8	5	4
7	2	3	6

No. 22.

1	16	10	7
13	4	6	11
8	9	15	2
12	5	3	14

8th Arr.

1	8	5	4
6	3	2	7

No. 23.

1	16	10	7
11	6	4	13
8	9	15	2
14	3	5	12

9th Arr.

1	8	3	6
7	2	5	4

No. 24.

1	16	6	11
13	4	10	7
12	5	15	2
8	9	3	14

10th Arr.

1	8	3	6
4	5	2	7

No. 25.

1	16	6	11
7	10	4	13
12	5	15	2
14	3	9	8

11th Arr.

1	8	2	7
6	3	5	4

No. 26.

1	16	4	13
11	6	10	7
14	3	15	2
8	9	5	12

12th Arr.

1	8	2	7
4	5	3	6

No. 27.

1	16	4	13
7	10	6	11
14	3	15	2
12	5	9	8

Second Group.

13th Arr.

1 7 2 8
6 4 5 3

No. 28.

1	14	4	15
11	8	10	5
16	3	13	2
6	9	7	12

14th Arr.

1 7 2 8
4 6 3 5

No. 29.

1	14	4	15
7	12	6	9
16	3	13	2
10	5	11	8

15th Arr.

1 6 3 8
7 4 5 2

No. 30.

1	12	6	15
13	8	10	3
16	5	11	2
4	9	7	14

16th Arr.

1 6 3 8
4 7 2 5

No. 31.

1	12	6	15
7	14	4	9
16	5	11	2
10	3	13	8

17th Arr.

1 4 5 8
7 6 3 2

No. 32.

1	8	10	15
13	12	6	3
16	9	7	2
4	5	11	14

18th Arr.

1 4 5 8
6 7 2 3

No. 33.

1	8	10	15
11	14	4	5
16	9	7	2
6	3	13	12

This makes 288 harmonic squares, of which one-third are perfectly harmonic the other 192 less perfectly so.

Series 3.—Magic Squares.

Yet another series, in which the squares add equally in every column and line and regularly in several other directions, but not diagonally, furnishes the means of producing thousands of ordinary magic squares.

In this series the trial arrangements add 18 in each line; the extremes add 18 and the means 18. The resulting squares add 34 vertically, horizontally, and other regular ways, but not diagonally. The numbered trial arrangements are here shown in order:

First Group.

19th.	20th.
1 8 5 4	1 8 5 4
7 3 2 6	6 2 3 7

21st.	22d.	23d.	24th.	25th.	26th.
1 7 6 4	1 7 6 4	1 7 6 4	1 6 7 4	1 6 7 4	1 6 7 4
8 3 2 5	5 3 2 8	5 2 3 8	8 2 3 5	5 2 3 8	5 3 2 8

27th.	28th.	29th.	30th.
1 5 8 4	1 5 8 4	1 5 8 4	1 5 8 4
7 3 2 6	7 2 3 6	6 2 3 7	6 3 2 7

Second Group.

31st.	32d.
1 8 3 6	1 8 3 6
7 5 2 4	4 2 5 7

33d.	34th.	35th.	36th.	37th.	38th.
1 7 4 6	1 7 4 6	1 7 4 6	1 4 7 6	1 4 7 6	1 4 7 6
8 5 2 3	3 5 2 8	3 2 5 8	8 2 5 3	3 2 5 8	3 5 2 8

39th.	40th.	41st.	42d.
1 3 8 6	1 3 8 6	1 3 8 6	1 3 8 6
7 5 2 4	7 2 5 4	4 2 5 7	4 5 2 7

Third Group.

43d.	44th.
1 8 2 7	1 8 2 7
6 5 3 4	4 3 5 6

45th.	46th.	47th.	48th.	49th.	50th.
1 6 4 7	1 6 4 7	1 6 4 7	1 4 6 7	1 4 6 7	1 4 6 7
8 5 3 2	2 5 3 8	2 3 5 8	8 3 5 2	2 3 5 8	2 5 3 8

51st.	52d.	53d.	54th.
1 2 8 7	1 2 8 7	1 2 8 7	1 2 8 7
6 5 3 4	6 3 5 4	4 3 5 6	4 5 3 6

Fourth Group.

55th.	56th.	57th.	58th.	59th.	60th.
1 7 2 8	1 7 2 8	1 7 2 8	1 7 2 8	1 7 2 8	1 7 2 8
6 5 4 3	4 3 6 5	5 6 3 4	5 3 6 4	3 5 4 6	3 4 5 6

61st.	62d.	63d.	64th.	65th.	66th.
1 6 3 8	1 6 3 8	1 6 3 8	1 6 3 8	1 6 3 8	1 6 3 8
7 5 4 2	4 2 7 5	5 7 2 4	5 2 7 4	2 5 4 7	2 4 5 7

67th.	68th.	69th.	70th.	71st.	72d.	73d.	74th.
1 5 4 8	1 5 4 8	1 5 4 8	1 5 4 8	1 5 4 8	1 5 4 8	1 5 4 8	1 5 4 8
7 6 3 2	7 3 6 2	6 7 2 3	6 2 7 3	3 7 2 6	3 2 7 6	2 6 3 7	2 3 6 7

75th.	76th.	77th.	78th.	79th.	80th.
1 4 5 8	1 4 5 8	1 4 5 8	1 4 5 8	1 4 5 8	1 4 5 8
7 3 6 2	6 2 7 3	3 7 2 6	3 2 7 6	2 6 3 7	2 3 6 7

81st.	82d.	83d.	84th.	85th.	86th.	87th.	88th.
1 3 6 8	1 3 6 8	1 3 6 8	1 3 6 8	1 3 6 8	1 3 6 8	1 3 6 8	1 3 6 8
7 5 4 2	7 4 5 2	5 7 2 4	5 2 7 4	4 7 2 5	4 2 7 5	2 5 4 7	2 4 5 7

89th.	90th.	91st.	92d.	93d.	94th.	95th.	96th.
1 2 7 8	1 2 7 8	1 2 7 8	1 2 7 8	1 2 7 8	1 2 7 8	1 2 7 8	1 2 7 8
6 5 4 3	6 4 5 3	5 6 3 4	5 3 6 4	4 6 3 5	4 3 6 5	3 5 4 6	3 4 5 6

To show what kind of squares this last series of arrangements will make, a few samples are here shown:

No. 34.
28th Arr.

1	10	16	7
13	4	6	11
8	15	9	2
12	5	3	14

No. 35.
49th Arr.

1	8	12	13
3	6	10	15
14	11	7	2
16	9	5	4

No. 36.
64th Arr.

1	12	6	15
9	4	14	7
16	5	11	2
8	13	3	10

No. 37.
96th Arr.

1	4	14	15
5	8	10	11
16	13	3	2
12	9	7	6

This makes 1,536 magic squares that may be constructed from that one scheme, 288 of which squares are harmonic.

INSTRUCTIONS.—To construct a primary square from one of the above trial arrangements:

1st. Draw a blank square of 16 places; and note the places for the odd numbers, as in the scheme.

2d. Apply the eight numbers of the trial arrangement selected, in their order, to the upper ends of the coupling lines, or conceive them to be so applied.

3d. Double each number of the trial arrangement, and place the products in spaces corresponding to both ends of the respective arrows, first subtracting 1 from the number falling in a space noted for an odd number.

SCHEME II (No. 39 OF SCHEDULE).

Scheme II (figs. 33 and 34) is the same as scheme I turned over on its direct central diagonal as an axis. No. 1 still occupies the upper left-hand corner. The upper line in scheme I becomes the left-hand column in scheme II. All the columns of scheme I are converted into lines and the lines into columns. Fig. 34 is simply fig. 33 reversed, as fig. 26 was fig. 25 inverted, and as in that scheme seven of the derived squares will be like 33; eight of them like fig. 34. The coupling arrows in this scheme will be numbered at their left-hand end.

The first six arrangements, corresponding to the six harmonic arrangements of scheme I, are here shown with their corresponding squares:

1st Arrangement. No. 38.

1	8
7	2
6	3
4	5

1	15	8	10
14	4	11	5
12	6	13	3
7	9	2	16

2d Arrangement. No. 39.

1	8
7	2
4	5
6	3

1	15	12	6
14	4	7	9
8	10	13	3
11	5	2	16

3d Arrangement. No. 40.

1	8
6	3
7	2
4	5

1	15	8	10
12	6	13	3
14	4	11	5
7	9	2	16

4th Arrangement. No. 41.

1	8
6	3
4	5
7	2

1	15	14	4
12	6	7	9
8	10	11	5
13	3	2	16

5th Arrangement. No. 42.

1	8
4	5
7	2
6	3

1	15	12	6
8	10	13	3
14	4	7	9
11	5	2	16

6th Arrangement. No. 43.

1	8
4	5
6	3
7	2

1	15	14	4
8	10	11	5
12	6	7	9
13	3	2	16

All the other arrangements of scheme I, up to the 96th, are equally applicable to this scheme; and from each arrangement 16 squares can be constructed with equal facility with those of scheme I.

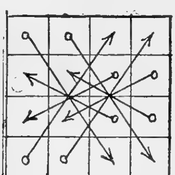


Fig. 33.

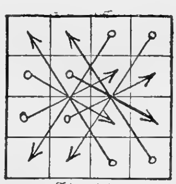


Fig. 34.

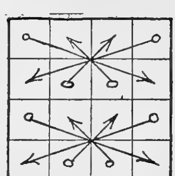


Fig. 35.

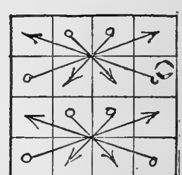


Fig. 36.

SCHEME III (No. 45. OF SCHEDULE).

This scheme (figs. 35 and 36) is like scheme I, except that the medial lines are transposed. In the trial arrangements the lines apply to the first and third (or upper alternate) lines of the square, instead of the first and second, as in scheme I. The upper line of the arrangements answers to the upper half of the square; the lower line to the lower half. All the harmonies and characteristics spoken of scheme I are equally true of this.

Samples of the harmonic squares yielded by this scheme are here shown:

1st Arr.

1	7	6	4
8	2	3	5

No. 44.

1	14	12	7
8	11	13	2
15	4	6	9
10	5	3	16

6th Arr.

1	4	7	6
8	5	2	3

No. 45.

1	8	14	11
12	13	7	2
15	10	4	5
6	3	9	16

Comparison of these squares may be made with similar arrangements in scheme I.

SCHEME IV. (No. 26 OF SCHEDULE).

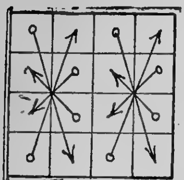


Fig. 37.

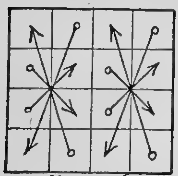


Fig. 38.

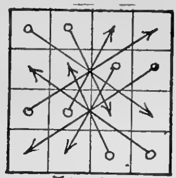


Fig. 39.

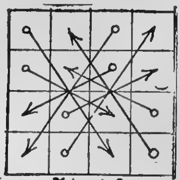


Fig. 40.

This scheme (figs. 37 and 38) is the same as scheme III turned over on its direct central diagonal, and as scheme II, with the central columns transposed.

The coupling arrows in this, as in scheme II, are to be numbered at their left-hand end. The vertical columns of the trial arrangements apply to the respective halves of the square.

One or two squares are given by way of comparison with those of scheme II.

2d Arrangement.
No. 46.

1 8
7 2
4 5
6 3

1	12	15	6
14	7	4	9
8	13	10	3
11	2	5	16

4th Arrangement.
No. 47.

1 8
6 3
4 5
7 2

1	14	15	4
12	7	6	9
8	11	10	5
13	2	3	16

All the arrangements shown for scheme I are equally applicable to the other three. This makes for the four schemes 384 arrangements of 16 squares each; or in all so far 6,144 squares, no two alike, of which 1,152 are perfectly harmonic, 384 of them to the highest degree.

OTHER SCHEMES.

But the foregoing schemes are not the only ones that can be made, though they are more harmonic than others. I will now introduce several other schemes and show at least one square made according to each by the first arrangement. It should be said here that the same arrangements will not answer for all alike; but each set of schemes has its own peculiarities and requires its own series of arrangements.

No. 48.

{ 1 7 6 4 / 8 2 3 5 }

1	13	12	8
16	4	5	9
7	11	14	2
10	6	3	15

Scheme V (fig. 39) is a variation of scheme I. The variation consists in reversing the couplets of the second and fourth quaterniads, which in the scheme stand parallel with their complementary or opposite couplets. (Square No. 48.)

No. 49.

{ 1 8 / 7 2 / 6 3 / 4 5 }

1	16	7	10
13	4	11	6
12	5	14	3
8	9	2	15

Scheme VI (fig. 40) differs from scheme II exactly as scheme V differs from scheme I and has the same characteristics. (See square No. 49.)

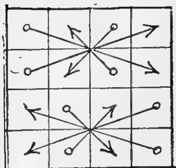


Fig. 41.

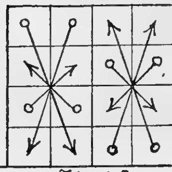


Fig. 42.

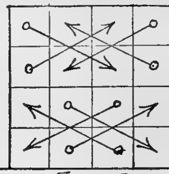


Fig. 43.

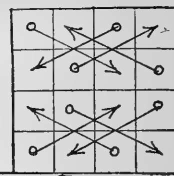


Fig. 44.

No. 50.

1 7 6 4
8 2 3 5

1	14	11	8
7	12	13	2
16	3	6	9
10	5	4	15

Scheme VII (fig. 41) is a variation of scheme III, and differs from it as scheme V differs from scheme I.

No. 51.

1 8
7 2
6 3
4 5

1	7	16	10
14	12	3	5
11	13	6	4
8	2	9	15

Scheme VIII (fig. 42) differs from scheme IV, as scheme V differs from scheme I. (See square No. 51.)

No. 52.

1 7 6 4
8 2 3 5

1	14	12	7
11	8	2	13
6	9	15	4
16	3	5	10

In scheme IX (fig. 43) the lines of the trial arrangement govern the outer opposite lines of the squares, instead of alternate or adjacent lines, as in former schemes. That is to say, the lines of the trial arrangement as they stand are to be applied to the first and fourth lines; their doubles, then, will fall in the outer lines of the square to be formed, and the mates in the inner lines.

No. 53.

1 7 6 4
8 2 3 5

1	14	11	8
12	7	2	13
6	9	16	3
15	4	5	10

In scheme X (fig. 44), also, the trial arrangement governs the outer opposite lines. (See square No. 53.)

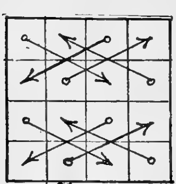


Fig. 45.

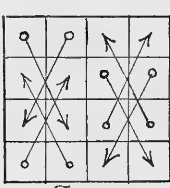


Fig. 46.

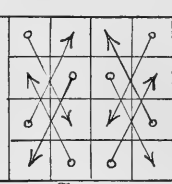


Fig. 47.

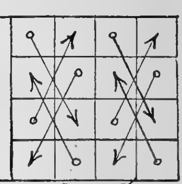


Fig. 48.

No. 54.

1 7 6 4
8 2 3 5

1	14	11	8
12	7	2	13
5	10	15	4
16	3	6	9

Scheme XI—Knight's Tour.—This scheme (fig. 45) is not harmonic; in a square of four it gives ordinary magic squares. Its defect is that it throws four even numbers into one diagonal and none into the other, thereby increasing that diagonal by 2 and decreasing the other by the same amount. But in a square of eight it does very well; because opposite quarters can be easily fitted to balance. The scheme differs from scheme X in reversing or inverting (technically condiverting) the lower half.

No. 55.

1	11	6	16
14	8	9	3
12	2	15	5
7	13	4	10

Scheme XII (fig. 46) is the same as scheme IX turned over on its direct central diagonal. The two columns of the trial arrangement govern the outer opposite columns of the squares.

{ 1 8 / 7 2 / 6 3 / 4 5 }

No. 56.

1 8 / 7 2 / 6 3 / 4 5

1	12	6	15
14	7	9	4
11	2	16	5
8	13	3	10

Scheme XIII (fig. 47) is like scheme X turned over on its direct diagonal. It is governed the same as scheme X.

No. 57.

1 6 / 5 2 / 8 3 / 4 7

1	16	11	6
10	7	4	13
15	2	5	12
8	9	14	3

Scheme XIV, Knight's tour (fig. 48), can be used separately or in combination with scheme XI.

The regular transpositions allowed in the squares of all other schemes are not applicable to this or to scheme XI. These two schemes are necessarily governed by rules of their own.

About 40 other schemes may be constructed, all more or less defective, though many squares may be made from them, sometimes remedying the defect by transposing two pairs of contiguous couplets, or by other means. But schemes that are but poorly adapted to squares of four are well adapted to squares of eight; so that perfect squares of 64 places are much easier made than squares of 16 places, and can be made in much greater variety.

Here are two more schemes. The first is that used in laying 16-page forms in ordinary book printing.

Scheme XV.

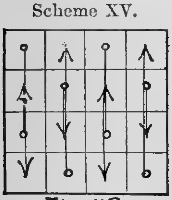


Fig. 49.

And the one arrangement necessary for proper folding is:

{ 1 8 7 2 / 4 5 6 3 } Which gives the primary square:

No. 58.
Primary.

1	16	13	4
8	9	12	5
7	10	11	6
2	15	14	3

This primary square shows the relative positions of the pages in the printed sheet before folding.

The pages are laid in *inverted* order on the imposing stone. They may also, for various reasons, be laid in three other positions, as shown in the four following transpositions:

No. 1.
Regular Form.
(Inverted.)

2	15	14	3
7	10	11	6
8	9	12	5
1	16	13	4

Printing first four pages outside.

No. 2.
Primary square indiverted.

14	3	2	15
11	6	7	10
12	5	8	9
13	4	1	16

Throwing last four pages outside.

No. 3.
Primary square converted.

8	9	12	5
1	16	13	4
2	15	14	3
7	10	11	6

Placing last four pages in center.

No. 4.
Primary square condiverted.

12	5	8	9
13	4	1	16
14	3	2	15
11	6	7	10

Making-up first four pages in center.

In the case of music books, where the pages are longest from front to back, the forms are made up by a different scheme. This is shown in Scheme XVI.

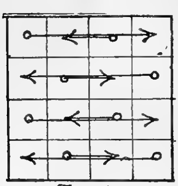


Fig. 50.

The arrangement of the couplets is:

1 8
4 5
3 6
2 7

And the primary square is:

No. 58.
Primary Square.

1	16	15	2
8	9	10	7
5	12	11	6
4	13	14	3

No. 5.
Regular Form.

4	13	14	3
5	12	11	6
8	9	10	7
1	16	15	2

With first four pages outside.

No. 6.
Indiverted Form.

14	3	4	13
11	6	5	12
10	7	8	9
15	2	1	16

With last four pages outside.

No. 7.
Converted Form.

8	9	10	7
1	16	15	2
4	13	14	3
5	12	11	6

With last four pages in center.

No. 8.
Condiverted Form.

10	7	8	9
15	2	1	16
14	3	4	13
11	6	5	12

With first four pages in center.

In all the foregoing forms, the outer columnar pairs are equal; the inner columnar pairs are equal; each line adds 34; each *pair* of pages adds 17; each quarter adds 34; in short, each pair of pages with any other pair adds 34. In all the transpositions under either scheme, the pages of any one line are the same in all; the pages of any one column are the same in all; the pages of any one quarter are the same in all the forms.

Schedule of Schemes.

In this schedule, the "first couplet" will be understood to occupy the upper left-hand corner place and another place to be indicated in the schedule. The "adjacent couplet" will occupy the adjacent space below, and another place which is indicated in the terms of the "first couplet." The "adjacent pair" will signify the other half of the upper left-hand quarter (a columnar pair) and the pair that is coupled with them. The "adjacent quarter" is the upper right-hand quarter. The "opposite half" is in this case the lower half.

	First couplet.	Adjacent couplet below.	Adjacent pair (beside).	Adjacent quarter beside.	Opposite half (below).
1	Same col. adj. line,		parallel,	inverted,	similar.
2	" "		"	"	reversed.
3	" "		inverted,	similar,	similar.
4	" "		"	"	reversed.
5	" "		"	contrary,	similar.
6	Same col. alt. line,	concurrent,	"	similar,	
7	" "	"	"	contrary,	
8	" "	recurrent,	"	similar,	
9	" "	"	similar,	dissim.,	
10	Same col. opp. line,	concurrent,	"	similar,	
11	" "	"	"	contrary,	
12	" "	recurrent,	"	inverted,	
13	" "	"	inverted,	similar,	(Sch. XV.)
14	Adj. col. same line,	parallel,		"	reverse.
15	" "	"		reverse,	dissim.
16	" "	reversed,		similar,	similar.
17	" "	"		"	reverse.
18	" "	"		reversed,	similar.
19	Adj. col. adj. line,	transverse,		similar,	reverse.
20	" "	"		reverse,	dissim.
21	" "	reverse,		inverted,	similar.
22	" "	"		"	reverse.
23	Adj. col. alt. line,	reversed,	similar,	dissim.,	(Sch. XII.)
24	" "	"	dissim.,	contrary,	(Sch. XIII.)
25	" "	"	"	similar,	(Sch. XIV.)
26	Adj. col. opp. line,	"	"	(Sch. IV),	similar.
27	Adj. col. opp. line,	reversed,	similar,	(Sch. VIII),	inverted.
28	Alt. col. same line,	parallel,	reversed,		dissim.
29	" "	reversed,	dissim.,		similar.
30	" "	"	similar,		"
31	" "	"	"		dissim.
32	Alt. col. adj. line,	concurrent,	reversed,	(Sch. IX),	"
33	" "	recurrent,	dissim.,	(Sch. X),	inverted.
34	" "	"	"	(Sch. XI),	similar.
35	Alt. col. alt. line,	reversed,	"	dissim.,	
36	" "	"	"	similar,	
37	" "	"	similar,	dissim.,	
38	" "	parallel,	reversed,	similar,	
39	Alt. col. opp. line,	recurrent,	similar,	dissim.,	(Sch. II).

	First couplet.	Adjacent couplet below.	Adjacent pair (beside).	Adjacent quarter beside.	Opposite half (below).
40.............	Alt. col. opp. line,	concurrent,	reversed,	similar,	(Sch. VI).
41.............	Opp. col. same line,	parallel,	"	....	reversed.
42.............	" "	reversed,	similar,	....	dissim.
43.............	" "	"	dissim.,	(Sch. XVI),	similar.
44.............	" "	"	"	....	reversed.
45.............	Opp. col. adj. line,	recurrent,	"	(Sch. III),	"
46.............	" "	concurrent,	reversed,	(Sch. VII),	"
47.............	Opp. col. alt. line,	parallel,	"	dissim.,	(Sch. I)
48.............	" "	reversed,	similar,	"	(Sch. V).
49.............	Opp. col. opp. line,	concurrent,	reversed,	"	....
50.............	" "	recurrent,	similar,	"	....
51.............	" "	"	dissim.,	similar,	....
52.............	" "	"	"	dissim.,	....

The above schedule does not include schemes that do not fulfil the requirements—to provide for "two odd numbers, and no more, in each column, line, and diagonal." Even the schemes in the above schedule differ very much as to their capacity. Those selected and shown by diagram (Schemes I to IV et seq.) are the most perfect.

Special Sums and Varying Series.

Suppose it be desired to construct a square that will add a certain number in each column or line, it is only necessary to *take as extremes of the series two numbers whose sum equals half of the number desired;* then select the other fourteen numbers of the series between those two.

Nor is it necessary that the several terms of the series shall be equidistant; it is only necessary that the common differences shall be harmonic, rhythmic, or concordant. For instance, the series 1, 3, 6, 8, 12, 14, 17, 19, 23, 25, 28, 30, 34, 36, 39, 41 is harmonic; because the differences rise and fall with a certain rhythm that fully satisfies the requirement. In other words, the differences 2, 3, 4, recur regularly.

The following examples are given to show some of the possibilities of these harmonic squares. These squares are made according to square No. 1, 1st arrangement, Scheme I:

No. 59.
Common differences 1, 1, 1, 2.

1	15	13	7
16	4	6	10
8	12	14	2
11	5	3	17

Sums = 36.

No. 60.
Common differences 1, 1, 2, 1.

1	16	13	8
17	4	7	10
9	12	15	2
11	6	3	18

Sums = 38.

No. 61.
Common differences 1, 1, 2, 2.

1	17	14	8
18	4	7	11
9	13	16	2
12	6	3	19

Sums = 40.

No. 62.
Common differences 1, 1, 2, 3.

1	18	15	8
19	4	7	12
9	14	17	2
13	6	3	20

Sums = 42.

Or suppose, for instance, it be desired to make the sums equal 100, it can be done in many different ways. The following examples from varying series will show some of the modes of accomplishing this result:

No. 63.
Common differences 3, 3, 4, 4.

1	43	36	20
46	10	17	27
23	33	40	4
30	14	7	49

Sums = 100.

No. 64.
Common differences 1, 4, 8, 8.

1	44	35	20
48	7	16	29
21	34	43	2
30	15	6	49

Sums = 100.

No. 65.
Common differences 2, 4, 5, 6.

1	43	36	20
47	9	16	28
22	34	41	3
30	14	7	49

Sums = 100.

No. 66.
Common differences 2, 3, 6, 8.

1	44	36	19
47	8	16	29
21	34	42	3
31	14	6	49

Sums = 100.

All of the above squares are harmonic, and have all the characteristics of the squares of Scheme I, notwithstanding their varying differences.

There are four grades of differences in all these squares, namely:

1st. The differences between adjacent numbers, as between the first and second, the third and fourth, etc. There are eight of these.

2d. The differences between adjacent pairs, thus coming in the middle of each quaterniad. There are four of these.

3d. The differences between adjacent quaterniads. There are two of these.

4th. The difference between the two halves of a series. This is but one.

The least difference that can be used, without repetition of a number, is 1. Any excess of difference between the extremes of a series more than 1 for each term may be used entirely in the 4th grade, or may be distributed among all the grades. When there is an excess of 1 it must be used in the 4th grade, as in the square "Sums equal 36" above. An excess of 2 or more may be used in the 3d or 4th grade, or both, as in the three squares "sums equal 38, 40, and 42" above. An excess of 4 or more may be used in either or all of the last three grades. An excess of 8 or more may be distributed anywhere, as in the squares "sums equal 100" above. Excess of difference must be distributed according to the following

Rule.—So distribute the excess that the differences in any one grade will be exactly the same throughout the varying series.

This can easily be done thus:

A difference of 1 in the first grade equals.........	8
A difference of 1 in the second grade equals......	4
A difference of 1 in the third grade equals........	2
A difference of 1 in the fourth grade equals.......	1
Total	15

A difference of 1 in the first grade is equal to 2 in the second, 4 in the third, and 8 in the fourth, as to results. Thus may any number be easily distributed and series so arranged that squares may be made to sum up any even number.

Odd Sums.

Should it be desired to make a square add an odd number, it may be accomplished without fractions by making an extra difference of 1 in the last position of third grade, thus:

No. 67.

1	12	15	7
16	6	4	9
8	14	11	2
10	3	5	17

Sums = 35.

No. 68.

1	13	16	7
17	6	4	10
8	15	12	2
11	3	5	18

Sums = 37.

In which an extra difference of 1 is placed between the third and fourth sets. These squares, which add 35 and 37, respectively, are arranged according to the third arrangement of scheme I, as shown in square No. 18, that arrangement being best adapted to this purpose. But such squares, though they answer every requirement of a "magic square," are nor harmonic.

SUMS LESS THAN 34 AND NEGATIVE SUMS.

In forming these sums, the rule is just the same as for forming special sums, namely, to take for the extremes of the series two numbers whose sum equals half of the number desired; but in this case it presupposes the necessity of taking for the lower numbers of the series minus or negative numbers. A few squares, to show the manner of their formation, will be sufficient to give a good insight into this:

No. 69.

0	11	13	6
14	5	3	8
7	12	10	1
9	2	4	15

Sums = 30.

No. 70.

-4	8	10	3
11	2	-1	5
4	9	7	-3
6	-2	1	12

Sums = 17.

No. 71.

-4	8	10	2
11	1	-1	5
3	9	7	-3
6	-2	0	12

Sums = 16.

No. 72.

-8	3	5	-2
6	-3	-5	0
-1	4	2	-7
1	-6	-4	7

Sums = —2.

These squares are perfectly harmonic.

NUMBERS OF SERIES.

The simple arithmetical series 1 to 16, adding in the squares 34, is only one. That is to say: there is only one series of positive integers that can be found, without repetition, that will, when the numbers are arranged in a square, add 34 in each line, column, diagonal, etc. The same is true of the series adding 36; there is only one series. There are three series adding 38, and three adding 40. Thus, the series adding 38 are:

1.—	1	2	3	4	5	6	7	8	11	12	13	14	15	16	17	18
2.—	1	2	3	4	6	7	8	9	10	11	12	13	15	16	17	18
3.—	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

The number of series adding in square 42 and 44 is 7 of each; the number of series adding 46 and 48 is 13 of each; the number adding 50 and 52 is 23 for each; adding 54 and 56 is 37; adding 58 and 60 is 57; the number of series that will each separately add in square 62 or 64 is 83. Thus the number of series that will produce a given number constantly rises in an ever-increasing ratio; and when we come to series adding in square 100, we find there are no less than 895 series, and of series adding 102, there are 1,085.

The ratio of increase is not irregular, but is peculiar. The mode of forming the series is similar to that of forming any figurate series, except that each successive sum, until the series of increase is reached, is duplicated or written twice. This is shown by braces, thus:

		1				1				1				1		
	1		1		2		2		3		3		4		4	
	1	1	2	2	4	4	6	6	9	9	12	12	16	16	20	20
Increase	1	2	4	6	10	14	20	26	35	44	56	68	84	100	120 etc.	
Series complete	1	3	7	13	23	37	57	83	118	162	218	286	370	470	590 etc.	
Sums	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	

POSSIBILITIES.

It has been shown that by the different arrangements and transpositions more than 6,000 squares (6,144) may be constructed from a single series (1 to 16) according to the first four schemes; and it is presumed that at a low estimate at least four times as many more may be made from the remaining 48 schemes that are possible as shown in the schedule, thus making upward of 30,000 squares, no two alike, adding 34 in 10 or more different ways, that may be built up from that one series.

Now, under these considerations (and they are capable of demonstration), it will be evident that in case of squares adding 38, which may be done by three different series, there may be three times as many, or 90,000 made; as to squares adding 42 or 44, there may be seven times as many, or over 200,000 made; and when it comes to squares adding 100, which can be done by 895 different series, the number of squares that may be constructed, all different, is 895 times 30,000, or say 27,000,000, and of squares adding 102 no less than 33,000,000, no two alike, all magic, and at least one-fourth of them, or say 8,000,000, perfectly harmonic. Such numbers are beyond easy comprehension, and almost beyond belief. By way of better conceiving the import of such immense numbers, it may be stated that if a person were to construct at the rate of say 25 16-space squares an hour (and that would be found reasonably rapid), and work four hours a day for 270 days in the year, and not get sick or tired, and live long enough, it would take him just 1,000 years to make the 27,000,000 different squares, "each adding 100 in 10 or more different ways." Can human penetration farther go? Ah, yes, immeasurably farther.

Square of Six.

The square of six is produced by multiplication, in various ways, of the square of three and the square of two. For instance: the thirty-six places may be divided into four quarters, and each quarter arranged according to the square of three; or the square may be divided into nine sections, and each section filled according to the square of two.

I here produce several as samples:

No. 1.

23	3	29	24	2	30
28	17	12	25	18	11
7	35	14	8	34	13
22	4	31	21	1	32
26	19	10	27	20	9
5	33	15	6	36	16

No. 2.

23	24	3	2	29	30
22	21	4	1	31	32
28	25	17	18	12	11
26	27	19	20	10	9
7	8	35	34	14	13
5	6	33	36	15	16

No. 3.

24	33	19	10	8	17
15	6	28	1	26	35
34	7	5	14	30	21
16	25	23	32	12	3
20	29	27	18	13	4
2	11	9	36	22	31

These squares are all laid like the scheme in fig. 2, Square of Three.

So far as the arrangement of the four numbers in each section, or in the respective places in the four quarters, is concerned, it is necessarily various; but since there are twenty-four methods of laying these numbers, as shown in Square of Two, and only nine of them can possibly be used, it allows a very wide latitude in the selection of methods.

The first step necessary in producing such a square is to arrange the numbers 1, 2, 3 and 4 into sections in such a way that they will add equally in each line, column, diagonal, and such other directions as may be chosen, thus:

A.

3	4	3	2	1	2
2	1	4	1	3	4
4	1	1	2	4	3
2	3	3	4	2	1
3	4	3	2	2	1
1	2	1	4	3	4

B.

1	3	4	2	2	3
2	4	3	1	1	4
3	4	1	3	3	1
2	1	2	4	2	4
3	2	4	2	3	1
4	1	1	3	4	2

C.

2	1	3	2	3	4
3	4	1	4	1	2
4	3	1	2	4	1
2	1	3	4	2	3
1	2	3	2	3	4
3	4	4	1	2	1

Etc., in many, many ways.

Then next, according to one of the schemes in the Square of Three, add to all the numbers in each of the sections the respective numbers 0, 4, 8, 12, 16, 20, 24, 28, and 32.

Or, divide the thirty-six numbers into four sets of nine each and take one from each set for each of the respective positions. This will be equivalent to adding to all the numbers of each section the amounts 0, 1, 2, 3, 4, 5, 6, 7, and 8, and to the several numbers in each section the amounts 0, 9, 18, and 27. Various other methods may be pursued.

In the above squares, Nos. 1, 2, and 3, it will be seen that not only does each line, column, and diagonal add 111, but that any four numbers taken regularly and at equal distances from the center add 74, also that the transverse semi-diagonals in opposite quarters add 111; also transverse tertio-diagonals add 111.

These squares bear transposing after a manner similar to the transpositions in the square of four. It is possible to transpose so as to bring any required number into the upper left-hand corner, and still preserve the harmony of the square.

A few examples are given of transpositions from square No. 3:

No. 4.

1	24	6	35	26	19
28	33	15	17	8	10
23	7	34	21	12	14
32	16	25	3	30	5
9	20	29	4	13	36
18	11	2	31	22	27

No. 5.

2	11	18	27	22	31
29	20	9	36	13	4
25	16	32	5	30	3
32	7	23	14	12	21
15	33	28	10	8	17
6	24	1	19	26	35

No. 6.

3	30	5	32	16	25
4	13	36	9	20	29
31	22	27	18	11	2
35	26	19	1	24	6
17	8	10	28	33	15
21	12	14	23	7	34

No. 7.

4	13	36	9	20	29
31	22	27	18	11	2
21	12	14	23	7	34
3	30	5	32	16	25
35	26	19	1	24	6
17	8	10	28	33	15

No. 8.

5	30	3	25	16	32
36	13	4	29	20	9
27	22	31	2	11	18
19	26	35	6	24	1
10	8	17	15	33	28
14	12	21	34	7	23

No. 9.

6	24	9	19	26	35
15	33	28	10	8	17
34	7	23	14	12	21
25	16	32	5	30	3
29	20	9	36	13	4
2	11	18	27	22	31

Any number in this square except 7, 9, 10, 12, 16, 28, 30, and 36, may be brought into the upper left-hand corner. These eight numbers immediately surround the central square of four numbers in square No. 9. These numbers, too, may be put into the same corner; but in that case the sums of the diagonal lines will not be 111.

Squares like the above may be produced almost without limit. They are, however, not harmonic. In explanation of this it may be said that a perfectly harmonic square of 6 places on a side is impossible; since, in every attempt at it there will always be found left four numbers that can only be put in according to the square of two, and since this adds equally only twice, while six additions are needed, a choice must be made.

I now present a square on the old-fashioned plan—that of transposing numbers from their regular order vertically and horizontally. There is no special merit in this; and I only present it to show that, in addition to the lines, columns, and diagonals adding regularly 111, the six numbers on either side of the center, and some curious basket-shaped figures (to be pointed out) near the center also add the same. For instance, the following numbers add together 111: 16, 23, 21, 27, 14, 10; 15, 10, 22, 20, 27, 17; 22, 14, 15, 9, 23, 28; 21, 28, 16, 17, 9, 20; 21, 13, 8, 4, 30, 35; 28, 9, 23, 15, 16, 20; 14, 21, 22, 17, 10, 27; 23, 14, 28, 15, 21, 10; and, finally, 9, 16, 22, 27, 20, 17. Almost any number will add one-third of 111 [37] with the number diametrically opposite; and any four numbers at the corners of a rectangle, rhomb, rhomboid, or square, having for

No. 10.

1	5	33	34	2	6
12	26	28	9	29	7
19	23	15	16	20	18
13	14	21	22	17	24
30	8	10	27	11	25
31	35	4	3	22	36

its center the center of the square, will add 74, or two-thirds of 111. Many other squares similar to this may be constructed, and some of them exhibit singular features, but none of them are of special merit.

Enough has been shown now by which any one may construct all the squares of 36 places that he may wish, and place any numbers in any desired position.

Square of Eight.

These squares are laid according to any of the schemes for the square of four, but not forgetting the square of two. They are very easy, and hundreds of thousands of them may easily be produced. For, schemes that do not readily work in a square of 4 do well in a square of 8, and none of them fail.

There are three general methods of constructing a square of 8, namely:

1st. To divide the square into sixteen sections, and arrange the square as a quadruple square of sixteen places.

2d. To arrange it in four separate squares of sixteen places each, side by side.

3d. To place one square in the center, two dimidiated squares, either right-side out or inside out, on the four opposite sides, and one quartered square at the four corners.

There are many modes of arranging the series to fill the respective squares, two of which are here shown:

First Method.

Here are shown two squares constructed according to the first method. They are laid according to the third arrangement of scheme I (see square No. 33), Square of Four, and the diagonal (No. 3) method of the Square of Two in its four different aspects:

No. 1.

1	3	48	46	54	50	27	31
5	7	44	42	56	52	25	29
59	63	22	18	16	14	33	35
57	61	24	20	12	10	37	39
32	30	49	51	43	47	6	2
28	26	53	55	41	45	8	4
38	34	11	15	17	19	64	62
40	36	9	13	21	23	60	58

No. 2.

1	17	60	44	46	14	23	55
33	49	28	12	62	30	7	39
31	63	38	6	52	36	9	25
15	47	54	22	20	4	41	57
56	40	13	29	27	59	34	2
24	8	45	61	11	43	50	18
42	10	19	51	5	21	64	48
58	26	3	35	37	53	32	16

In No. 1 the sixty-four numbers are taken as two series, the odd numbers in one series, the even numbers in another; then four consecutive odd numbers are taken in one group to represent an odd number, four even ones to represent an even number, then filling as a quadruple square of 4.

In No. 2 the sixty-four numbers are divided into four series, and the first number of each series is taken to fill the first quadruple member of the square, the second number to fill the second member, and so on.

These two are not the only ways that numbers may be taken to fill the squares. The sixty-four numbers may be divided into series of 32, 16, 8, 4, 2 or 1 places; the series may be regular, alternate, or half complementary; they may be direct or half reversed; each group of four may be taken in regular order, either direct, reversed, or crosswise of the series, or one-half may be complementary to the other half.

Any of the schemes and arrangements in Square of Four is applicable to this square; and many of them are better adapted to this square than to the Square of Four.

The harmony of the square, aside from the scheme and arrangement, is owing largely to

(a) The preparation of the series;

(b) The mode of selection of the groups to fill the quadruple squares; and

(c) The mode of laying the several groups.

PLAN.

In laying any of these squares, in order to have them perfectly harmonic, it will be necessary to observe several precautions:

1st. The several groups of four numbers must be so commenced in the different quadruple squares that no two in the same double line or double column shall begin in the same relative position, and not more than two in each diagonal.

2d. Increase in the first square may be made in either of three directions; but no two of the quadruple squares in any column or line should increase in the same direction, and no more than two in the diagonals.

This may be accomplished by commencing the different quadruple squares according to a prepared plan, as either of the following, the numbers indicating the relative square in each quadruple square:

A.

1	4	3	2
2	3	4	1
4	1	2	3
3	2	1	4

B.

1	4	2	3
3	2	4	1
4	1	3	2
2	3	1	4

C.

1	3	4	2
4	2	1	3
2	4	3	1
3	1	2	4

D.

1	2	3	4
3	4	1	2
4	3	2	1
2	1	4	3

And increase in each of the quadruple squares may be made thus:

right	up	down	left
left.	down	up	right
up	right	left	down
down	left	right	up

These plans are offered merely as suggestions. It will readily be seen that many different plans and modes may be adopted, including four diagonal directions.

Second Method.

Here are presented the same squares as Nos. 1 and 2, constructed according to the second method:

No. 3.

1	48	54	27	3	46	50	31
59	22	16	33	63	18	14	35
32	49	43	6	30	51	47	2
38	11	17	64	34	15	19	62
5	44	56	25	7	42	52	29
57	24	12	37	61	20	10	39
28	53	41	8	26	55	45	4
40	9	21	60	36	13	23	58

No. 4.

1	60	46	23	17	44	14	55
31	38	52	9	63	6	36	25
56	13	27	34	40	29	59	2
42	19	5	64	10	51	21	48
33	28	62	7	49	12	30	39
15	54	20	41	47	22	4	57
24	45	11	50	8	61	43	18
58	3	37	32	26	35	53	16

These squares are sufficiently harmonic to add 130 in all the different ways indicated in Square of Four.

No. 3 is obtained from No. 1 by transposition; No. 4 from No. 2.

Third Method.

Here, now, are two squares written by the third method indicated. They are derived by transposition from Nos. 3 and 4, respectively:

No. 5.

1	48	3	46	50	31	54	27
59	22	63	18	14	35	16	33
5	44	7	42	52	29	56	25
57	24	63	20	10	39	12	37
28	53	26	55	45	4	41	8
40	9	36	13	23	58	21	60
32	49	30	51	47	2	43	6
38	11	34	15	19	62	17	64

No. 6.

1	60	17	44	14	55	46	23
31	38	63	6	36	25	52	9
33	28	49	12	30	39	62	7
15	44	47	22	4	57	20	41
24	45	8	61	43	18	11	50
58	3	26	35	53	16	37	32
56	13	40	29	59	2	27	34
42	19	10	51	21	48	5	64

These squares, and all other squares built upon some definite plan, are perfectly harmonic, both as wholes and as parts.

Knight's Tour Squares.

These squares are constructed according to Schemes XI and XIV of the Square of Four. They solve the problem of passing the knight by his peculiar leaps over the sixty-four squares of the chess-board without doubling or missing a square.

These squares are not harmonic. Of the thousands of different solutions of the problem very few are harmonic to any degree.

There are three methods of constructing squares according to these schemes in order to have them at all harmonic.

1st. Reversing the direction after passing once around with each series of sixteen numbers, thus making three reversals.

2d. Reversing after placing the first series, running twice around in the contrary direction, then reversing again at the end of the third series.

3d. Reversing once for all after placing the first two series.

Four squares are here shown, illustrating the methods of making squares of this kind:

No. 7.

19	64	47	2	49	32	15	34
46	3	18	63	16	35	50	31
61	20	1	48	29	52	33	14
4	45	62	17	36	13	30	51
21	60	5	44	53	28	37	12
6	43	24	57	40	9	54	27
59	22	41	8	25	56	11	38
42	7	58	23	10	39	26	55

One turn.

No. 8.

31	2	47	50	33	64	15	18
48	51	32	1	16	19	34	63
3	30	49	46	61	36	17	14
52	45	4	29	20	13	62	35
5	28	41	56	9	60	37	22
44	53	8	25	40	21	12	59
47	6	55	42	57	10	23	38
54	43	26	7	24	39	58	11

Two turns.

No. 9.

63	2	31	34	47	50	15	18
32	35	62	1	14	17	48	51
3	64	33	30	49	46	19	16
36	29	4	61	20	13	52	45
5	60	25	40	9	44	21	54
28	37	8	57	24	53	12	43
59	6	39	26	41	10	55	22
38	27	58	7	56	23	42	11

Three Turns.

No. 10.

5	44	19	38	3	54	21	28
18	37	4	43	20	27	2	53
45	6	39	26	55	10	29	22
36	17	58	7	42	23	52	1
59	46	25	40	9	56	11	30
16	35	8	57	24	41	64	51
47	60	33	14	49	62	31	12
34	15	48	61	32	13	50	63

Endless Chain.

These squares are very variable, but are not transposable except by inversion, reversion, reinversion, and rotiversion. The number 1 may be placed anywhere; but, if moved from its present position, the little harmony the squares here have is broken. The four squares above are all "endless chains."

U. S. Grant Harmonic Square.

The following square, first published in the Topeka *Daily Capital* July 29, 1885, the day of General Grant's funeral, is shown here to illustrate one of the practical applications to which harmonic forms may be applied. It contains all the years of General Grant's life systematically arranged:

1864	1823	1883	1844	1840	1834	1855	**1885**
1874	1853	1857	1830	1879	1861	1832	1842
1829	1866	1838	1881	1827	1849	1876	1862
1847	1872	1836	*1859*	*1868*	1870	1851	1825
1882	1856	1837	*1839*	*1848*	1871	1835	1860
1845	1831	1858	1880	1826	1869	1841	1878
1865	1871	1846	1828	1877	1850	1854	1833
1822	1852	1873	1867	1863	1824	1884	**1843**

"The four corners represent eras or points of greatest prominence in his life. His first entry into life was in 1822, in the lower left-hand corner. The next great prominent event of his life was his graduation from the military academy and entry into the army in 1843, found in the lower right-hand corner. The third important era in his life, when he first came most prominently before the American people, was in 1864, when he was made lieutenant-general, and when he "proposed to fight it out on this line if it took all summer," which he did. This date is the most conspicuous, being in the upper left-hand corner. The final prominent number is the present year, the date of his triumphal departure, to be found in the upper right-hand corner. His life, considered as a harmonic square, is complete.

"Let it be observed that the difference between these most prominent dates is exactly twenty-one years, thus marking his life into three periods of equal duration, namely: The first, that of youth and study; the second, that of diligent labor; and the third, that of triumphs and rewards. The sum of these four numbers is 7,414.

"The four central numbers of the above square represent also four notable dates in his private or public life, less important than the other four, namely: 1839, his entry into West Point military academy; 1848, his marriage; 1859, his industrious laboring as a tanner at Galena, Ill., which fact figured so prominently in his first presidential campaign; and 1868, his election to the presidency of the United States. The sum of these four numbers is 7,414.

"Aside from the foregoing statements, the peculiar properties of the above square are such that each line, column, or diagonal, foots up 14,828. Any semi-diagonal or diagonal of four places, added to the opposite semi-diagonal, sums up 14,828. Any half line or half column, commencing at one end, added to any other half line or half column, makes 14,828. Any four in a square inclosed by heavy lines, added to any other similar square, is 14,828. Any four numbers whatever, taken at random anywhere, added to four taken similarly and diametrically opposite, will equal 14,828. The foregoing statements will afford several hundred thousand ways of footing up 14,828.

"Divide the entire square into four equal parts. Each quarter is harmonic by itself. Each line and each column in each quarter sums up 7,414. Each transverse or direct semi-diagonal of two places, added to an opposite transverse or direct semi-diagonal of the same quarter, adds 7,414.

"Divide the square into sixteen equal parts. The sum of the four numbers of each such part is 7,414. Any pair of numbers, added to a similar pair diametrically opposite, equals 7,414. Two numbers taken anywhere, added to the two numbers diametrically opposite, equal 7,414.

"Finally, any number, added to the number diametrically opposite, is equal to 3,707. This number is composed of the prime factors 11 and 337.

"It is believed that the footings indicated, together with many others not mentioned, can be obtained in more than a million different ways, or say as many as there were men in the federal army."

SECTION II. OTHER PLANE FORMS.

HEXAGONS.

I present a harmonic hexagon (fig. 51), which will, no doubt, win admiration for its beautiful symmetry and perfect harmony.

Harmonic Hexagon.

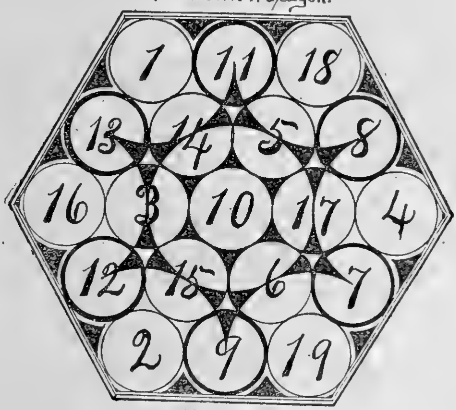


Fig. 51.

In this hexagon any full line of three places adds 30, whether along one side or through the center; any line of four places equals 40; of five places 50. The inner circle of six adds 60; the outer circle of 12 adds 120. The numbers in the middle of each of the sides, being at the apices of two large triangles (as 11, 12, 7), add 30 for each three. The same six numbers, each taken separately in connection with the two adjacent numbers of the inner circle, thus forming six small triangles, adds each 30, as 11, 14, 5. Any two opposite numbers add 20; any four, forming a parallelogram (rectangle, rhomb, or rhomboid) having its center at center of hexagon, add 40; the extremes of any outer line and the means of the opposite interior line, as 1, 18, 6, 15, add 40; any pair at one end of an outer line, added to the adjacent pair of an alternating outer line, as 1, 11, 16, 12, add 40. The three numbers on any side, added to either of six other possible pairs, add 50. Six numbers in any order, three on one side and three diametrically opposite, add 60; the three of any outer line and the three of an alternating outer line, as 1, 11, 18, 2, 12, 16, add 60. Any eight, four on either side, complementary to four opposite, add 80. Alternate outer lines sum up 90; adjacent pairs of alternate outer lines, with the transverse central row, as 1, 11, 16, 12, 2, 15, 10, 5, 18, add 90; any small triangle and two adjacent sides equal 90; same with two alternate sides equal 90; same with opposite and one adjacent side equal 90; two alternate small triangles and either of four sides equal 90. Any ten, half complementary to other half, equal 100; any twelve, ditto, equal 120; any fourteen, the same, 140; any sixteen 160.

Thus, in the above hexagon, we may find nine sums of 20 each; 23 sums of 30 (14 independent and the nine sums of 20 added to the central number); 57 sums of 40; 93 sums of 50; 147 sums of 60; the same of 70 (the same sums with central number added); 126 sums of 80; 82 sums of 90; 70 sums of 100; the same of 110; 60 sums of 120; the same of 130; 28 sums of 140; 42 sums of 150; 23 sums of 160; 9 sums of 170; one sum of 180 and one of 190. In all cases, whatever numbers are added, if they are added as indicated, will add 10 for each number taken, the same as if the numbers were all 10's.

TRANSPOSITIONS.

By inverting, reversing, etc., as in the squares, twelve apparently different harmonic hexagons may be obtained from this one; but which are in reality only different views of the same hexagon.

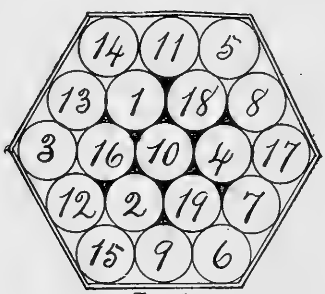


Fig. 52.

Again, by transposing the inner circle for the outer corners, number for number, an apparently new hexagon (fig. 52) is formed from this; but which a careful study will show is only one form of transposition; and which may also, by reversion, inversion, etc., be transformed into twelve other hexagons, making twenty-four in all. All these hexagons have the same harmonic properties as the first. Whatever is true of one is true of all.

Four of those hexagons, showing apparent differences, are here presented:

2 12 16	6 7 17	3 12 15	18 11 1
9 15 3 13	9 19 4 8	13 16 2 9	8 5 14 13
19 6 10 14 1	15 2 10 18 5	14 1 10 19 6	4 17 10 3 16
7 17 5 11	12 16 1 11	11 18 4 7	7 6 15 12
4 8 18	3 13 14	5 8 17	19 9 2

In figure 54 a second harmonic hexagon is presented, which has all the peculiarities ascribed to figure 51, and which is capable of the same number

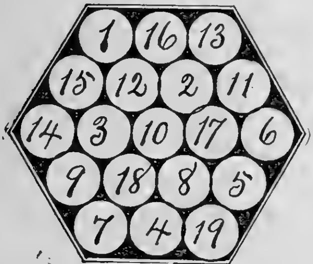


Fig. 54.

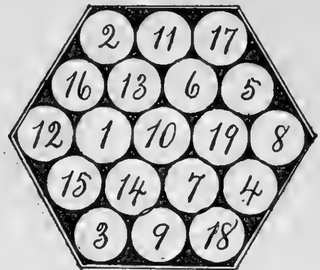


Fig. 55.

of transpositions, one of which is shown in fig. 55, appearing like an altogether different harmonic hexagon.

In fig. 56 a third harmonic hexagon is shown, having the same peculiari-

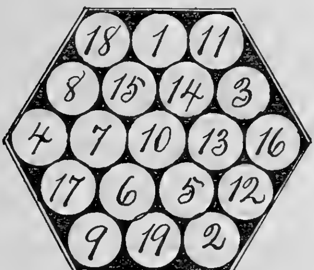


Fig. 56.

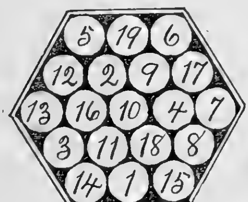


Fig. 57.

ties and capable of the same transpositions as the other two, one of which is shown in fig. 57.

Figure 58 presents a fourth harmonic hexagon, with the same peculiarities

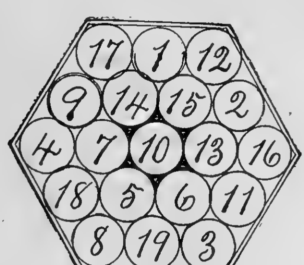


Fig. 58.

Fig. 59.

and capable of the same transpositions as the others, one of which is shown in fig. 59.

This makes ninety-six harmonic hexagons, all having the same peculiarities as the hexagon in fig. 51, and equally harmonic in every respect.

A harmonic hexagon of 37 places has not yet been constructed. A magic hexagon of 37 places is presented in fig. 60, each row of which, in any direction, adds as many times the central number as the number of places in the row. This is not harmonic.

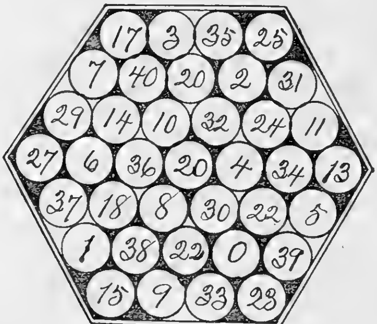


Fig. 60.

PENTAGONS.

A magic pentagon is presented in figure 61, in which the rows of numbers

Fig. 61.

on either side add as many times the central number as the number of pentagons in the row. The five pentagons in any corner added to the middle pentagon at the opposite side, adds six times the central number.

The harmony of arrangement of the numbers may readily be seen on inspection.

OCTAGONS.

A single octagon (a modified circle) is presented in figure 62, in which the alternate series is used instead of the numerical series. In this octagon

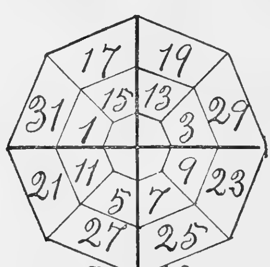


Fig. 62

the outer circle is exactly three times the diameter in any direction. Each of the quarters is equal to the diameter, and the sum of the inner circle is the same. There is nothing remarkable about this.

RHOMBS.

In figure 63 is presented a harmonic rhomb or diagonal square, in which

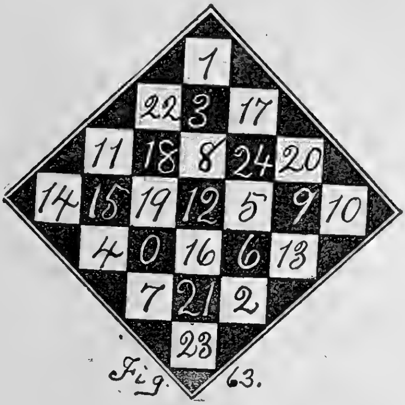


Fig. 63.

the full lines in any direction are always as many times the central number as the number of places in the line. Black and white numbers may be added separately or together in the central lines.

STARS AND CIRCLES.

In figure 64 is presented a six pointed star, which is, so far, the most harmonic in every respect of all forms presented. Lines, triangles, and circles, whether taken at one side or through the middle, always add as many times

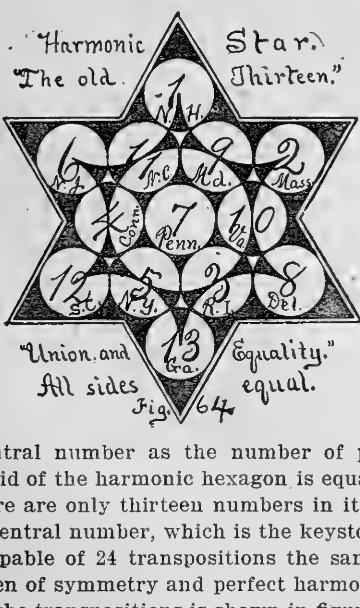


Fig. 64

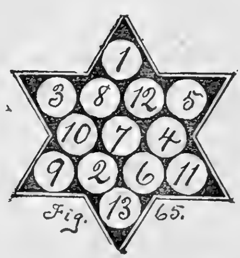


Fig. 65.

the central number as the number of places taken. Everything that has been said of the harmonic hexagon is equally true of this.

There are only thirteen numbers in it; but, without changing the position of the central number, which is the keystone upon which the entire star rests, it is capable of 24 transpositions the same as the harmonic hexagon. As a specimen of symmetry and perfect harmony, it excels all forms yet presented. One of the transpositions is shown in figure 65.

A new hexagonal star is presented in figure 66, in which each of the ten full lines of five places adds five times the central number, and each of the

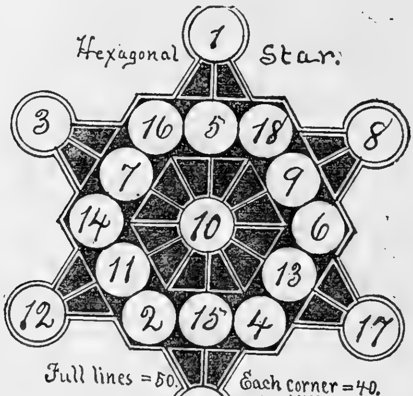


Fig. 66.

corners except two, with the adjacent three places, adds four times the central number. This star is not harmonic.

A magic pentagonal star is shown in figure 67, in which each of the full lines except two adds five times the central number.

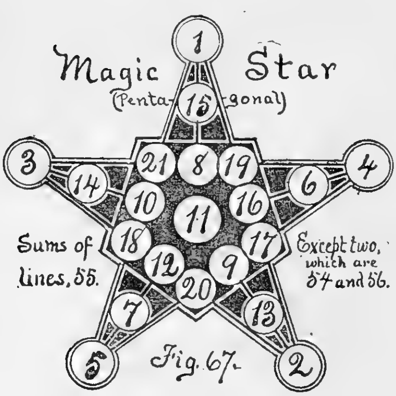


Fig. 67.

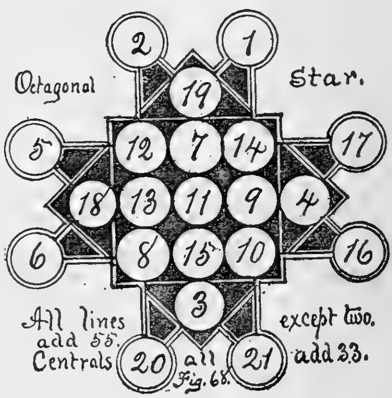


Fig. 68.

In the octagonal star (figure 68) each of the full lines except two adds five times the central number. The square in the center adds equally in every direction. It is not harmonic, though many arrangements may be made.

In the small circle (fig. 69) the circumference equals three times the diameter in both inner and outer circles, adding diameters of circles separately.

In figure 70, which is the square of 4 in a new form, the diameter and the quarters are equal, as in the case of the octagon (fig. 62), which is a modification of this; and the circumference, owing to the series, is slightly less than three times the diameter. The series in figure 62 is adapted to making the circumference equal three times the diameter.

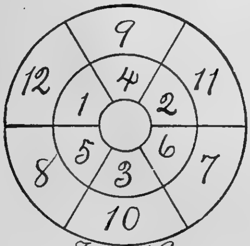


Fig. 69.

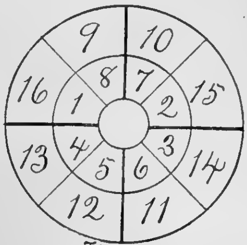


Fig. 70.

In figure 71, which is a further modification of the same circle, the circumference bears relation to the diameter as 3.1416 to 1. Each of the quarters add 1 equally with the diameter. The sum of the inner circle (.8584) is equal

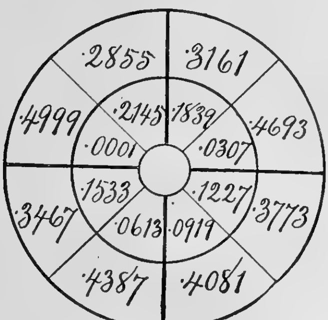


Fig. 71.
$D:C=1:\pi$

to the difference between 3.1416 and 4. This series is only one of many thousands that may be made to produce this result; and is presented because it happened to be the first one tried, and to show that series may be arranged in any form to produce any reasonable desired result. The series can just as well be extended to produce π (Pi) to any number of decimal places without the least variation.

In figure 72 the trigonal series is used instead of an arithmetical series; yet the relations of diameters to each other are not changed. Diameters alike equal 380.

Trigonal Series.

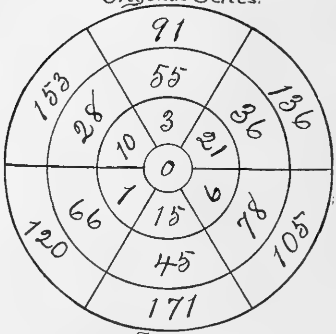


Fig. 72.

Square Series.

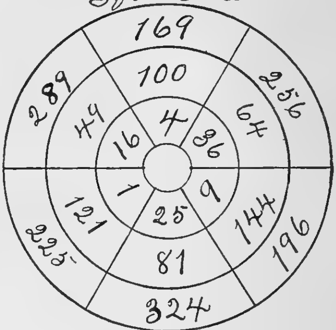


Fig. 73.

In figure 73 the square series is inserted with the same result. Diameters equal 703.

These series, trigonal and square, are placed in the form of Greek crosses, in which the columns and lines all add equally. (Figs. 74 and 75.)

Trigonal Series.

1	78	105	28
120	21	10	45
36	91	66	3
55	6	15	136

Fig. 74.

Square Series.

1	144	196	49
225	36	16	81
64	169	121	4
100	9	25	256

Fig. 75.

Besides columns and lines adding equally in the above crosses, the following pairs of equal sums are obtainable: Opposite quarters are equal; curves, having for their centers the centers of the crosses, or the middle points of the termini of the crosses, and consisting of the means of one column or line and the extremes of the adjacent one, are equal to a parellel curve in the opposite half of the square. For instance: $78 + 120 + 36 + 6 = 28 + 10 + 66 + 136$. The corner numbers, outside the cross, are to be considered in calculating quarters and curves.

In figure 76 is presented a parallelogram transformed into a circle, in which all diameters, circles, and prolate cycloidal lines (indicated by dotted lines) add equally, as they would do if the numbers were arranged in a rectangle.

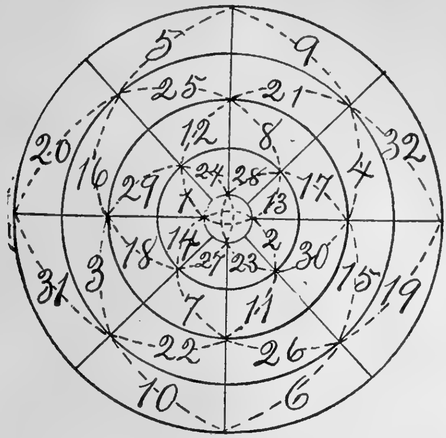


Fig. 76.

The above circles and squares are all perfectly transposable, without marring the harmony of arrangement of the numbers within the figures.

Other plane forms and all volumetric forms will be left to a future time. Many of them are already prepared; but there is much to do yet.

FORMULA.

To determine the sum of any line in any square, rectangle, star, or circle, multiply half the sum of the extremes of the series by the number of places in a line. Expressed algebraically, the formula would appear thus:

$$\frac{(l+f)}{2}p=s$$

In which l represents the last term of the series; f represents the first term; p represents the number of places in a line; and s stands for sum. This is true of any series, whatever the first term and whatever the common difference. In nearly all forms given heretofore, the first term of every series has been 1 and the common difference 1; yet whatever is said of those series is equally true of any other series similarly arranged.

TWENTY-SEVENTH ANNUAL MEETING.

PROCEEDINGS.

The Academy convened in Science hall of the State Agricultural College, at Manhattan, Thursday, December 27. President Sayre occupied the chair. The President appointed the following committees:

On program and press: E. C. Murphy, N. S. Mayo, C. M. Breese.

On membership: Robt. Hay, I. D. Graham, J. M. Price.

On resolutions: W. A. Harshbarger, E. H. S. Bailey, S. W. Williston.

On nominations: A. S. Hitchcock, A. H. Thompson, E. A. Popenoe.

On time and place of next meeting: J. T. Willard, B. B. Smyth, D. S. Kelly, F. H. Snow, W. Knaus.

In the evening the Academy and friends were entertained in the Agricultural Science hall by a lecture by the retiring President, Dr. L. E. Sayre, on the subject, "Medicinal Plants." The lecture was illustrated by numerous lantern slides representing many of the plants of the materia medica in cross-section, powder, growing form, and method of cultivation.

Friday, December 28, the Academy met in the chemical laboratory of the Agricultural College.

The following gentlemen were elected to membership: B. F. Eyer, Hiawatha; J. W. Beede, Topeka; V. L. Layton, Lawrence; H. P. Cady, Lawrence.

Treasurer D. S. Kelly made his report. The report was accepted and adopted, after reference to an auditing committee consisting of J. M. Price and C. M. Breese.

The following papers were then read:

1. The Eastern Extension of the Cretaceous Formations in Kansas, together with Notes on Certain Sand Hills, by Robt. Hay.
2. The Collection and Storage of Water in Kansas, by E. C. Murphy.
3. Rock Exposures about Atchison, by J. M. Price.
4. Atchison Coal, by E. B. Knerr.
5. Two New Streptococci, Probably Pathogenic, by N. S. Mayo.
6. Geometrical Models, by Arnold Emch.
7. Chemical Examination of Counterfeit Gold Dust, by V. L. Layton and H. P. Cady.
8. How the Pheasant Drums, by J. R. Mead.
9. Sand Dune Collecting Notes, by W. Knaus.
10. A Study of Premolars, by A. H. Thompson.
11. Geology in Southeast Kansas, by E. Haworth.
12. New Cretaceous and Tertiary Vertebrates, by S. W. Williston.
13. Velocity of Wind at Lawrence for Twenty Years, by F. H. Snow.
14. An Annotated List of Birds of Manhattan and Vicinity, by D. E. Lantz.
15. Notes on Loxia Curvirostra Stricklandii, by D. E. Lantz.

The following persons were elected to membership: Miss Bertha Kimball, Manhattan; Erasmus Haworth, Lawrence; J. B. S. Norton, Manhattan; Miss

Lora Walters, Manhattan; A. W. Jones, Salina; C. B. Hoffman, Oberlin; J. T. Lovewell, Topeka; D. E. Lantz, Manhattan; Arnold Emch, Lawrence; J. D. Walters, Manhattan.

Professor Popenoe extended an invitation to the Academy to assemble in the new Library and Agricultural Science hall shortly after 6 p. m., for the purpose of dedicating the building and to partake of the banquet. The invitation was accepted. J. T. Willard, as chairman of the committee on time and place of meeting, reported the following:

"Your committee recommends that we meet during the holidays the next week after the meeting of the State Teachers' Association, at Lawrence." On motion, the report was adopted, and it was voted to meet accordingly.

In the evening the Academy met in the new Science hall to enjoy the banquet and dedicatory exercises in that building. About 100 members and guests were present. Speeches were made as follows:

For the Kansas Academy of Science—Dr. L. E. Sayre; subject, "Science and Industries." Dr. A. H. Thompson; subject, "Books as Tools of Science."

For the building—Hon. Wm. Knipe, Manhattan; Seymour Davis, Topeka.

For the college—Rev. Washington Marlatt, Manhattan; W. D. Street, Oberlin.

For the alumni—S. W. Williston, Lawrence; F. A. Waugh, Stillwater, O. T.

For education—F. H. Snow, Lawrence; F. D. Coburn, Topeka.

For the state—Geo. T. Anthony, Ottawa; G. W. Glick, Atchison.

For the world—W. B. Sutton, Russell.

Saturday, the Academy met in chemical laboratory, President Sayre in the chair.

The following officers were reported elected for the ensuing year: President, W. Knaus; First Vice-President, I. D. Graham; Second Vice-President, S. W. Williston; Secretary, E. B. Knerr; Treasurer, D. S. Kelly; Librarian, B. B. Smyth; Curators, B. B. Smyth, A. H. Thompson, Robt. Hay.

The following were elected to membership: J. E. Taylor, Berryton; A. S. Dunstan, Lawrence.

Librarian B. B. Smyth offered his report, which was adopted. The recommendation that the list of correspondents of the Academy be published was referred to the publication committee. It was the opinion of the Academy that the list should be published.

The report of the Curators was presented by B. B. Smyth, and adopted and a vote of thanks was given the Curators for their efficient labors.

B. B. Smyth exhibited the certificate of membership ordered at last meeting.

The following papers were read:

16. Variation in the Composition of Taraxacum Root, by L. E. Sayre.
17. The Rotation of Mercury and Venus, by E. Miller.
18. Conorhinus: its Life History and Habits, by Miss Bertha Kimball.
19. Oil and Natural Gas in Kansas, by E. H. S. Bailey.
20. Terminal Boulder Train in Shawnee County, by B. B. Smyth.
21. The Topeka Coal Hole, by B. B. Smyth.

The following papers were read by title:

22. Volcanic Effects in Kansas, by Z. S. Sharp.
23. Some Remarkable Sink-holes in Sherman County, by Robert Hay.
24. A List of Wyandotte County Ferns, with Notes, by Minnie Reed.
25. Additions to the Flora of Kansas, by B. B. Smyth.
26. A New Collecting Ground for Cicindela Limbata, by W. Knaus.

27. An Undescribed Rhincolus from Central Kansas, by W. Knaus.

28. Ethyl and Methyl Alcohol on Ortho- and Meta-diazo-benzene-sulphonic Acid, by E. C. Franklin.

29. Curvature of Fans, by E. C. Murphy.

30. Harmonic Series, by B. B. Smyth.

31. Botanical Notes from Northwest Kansas, by B. B. Smyth.

32. Recent Cutting of the Missouri River at Atchison, by J. M. Price.

33. Parasitism in Aphyllon uniflorum, by J. M. Price.

34. A Theory of the Cosmos, by E. B. Knerr.

35. Cattle Poisoning by Nitrate of Potash, by N. S. Mayo.

36. A Preliminary List of Kansas Hymenoptera, by E. A. Popenoe.

37. Economic Plants of Japan, by C. C. Georgeson.

38. Notes on Plants in the Herbarium of the State Agricultural College, by A. S. Hitchcock.

39. Erysipheae of Riley County, Kansas, by Lora L. Walters.

40. Kansas University Water Supply, by E. C. Murphy.

The Academy then adjourned to meet in one year at Lawrence, as per resolution.

E. B. KNERR, Secretary.

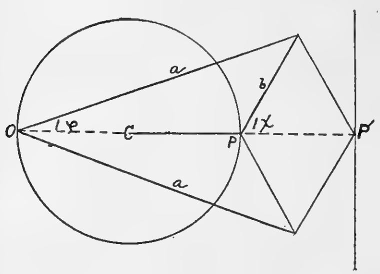
MATHEMATICAL MODELS.

By ARNOLD EMCH, of the State University, Lawrence.

By an ordinary consideration of geometrical forms it might appear that a mathematical model could have but a theoretical interest, and non-mathematicians are mostly liable to the opinion that solid representations in space be rather curiosities than practical schemes. This opinion was prevailing even among mathematicians until some 20 years ago, when besides of the analytical results particular stress was also laid upon the conception of the geometrical forms. It was perceived that real progress in mathematics could only be made by aid of geometrical illustrations, and since that time the geometrical standpoint—geometry taken in the most general sense—is dominant in mathematical investigation. At present it is not sufficient to know and to discuss the analytical equation of a geometrical form; its real shape must be studied also. Thus, if a plane configuration, or a representation by descriptive geometry is too complicated, or not conspicuous enough, a model of the form is constructed. This enables the student or the investigator to see the essential features of the form, and suggests to him new ideas. Moreover, it is obvious that by the constant reference to real forms many problems of technics come into account which by a purely analytical method, with the exclusion of every configuration, never would be taken up. In this manner the very important connection between science and technics can be maintained, and there is no danger that mathematics will branch off too much from its technical application.

A simple illustration for this method is, for instance, Peoncellier's diagram, which transforms a circular movement into a movement of a straight line. Peoncellier published a solution of this problem in the "Nouvelles Annales de Mathematic," in 1864. The main part of the apparatus for the realization of this movement on a straight line is called "inversor," because it produces the relation of the inversion.

The "inversor" consists of two bars of equal length which are connected in the point O (see figure), and between which a system of other bars in shape of a rhombus is put in. At all connection points of the bars are links, so that the whole system is moveable. If the point O is kept fixed, and if one point of the rhombus, P, moves at pleasure, the other point, P′, will move such that it is inverse to P, or $OP \times OP' = \text{const.}$ For, by using the designations of the figures, the relations exist:



$$
\begin{aligned}
a \sin e &= b \sin x, \text{ or} \\
O &= a^2 \sin^2 e - b^2 \sin^2 x \\
OP &= a \cos e - b \cos x \\
OP' &= a \cos e + b \cos x \\
\hline
OP \times OP' &= a^2 \cos^2 e - b^2 \cos^2 x \\
\text{adding } O &= a^2 \sin^2 e - b^2 \sin^2 x \\
\hline
OP \times OP' &= a^2 - b^2 = \text{const.}
\end{aligned}
$$

Thus, the inversor realizes the transformation by reciprocal radii in regard to a circle with O as a center and $\sqrt{a^2 b^2}$ as a radius. Now it is easy to produce a straight line by P′. To perform this it is only necessary to move the point P on a circle passing through O. This can be done by connecting the center C of the circle with the point P by a seventh bar C P.

As to mathematical means of illustrations in general, and their utility, it may be well to mention some points of Felix Klein's lectures on mathematics, on the occasion of the World's Fair, in Chicago. (Felix Klein, of Gottingen, at present one of the most eminent mathematicians, and well known to American universities, delivered those lectures before the members of the Congress of Mathematics, at Northwestern University, Evanston, Ill.)

Among mathematicians in general three main categories may be distinguished, and perhaps the names logicians, formalists and intuitionists may serve to characterize them. (1) The word logician is here only intended to indicate that the main strength of the men belonging to this class lies in their logical and critical power, in their ability to give strict definitions, and to derive rigid deductions therefrom. (2) The formalists among the mathematicians excel mainly in the skilful formal treatment of a given question, in devising for it an "algorithm." (3) To the intuitionists, finally, belong those who lay particular stress on geometrical intuition, not in pure geometry only, but in all branches of mathematics. What Benjamin Pearce has called "geometrizing a mathematical question" seems to express the same idea.

Klein ranks himself to the logicians and intuitionists, and possesses the power and ability of both. The main feature of this combination lies in the "refined intuition." Refined intuition characterizes the most successful mathematical schools of the present, and does not properly mean intuition as it is required for an artisan or a draughtsman. The latter, or the naive intuition, is not exact, while the refined intuition is not properly intuition at all, but arises through the logical development from axioms considered as perfectly exact. Not all mathematicians have this point of view, what might be explained by the fact that the degree of exactness of the intuition of space is different in different individuals,—perhaps in different races. Klein points out, as if a strong naive space-intuition were an attribute pre-eminently of the Teutonic race, while the critical, purely logical sense is more fully developed in the Latin and Hebrew races.

But in general the henristic value of the applied sciences as an aid to discover new truths in mathematics is at present more recognized than ever before. Besides the great importance in technics on other applied sciences of mathematics, the henristic method is the most successful in pedagogics. An education which develops in the student a strong intuition produces, as the history of pedagogics shows it, the best results. It was one of the first principles of Pestalozzi, and is useful as well in the higher as in the common schools. The incomparable success of the lectures of the great mathematician Steiner was due to this method. Steiner himself had such an unusual intuition of space that it was easy for him to make the most difficult constructions of descriptive geometry by imagination, and to see clearly before his powerful mind complicated geometrical configurations. That a strong intuition is of a general value may be stated by the same Steiner. Whenever he visited an art exhibition artists and experts were surprised by his quick and correct criticism. It took him only a glance on a person to not forget her image any more.

People generally believe that intuition, like fine arts, must be born with a person. This may be true in a certain sense, and only to a certain limit.

Education and training, however, can produce a good deal of what is called ability and art in common life. I shall give an example which may suggest a test for the quality of the naive intuition of a person. Most of the people that look at a tree think it to be a very simple object of art. If they would shut their eyes at the moment of this intuition, and try to imagine exactly the tree which they just were going to see, they would find out how strong their intuition was. Even representants of the purely analytical school would be surprised after this test. Thus, it is the aim of the leading mathematicians of the present to proceed from the naive intuition to the refined intuition, i. e., to combine the critical power of logic with the usefulness of intuition.

When I was in Zurich, an eminent mathematician, who is now in Germany, lectured on the theory of functions; but his treatment of the subject was purely analytical. One day a student showed him a short geometrical demonstration of one of his theorems. The professor looked at it, and said: "This seems to be a very elegant prove, indeed, but I am sorry to say that I cannot understand it—I am not a geometrician." However valuable those lectures have been, such a one-sided standpoint cannot be taken any more. One-sidedness must disappear.

The question now arises as to how produce a stronger intuition. It has been answered many times with more or less success, and by the most prominent educators. According to their statements, the only way is a thorough course in what is called mathematical graphics.

From what has been said before it will be understood that we define mathematical models in the most general sense, i. e., as geometrical figures and configurations, and mathematical models in a narrower sense as geometrical and mechanical models. All these objects serve the one educational purpose to refine the intuition, and thereby the efficiency of applied sciences, or technics. Now I will proceed to what might appear first from the title of the paper, namely, the geometrical models or geometrical means of illustration.

In the accounts of the investigations of Euler, Newton and Cramer we find numerous figures. The interest for the construction of models was first produced in France, where, under the influence and the example of Monge, a great number of thread models of surfaces of the second order, conoids and helicoids were being constructed. A further progress was made by Bardin (1855). He had made cast models of stone-cuts, gearings, and many other things. His collection was greatly enlarged by Muret. These schemes were not appreciated by French mathematicians, while Cayley and Henrici (1876) exhibited in London mathematical models besides other scientific apparatus of the universities of Cambridge and London. In Germany the construction of models received an impetus, but after the assimilation of projective by descriptive geometry. Plucker drew already in 1835 the shapes of the curves of the third order, and made in 1868 the first larger collection of models, consisting of models of complex surfaces of the fourth order. Klein added to it some more models of the same character. A special surface of the fourth order, the wave surface of crystals with two axes, was constructed by Magnus in Berlin, and Soleil in Paris, in 1840. Fiedler, in Zurich, is the constructor of the first model of a surface of the third order with its 27 straight lines. He constructed it in 1868, when he was a professor in Prague, and always used to have it suspended at the ceiling of his study or parlor. Now this model is a historical curiosity of the mathematical collection of the Polytechnic of Zurich. Models of surfaces of the fourth order were made by Kummer from 1860 to 1870. His pupil-disciple, Schwarz, constructed also a set of models, among which are minimal surfaces and the central surface of the ellipsoid. On the occasion of a meeting of mathematicians in Gottingen, a large exhibition of models was arranged, which had a great success. Thus, A. Brill, F. Klein and W. Dyck started the construction of models in the mathematical seminary of the Polytechnic Institute of Munich in a systematic manner. Since 1877 more than a hundred models of all kinds have appeared there. They are not all intended purely for mathematical teaching, but also for the use in lectures on perspective, mechanics, and mathematical physics. As it is seen from this fact, higher institutions of mathematical learning begin to put particular stress upon the collection of models as means of illustration. The value of mathematical models is almost inappreciable, because there are no other means that contribute more to a refined intuition. Collections of mathematical models will become, for the mathematical departments of the universities, polytechnics, and colleges, what the museums of natural history are for the biological departments.

THE PERIODS OF ROTATION OF MERCURY AND VENUS, AND THE SATELLITES OF THE SOLAR SYSTEM.

By E. MILLER, Kansas University, Lawrence, Kan.

Long ago, when our moon was in a plastic condition and the earth's attraction forced great tidal waves of liquid or gaseous matter to roll over her surface, a marvelous effect was produced. The rotation period of the moon was gradually brought into coincidence with the period of her revolution.

The principle involved in such planetary interaction is known as the theory of "tidal friction", and was first announced to the world by the German philosopher, Kant, in 1754. But not until near the middle of the nineteenth century did it begin to play any important part in astronomical theories.

In this paper I propose to consider the synchronism of the rotation and revolution periods of the planets Mercury and Venus, and of all the satellites of the solar system, basing my argument upon recent astronomical observations. Up to the year 1889, no definite period of rotation had been assigned to the planet Mercury; but in that year the Italian astronomer, Schiaparelli, discovered from certain marks upon the surface of the planet that the revolution of Mercury around the sun and his rotation upon his axis were coincident, each requiring a period of about 88 days.

In the year 1666, Domenico Cassini, an Italian, estimated the period of the rotation of the planet Venus at 23 hours and 21 minutes. Another observer placed it at 24 days, 8 hours; Schroeter gave it a period of 23 hours and 28 minutes; and others still put it at 23 hours, 21 minutes, and 22 seconds. The first accurate observations upon Venus, made in this case also by Schiaparelli, with his splendid equipment, his unrivaled Italian skies, and his unsurpassed powers of vision, have given us something reliable and definite, establishing almost beyond a doubt that Venus rotates in precisely the same time that she requires to perform one revolution, that is 224 days, 7 hours.

Mercury and Venus, of all the planets, are the only ones that resemble our moon in their periods of rotation and revolution, and, just as our satellite turns but one face towards the earth, so in like manner do our inner neighbors turn but one face towards their primary, the sun.

"We can scarcely, indeed, realize, without some approach to dismay, the physical condition of a globe turning always the same face towards the sun. Over one hemisphere, the perpetual glare of unending day; on the other, darkness without the hope of dawn." (Clerke.)

Now Laplace's nebular hypothesis being accepted as fact, many millions of years ago, the nebulous ring out of which the earth and moon were formed, separated from the inner mass. The moon was, no doubt, a part of the ring, and is, therefore, as old as the earth. Both were intensely heated liquid or gaseous substances, and the smaller exposed to the greater attractive power of the larger, was pulled into an orbit of revolution about the latter. The earth's tidal action upon the lunar substance, would, in the course of millions of years, gradually change the rotation-rate so as to make it coincide with its period of revolution about the earth. A great tidal wave would rush over the moon's surface in the direction of the earth, and at the same time another would be formed on the opposite side of the moon. As the lunar body cooled, in the lapse of ages, there would result an elongated rigid mass, having its longest axis pointing always towards the earth. As long as the moon remained in the liquid or gaseous state, but contracting, and therefore increasing her distance from the earth, the trend towards a fixed and final shape and fixed periods of rotation and revolution would be very evident. "The evidence for the efficiency in bringing about the actual configuration of the lunar-terrestial system" is not weakened by any contrary hypothesis.

Accepting all of the foregoing with regard to the moon, namely, that millions of years ago our satellite was in a liquid, or viscous, or gaseous condition; that its surface was swept by immense tides produced by the earth's attraction; that its longest axis was made to point always towards the earth; and that the rotation period and revolution period were forced into coincidence; let us see whether the same things are true of other bodies in the solar system.

The discovery of Schiaparelli has made known the fact that Mercury and Venus sustain the same relation to the sun that our moon does to the earth. The close proximity of these planets to the sun when they were in a gaseous state, and the tremendous tidal action of the sun upon their masses, shaped their destiny. But, passing to the earth, a different order of things, that is, a different law, must have been in operation. Our planet turns in one year its entire surface to the sun; her rotation period is not synchronous with that of her period of revolution; and her longest axis does not point toward the sun. Somewhere, then, between Venus and the earth, is the dividing line outside of which the sun's power is so much diminished that earth and all the other outer planets, have their periods of rotation and revolution, none coincident, and their entire surfaces are exposed at some time in their respective revolutions to the sun's rays.

But how is it as to the satellites themselves? We know the condition of our moon and her relation to the earth.

In 1877, Mars was discovered to have two satellites, the outer one at a distance of 14,600 miles from the center of the planet, and the inner distant only 5,800 miles. Now, these distances are in comparison less than the distance of our moon from the earth, and the satellites themselves being acted upon to a less degree, on account of distance, by the solar attractive power, are controlled by the comparatively nearer and therefore greater power of Mars. The fact, too, that the diameter of the larger or inner satellite does not exceed 16 miles, and that of the outer 14 miles, makes it more than probable that the Martial tide-raising power exerted upon these little bodies must compel their rotation and revolution periods to coincide, and their longest axes to be directed towards Mars himself.

The action of the satellites of Mars upon each other may to some extent modify the relations between the periods of rotation and revolution, but owing to their proximity to their primary and his great size as contrasted with theirs, this modification must be dwarfed into insignificance.

Let us now pass to the consideration of the satellites of Jupiter. In the November number of Astronomy and Astro-Physics, appears an article "On Recent Observations of the Satellites of Jupiter," by W. H. Pickering, of the Lowell observatory, Arizona. From that article I quote the following: "As it would seem that some astronomers are still doubtful about the accuracy of my observations made upon these bodies (Jupiter's satellites) in 1892, I will describe one made upon September 18 of the present year (1894), which is, I think, of interest for several reasons. At 16 hours 34 minutes, the 18-inch Brashear telescope showed that the first and third satellites were very near together, and that both of them presented elongated discs, the elongations being nearly at right angles to one another. The second and fourth satellites were also slightly elongated, but in different directions. The 12-inch Clark telescope was then turned upon the planet, and the observations repeated without difficulty. I went next to the 6-inch Clark, and was surprised to find that with a power of 400, not only the elongations of the first and third were easily seen, but even that of the fourth could be detected. I especially noted that the elongations had precisely the same position angles relatively to each other as in the larger instruments." Again, "since the elongations occurred in different directions for the different satellites, the appearance clearly could not be due to atmospheric conditions, or to the eye. Since identically the same appearance was seen in three different telescopes, it could not be instrumental; and, finally, since the elongation has been seen at different times by at least half a dozen different persons, it cannot be a permanent idiosyncrasy."

The elongated forms of the satellites of Jupiter, referred to by Mr. Pickering, can be accounted for on the tidal theory; and if such be the fact, in all probability their periods of rotation and of revolution must be coincident, unless the third and fourth satellites are at a distance from Jupiter proportionally greater than Venus is from the sun, or our moon is from the earth, the masses of Jupiter and his satellites being taken at their estimated values. The difficulty that presents itself with regard to the elongations of the first and third satellites "being at right angles to one another" can easily be put out of the way, when we consider the many different relative positions of the satellites and Jupiter as observed from our earth standpoint. The new inner satellite discovered by Mr. Barnard, of Lick observatory, will, of course, present no difficulty, if my statements with regard to the other satellites be allowed. Although Mr. Proctor says that "there are reasons for believing that the moons of Jupiter are (not all of them, at any rate) in the same condition as our moon", and that "changes of luster occur such as cannot be wholly explained by the rotation of these bodies on their axes, either like our own moon once in each circuit around their primary"; yet, "if the age of Jupiter's satellites corresponds to that of our own moon, the retarding tidal action caused by a planet whose mass is 315 times that of the earth must have brought about a synchronism between the rotation and revolution periods long ere this." The elongation of each of the four outer satellites discovered or observed by Mr. Pickering, the proximity of all of them to their primary, and the comparative masses and densities of the members of the Jovian system, all point unmistakably to the correspondence of the rotation and revolution periods of the satellites respectively.

In like manner it may be affirmed that the satellites of Saturn, Uranus, and Neptune are controlled.

The perturbations produced among the satellites of the major planets upon one another are not sufficient to destroy the validity of a general law such as has been outlined in the foregoing.

We have no reason to discredit the conclusions of Schiaparelli, for they are recognized as the best that have so far been reached. As the force of gravity varies inversely as the squares of the distances, and directly as the product of the masses of the attracting bodies, a glance at the following relations will show the scope of the law we are attempting to unfold:

(a) The sun, at a distance of 67,000,000 miles from the planet Venus, and with a mass 425,000 times as great as that of the planet, has, according to Schiaparelli, forced the rotation and revolution periods of the planet to be coincident.

(b) Beyond Venus, away from the sun, the latter body fails to produce a like result upon the other planets.

(c) The earth is 238,000 miles from her satellite, has a mass 81 times as great, and the two periods are coincident.

(d) Jupiter's first and second satellites are in the same relation to their primary that our moon is to the earth.

Jupiter is 1,167,000 miles from his outer satellite, has a mass 42,480,000 times as great, and has given to the satellite an elongated or ellipsoidal form, a result of the tremendous pull of the planet upon the former plastic condition of the satellite. It must follow that No. 4 has motions just as the first and second have, and always shows the same face to the primary.

(e) The distance, mass, and gravitation relations of the third and fifth Jovian satellites, and of all the moons of Saturn, Uranus, and Neptune, being substantially the same as those of our moon, it is safe to say that their rotation and revolution periods are coincident, and they never show but one face to their primaries.

Whatever we may think as to the moon's past, and however long we may suppose her period of rotation to have been when she started on her career as an independent body, the fact that she turns the same face constantly towards us, tells us of long stretches of time, in her history, that must be measured by millions of years. And upon the hypothesis that millions, and perhaps tens of millions, of years ago, the moon was a mass of liquid or gaseous matter, and that in this condition, she was exposed during all those ages to the earth's pull or attraction, it can be easily seen that the period of her rotation and that of her revolution would be gradually forced into coincidence.

And so, when we consider the facts already established concerning all the satellites of our system, as well as those pertaining to the movements of the planets Mercury and Venus; when we consider the law of gravitation, the masses and the distances of all these bodies; and, further, when we understand the meaning of the observations of Schiaparelli and Pickering, we must conclude that the modern theory of "tidal friction" when applied to the satellites, is true.

THE NEW WATER-SUPPLY OF THE UNIVERSITY OF KANSAS.

By E. C. MURPHY, Lawrence, Kan.

From the opening of the University of Kansas, in 1866, until the construction of the Lawrence city water-works, in 1887, the water supply of the university consisted of the rainfall on the buildings, stored in cisterns. From the cisterns it was pumped into tanks near the top of the buildings, from whence it was distributed.

From the last-named date to December, 1894, the water, except that for drinking purposes, had been supplied by the city water company from the Kansas river. It was necessary to pump a part of this water into the tanks, as the city pressure is not sufficient to force the water to all parts of the buildings.

In the summer of 1893 the water company stopped pumping on account of difficulty with the city, thus cutting off the water from the university for about a week. This fact, together with a desire for a less expensive supply, led the regents to seek another source of supply. It was believed that the low ground south of the university would furnish sufficient water, and so a lot 50x127 feet, about 800 feet from the engine-house, was purchased.

Two wells and an intercepting tunnel were constructed. One well is 10 feet in diameter and 40 feet deep; the other, which is 25 feet from it, is 6 feet in diameter and 30 feet deep. The tunnel, which is 125 feet long, connects the wells and extends east and west parallel to the surface slope. Its center line is 27 feet below the surface of the ground. The wells are lined with rock, the tunnel is filled with rock.

The material through which the wells pass is alluvium, consisting mostly of clay, fine sand, and "soapstone." The latter layer is 30 feet below the surface. The bottom of the tunnel rests on it, and the large well extends 10 feet into it.

The water is pumped from the wells into four tanks in the buildings, the combined capacity of which is 5,500 gallons.

The pump is of the rotary type, makes 400 revolutions per minute, and has a capacity of 100 gallons per minute. It is 24 feet below the surface of the ground in the large well and is under water a part of the time. It is worked by a 7½ horse-power electric motor.

The water is clear and of good quality, as shown by the following chemical analysis, made by Mr. H. P. Cady, in the university chemical laboratory:

	Parts per 100,000.
Sodium chloride	3.09
Silicon dioxide	1.40
Ferric oxide	.48
Calcium sulphate	10.62
Calcium carbonate	14.58
Magnesium carbonate	4.51
Total	34.68

The capacity of the plant has not been fully tested. In case it fails to supply the ever-increasing need of the university, it is the intention to sink more wells.

The total cost of the plant is about $1,000. The cost of operating is very little, as the engine used for running the shop machinery supplies the electric motor with power.

HARMONIC SERIES.

HARMONIES OF THE CHEMICAL ELEMENTS.

By B. B. SMYTH.

The development of harmonic forms from arithmetical and figurate series; and the study of harmonical series in the phyllotactic arrangement of leaves, scales, etc., of plants and their fruits; in the waves, tones, and velocities of music, light, and electricity; in the distances, weights, and movements of the planets and their satellites; in organic chemistry; and the finding of harmony everywhere in nature has led to researches to determine what harmony there should be in the constitution of the primary elements and in their respective properties.

Earliest researches were happily made in wrong directions, resulting in negative knowledge, which serves as a lamp to positive knowledge. The atomic weights of all the elements were first resolved into their prime factors, with a view to determining a relation between their weights and valences. The result was generally negative.

One difficulty lies in the fact that a slight error in the determination of the atomic weight of an element would lead to a conclusion entirely erroneous.

For instance, the atomic weight of gold is often given as 197. It is also sometimes given as 199. Each of these is a prime number; and if either were correct, and the atomic weights were in exact multiple proportion, gold could have only one valency, namely monovalency. But gold is also trivalent. Yet the factor 3 does not enter into either of these numbers. If the atomic weight were shown to be 198, then the metal might be divalent or even hexavalent as well as trivalent.

In a few cases (as, for instance, Ca 40, Cd 112, and Hg 200, which are divalent; Al 27, Ga 69, and Sm 150, which are trivalent; C 12, and Ti 48, which are tetravalent; As 75, and Sb 120, which are pentavalent; Mo. 96, and U 240, which are hexavalent), the atomic weight appears to be in multiple proportion to the valency; but in most cases there is no such concordance. If this were true, N 14, Fe 56, and Sn 119, should be heptavalent; and Ca 40, Mn 55, Br 80, Te 125, Sm 150, Tb 160, Pt 195 and Hg 200 should be pentavalent. Similarly, O 16, Ca 40, Br 80, Sb 120, Tb 160 and Hg 200 should be tetravalent if not pentavalent.

This is a field that has been worked over thoroughly by many eminent chemists in the last forty years; yet at this late day there are golden grains to be garnered even by a mathematician; and, whether new or old, these ideas are presented to show the harmonies that exist in the constituent properties of the several chemical elements.

On these charts I have arranged the elements in octaves as done thirty years ago by Newlands, and much better done four years later by the Russian chemist Mendeléeff, that being the most rational method yet devised for a classification of the chemical elements. The arrangement of Dr. Charles Skeele Palmer, of the University of Colorado, is an admirable one, and a vast improvement over that of Mendeléeff. I have, however, modified that arrangement to some extent to accord with recent discoveries in inorganic chemistry.

According to their specific gravities, the elements, after the first two octaves, are arranged in hecdecades. In the first two octaves the specific gravities increase in a general way to the middle of each octave, then decrease to the end. The common difference in the atomic weights of these two octaves is 2.

After the first two octaves the specific gravity increases somewhat irregularly to the middle of each hecdecade, then decreases similarly to the end. The common difference in atomic weights is 3. Irregularities in atomic weight do not change this mean until the fourth hecdecade, where there seems to be a slight reduction.

Each hecdecade consists of two full octaves, an accrescent, in which the specific gravities of the several successive elements increase to the end of the octave; and a decrescent, in which the specific gravities regularly fall off from the beginning of the octave to the end.

The first table contains an additional—a hypothetical—octave, containing the one element hydrogen. Whether this octave shall ever be filled through future discoveries, or by placing therein some of the elements already known and wrongly placed in some other octave, remains to be seen.

The atomic weights are, unless otherwise specified, as published by Dr. F. W. Clarke, chief chemist U. S. geological survey, January 1, 1894.

HYDROGEN (HYPOTHETICAL) OCTAVE.

Valence.	Harmonic series.		Element.	Atomic weight. ($O = 16$)	Difference.	Specific gravity. ($H_2O = 1$)	Variation.
	At. Wt.	Spec. Grav.					
I	1	.35	H	1	0	0.025	
II	1.5	.54					
III	2.25	.82					
IV	3	1.22					
III, V	4	.93					
II, VI	5	.69					
I, VII	6	.52					

LITHIUM OCTAVE.

Valence.	Harmonic series.		Element.	Atomic weight. ($O = 16$)	Difference.	Specific gravity. ($H_2O = 1$)	Variation.
	At. Wt.	Spec. Grav.					
I	7	.58	Li	7	0	0.58	.00
II	9	.90	Gl ?	9	0	1.85	+1.05
III	11	1.36	B ?	11	0	2.61	+0.97
IV	13	1.95	{ C	12	—1	2.25*	+0.15
III, V	15	1.48	{ N	14	—1	0.88	—0.40
II, VI	17	1.11	{ O	16	—1	1.11	.00
I, VII	19	.83	F	19	0	——	
VIII	21	.65					

* Graphite.

Between Boron and Carbon is a half-step or minor step; between Oxygen and Fluorine is a step and a half or major step. There is room for an additional element between O and F; possibly room for elements with C and N.

Boron and Glucinum seem to differ widely in some respects from the requirements of the positions they occupy; but in the absence of positive knowledge, they are allowed to remain in the series as placed by Mendeléeff.

Sodium Octave.

Valence.	Harmonic series.		Element....	Atomic weight. (O = 16)...	Difference...	Specific gravity. (H_2O = 1)..	Variation....
	At. Wt.	Spec. Grav.					
I	23	.97	Na	23.1	+0.1	0.97	0
II	25	1.50	Mg	24.3	–0.7	1.75	+.17
III	27	2.22	Al	27	0.	2.68	+.21
IV	29	2.84	Si	28.4	–0.6	2.48	–.12
III, V	31	2.35	P	31	0.	2.34	0
II, VI	33	{ 2.01 /	S	32.1	–0.9	2.07	+.03
			....	....	....	....	....
I, VII	35	1.33	Cl	35.5	+0.5	1.33	0
VIII	37	1.00	....	....	....	....	....

The differences in atomic weight between Na and Mg, between Al and Si, and between P and S, are minor steps; the differences between Mg and Al, between Si and P, and between S and Cl, are major steps. They recur regularly.

Potassium Hecdecade.

Valence.	Harmonic series.		Element....	Atomic weight. (O = 16)...	Difference....	Specific gravity. (H_2O = 1)..	Variation....
	At. Wt.	Spec. Grav.					
I	39	1.05	K	39.1	+0.1	.87	-.17
II	42	1.79	{ Ca /	40 /	–2 /	1.70 /	–.05 / ....
III	45	2.69	Sc	44	–0.1	....	....
IV	48	3.69	Ti	48	0	....	....
III, V	51	5.00	V	51.4	+0.4	5.87	+.17
II, VI	54	6.60	Cr	52.1	–1.9	6.81	+.03
II, IV }	57	{ 7.20	Mn	55	–2	7.20	
(VII) }		} 8.00	Fe	56	–1	8.00	
II, IV }	60	{ 8.90	Ni	58.9	–1.1	8.90	
VIII }		} 9.09	Co	59.7	–0.3	8.96	–.
II, I	63	8.50	Cu	63.6	+0.6	8.90	+.
II	66	7.40	Zn	65.3	–0.7	7.12	–.
III	69	6.43	Ga	69.1	+0.1	5.95	–.
IV	72	5.60	Ge	72.3	+0.3	5.47	–.
III, V	75	4.87	As	75	0	4.71	–.
II, VI	78	4.23	Se	79	+1	4.31	+.
I, VII	81	3.37	Br	80	–1	3.19	–. 3

Ni and Co appear to be doublets or twins. So, also, appear Mn and Fe. They are complementary to each other. Ca and Se are each one side of its systematic position. Their complementary elements are yet to be discovered.

RUBIDIUM HECDECADE.

Valence.	Harmonic series.		Element.....	Atomic weight (O = 16).....	Difference....	Specific gravity (H_2O=1)	Variation.....
	At. Wt.	Spec. Grav.					
I	84	1.40	...... Rb	...... 85.5	...... +1.5	...... 1.52	...... +.08
II	87	2.38	Sr	87.6	+0.6	2.50	+.05
III	90	3.58	Yt	89.1	—0.9	......	......
IV	93	4.90	Zr	90.6	—2.4	4.15	—.15 ......
III, V	96	6.67	Cb	94	—2	6.75	+.01
II, VI	99	8.80	Mo	96.1	—3	8.60	—.02 ......
II, VII	102	10.82	Ru	101.6	—0.4	11.44	+.06
II, IV VIII	105	12.12	Rh Pd	103 106.6	—2 +1.6	12.10 11.85	.00 —.02
I	108	10.90	Ag	107.9	—0.1	10.50	—.04
II	111	9.50	Cd	112	+1	8.65	—.09
III	114	8.23	In	113.7	—0.3	7.42	—.09
IV	117	7.14	Sn	117.8	+0.8	7.25	+.01
III, V	120	6.21	Sb	120	0	6.70	+.08
II, VI	123	5.40	...... Te	 125	...... +2	...... 6.20	...... +.15
I, VII	126	4.30	I	126.9	+0.9	4.90	+.04

CESIUM HECDECADE.

Valence.	Harmonic series.		Element.....	Atomic weight (O = 16).....	Difference....	Specific gravity (H_2O = 1)...	Variation.....
	At. Wt.	Spec. Grav.					
I	129	1.87	Cs	132.9	+3.9	1.88	00
II	132	3.18	Ba	137.4	+5.4	3.75	+.18
III	135	4.75	La	138.2	+3.2	6.10	+.29
III, IV	138	6.50	Ce Nd	140.2 140.5	+2.2 +2.5	6.70	+.03 ......
III, (V)	141	8.89	Pr	143.5	+2.5	......	......
VI	144	11.64	......	......	......	......	......
VII	147	14.48	......	......	......	......	......
III, (IV) (VIII)	150	16.16	(Sm	150	0)	......	......
III, (I)	153	13.97	(Da	154	+1)	......	......
III, (II)	156	12.20	(Gd	156.1	+0.1)	......	......
III	159	10.52	(Tb	160	+1)	......	......
IV	162	9.13	......	......	......	......	......
III, (V)	165	7.92	(Er	166.3	+1.3)	......	......
III, (VI)	168	6.89	(Tu	170.7	+2.7)	......	......
III, (VII)	171	5.50	(Yb	173	+2)	......	......

Between Cs and Ba is a major step; between Ba and La is a minor step; Ce and Nd appear to be twins; otherwise Nd is superfluous.

The entire hecdecade needs revision. The first four elements, whose specific gravities have been carefully determined, appear to have their atomic weights too high to correspond with their specific gravities. Especially is this true of Barium. If the harmonic series of atomic weights were increased three units, La would be the only element outside the limit of variation. Barium would then correspond exactly as to its atomic weight and specific gravity, owing to the recent redetermination of the atomic weight by Richards. Care was taken in this redetermination to eliminate all lighter metals of the same group, as Ca, Sr, etc. Effort should now be made to eliminate from Ba, La, and Ce, the heavier metals, II, III and IV of the Tantalum octave. This should bring them within the harmonic law.

The rest of the hecdecade is arranged simply according to atomic weight. The valency cuts no figure in the case. They are all represented as trivalent. It is inconceivable that all the elements of a hecdecade except the first two should be trivalent. None of them correspond with the specific gravities opposite to which they are placed. The specific gravity of Davydium (9.39) would show that it belongs, not where it is placed but further down the scale. The other properties, as valence, brittleness, melting point, electrical status, spectral lines, transparency to certain forms of radiant energy, etc., must determine its position. The same is true of the other elements.

(GOLD) HECDECADE.

Valence.	Harmonic series.		Element....	Atomic weight (O = 16)....	Difference....	Specific gravity (H_2O=1)	Variation....
	At. Wt.	Spec. Grav.					
I	174	2.49					
II	177	4.26					
III	180	6.40					
IV	183	8.65					
III, V	186	11.86	Ta	182.6	—3.4	10.70	—.10
II, VI	189	15.80	W	184.9	—4.1	18.25	+.15
			......	187.1			
II, VII	192	19.30	Os	190.8	—1.2	22.48	+.17
II, IV	195	21.55	Ir	193.1	—1.9	21.80	+.01
(VIII)			Pt	195	0	21.50	00
III, I	198	17.86	Au	197.3	—0.7	19.30	+.08
I, II	201	15.60	Hg	200	—1	14.40	—.08
III	204	13.50	Tl	204.2	+0.2	11.90	—.12
IV	207	11.70	Pb	207	0	11.30	—.03
III, V	210	10.18	Bi	208.9	—1.1	9.82	—.03
II, VI	213	8.80					
I, VII	216	7.03					

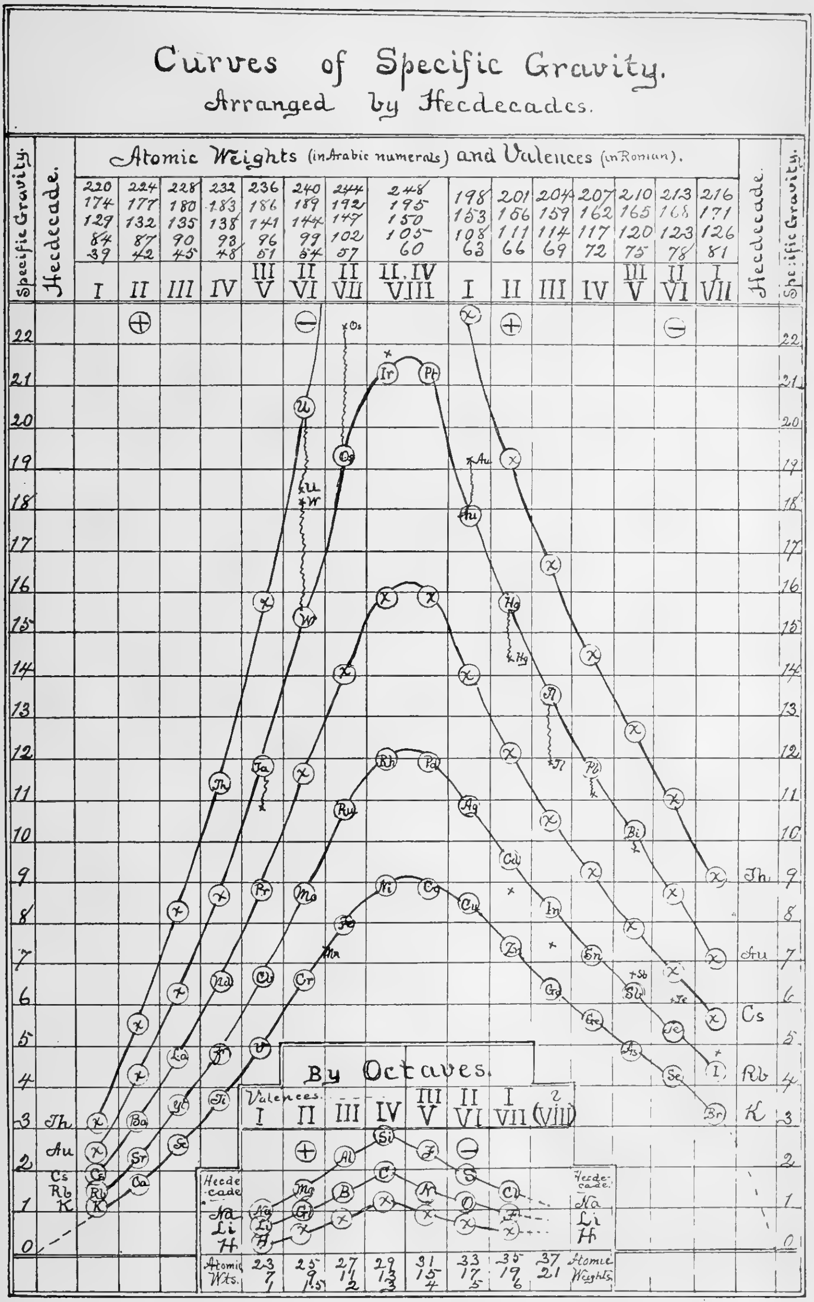
In all this hecdecade the atomic weights as determined seem to be too low to correspond with the specific gravities. This is especially true of Tungsten and Osmium.

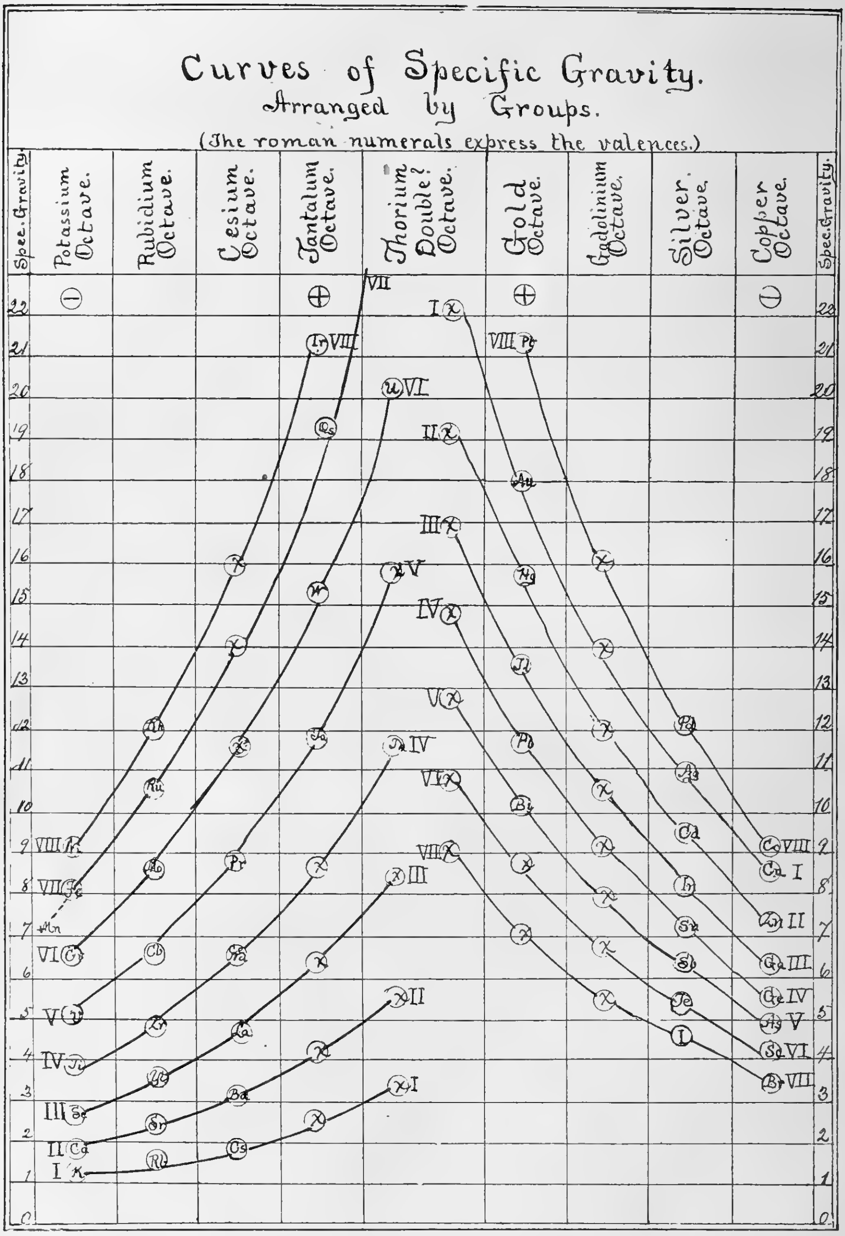
(THORIUM) HECDECADE?

Valence.	Harmonic series.		Element....	Atomic weight (O = 16)....	Difference....	Specific gravity (H_2O=1)	Variation....
	At. Wt.	Spec. Grav.					
I	220	3.11					
II	224	5.56					
III	228	8.33					
IV	232	11.23	Th	232.6	+0.6	11.23	.00
III, V	236	15.40					
II, VI	240	20.50	U	239.6	—0.4	18.40	—.10
I, VII	244	25.05					
VIII	248						

Not enough is known of this hecdecade to know whether the common difference in atomic weights is 3, 3½, or 4; nor whether it is a hecdecade of two octaves or something else. Whether the limit of chemical elements is reached in this hecdecade, or whether they continue indefinitely to increase in atomic weight and specific gravity as more new elements are discovered; or whether they will all at last be resolved into still simpler forms, remains for the future to tell.

I here present two graphic charts showing the curves of specific gravity, arranged first by hecdecades, second by groups.


Curves of Specific Gravity.
Arranged by Hecdecades.
Atomic Weights (in Arabic numerals) and Valences (in Roman).
Specific Gravity.
Hecdecade.
By Octaves.
Valences.
Atomic Wts.
Atomic Weights.



The rate of increase in specific gravity in the elements nearest the culminating point in the curve of each hecdecade is 34½ per cent., thus: Co (K VIII) 9.00; Rh (Rb VIII) 12.10; —— (Cs VIII) 16.24; and Ir (Au VIII) 21.80. Os (Au VII) is 22.40, which is still higher; but the specific gravity of

Os is excessive and not a fair average. Os may contain an undiscovered element (Th VII) of still higher atomic weight and specific gravity. The curves, however, are calculated on an increase of 33⅓ per cent. for the culminating point, thus: K VIII, 9.09; Rb VIII, 12.12; Cs VIII, 16.16; and Au VIII, 21.55. This places Co 1 per cent. below and Ir 1 per cent. above the culmination. According to this calculation, if there were an element at Th VIII its specific gravity would be 28.73; but, according to those that already exist, as Co, Rh, and Ir, in which the rate of increase is 34½ per cent., the specific gravity would be 29.25. In the case of the twin metals, Ni, Pd, and Pt, standing with Co, Rh, and Ir, at the culmination of the curves, the variation is so slight it need not be taken into account.

The average rate of increase in specific gravity of the several successive members of each of the accrescent octaves, while not uniform, is approximately 36 per cent. The decrease in specific gravity of the several successive members of the decrescent octaves averages 13⅓ per cent., or, computing backward and upward from the lowest element in each octave, the increase is 15 per cent.

There are eight groups in the accrescent octaves and seven in the decrescent, fifteen in all. The rate of increase in specific gravity in the several elements of each group in the accrescent octaves is strictly 33⅓ per cent. The members of the Thorium octave are an exception; the increase is only 15 per cent. The increase of specific gravity in the several elements of each group in the decrescent octaves is 28 per cent. The Thorium hecdecade is no exception; there are no known elements in the decrescent octave of the Thorium hecdecadal series. Hence there is no decrescent octave; and the term hecdecade is simply used in this case for convenience and comparison.

Harmonies of the Hecdecades.

The atomic weights, while not strictly a uniform arithmetical series, are nevertheless harmonic to a degree. Like the tones in music, there are whole steps and half steps, major steps and minor steps, as already shown, and occasionally doublets or twins. Perhaps when all the elements in nature have been discovered, there will be a "chromatic" series in each octave. That these atomic weights are harmonic is readily shown by placing them in the form of a square, thus:

Potassium Hecdecade.

				238.9
K I 39.1	Ga III 69.1	As V 75	Mn VII 55	238.2
Se VI 79	Cr VI 52.1	Ti IV 48	Ni IV 59.3 Co	238.4
Fe IV 56	Ge IV 72.3	Zn II 65.3	Ca II 40	233.6
Cu I 63.6	Sc III 44	V V 51.4	Br VII 80	239.0
237.7	237.5	239.7	234.3	236.5

Besides the sums in the margin, obtained by addition of the lines, columns, and diagonals, we obtain the following sums from this square: The four corners, K, Mn, Cu and Br equal 237.7; the central square, Cr, Ti, Ge and Zn equal 237.7; parallelograms, Se, Fe, Co and Ca equal 234.3; Ga, As, Sc and V equal 239.4; diagonal quadrats, Ga, Fe, V and Co equal 235.8; As, Se, Sc and Ca equal 238; rhombs, K, Ge, Ti and Br equal 239.4; Mn, Zn, Cr and Cu equal 236; rhomboids, K, Sc, As and Br equal 238.1, etc., etc. In all of these sums the greatest is 239.7, and the least is 233.6, a difference of 6.1, equal to 2½ per cent., or 1¼ per cent. on each side of a fixed mean.

By rejecting fractions and bringing Ca within the limit of variation and changing slightly the elements in the third column, we obtain the following:

POTASSIUM HECDECADE. 237

K I 39	Ga III 69	As V 74	Mn VII 55	237
Se VI 79	Cr VI 52	Ti IV 47	Ni IV 59 Co	237
Fe IV 56	Ge IV 72	Zn II 66	Ca II 43	237
Cu I 63	Sc III 44	V V 50	Br VII 80	237
237	237	237	237	237

Here it may be seen that, though the atomic weights are not an arithmetical series, all sums, taken as before, are equal, showing that the series is harmonic.

A similar result is obtainable from a similar placing of the atomic weights of the Rubidium hecdecade, thus:

RUBIDIUM HECDECADE. 417.9

Rb I 85.5	In III 113.7	Sb V 120	Ru VII 101.6	420.8
Te VI 125	Mo VI 96.1	Zr IV 90.6	Pd IV 106.6	418.3
Rh IV 103	Sn IV 117.8	Cd II 112	Sr II 87.6	420.4
Ag I 107.9	Yt III 89.1	Cb V 94	I VII 126.9	417.9
421.4	416.7	416.6	422.7	420.5

The greatest sum in this square is 422.7; the least is 416.6. The difference is 6.1, which is 1.4 per cent., or less than three-fourths of one per cent. on either side of a fixed mean.

CESIUM HECDECADE.

				611.9
Cs I 132.9	III 163	Tu V 170.7	Sm VII 150	616.1
Yb VI 173	VI 147	Ce IV 140.5 Nd	Da IV 154	614.5
IV 153	Er IV 166.3	Tb II 160	Ba II 137.4	616.7
Gd I 156.7	La III 138.2	Pr V 143.5	VII 175	612.8
615.0	614.5	614.7	616.4	614.9

The Cesium hecdecade similarly arranged gives results in which the greatest differences are less than one-half of one per cent. on either side of a fixed mean.

CESIUM HECDECADE.

				601.2
Cs 132	Tb 160	Er 166.3	Pr 143.5	601.8
Tu 170.7	Ce 140.2	Nd 140.5	Sm 150	601.4
146	164.2	Gd 156.1	135	601.3
Da 153	Ba 137.4	La 138.2	Yb 173	601.6
601.7	601.8	601.1	601.5	601.3

A rearrangement of the elements of this hecdecade, so as to separate Nd from Ce brings the results so nearly equal that the square is almost perfectly harmonic. Addition of the corner and central squares, the parallelograms, diagonal quadrats, etc., scarcely increases the variation from a fixed mean.

In the gold hecdecade there are only ten elements. The square must be filled up with the atomic weights of six unknown elements, thus:

Gold Hecdecade.

				777.7
I 174	Tl III 204.2	Bi V 208.9	Os VII 190.8	777.9
VI 213	VI 187.1	Ta V 182.6	Pt IV 195	777.7
Ir IV 193.1	Pb IV 207	Hg II 200	II 177	777.1
Au I 197.3	III 179.5	W VI 184.9	VII 216	777.7
777.4	777.8	776.4	778.8	777.1

Thus arranged, the gold hecdecade forms a square more perfectly harmonic than any of the lower hecdecades.

It should be easy, from a study of these hecdecadal tables and graphic charts to predetermine the characteristics and properties of any element before its discovery with a greater degree of accuracy than could have been done by Mendeléeff's octaves. I confidently await such discovery.

A DYING RIVER.

By J. R. MEAD, Wichita.

The Arkansas is the largest river in the state of Kansas, and was considered a navigable river to the mouth of the Little Arkansas by the United States government. When the county was surveyed its banks were meandered, leaving a river bed of 800 or 1,200 feet in width as the property of the general government, and to some extent the river was used in Kansas as a highway of travel and traffic until the coming of the white man, who robbed it of its water, and exterminated the millions of bison and other forms of animal life which once grazed on the bordering luxuriant meadows and quenched their thirst in its ripplng waters. The writer's observation of the rivers of Kansas only extends back to 1859. At that time, and until some years after the settlement of the country, the Arkansas was a river in fact as well as in name, usually flowing from bank to bank. From Mr. William Mathewson, a noted plainsman, I learn that as early as 1852 boats were built at Pueblo, Colorado, in which mountain traders and trappers, sometimes in parties of 15 or 20 in one boat, with their effects, floated down the swift current of the river to Arkansas, and from 1870 to 1880 boats were built at Wichita to descend the river, some propelled by steam; in one instance two young men built a boat at Wichita and navigated river and gulf to Florida.

At that time the river had apparently pursued its accustomed way unchanged for centuries; it had well-defined banks, with a width of 800 to 1,200 feet, the river very seldom overflowing the valleys, but a few feet higher than its level. From the state line up to the present county of Reno heavy timber fringed its banks. Occasionally the river was a dry bed of sand above the mouth of the ever-flowing Little Arkansas for a couple of months in the fall. The country adjacent to the Arkansas on either side for many miles is underlaid by a bed of sand in which the waters of the river disappear in a season of drouth, except in deep holes which were below the level of the underflow. Fish gathered in these holes in great numbers, and herds of buffalo traveled up and down the sandy bed hunting for water. Suddenly the sandy bed would again become a river, the rushing water coming down with a front of foam two or three feet deep. The river was dry in the falls of 1863 and 1865. In 1867 came a great flood; the river was bank full all the season, and overflowing the adjoining low valleys. Indians crossed their families in tubs made of a single buffalo hide, and swam their horses, and the writer saw a four-mule team and heavy freight wagon swept away by the swift current. But little sediment was deposited on the overflowed lands, but the boiling, rushing water was constantly moving the sandy river-bed towards the Gulf. There was no opportunity for the formation of islands; the sand bars were constantly changing and moving down stream.

Before the settlement of the country the bordering plains were tramped hard and eaten bare by innumerable buffalo, allowing the rainfall to speedily flow into the ravines and creeks, thence to the river as from a roof. The breaking up of the soil consequent upon the settlement of the country allowed the rainfall to soak into the ground, and the river soon ceased to carry its usual volume of water, not noticeable until about 1880. In addition to this, numerous irrigating ditches were dug in western Kansas and in Colorado, sufficient at the present time to divert the entire water of the river to the thirsty plains. Thus for the past 10 or 15 years we have observed the evolution of a great river into a sandy waste or insignificant stream. Nature has undertaken to accommodate itself to the changed conditions. The once moving sandbars become fixed, and are speedily covered with young cottonwoods and willows from seed sown by the wind. They grow rapidly, binding the soil with their roots. When a freshet occurrs it is not of sufficient duration to undermine and wash away the embryo island, but deposits several inches of mud and sand among the young trees; these thrive and grow rapidly. The wind blowing the sand from the dry river bed aids in building up the island. By the time another freshet comes down the islands are firmly established, soon become groves of timber, gaining in elevation and solidity each year. In time the upper end of the islands become connected with the shore, forming a lagoon, which soon fills with a slimy, slippery, blue paste, deposited from the exceedingly muddy water coming down the river in late years in time of flood. In drying, this mud becomes a tough, sticky clay, known locally as hardpan or gumbo. This process explains the spots and streaks of this substance found in the Arkansas valley. An illustration of this formation can be seen at the mouth of the Little Arkansas river, where formerly was a long, narrow lake of considerable depth and of pure, clear water, the wintering place for huge cat, buffalo and other fish. By the diversion of the water of the little river into Chisholm creek, for milling purposes, this lake became a stagnant pool, into which the muddy water of the big river backed each time it came down in a flood, where the sediment, settling to the bottom, formed a mass of so little consistency that an oar or a boat would pass through it almost as easily as through water; but after the flood had subsided, leaving it to solidify and dry, it became almost as firm as a rock and as tough as leather, not "adobe" soil, but "gumbo." Thus was destroyed the wealth of molluscan life for which our river was noted. The beautiful minnows, anodontas and margaritinas have disappeared from their favorite home.

During most of the year 1893 the Arkansas river above the junction of the little river has been entirely dry; below that point it is an insignificant stream which a school boy can roll up his pants and wade across. In a comparatively short time, in southern Kansas, timber will occupy the former site of the Arkansas river, through which will flow a stream a few rods wide.

This wonderful change has been brought about by our so-called civilization within the last 15 years. Fortunate indeed are those who were permitted to behold the beauties of this valley and river when it was the home of the Indian and buffalo—just as God made it.

HOW THE PHEASANT "DRUMS."

By J. R. MEAD, Wichita.

The ruffed grouse, *Bonasa umbellus* (Linn.), commonly known as the "pheasant", and in the New England states as "partridge", is one of the most widely distributed non-migratory birds of the United States, formerly common in eastern Kansas. The writer has observed and hunted them from the hills of Vermont to the western slope of the Rocky Mountains.

They were among the first feathered inhabitants of the timber noticed by the followers of Capt. John Smith, or those who landed from the "Mayflower." Yet to the present day its habits are to most people unknown, and to ornithologists a disputed question how their peculiar drumming sound is produced, once so commonly heard in the spring of the year in the timber hills and river bottoms, yet so seldom observed, some claiming it was done by the bird running along a log and striking it with his wings; others by his beating a hollow log with his wings; and still others, including our lamented Colonel Goss, as expressed to the writer in course of conversation, by striking their wings together.

None of these is correct. The drumming is produced by the bird standing erect, inflating his lungs and body with air and then beating his breast with horizontal strokes of his wings. The drumming is done by the male bird during the breeding season to attract his mates. No other bird has a similar love call. It is peculiar, unique.

My boyhood days were spent on my father's farm in Iowa, which included in part the Mississippi river bluffs, covered with timber. I was an ardent hunter and student of natural history from the great book of nature. Pheasants were abundant, and early attracted my attention by their peculiar muffled drum, so difficult for the unpracticed ear to locate. On several occasions I have lain for hours concealed within two rods of the log on which stood a pheasant in plain view, drumming at intervals of about 10 minutes.

The male bird in that locality invariably selected a fallen log, free from limbs, and usually destitute of bark or sap from years of exposure, lying in a grove of saplings clear of underbrush or low limbs, affording an unobstructed view in every direction, but protected overhead from birds of prey. Each male bird had his log, which he occupied during April and May, and hither came the mother birds to meet their polygamous lord.

The male drummed from daylight until about 10 o'clock, and again in the evening—during cloudy days at intervals all day, and could be heard in the silent woods for half a mile. There was no striking of the log with his wings, no striking of his wings against each other, no hollow log. When the impulse came, which in the morning would be at intervals of about 10 minutes, the proud bird would stand as erect as possible to his extreme height, almost leaning backwards, his breast prominent and nearly perpendicular, inflating his lungs and body, the feathers on his body lying close and compact, he would spread his wings as in the act of flying, and strike his expanded breast rapidly, the first three or four strokes at intervals of about two seconds, then rapidly increasing until at the close, the drum beats were merged into a continuous flutter. The paroxysm over, the bird would resume his ordinary

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position, silent, motionless, listening, patiently awaiting the coming of his shy, timid mates.

The hens sometimes came walking from a neighboring thicket, more frequently flying from a distance with such noiseless wing they would not be heard until they dropped on the leaves near by, quite in contrast to their whirring flight when startled by the hunter.

In Montana, at an altitude of 8,000 feet, I have observed pheasants drumming from a fallen pine tree lying in a willow thicket while the snow was a foot deep, and the mating season continued until late in June.

Let us preserve as much as possible of the facts in natural history we have observed, for by another generation most of our bird and animal life will have ceased to exist, except in such changed conditions they will retain but little of their original habits.

AN ANNOTATED LIST OF THE BIRDS FOUND NEAR MANHATTAN, KANSAS.

By D. E. LANTZ, State Agricultural College.

The following list of birds is largely based upon the results of personal observations made during the past 14 years. The birds included have all been captured either by myself or others within the radius of a dozen miles of Manhattan. No bird is included on my own authority unless I have either seen the bird alive under circumstances which fix its identity without doubt, or have handled properly authenticated specimens. A few are included on the authority of Dr. C. P. Blachly, to whom I am greatly indebted for the privilege of verifying the identity of specimens in his collection and for notes concerning them.

The arrangement follows that of the Check-list of the American Ornithologists' Union. The asterisk (*) is prefixed to the names of birds known to breed here.

1. Colymbus auritus Linn. Horned Grebe. Migratory; rare. Included on the authority of Doctor Blachly.
2. Colymbus nigricollis californicus (Heerm.) American Eared Grebe. Migratory; not rare.
3. Podilymbus podiceps (Linn.) Pied-billed Grebe. Summer resident; rare. Common in migration.
4. Urinator imber (Gunn.) Loon. Migratory; not rare.
5. Larus argentatus smithsonianus Coues. American Herring Gull. Migratory; rare.
6. Larus delawarensis Ord. Ring-billed Gull. Migratory; common.
7. Larus franklinii Sw. & Rich. Migratory; not rare.
8. Larus philadelphia (Ord.) Bonaparte's Gull. Migratory; rare.
9. Sterna forsteri Nutt. Forster's Tern. Migratory; common.
10. Hydrochelidon nigra surinamensis (Gmel.) Black Tern. Common in migration about May 1.
11. Phalacrocorax dilophus (Sw. & Rich.) Double-crested Cormorant. Migratory; common.
12. Pelecanus erythrorhynchus Gmel. American White Pelican. Migratory; common.
13. Merganser americanus (Cass.) American Merganser. Winter sojourner; not common. Several taken.
14. Merganser serrato Linn. Red-breasted Merganser. Rare. Included on authority of Doctor Blachly.
15. Lophodytes cucullatus (Linn.) Hooded Merganser. Resident; rare. A pair taken on Deep creek late in April, 1880. The female had well-developed ova.
16. Anas boschas Linn. Mallard. Resident; rare; in migration common.
17. Anas obscura Gmel. Black Duck. Included on the authority of Doctor Blachly; but there is a probability of error in identity. The specimen has passed from Doctor Blachly's possession, but was probably Anas fulvigula maculosa (Senn.) Mottled Duck.
18. Anas strepera Linn. Gadwall. Summer resident; rare; common in migration.

19. Anas americana Gmel. Baldpate. Very common in migration.
20. Anas carolinensis Gmel. Green-winged Teal. Abundant in migration.
*21. Anas discors Linn. Blue-winged Teal. Summer resident; rare; abundant in migration. Twice, in midsummer, I have come across the female of this duck with a brood of young only a few days old.
*22. Spatula clypeata (Linn.) Shoveler. Summer resident; rare. Common in migration. Have seen them on Eureka lake in June in pairs, and they undoubtedly breed there.
23. Dafila acuta (Linn.) Pintail. Migratory; abundant.
*24. Aix sponsa (Linn.) Wood Duck. Summer resident; formerly common, now rather rare. Two nests found, but I have not taken any eggs.
25. Aythya americana (Eyt.) Redhead. Migratory; abundant.
26. Aythya vallisneria (Wils.) Canvas Back. Migratory; some years common.
27. Aythya affinis (Eyt.) Lesser Scaup Duck. Migratory; common.
28. Aythya collaris (Donov.) Ring-necked Duck. Migratory; common.
29. Glaucionetta clangula americana (Bonap.) American Golden-eye. Migratory; not common.
30. Charitonetta albeola (Linn.) Buffle-head. Migratory; sometimes common.
31. Erismatura rubida (Wils.) Ruddy Duck. Migratory; common.
32. Chen hyperborea (Pall.) Lesser Snow Goose. Common in migration.
33. Anser albifrons gambeli (Hartl.) American White-fronted Goose. Migratory; common.
34. Branta canadensis (Linn.) Canada Goose. Migratory; abundant. A few remain during the winter.
35. Branta canadensis hutchinsii (Sw. & Rich.) Hutchins Goose. Abundant migrant.
36. Olor columbianus (Ord.) Whistling Swan. Migratory; rare.
37. Olor buccinator (Rich.) Trumpeter Swan. Migratory; rare.
*38. Botaurus lentiginosus (Montag.) American Bittern. Summer resident; not rare. No nests found.
39. Botaurus exilis (Gmel.) Least Bittern. Migratory; common.
*40. Ardea herodias Linn. Great Blue Heron. Summer resident; common. Nest in communities in large trees along our creeks.
41. Ardea egretta Gmel. American Egret. Summer visitant. Have seen them only during August.
*42. Ardea virescens Linn. Green Heron. Summer resident; common.
43. Nycticorax nycticorax naevius (Bodd.) Black-crowned Night Heron. Summer resident in the state; rare in this locality.
44. Grus americana (Linn.) Whooping Crane. Migratory. Sometimes common in spring migration.
45. Grus mexicana (Muell.) Sandhill Crane. Migratory; common.
*46. Rallus elegans Aud. King Rail. Summer resident; rare. Common in migration.
47. Rallus virginianus Linn. Virginia Rail. Migratory; not common. Have seen them only in autumn migration.
*48. Porzana carolina (Linn.) Sora. Summer resident; rare. Common in migration.
*49. Porzana jamaicensis (Gmel.) Black Rail. Summer resident; rare.
50. Ionornis martinica (Linn.) Purple Gallinule. A single specimen, the only record for this state, was captured April 14, 1893.

*51. Fulica americana Gmel. American Coot. Summer resident; rare. Abundant in migration.

52. Phalaropus tricolor (Vieill.) Wilson's Phalarope. Migratory; common.

53. Recurvirostra americana Gmel. American Avocet. Summer resident in western Kansas. Common here during migration.

54. Philohela minor (Gmel.) American Woodcock. Rare in this vicinity. Four specimens seen in a residence of 16 years.

55. Macrorhamphus scolapaceus (Say.) Long-billed Dowitcher. Migratory; not rare.

56. Micropalama himantopus (Bonap.) Stilt Sandpiper. Migratory; rare. Inserted on the authority of Doctor Blachly.

57. Tringa maculata Vieill. Pectoral Sandpiper. Migratory; common.

58. Tringa fuscicollia Vieill. White-rumped Sandpiper. Migratory; common.

59. Tringa minutilla Vieill. Least Sandpiper. Migratory; abundant.

60. Ereunetes pusillus (Linn.) Semipalmated Sandpiper. Migratory; rare. Inserted on authority of Doctor Blachly.

61. Totanus melanoleucus (Gmel..) Greater Yellowlegs. Migratory; common. The earliest spring arrival among our Limicolae.

62. Totanus flavipes (Gmel.) Yellowlegs. Migratory; common.

63. Totanus solitarius (Wils.) Solitary Sandpiper. Migratory; common.

64. Symphemia semipalmata inornata Brewst. Western Willet. Migratory; rare.

*65. Bartramia longicauda (Bechst.) Bartramian Sandpiper. Abundant summer resident. Begin laying about May 1. Are frequently killed by hunters during the nesting season, and even after the young are hatched.

*66. Actitis macularia (Linn.) Spotted Sandpiper. Summer resident; not common. Abundant in migration.

67. Numenius longirostris Wils. Long-billed Curlew. Common in migration.

68. Numenius borealis (Forst.) Eskimo Curlew. Migratory; common.

69. Charadrius dominicus Muell. American Golden Plover. Migratory; rare. Inserted on authority of Doctor Blachly.

*70. Aegialitis vocifera (Linn.) Killdeer. Summer resident; common.

71. Aegialitis semipalmata Bonap. Semipalmated Plover. Migratory; rare. Inserted on authority of Doctor Blachly.

*72. Colinus virginianus (Linn.) Bob-white. Resident; abundant.

73. Bonasa umbellus (Linn.) Ruffed Grouse. The Blue river is probably the western limit of the occurrence of this bird in Kansas. A pair of the birds wintered on Cedar creek, some five miles north of Manhattan, a few years ago, but were killed before the opening of spring by a farmer who had been especially urged to look after their preservation.

*74. Tympanuchus americanus (Reich.) Prairie Hen. Resident; common. Formerly abundant. Their growing scarcity is due in large measure to the burning of pastures in the nesting season.

75. (Extinct.) Meleagris gallopavo Linn. Wild Turkey. Common here when the country was first settled. They have long since disappeared.

*76. Zenaidura macroura (Linn.) Mourning Dove. Summer resident; abundant. Occasionally remain all winter in sheltered places near corrals.

*77. Cathartes aura (Linn.) Turkey Vulture. Summer resident; common. Often nest under rock ledges along our bluffs.

78. Elanoides forficatus (Linn.) Swallow-tailed Kite. Some seasons abundant in summer, when they undoubtedly breed. Have seen none for about 10 years.

*79. Circus hudsonius (Linn.) Marsh Hawk. Resident; common.

80. Accipiter velox (Wils.) Sharp-shinned Hawk. Rather common in migration.

*81. Accipiter cooperi (Bonap.) Cooper's Hawk. Resident; but rarely seen in winter.

82. Accipiter atricapillus (Wils.) American Goshawk. Winter visitor; rare.

*83. Buteo borealis (Gmel.) Red-tailed Hawk. Resident; common.

84. Buteo borealis calurus (Cass.) Western Red-tail. A well-marked specimen of this dark western race has just been added to the museum of the Agricultural College.

85. Buteo borealis harlani Ridgw. Harlan's Hawk. Winter visitant; rare.

86. Buteo lineatus (Gmel.) Red-shouldered Hawk. Resident; rare. Included on authority of Doctor Blachly.

*87. Buteo swainsoni Bonap. Swainson's Hawk. Resident; not common.

88. Archibuteo lagopus sancti-johannis (Gmel.) American Rough-legged Hawk. Winter sojourner; common.

89. Aquila chrysaetos (Linn.) Golden Eagle. Winter sojourner; rare.

90. Haliaetus leucocephalus (Linn.) Bald Eagle. Formerly resident; now an occasional winter sojourner.

91. Falco rusticalus Linn. Gray Gyrfalcon. Accidental winter visitor. A single specimen was captured December 1, 1880, by Mr. A. L. Runyon.

92. Falco peregrinus anatum (Bonap.) Duck Hawk. Not common. Seen only during spring migration, but it may breed.

93. Falco columbarius Linn. Pigeon Hawk. Migratory; rare.

*94. Falco sparverius Linn. American Sparrow Hawk. Resident; common. They do good work in destroying the English sparrow in our towns, and ought to be protected.

95. Pandion haliaetus carolinensis (Gmel.) American Osprey. Summer resident; rare.

*96. Strix pratincola Bonap. American Barn Owl. Resident; common. Took a set of four eggs in August, 1893.

*97. Asio wilsonianus (Less.) American Long-eared Owl. Resident; common.

*98. Asio accipitrinus (Pall.) Short-eared Owl. Resident; common.

*99. Syrnium nebulosum (Forst.) Barred Owl. Resident; common. Not often met with in winter.

100. Nyctale acadica (Gmel.) Saw-whet Owl. Winter sojourner; rare.

*101. Megascops asio (Linn.) Screech Owl. Resident; common.

*102. Bubo virginianus (Gmel.) Great Horned Owl. Resident; common.

103. Nyctea nyctea (Linn.) Snowy Owl. Winter visitant; rare.

104. Speotyto cunicularia hypogaea (Bonap.) Burrowing Owl. One killed west of town in March, 1894, and reported to me by Mr. J. A. Plowman, who is well acquainted with these birds in their breeding range. In my opinion the burrowing owl is to a great extent migratory.

105. (Extinct.) Conurus carolinensis (Linn.) Carolina Paroquet. Not now to be found. Formerly common in the heavy timber just east of town.

*106. Coccyzus americanus (Linn.) Yellow-billed Cuckoo. Summer resident; common.

*107. Coccyzus erythrophthalmus (Wils.) Black-billed Cuckoo. Summer resident; not so common as the last named.

*108. Ceryle alcyon (Linn.) Belted Kingfisher. Summer resident; common.

*109. Dryobates villosus (Linn.) Hairy Woodpecker. Resident; common.

*110. Dryobates pubescens (Linn.) Downy Woodpecker. Resident; common.

111. Sphyrapicus varius Linn. Yellow-bellied Sapsucker. Migratory; rare. A single specimen, captured by Mr. Louis Parker.

112. Ceophloeus pileatus (Linn.) Pileated Woodpecker. Resident; rare. One seen by the writer, and one in the collection of Doctor Blachly.

*113. Melanerpes erythrocephalus Linn. Red-headed Woodpecker. Summer resident; abundant.

*114. Melanerpes carolinus (Linn.) Red-bellied Woodpecker. Resident; common.

*115. Colaptes auratus (Linn.) Flicker. Resident; abundant.

116. Colaptes cafer (Gmel.) Red-shafted Flicker. Winter sojourner; common.

117. Antrostomus vociferus (Wils.) Whip-poor-will. Summer resident; very rare. A single bird heard.

*118. Phalaenoptilus nuttalli (Aud.) Poor-will. Summer resident; common.

*119. Phalaenoptilus nuttalli nitidus Brewst. Frosted Poor-will. Summer resident; not uncommon. Three sets of the eggs of this new form were taken in this county by Mr. Eben Blachly. The first of these was secured for the collection of Capt. B. F. Goss (deceased), of Pewaukee, Wis., and is now in the public museum in Milwaukee. Another set is in the museum of the Kansas Agricultural College.

*120. Chordeiles virginianus (Gmel.) Nighthawk. Summer resident; common.

*121. Chaetura pelagica (Linn.) Chimney Swift. Summer resident; abundant.

*122. Trochilus colubris Linn. Ruby-throated Hummingbird. Summer resident; rare. Rather common in migration.

*123. Tyrannus tyrannus (Linn.) Kingbird. Summer resident; abundant.

*124. Myiarchus crinitus (Linn.) Crested Flycatcher. Summer resident; common.

*125. Sayornis phoebe (Lath.) Phoebe. Summer resident; common.

*126. Contopus virens (Linn.) Wood Pewee. Summer resident; common.

*127. Empidonax acadicus (Gmel.) Acadian Flycatcher. Summer resident; common except in dry seasons. Nest in colonies of three or four pairs near together.

128. Empidonax pusillus traillii (Aud.) Traill's Flycatcher. Probably summer resident, but have been seen only in spring migration. Nests have been found in Marshall county.

129. Empidonax minimus (Baird.) Least Flycatcher. Migratory; not common.

130. Otocoris alpestris (Linn.) Horned Lark. Rare winter sojourner.

*131. Otocoris alpestris praticola (Hensh.) Prairie Horned Lark. Resident; common.

132. Pica pica hudsonica (Sab.) American Magpie. Very rare winter visitant.

*133. Cyanocitta cristata (Linn.) Blue Jay. Resident; abundant in summer. Only a few remain during winter.

*134. Corvus americanus Aud. American Crow. Resident; abundant.

135. Dolichonyx oryzivorus (Linn.) Bobolink. Migratory; common. In very wet seasons they linger until about the first of June, and probably occasionally remain to breed.

*136. Molothrus ater (Bodd.) Cowbird. Summer resident; abundant.

137. Xanthocephalus xanthocephalus (Bonap.) Yellow-headed Blackbird. Common in migration.

*138. Agelaius phoeniceus (Linn.) Red-winged Blackbird. Summer resident; abundant.

*139. Sturnella magna (Linn.) Meadowlark. Resident; not common.

*140. Sturnella magna neglecta (Aud.) Western Meadowlark. Resident; abundant.

*141. Icterus spurius (Linn.) Orchard Oriole. Summer resident; abundant.

*142. Icterus galbula (Linn.) Baltimore Oriole. Summer resident; abundant.

143. Scolecophagus carolinus (Muell.) Rusty Blackbird. Winter sojourner; not common.

144. Scolecophagus cyanocephalus (Wagl.) Brewer's Blackbird. Common in migration. Arrive in February or early in March.

145. Quiscalus quiscala aeneus (Ridgw.) Bronzed Grackle. Abundant summer resident. A few remain during winter.

146. Carpodacus purpureus (Gmel.) Purple Finch. Migratory; rare.

147. Loxia curvirostra minor (Brehm.) American Crossbill. Irregular winter visitant; rare.

148. Loxia curvirostra stricklandi Ridgw. Mexican Crossbill. Irregular winter visitant; common.

149. Acanthis linaria (Linn.) Redpoll. Winter visitant; rare. A single specimen taken by Doctor Blachly, January, 1881.

*150. Spinus tristis (Linn.) American Goldfinch. Resident; abundant.

151. Spinus pinus (Wils.) Pine Siskin. Winter sojourner. Abundant some seasons, entirely absent in others.

152. Plectrophenax nivalis (Linn.) Snowflake. Winter visitant; rare. Included on authority of Doctor Blachly.

153. Calcarius lapponicus (Linn.) Lapland Longspur. Winter sojourner; abundant.

154. Calcarius ornatus (Towns.) Chestnut-collared Longspur. Winter sojourner; common.

155. Poocaetes gramineus (Gmel.) Vesper Sparrow. Common in migration.

156. Ammodramus sandwichensis savanna (Wils.) Savanna Sparrow. Migratory; common.

*157. Ammodramus savannarum passerinus (Wils.) Grasshopper Sparrow. Summer resident; abundant.

158. Ammodramus leconteii (Aud.) Leconte's Sparrow. Migratory; rather common.

159. Ammodramus caudacutus nelsoni Allen. Nelson's Sparrow. Summer resident; rare. No nests found.

*160. Chondestes grammacus (Say.) Lark Sparrow. Summer resident; abundant.

161. Zonotrichia querula (Nutt.) Harris's Sparrow. Winter sojourner; abundant. Remain from October to May. Latest record of occurrence, May 23.

162. Zonotrichia leucophrys (Forst.) White-crowned Sparrow. Migratory; not so common as the next form.

163. Zonotrichia intermedia Ridgw. Intermediate Sparrow. Migratory; common. Arrive later than the last named.

164. Zonotrichia albicollis (Gmel.) White-throated Sparrow. Migratory; common.

165. Spizella monticola (Gmel.) Tree Sparrow. Winter sojourner; abundant.

*166. Spizella socialis (Wils.) Chipping Sparrow. Summer resident; common.
167. Spizella pallida (Swains.) Clay-colored Sparrow. Migratory; abundant.
*168. Spizella pusilla (Wils.) Field Sparrow. Summer resident; common.
169. Junco hyemalis (Linn.) Slate-colored Junco. Winter sojourner; abundant.
170. Junco hyemalis oregonus (Towns.) Oregon Junco. Winter sojourner; common.
171. Melospiza fasciata (Gmel.) Song Sparrow. Rather common winter sojourner. More abundant in spring migration.
172. Melospiza lincolni (Aud.) Lincoln's Sparrow. Migratory; common.
173. Melospiza georgiana (Lath.) Swamp Sparrow. Not common; seen only in migration.
174. Passerella iliaca (Merr.) Fox Sparrow. Winter sojourner; but more common in spring migration.
*175. Pipilo erythrophthalmus (Linn.) Towhee. Summer resident; common. A few remain during the winter.
176. Pipilo maculata arcticus (Swains.) Arctic Towhee. Migratory; common. Occasionally seen in winter.
*177. Cardinalis cardinalis (Linn.) Cardinal. Resident; common.
*178. Habia ludoviciana (Linn.) Rose-breasted Grosbeak. Summer resident; common. Rare in this locality before 1890.
179. Habia melanocephala (Swains.) Black-headed Grosbeak. Probably a rare summer resident. A single specimen seen in late summer. The birds were found to be common in Cloud county in August, 1889.
*180. Guiraca caerulea (Linn.) Blue Grosbeak. Summer resident; common.
*181. Passerina cyanea (Linn.) Indigo Bunting. Summer resident; common.
*182. Spiza americana (Gmel.) Dickcissel. Summer resident; abundant.
*183. Piranga erythromelas Vieill. Scarlet Tanager. Summer resident; quite common.
184. Piranga rubra (Linn.) Summer Tanager. Summer resident; rare. A single specimen seen.
*185. Progne subis (Linn.) Purple Martin. Summer resident; abundant.
*186. Petrochelidon lunifrons (Say). Cliff Swallow. Once an abundant summer resident. A small colony still annually nest at the Agricultural College barn.
*187. Chelidon erythrogaster (Bodd.) Barn Swallow. Summer resident; common.
*188. Tachycineta bicolor (Vieill.) Tree Swallow. Summer resident; rare. Common in migration. I have found them nesting at Eureka Lake.
*189. Clivicola riparia (Linn). Bank Swallow. Summer resident; abundant.
*190. Stelgidopteryx serripennis (Aud.) Rough-winged Swallow. Summer resident; common.
191. Ampelis garrulus Linn. Bohemian Wax-wing. Winter visitant; rare. Seen only once, when I shot three from a large flock, December 6, 1879.
192. Ampelis cedrorum (Vieill.) Cedar Waxwing. Common; apparently found only in migration. Remain late in May.
193. Lanius borealis Vieill. Northern Shrike. Winter sojourner; common.
*194. Lanius ludovicianus excubitorides (Swains.) White-rumped Shrike. Summer resident; common. Begin laying late in April.
*195. Vireo olivaceus (Linn.) Red-eyed Vireo. Summer resident; common.
*196. Vireo gilvus (Vieill.) Warbling Vireo. Summer resident; common.
*197. Vireo flavifrons Vieill. Yellow-throated Vireo. Summer resident; rare.
198. Vireo noveboracensis (Gmel.) White-eyed Vireo. Summer resident;

rare. I have never met with this species in Kansas, but include it in this list on the authority of Colonel Goss and Doctor Blachly.

*199. Vireo bellii Aud. Bell's Vireo. Summer resident; abundant.

200. Mniotilta varia (Linn.) Black and White Warbler. Summer resident; rare. Common in migration.

*201. Protonotaria citrea (Bodd.) Prothonotary Warbler. Summer resident; common.

202. Helminthophila celata (Say). Orange-crowned Warbler. Migratory; common.

203. Helminthophila peregrina (Wils.) Tennessee Warbler. Migratory; common.

*204. Dendroica aestiva (Gmel.) Yellow Warbler. Summer resident; abundant.

205. Dendroica coronata (Linn.) Myrtle Warbler. Migratory; abundant. Sometimes seen in winter.

206. Dendroica striata (Forst.) Black-poll Warbler. Migratory; abundant.

207. Seiurus auricapillus (Linn.) Oven-bird. Summer resident; very rare. Common in migration.

208. Seiurus noveboracensis (Gmel.) Water-thrush. Migratory; rare.

*209. Seiurus motacilla (Vieill.) Louisiana Water-thrush. Summer resident; common.

*210. Geothlypis formosa (Wils.) Kentucky Warbler. Summer resident; common.

*211. Geothlypis trichas occidentalis Brewst. Western Yellow-throat. Summer resident; not common.

*212. Icteria virens (Linn.) Yellow-breasted Chat. Summer resident; common.

213. Sylvania canadensis (Wils.) Wilson's Warbler. Migratory; common.

*214. Setophaga ruticilla (Linn.) American Redstart. Summer resident; common. Abundant in migration.

215. Anthus pensilvanicus (Lath.) American Pipit. Migratory; common.

*216. Mimus polyglottos (Linn.) Mockingbird. Summer resident; formerly common, now rather rare.

*217. Galeoscoptes carolinensis (Linn.) Catbird. Summer resident; abundant.

*218. Harporhynchus rufus (Linn.) Brown Thrasher. Summer resident; abundant.

*219. Salpinctes obsoletus (Say.) Rock Wren. Summer resident; rare.

*220. Thryothorus ludovicianus (Lath.) Carolina Wren. Resident; formerly common, but now rare.

*221. Thryothorus bewickii bairdi (Salv. & Godm.) Baird's Wren. Summer resident; not common.

*222. Troglodytes aedon aztecus Baird. Western House Wren. Summer resident; abundant.

223. Troglodytes hiemalis Vieill. Winter Wren. Winter sojourner; rare.

224. Cistothorus stellaris (Licht.) Short-billed Marsh Wren. Migratory; rare. Included on the authority of Doctor Blachly.

225. Cistothorus palustris (Wils.) Long-billed Marsh Wren. Summer resident; rare. Common in migration.

226. Certhia familiaris americana (Bonap.) Brown Creeper. Winter sojourner; common.

*227. Sitta carolinensis Lath. White-breasted Nuthatch. Resident; common.

228. Sitta canadensis Linn. Red-breasted Nuthatch. Migratory; rare. Only two specimens seen.

*229. Parus bicolor Linn. Tufted Titmouse. Resident; common.

*230. Parus atricapillus Linn. Chickadee. Resident; common.

*231. Parus atricapillus septentrionalis (Harris). Long-tailed Chickadee. Resident, but not so common as the last named.

232. Regulus calendula (Linn.) Ruby-crowned Kinglet. Migratory; common.

*233. Polioptila caerulea (Linn.) Blue-gray Gnatcatcher. Summer resident; rare. In migration common. Two nests found.

234. Myadestes townsendii (Aud.) Townsend's Solitaire. Winter resident; rare. A single specimen was taken by Doctor Blachly.

*235. Turdus mustelinus Gmel. Wood Thrush. Summer resident; abundant.

236. Turdus ustulatus swainsonii (Cab.) Olive-backed Thrush. Migratory; common from 1st to 10th of May.

*237. Merula migratoria (Linn.) American Robin. Resident; abundant.

*238. Sialia sialis (Linn.) Bluebird. Resident; common.

239. Sialia arctica (Swains.) Mountain Bluebird. Winter sojourner; not uncommon.

240. (In doubt.) Coccothraustes vespertina (Coop.) Evening Grosbeak. Winter visitant; rare. A single bird, seen December 5, 1888, was identified as of this species. I could not secure the specimen, but a long and careful estimate of its characteristics at fair range of vision satisfied me at the time as to its identity. My only doubt grows out of the fact that the bird was alone when seen.

I have omitted Bullock's Oriole, Icterus bullocki (Swains.), from the foregoing list. I am satisfied that the bird has not been seen in this locality. The report made by me to Prof. W. W. Cooke, in 1883, was based upon the observations of another person. I subsequently satisfied myself of the fact that the person was in error; but the report had been forwarded to Professor Cooke. It crept into the "Report on Bird Migration in the Mississippi Valley," and although I had personally called the attention of Colonel Goss to the error, he failed to remember it in preparing his "History of the Birds of Kansas" for the press. The authority for including this bird in the list of Kansas birds, so far as I know, rests solely on the early catalogue of Professor Snow.

NOTES ON LOXIA CURVIROSTRA STRICKLANDI Ridgw.

By D. E. LANTZ, Manhattan, Kan.

The Mexican race of red crossbills was first identified in Kansas by Prof. L. L. Dyche, who observed them at Lawrence, November 1, 1885, and secured specimens November 5. In the same year they were taken at Manhattan by the writer, November 21, and at Emporia by Prof. V. L. Kellogg, December 23.

Previous to 1885, I had seen but a single flock of crossbills in this state. This was in November, 1880, and I did not secure any specimens. Naturally, I referred the birds to variety americana, as this was included in the catalogues of both Professor Snow and Colonel Goss. There is now the probability that this flock was of the Mexican variety, since this has proved to be the common bird in our state.

Since 1885, the Mexican red crossbill has been observed at Manhattan as an irregular winter sojourner, as the following record will show:

In 1886, they were seen January 6, October 29, November 20.

In 1887, January 21 and 25.

In 1888, January 8, February 18, November 7, 8, 24, 28, December 8, 16, 24.

In 1889, January 21, 24, 30, February and March daily, April 7, 11, 15, 25. Always in large flocks.

In 1890 no crossbills were seen.

In 1891 seen only on December 26.

In 1892, March 24, 28, April 4, 23; the flock seen on the latter date consisted of about 20, all females.

In 1893, on February 15, saw a flock of five flying. No others seen during the year.

In 1894, first seen November 14, on the college grounds. Several were taken by Mr. G. B. Norris, November 17. Have been seen in small flocks several times since.

The specimens secured at Manhattan present great variations in size, especially in the measurements of the bill, yet there can be no doubt as to their identity. In 1883, Mr. Robert Ridgway published a Review of the American Red Crossbills (Proc. Biolog. Soc. of Wash., vol. II, 1883, pp. 84-107), in which he proposed to separate them into three races: Loxia curvirostra americana (Wils.), Loxia curvirostra mexicana Strickl., and Loxia curvirostra bendirei Ridgw. This last he described as a new variety, larger than americana and smaller than mexicana, between which it was considered intermediate. He gave its habitat as chiefly in the western mountain regions of the United States; spreading eastward in winter even to Massachusetts and Maryland. Had this race been adopted by the A. O. U. committee on classification and nomenclature, the Kansas birds would have been referred to the variety bendirei. But the committee rejected the new race and adopted the two varieties minor (equivalent to Americana) and Stricklandi (equivalent to Mexicana), uniting under the latter race the western and Mexican forms, and naming it in honor of Strickland, who first described it in 1851, the type specimens being obtained from near the City of Mexico.

A contrast of the habits of the two races of American red crossbills seems to show a marked and constant difference in their time of nidification. The eastern bird nests very early in the year, often while the snow is still upon the ground, February and March being the favorite months. The western form rarely nests before May. (Trippe.) Mr. Trippe referred his Colorado specimens to the variety Americana, but admitted that some of them approached variety Mexicana in measurements. According to the opinion of Mr. William Brewster (Auk, vol. III, p. 261), all of the western birds should be referred to the variety Stricklandi.

At Manhattan I have watched very carefully for signs of nidification on the part of the crossbills, but have observed none. The birds have been heard in full song in the spring, but have shown no signs of mating. They always appear in flocks, males and females together, except in the one instance already noted. They have remained until late in April with only a slight increase in restlessness observable. That is, they became less tame than in midwinter, and took wing more quickly on being approached. It is probable that these birds will be found nesting in the northwestern part of Kansas, and in the pine hills of northwest Nebraska.

The food of the crossbills is not greatly varied; seed from pine cones seems to be a favorite, and when intent upon the work of securing the seeds, they seem to be especially tame. I have several times secured the live birds by merely grasping them in my hand while thus engaged on low branches. When released the birds soon returned to their occupation of feeding. The seed of the wild sunflower is another favorite food, and I have often seen them in company with flocks of American goldfinches engaged in feeding on this rather abundant weed. Late in April I have also seen them feeding on the dried seed-balls of the Osage orange along our hedges. Professor Dyche reports them as feeding upon hemp-seed, this being the only food found in the 40 specimens secured by him in 1885.

SAND-DUNE COLLECTING.

By W. KNAUS.

For the past four years it has been my custom to collect Coleoptera among the sand dunes and "blow-outs" along the northern valley of the Arkansas river and some 20 miles southwest of McPherson, Kan., and two or three miles southwest of Medora, a station on the Rock Island railway, in Reno county.

The sand dunes and hills are the sport of the winds which cut out immense excavations from the white sand, piling it out on the prairie in great heaps. The margins of these dunes and the excavations are the favorite resort of several species of Cicindelidae, Scarabeidae, Tenebrionidae and other Coleoptera.

I first collected in this locality in May, 1891, making my first trip on the 5th of the month. Before reaching the sand hills, I took along the railway track numbers of Cicindela vulgaris and repanda. Around the base of the dunes and the bottoms of the "blow-outs" Cicindela scutellaris were numerous and formosa less so. In the same locality I took a single Geopinus incrassatus, an Aphodius, Trox aequalis, two or three Melanotus fossils, a few Anomola binotata and Eleodes extricata, and two specimens of an Euphorid, since identified by Mr. Chas. Liebeck, of the American Entomological Society, as Stephanucha pilipennis Kraatz. Of this rare species I collected 10 specimens in the same place in May, 1893, and two specimens in May of this year. A single specimen, I believe, was collected by Professor Popenoe in the spring of 1893, at Manhattan.

The willows on the sand dunes yielded one specimen of Gastroidae formosa the first season, and two specimens this season.

In 1892 the season was two weeks later, and my collecting in this locality was done in the last half of May. Associated with Cicindela scutellaris and formosa, I took a few specimens of the beautiful venusta taken in western Kansas, but never before in central Kansas. I found none of this variety in 1893, but the present season they were almost as numerous as scutellaris or formosa, and I added a fine series to my duplicates.

The spring of 1893 was unusually cold and windy, and the dunes were higher and the "blow-outs" deeper than ever. My best collecting ground that season was at the bottom of the "blow-outs" from 7 to 9 a. m. The Coleoptera were sluggish and easily taken. Ten specimens of Stephanucha pilipennis were taken as they slowly walked over the sand or were found dead. Several Anomola binotata, one minuta and a fine lot of Chalcodermus collaris were taken along the sides of the "blow-outs." I also took two fine specimens of a black, shiny Cremastochilus, since identified as nitens. The carabidae taken were represented by a few specimens of Dyschirius globulosus, Tachys incurvus, Pterostichus erythropus, Nothopus zabroides, Stenolophus ochropezus, Harpalus herbivagus and a Harpalus sp.

The Chrysomelidae taken were a Graphops nebulosus and Pachybrachus tridens. The Stapalinidae were represented by a Philonthus varius, a Philonthus sp., and a Stenus sp. Two or three species of Saprinus, a species of Limnichus not before taken in the state; several Canthon ebenus, Chalepus trachepigus, two or three Cotalpa lanigera on willow catkins; a few Lacon rectangularis and a pretty Cardiophorus, Blapstinus dilatatus, and moestus not before taken in the state, a Tyloderma foveolatum, a Sphenophorus pertinax, several S. sculptilus with another species of the same genus, were also added to my collection that year.

The season of 1894 was marked by an abundance of several handsome and desirable species, and the total or almost total absence of others. I took only two specimens of Stephanucha, and not a single specimen of Chalcodermus collaris, so numerous the season before. Cicindela scutellaris, formosa and venusta were unusually abundant, and I this year succeeded in taking a fine series of the handsome, and not at all common, Cremastochilus nitens. Many of these shining fellows had a splotch of dull red on the center of each wing cover. They were sluggish and easily taken in the morning, but very active during the hotter parts of the day. I also took numbers of Canthon ebenus and Cotalpa lanigera, and two specimens of the rare Serica curvata; a few specimens of Strigoderma arboricola were also taken, and a number of Lachnosterna crassissima, and a single specimen of a Lachnosterna sp.

A species of Blapstinus and a few Luperus brunneus completed the collecting in this locality the present season. I consider it one of the best collecting grounds in the state, and shall endeavor to work it each year.

CONORHINUS SANGUISUGUS—ITS HABITS AND LIFE HISTORY.

By BERTHA S. KIMBALL, Manhattan.

Conorhinus sanguisugus, the blood-sucking cone-nose, is well known to most entomologists, and was first described from Georgia by Dr. LeConte. It is now a comparatively common insect in northern and western United States, and, like others of the reduviid family, is noted for its bloodthirsty habits. It has several common names besides that of cone-nose, being known as the big bed-bug, Mexican bed-bug or Texas bed-bug. The name *Conorhinus*, by which it is commonly known, is derived from two Greek words, meaning cone-nose, and the insect is defined as a bloodthirsty species which insinuates itself into houses for the purpose of sucking human blood.

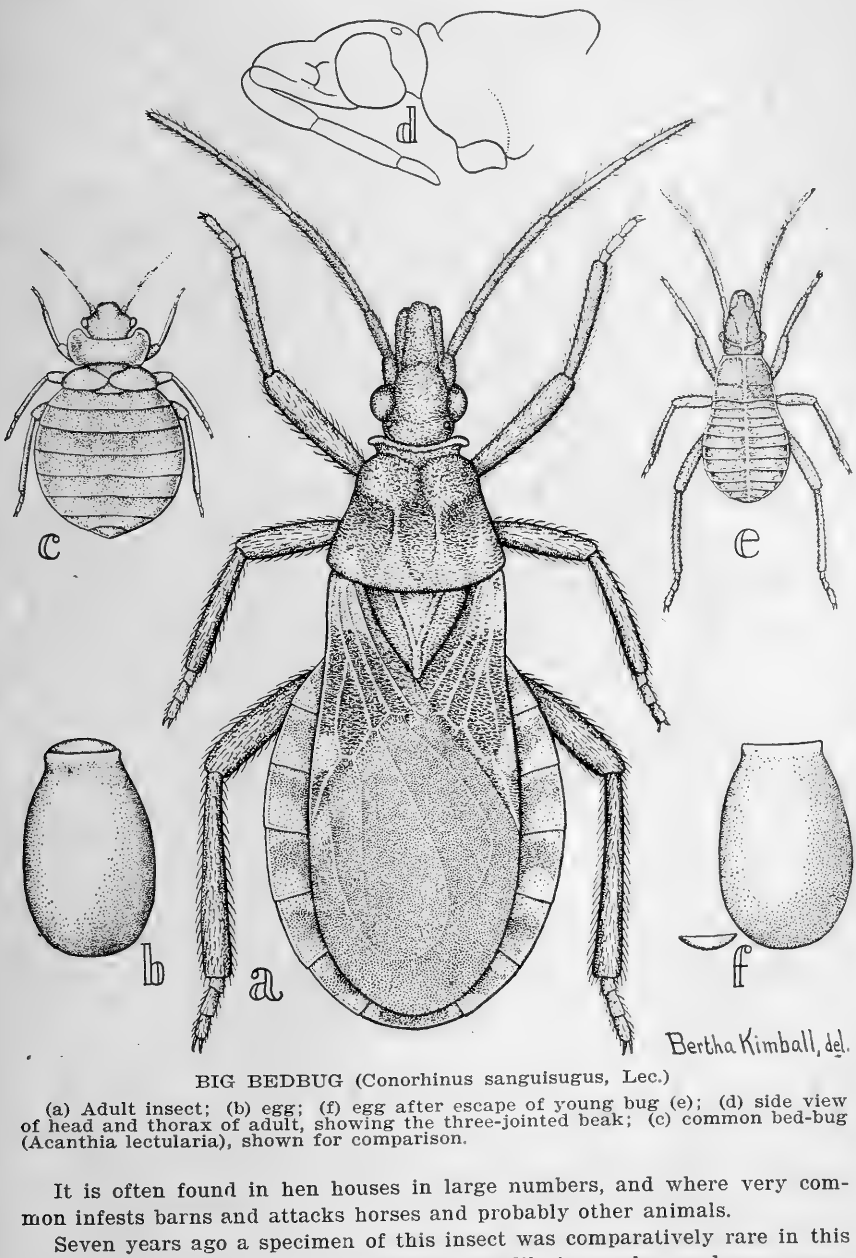
It has, of course, all the characteristics of the reduviid family, and as a species is distinguished particularly by the raised lines of its thorax and scutellum, and by its dull red markings. The conorhinus is an insect one inch in length and of a dull black color marked with red. The antennae are short, slender and four-jointed; the head narrow, thickened back of the eyes, with the ocelli, two in number, placed far apart; the thorax, which is triangular, constricted slightly before the middle, the front raised more than the posterior portion, with two diverging lines raised and extending backward, the sides and posterior portion margined with red; the scutellum small, with two raised lines meeting at the apex to form a V; the wings marked with two triangular red spots, one reaching from the base of the wing half the length of the scutellum, the other smaller and at the center of the wing; the abdomen with the sides strongly recurved and marked with six red spots; the legs slender, the posterior pair a little longer than the other two; the tarsi three-jointed.

The cone-nose differs greatly from the common bed-bug, Acanthia lectularia, which also infests sleeping apartments, and is only too well known to those who travel. The common bed-bug is much smaller, about three-sixteenths of an inch in length, flat and of a reddish-brown color. Its odor when touched or crushed is more than equaled by that of the cone-nose, which is so intense as to penetrate all parts of a room in which it happens to be molested, often leading to its discovery.

It is closely related to the masked bed-bug hunter, Opsicaetus personatus, which is said to enter rooms for the purpose of preying upon the common bed-bug. This species, however, is not found in the United States.

Those who do not notice closely, often confuse the cone-nose with our common boxelder bug, although, except perhaps in color, they are not in the least similar.

The bite or sting of the cone-nose is very painful and often even dangerous, the degree depending both upon the size of the insect and the sensitiveness of the person. It is accompanied by an almost intolerable itching and burning, and often followed by severe headache, nausea, and a feeling of depression often lasting for several days. The swelling from the bite is about as great as that ordinarily caused by a bee sting, but remains longer, and if rubbed, even after the swelling has disappeared, it will swell again. Camphor, ammonia, and the ordinary remedies for bites and stings afford some relief. Although ordinarily causing nothing more than great discomfort, fatal results have been reported from the bite or sting. Dr. LeConte thinks that many reports of spider bites are based on the stings of these or allied species.



BIG BEDBUG (Conorhinus sanguisugus, Lec.)

(a) Adult insect; (b) egg; (f) egg after escape of young bug (e); (d) side view of head and thorax of adult, showing the three-jointed beak; (c) common bed-bug (Acanthia lectularia), shown for comparison.

It is often found in hen houses in large numbers, and where very common infests barns and attacks horses and probably other animals.

Seven years ago a specimen of this insect was comparatively rare in this locality, but they seem to have increased steadily in number, and now appear altogether too frequently. Numerous inquiries have been received by Professor Popenoe during the summer as to this insect, showing it to be a growing nuisance throughout the state.

It is nocturnal in its habits, and seems to be attracted by the light of the lamp in the evening, and is often found crawling upon the screens or flying about the room. It makes a peculiar whirring sound when flying, easily distinguished from that of other insects when once noticed, and should be looked for at once, for sooner or later it finds its way to the sleeping room, much to the discomfort of its occupants. It is particular in its tastes, however, for often one occupant of a room will be entirely unmolested during the whole summer, while another suffers almost every night from the attacks of the insect. It is very difficult to discover unless looked for immediately after the pain of the bite has made its presence known, when it is usually found hiding among the bedclothes. But if left until morning it leaves the bed and hides in clothing or furniture about the room, generally escaping, to make its presence known again in a few days. It is very active, and when discovered runs swiftly but does not attempt to fly.

During August this summer (1894), a dozen bugs, captured at different times, were dropped into a bottle, where they were provided with flies, five or six at a time, upon which they probably fed during the night, as the flies were found dead in the morning. However, if neglected for several days, they seemed to experience no discomfort, and are probably able to go for some time without food. A grasshopper was once dropped into the bottle, but after several days was still alive, and, in its frantic efforts to escape bade fair to annihilate the bugs, which seemed afraid of it. They fed entirely at night and remained quietly at the bottom of the bottle during the day, but that they did crawl or fly during the night was proven by the fact that several eggs were found later, glued or attached in some way to the upper part of the bottle. August 27 several eggs were noticed in the bottle, and the number increased until there were 15 in all, the greater number of which rolled loosely about the bottle. The number laid by each insect was not noted, as so many were confined in one bottle. Soon after the eggs were laid the old bugs began to die. September 18, when the eggs began to hatch, all but two of the bugs were dead, and these died soon after. The egg, which is about the size of a mustard seed, and of a yellow color, is peculiar in its shape, resembling that of a bottle with a thickened rim around the tip, giving this portion the appearance of a stopper, especially after the egg hatches, as the insect pushes out this tiny saucer-like tip, which falls to the ground. Though yellow when first laid, the egg soon changes in color to pink, and then to red, as the insect develops within, until just before hatching, when the segments of the body can be seen through the transparent shell. The young insects are about one-eighth of an inch in length, very active, of a delicate pink color, the legs and antennae almost transparent. The head, prothorax, mesothorax and a spot on each side of the metathorax soon show a grayish tinge, and in a few days are black, the change taking place without molting. The small insects are almost if not quite as troublesome as the adult, and on account of their color and diminutive size are difficult to discover in the evening. Like the adults, they were provided with flies, and killed on an average four or five each night, having excellent appetites until about the middle of November, when they seemed no longer to care for food, and will probably pass the winter in this stage, eating nothing more until spring. Once, when the bugs had been forgotten from Saturday until Mon-day, and consequently were hungry, fresh flies were given them, the dish was partially covered, darkening it considerably, and the bugs were then watched feeding. One small insect with its extended beak, formidable-looking even in such a little creature, approached a half-dead fly until it touched it, when, bracing itself firmly, it pushed so hard as to roll the fly over, although it was many times larger than the bug. The sense of touch of these small cone-noses seemed not to be very delicate, as they prodded alike upon all parts of the fly's body, trying first the wing, then the eyes, and finally succeeded in puncturing the abdomen. To withdraw the beak, the insect, after bracing itself again, gave a sudden pull backward, and if the cover darkening the dish was removed they immediately stopped feeding and hid themselves as quickly as possible. Without doubt, the cone-nose preys upon other insects, and, to that extent, is beneficial, but its bad deeds so outweigh its good ones, that it must be classed among the injurious insects. By many it has been credited with infesting dwellings for the purpose of preying upon the common bed-bug, but its designs are quite probably of a sinister kind, if "by their works ye shall know them" can be applied to the cone-nose as to the human race. The conclusion that they prey upon the common bed-bug must arise from a supposition, as the bugs are nocturnal, feeding at night and hiding if a light is brought into the room, so that such a habit could hardly have been actually observed. There seems to be no wholesale method of destroying them, and those who at first credit the cone-nose with good intentions, will, when once stung by this insect, be more than ready to pronounce it capable of assault with attempt to kill, and to declare with those who have already suffered from its attacks that sentiment, just as applicable to the body physical as to the body politic, "Eternal vigilance is the price of liberty."

PARASITISM IN APHYLLON UNIFLORUM.

By JOHN M. PRICE, Jr., Atchison, Kan.

The question how the Aphyllon uniflorum, or naked broom-rape, obtains its nourishment was asked in our botany class of the past year. This plant is peculiar in that it has no green parts, and it was not known to be parasitic. The botanies in our college library gave us no information upon this point.

Upon careful investigation, the writer found it to be a parasite. From the stem of the plant branch off small fleshy roots of from 6 to 18 inches in length, and these have, at short intervals, hook-like projections. These hooks touch against the roots of other plants, and it is through this channel that the Aphyllon obtains its nourishment. Considerable difficulty was experienced in securing specimens showing the hooks touching against the roots of other plants, as they were exceedingly tender and easily broken, but at length the writer obtained several specimens which removed all doubt in his mind.

These hooks do not wrap themselves around the roots upon which they are parasitic, nor even encircle them, but they simply touch against the roots and in general with the back or convex surface of the bend.

The Aphyllon appears to be parasitic upon many species of plants, but the three most frequently found were the asters, solidagos, and gramineae.

LONG-CONTINUED BLOOMING OF "MALVASTRUM COCCINEUM."

By MINNIE REED.

One of the most common wild flowers in western Kansas is Malvastrum coccineum, or false mallow. Its bright blossoms may be seen from earliest spring until the late fall frosts have killed the last green leaf. From May until October you can collect fine blooming specimens of this plant. How it retains its vitality, and continues blooming so long in such a dry climate is a mystery; yet there are the bright orange-pink flowers, seeds and thrifty leaves growing all through the long, dry, hot summer. There is no other plant in this region that has such a long blooming period. Even here in eastern Kansas there are very few, if any, plants that bloom so long; even plants in the same order or family. Our familiar hollyhock does not bloom more than two months, ordinarily.

This plant, like many others in this dry region, is covered with a rather coarse, hoary pubescence, to diminish evaporation and protect it from the sudden changes of temperature so common on the plains.

It is an herbaceous perennial, low growing or prostrate in habit, with five-parted or pedate leaves. It bears racemes of rather showy orange-pink flowers. The plants are usually from six inches to a foot in diameter, though sometimes larger. It usually grows in places where the buffalo grass has been killed out, as along old roads, in fields, or on gopher hillocks. There are many of our garden plants far less attractive than this western wild flower. Its bright flowers contrast pleasingly with its rough grayish foliage, and it brightens up the wide expanse of monotonous buffalo grass considerably, especially in early spring and summer, when it is most abundant. It might be well to add it to our list of cultivated ornamental plants.

ADDITIONS TO THE PLANTS OF KANSAS.

BASED ON PLANTS ADDED TO THE KANSAS STATE HERBARIUM.

By B. B. SMYTH.

Very little opportunity has been given the writer during the past two years to travel over the state making collections of its plants. Attention, however, has constantly been paid to it, and additions of hitherto unreported plants made to the state herbarium whenever anything new was offered. The following new plants have been added:

2638. Lepidium draba L. Emporia, Paola, etc. Sent by Miss Queen Gillett.

2639. Astragalus bigelovii Gray. Trego county. Sent by J. A. Rich.

2640. Astragalus elatiocarpus Sheldon. Manhattan. Collected by the writer. A variety undoubtedly of A. lotiflorus.

2641. Lespedeza leptostachya Gray. Shawnee county. By the writer.

2642. Psoralea pedunculata Vail. Shawnee county. Recognized in Shawnee county for the first time. Hitherto collected by the writer in Stafford county under the name of P. melilotoides.

2643. Vernonia noveboracensis, var. latifolia Gray. Shawnee county.

2644. Aster commutata Gray. Barton county. Collected some years ago. and previously undetermined.

2645. Aster grandiflorus L. Morainic hills of Shawnee county. Collected by Professor Harshbarger and the writer.

2646. Aster longifolius Lam. Low grounds of Shawnee county. Collected by Prof. W. A. Harshbarger and the writer.

2647. Aster polyphyllus Willd. Shawnee county. By the writer.

2648. Aster vimineus, var. foliolosus Gray. By Professor Harshbarger and the writer.

709. Berlandiera texana DC. Trego county. Sent by J. A. Rich.

2649. Collomia giliopsis Benth. Trego county. Collected by J. A. Rich.

2650. Plantago occidentalis Dec. Shawnee county. Collected by W. A. Harshbarger.

2651. Polygonum ramosissimum, var. prolificum Small. Shawnee county. By the writer.

2652. Planera aquatica Gmel. Southern Kansas. Coulter in Cont. U. S. Nat. Herb., II.

2653. Lachnanthes tinctoria Ell. Oswego. Sent by Doctor Newlon.

2654. Physcomitrium hookeri Hampe. Manhattan. Professor Kellerman and Miss Reed.

2655. Physcomitrium kellermani Mrs. B. Shawnee county. Collected by the writer and determined by Miss Minnie Reed.

2401. Climacium dendroides Web. & Mohr. Shawnee county. Collected by the writer and determined by Miss Reed.

2401. Climacium americanum Brid. Shawnee county. Collected by the writer and determined by Dr. G. N. Best. These two plants are the same. C. americanum is ordinarily regarded as a variety of C. dendroides. Dr. Best's determination is therefore probably correct, while Miss Reed's name is not wrong.

2656. Fissidens obtusifolius Wils., var. Kansanus. Rare. Shawnee county. Collected by the writer and determined by Miss Reed.

2657. Hypnum (Amblystegium) subtile Hoffm. Shawnee county. Collected by the writer and determined by Miss Reed.

2658. Hypnum (Amblystegium) vacillans Lesq. Shawnee county. Collected by the writer and determined by Miss Reed.

2659. Hypnum (Brachythecium) acutum Mitt. Shawnee county. Collected by the writer and determined by Miss Reed.

2660. Riccia frostii Aust. Shawnee county. Collected by the writer and determined by Dr. L. M. Underwood, Terre Haute, Ind.

THE GRASSES OF KANSAS.

By A. S. HITCHCOCK, Manhattan.

The following is a list of the grasses of Kansas, as represented by specimens in the herbarium of the Agricultural College. The nomenclature and arrangement is that of the "List of Pteridophyta and Spermatophyta" recently issued as a Memoir (vol. V) of the Torrey Botanical Club. For this reason no extended synonymy is given. Every citation has been verified, except where included in quotation marks. The citations not verified are as follows:

Andropogon Hallii Hack. Sitz. Akad. Wiss. Wien, 89: 127 (1884).
Panicum lineare Krock. Fl. Sil. 1: 95 (1787).
Homalocenchrus Mieg. In Hall. Hist. Stirp. Helv. 2: 201 (1768).
Agrostis mexicana L. Mant. 1: 31 (1767).
Sporobolus asper Kunth. Gram. 1: 68.
Vilfa heterolepis Gray. Ann. Lyc. N. Y. 3: 233 (1835).
Bouteloua Lag. Var. Cienc. y Litter. 2: 134 (1805).
B. hirsuta Lag. l. c.
Leptochloa mucronata Kunth. Gram. 1: 91.
Poa caroliniana Spreng. Mant. Fl. Hal. 33 (1807).
Eragrostis major Host. Gram. Austr. 4: 14 (1809).
Eatonia Raf. Journ. Phys. 89: 104 (1819).
Korycarpus Zea. Act. Matrit. (1806).
Distichlis Raf. Journ. Phys. 89: 104 (1819).
Panicularia Fabr. Enum. Pl. Hort. Helmst. 373 (1763).
Agropyron J. Gaertn. Nov. Comm. Petrop. 14: 539 (1770).
Sitanion elymoides Raf. Journ. Phys. 89: 103 (1819).

Professor Scribner has kindly answered several questions concerning nomenclature, and has aided in the determination of some of the species.

I also wish to thank the Missouri Botanical Garden for the privilege of using the excellent library there collected. Several original descriptions not in my private library were photographed, such as Lamarck's Encyclopedia, Walter's Fl. Car., and Hooker's Fl. Bor. Am. I have now either the original or a photograph of the original, of all the descriptions except those enumerated above.

After the citation of the original description is given the type locality as it appears in the work cited.

TRIPSACUM L. Syst. Ed. 10, 2: 1261 (1759). Includes two species, T. hermaphroditum, and the following:

T. dactyloides (L.) L. Syst. Ed. 10, 2: 1261 (1759). America. Wet places, west to Saline and Barber.

ANDROPOGON L. Spec. Pl. 1045 (1753). Twelve species; N. A. A. divaricatum, nutans, alopecuroides, virginicum.

A. Hallii "Hack. Sitz. Akad. Wiss. Wien, 89: 127 (1884)." The typical form occurs through the western part of the state, but it seems to be connected with A. provincialis Lam. by intermediate forms which are abundant through the central counties. It would seem best to call this a western variety under the name A. provincialis, var. Hallii (Hackel).

A. nutans avenaceus (Michx.) Hack. in DC. Monog. Phan. 6: 530 (1889).

A. avenaceum Michx. Fl. 1: 58 (1803). "In vastissimis pratis Illinoensibus." Prairies; common. Hackel unites Sorghum and Chrysopogon with Andropogon (DC. Mon. Phan. VI), and places the above species under the subgenus Sorghum. Bentham places the same species under Chrysopogon (Notes on Gramineae, 73). Chrysopogon was founded chiefly upon Andropogon gryllus L. (Trin. Fund. Agrost. 188) and is the same as Centrophorum Trin. Fund. Agrost. 106, which latter name should be used if the group be kept as a distinct genus. Sorghum halepense Pers. Syn. I, 101, occurs occasionally along railroad tracks in the southern part of the state, but probably has not become established.

A. provincialis Lam. Encycl. 1: 376 (1783) "21. Barbon de Provence, Andropogon provinciali, HR. Andropogon spicis digitatis, flosculis alternatim geminis, hermaphrodito aristato, sessili; masculo mutico, pedunculato. Ger. Prov. 107 t. 4. Gramen dactylon villosum, ramosum, altissimum, galloprovinciale. Tournef. 521. Cette plante a beaucoup de rapports avec celle qui precede, & n'en est peut-etre qu'une variete; neanmoins on l'en distingue en ce qu'elle est constamment plus grande, que ses feuilles sont plus larges, & que ses epis sont inegaux, & forment des digitations moins nombreuses. On trouve cette plante dans la Provence, & on la cultive au Jardin du Roi. Perennial. (V. V. sans fl.)" Prairie; common.

A. saccharoides glaucus (Torr.) Scribn. Mem. Torr. Bot. Club, 5: 28 (1894).

A. glaucum Torr. Ann. Lyc. N. Y. 1: 153 (1824). On the Canadian river. High plains, but usually in ravines; north and east to Hamilton, Saline, Harper.

A. scoparius Michx. Fl. 1: 57 (1803). In aridis sylvarum Carolinae. Prairie; common.

PASPALUM L. Syst. Ed. 10, 2: 855 (1759) includes P. dimidiatum, virgatu, paniculatum, distichu.

P. laeve Michx. Fl. I 44 (1803). In Georgia. Cherokee.

P. setaceum Michx. Fl. I, 43 (1803). In aridis Carolinae inferioris. Sandy soil; west to Clay, Saline, Reno, Seward.

ERIOCHLOA HBK. Nov. Gen. et Sp. 1: 94 (1815). E. distachya, polystachya.

E. punctata (L.) Hamilt. Prod. Pl. Ind. Occ. 5 (1825). Milium punctatum L. Syst. Ed. 10, 2: 872 (1759). No locality. Barber to Barton and Montgomery.

PANICUM L. Spec. Pl. 55 (1753); Gen. Pl. Ed. 5: 29 (1754). 20 species; N. A. P. americanum, crusgalli, sanguinale, filiforme, dichotomum, clandestinum, capillare, latifolium, virgatum.

P. autumnale Bosc., in Spreng. Syst. I, 320 (1825). No locality. Riley to Lincoln and Ness.

P. capillare L. Spec. 58 (1753). In Virginia, Jamaica. Common.

P. clandestinum L. Spec. 58 (1753). In Jamaica, Pennsylvania. Pottawatomie, Shawnee.

P. crusgalli L. Spec. 56 (1753). In Europae, Virginiae cultis. "Variat aristis, in aliis longitudine glumorum, in aliis decies." Common.

P. depauperatum Muhl. Descr. Gram. 112 (1817). Penns., Carolina. Prairie; Riley.

P. dichotomum L. Spec. 58 (1753). In Virginia. Prairie; west to Rooks.

P. lineare "Krock. Fl. Sil. 1: 95 (1787)." Riley, Pottawatomie, Greenwood.

P. obtusum HBK. Nov. Gen. et Spec. 1: 98 (1815). In planitie Montana regni Mexicani prope Guanaxuato et Burras. Ford, Barber, Seward, Morton, Hodgeman.

P. proliferum Lam. Encycl. 4: 747a (1797). "Cette espece est cultivee au Jardin du Museum; son lieu, natal ne m'est pas connu. Je la crois originaire de la Virginie ou de quelqu'autre partie de l'Amerique septentrionale." (The paging in this part of the volume is as follows: 720, 731 to 746, 737, 748, 749, 740, 741, etc.) West to Rooks and Reno.

P. sanguinale L. Spec. 57 (1753). In America, Europa australi. Common in cultivated or waste ground.

P. scoparium Lam. Encycl. 4: 744a (1797). "Cette plante a ete recueillie dans la basse Caroline par le Citoyen Michaux. (V. S.)" West to Rooks and Ford.

P. virgatum L. Spec. 59 (1753). In Virginia. Common.

P. waltheri Lam. Encycl. Suppl. 4: 282 (1816). "Panicum foliis ovalilanceolatis, amplexicaulibus, glaberis; vaginis subtomentosis, basi circa nodum, colloque barbatis; panicula sessili glabella, subramosa; glumis pubescentibus, valvula extima ovali. (N.) Panicum latifolium Michx. Flor. Bor. Amer. 1: pag. 49, ut non Linn. C'est a tort que Waltherius & Michaux ont pris cette plante pour le panicum latifolium, No. 86. Quoique tres-rapprochee, elle en differe evidemment par ses feuilles plus courtes, amplexicaules & non retrecies en petiole a leur base; par les gaines pubescentes, presque tomenteuses, barbues sur les noeuds a leur base & a leur orifice. La panicule est sessile, presque glabre, mediocrement rameuse, renfermee entre les feuilles superieures; les values calicinales tres-legerement pubescentes; l'exterieure ovale. Cette plante croit dans la Virginie & a la Caroline, dans les bois & les pres. Perennial. (V. s. in herb. Mich.)" Swartz makes the following note in his Obs. Bot. 36 (1791): "Panicum latifolium. S. V. 107, 27. S. pl. 160, 26. Obs. Synonym Sloanei non hujus, sed P. glutinosi. Prodr. p. 24." The following is the description given by Linnaeus, of P. latifolium L. Spec. 58 (1753): "Panicum panicula racemis lateralibus simplicibus, foliis ovato-lanceolatis collo pilosis. Gramen virginianum, lato brevique folio, panicula rariore. Moris. hist. 3, p. 196, f. 8; t. 5, f. 4. Gramen miliaceum sylvaticum maximum, semine albo. Sloan, jam. 34; hist. 1, p. 114, t. 71, f. 3. Habitat in America. Folia latitudine Commelinae, ad fauces amplexicaulia; extus collo circum fauces villoso, etiam basi foliorum margin piloso. Panicula valde mediocris ex racemis lateralibus, non subdivisis, sed pedicellos proprios, nec subdivisos proferentes. Flores mutici majusculi." Wyandotte, Cherokee.

SETARIA Beauv. Agrost. 113 (1812), not Ach. (1798). According to the rules of priority this name cannot be used for our foxtails, because it was used earlier for a group of lichens. For reasons given below it does not seem best to follow the check-list and use Chamaeraphis R. Br., as recommended by O. Kuntze. Hence I have retained Setaria, leaving it to a monographer to apply a new name. The original description of Setaria is said to occur in Palisot de Beauvois' work, Flor d'Oware et de Benin en Afrique, 1807, a work which I have not seen. (Bentham, Notes on Gramineae, 47.) Bentham states that the genus was there founded upon Setaria longiseta, which is not a Setaria as now recognized, but Pennisetum unisetum. Setaria, Beauv. Agrost. 51. "Panici spec., Lin. Juss., etc.; Orthopogonis spec. R. Brow." Following the description comes the list of species to be included in this genus: "Spec. Panicum erubescens, geniculatum, germanicum, glaucum, italicum, purpureum, sericeum, setosum, verticillatum, villosum, viride, umbrosum, vulpinum, muricatum." Chamaeraphis is thus defined in R. Br. Prod. 193 (1810): "Gluma biflora, bivalvis, valvula exteriore minima. Flosculi bivalves; exterior masculus, valvula exteriore textura interioris glumae; interior minor, chartaceus, femineus. Squamulae 2, hypogynae. Stamina 3. Styli 3! Stigmata plumosa. Semen perianthio cartilagineo inclusum. Gramen perenne; folia disticha, linearia, stricta, ligula rotundata. Spica unica (Hordei); floribus imbricatis, distichis; rachi flexuosae, parallelis; pedicellis brevibus, juxta apicem intus arista longissima instructis (unde nomen). Obs.—Affinitate proxima panicis, praesertim ultimae sectionis, a quibus vix differt nisi numen stylorum. 1. C. hordeacea. (T.) V. v." R. Brown's genus Orthopogon (l. c. 194) includes O. compositus (P. compositum L.), aemulus, flaccidus, imbecillis, and is Oplismenus Beauv. Pennisetum R. Br., Prod. 195, includes P. compressum, glaucum (Panicum glaucum L.), italicum (Panicum italicum L.), and is the same as Setaria Beauv., but not the same as Pennisetum Rich. in Pers. Syn. 1: 72 (1805). It is my opinion that as genera go in grasses both Setaria Beauv. and Chamaeraphis R. Br. are good genera and should not be united. Schlechtendahl (Linnaea, 31: 420, not vol. 35 as says Kuntze) says of Ioxophorus, after a discussion of its merits, ". . . . So bilde ich aus diesen Pflanzen eine eigene Abtheilung, welche man Gattung oder Panicum-section nach Belieben nennen mag, und bezeichne Sie mit einem eigenen Namen: Ixophorus." It is founded on Urochloa uniseta Presl, Rel. Haenk. 1: 319, a plant which Bentham says has not been identified. So this name cannot be safely taken up.

S. glauca (L.) R. & S. Syst. II, 490 (1817). Beauvois includes this in his genus Setaria as Panicum glaucum. Agrost. 51 (1812). Panicum glaucum L. Spec. 56 (1753). In Indiis. Common in cultivated ground.

S. viridis (L.) Beauv. Agrost. 51, and Atlas, pl. 13: fig. 3 (1812). In the description Beauvois merely includes this in his list of species as Panicum viride. In the index, "Panicum viride Lin. Vid. Setaria, Ib. [51]," and under Setaria, S. viridis. In the description of the plate this appears Setaria viridis. It seems proper to give Beauvois as the author of the above combination. P. glaucum (b) L. Spec. ((See above.) P. viride L. Syst. Ed. 10 (1759). Common in cultivated ground.

CENCHRUS L. Spec. Pl. 1049 (1753); Gen. Pl., Ed. 5: 470 (1754). Includes five species, three American, C. echinatus, tribuloides, frutescens.

C. tribuloides L. Spec. 1050 (1753). In Virginiae maritimis. Common in sandy soil.

HOMALOCENCHRUS "Mieg. in Hall. Stirp. Helv. 2: 201 (1768)."

H. oryzoides (L.) "Cl. Mieg. Act. Helvet. 14, p. 317; Hall, Hist. II, p. 202." Ex Pollich Hist. Pl. Palat. 1: 52 (1776). Phalaris oryzoides L. Spec. 55 (1753). "In Virginiae paludibus nemorosis." Wet places; Pottawatomie, Ellsworth, Rice, Riley, Rooks, Saline.

H. virginicus (Willd.) Britton. Trans. N. Y. Acad. Sci. 9: "14" [Reprint 13] (1889. Leersia virginica Willd. Spec. 1: 325 (1797). In America boreali. Wet places; Chase, Geary, Marion, Pottawatomie, Riley, Rooks, Shawnee, Saline, Wyandotte.

PHALARIS L. Spec. Pl. 54 (1753); Gen. Pl., Ed. 5: 29 (1754). Includes 5 species, only one given as American, P. oryzoides.

P. arundinacea L. Spec. 55 (1753). In Europae subhumidis ad ripas lacuum. Pottawatomie, Labette.

P. canariensis L. Spec. 54 (1753). In Europa australi, Canariis. Ellis county.

ARISTIDA L. Spec. Pl. 82 (1753); Gen. Pl., Ed. 5: 35 (1754). Includes only one species, A. adscensionis.

A. basiramea Engelm. Vasey in Bot. Gaz. 9: 76 (1884). Pottawatomie, Riley, Saline, Kingman.

A. dispersa Trin. & Rupr. Mem. Acad. St. Petersb., Ser. VI, 5: 129 (1842). Five varieties are referred to this: "(a) A. nana Steud., from Chile; (b) A. humilis HBK., from Venezuela; (c) A. bromoides HBK., from Ecuador; (d) A. coarctata HBK., from Mexico; (e) A. nigrescens Presl, from Mexico." Clark county, collected by Mr. M. A. Carleton.

A. fasciculata Torr. Ann. Lyc. N. Y. 2: 154 (1826). "Culm filiform, erect, branched; leaves narrow, flat, smooth; panicle elongated, sub-spiked; flowers fasciculate; calyx shorter than the corolla; awns nearly equal, spreading, longer than the flower. Description.—Culm two feet and more in height, smooth, terete, with short branches, slightly geniculate. Leaves long, very narrow, almost filiform at the extremity. Sheaths smooth. Stipule a bearded ring. Panicle 6-8 inches long, erect, many-flowered; flowers purplish, closely approximate on the extremities of the branches. Calyx two-glumed; glumes very unequal, linear lanceolate, acute, carinate, the inferior much shorter than the corolla, superior about as long as the corolla. Corolla on a short bearded stipe, two-valved, subcylindric, scabrous; inferior valve involute, half an inch long; awns longer than the flower, spreading, filiform, scabrous. Stamens three; anthers purplish. Germen linear, elongated; stigmas plumose. Hab.—In forests of the Canadian river. This species is nearly allied to A. purpurascens of Poiret, but is distinguished by its branched culm, its short calyx, and by its shorter awns." Professor Scribner refers the following to this species: Aristida purpurea Nutt. Fl. Ark. in Trans. Am. Phil. Scc., V, 145 (1837). "Panicula erectiuscula gracili; cal. valvulis remotis aristulatis apice bifidis; aristis capillaribus longissimis; foliis brevibus scabris. Hab.—On the grassy plains of Red river, in arid situations. Flowering in May. Obs.—Perennial; leaves narrow, short and scabrous; ligula pilose; culm about one foot high; panicle many-flowered, a little spreading, branches capillary; flowers commonly in pairs (after the manner of the genus), bluish purple; one valve of the calyx nearly double the length of the other, both bifid at the summit and shortly awned, the longer valve exceeding the corolla; awns equl, capillary, nearly three times the length of the corolla and scabrous; corolla minutely stipitate." Plains; east to Riley, Saline, Barber. A well marked form is referred to A. fasciculata by Professor Scribner, A. purpurea fendleriana Vasey. Mon. Grasses, 46 (1892). Aristida fendleriana Steud. Pl. Gram. Suppl. 420 (1855). "Caespitosa glaucescens; culmis erectis rigidulis simplicibus glabris (pedalibus et ultra); vaginis laevibus ore pilis aliquot tenuissimis minutis; ligula brevissima villosula vel nulla; foliis convoluto-teretibus rigidulis suberectis vel curvatis retrorsum scabriusculis ceterum glabris; panicula simplicissima racemosa (3-4 pollicari); radiis solitariis usque ternis uni-trifloris; glumis 2, valde inaequalibus acutis pallidis, inferiore duplo, breviore, superiore apice bifida aequante vel parum superante flosculum fere 4-lineatem basi glabrum sursum glabriusculum, brevi stipitatum, stipite albo-pilosulo: setis scabriusculis, intermedia breviore. Coll. Fendler, Nr. 973, New Mexico. [P. 135 post, Nr. 30. Aristida glauca insere.]" Seward county, Mr. M. A. Carleton.

A. humboldtiana Trin. & Rupr. Mem. Acad. St. Petrsb. Ser. VI, 5: 118 (1842). In regione subfrigida regni Mexicani inter Salamanca, Guanaxuato et Ovexeras, altitud. 5400—6600 ped. Haskell county.

A. oligantha Michx. Fl. I, 41 (1803). In vastissimis pratensibus Illinoensibus. Jefferson, Wyandotte, Miami, Shawnee, Riley, Labette, Harvey, Rice, Saline, Rooks, Barber, Clark, Smith.

A. purpurascens Poir. in Lam. Encycl. Suppl. 1: 452 (1810). Riley, Ellis, Stafford.

STIPA L. Spec. Pl. 78 (1753); Gen. Pl., 5: 34 (1754). Includes S. pennata, juncea, avenacea, the latter from Virginia.

S. coma Trin. & Rupr. Spec. Gram. Stipae, in Act. Petrop., Ser. VI, Tom. V, 75 (1842). Carleton House Fort, ad Fl. Saskatchewan (Drummond); ad ripas et in planitie Fl. Columbia prope "Missouri Portage" (Douglas). Seward, Wallace, Morton.

S. spartea Trin. Mem. Acad. Petrop., Ser. VI, Tom. I, 82 (1830). "V. spp. Amer. Bor." Prairies; Marshall, Jackson, Pottawatomie, Wabaunsee, Riley, Clay, Saline, McPherson, Barber, Sedgwick.

S. viridula Trin. Act. Petrop., Ser. VI, Tom. IV, 39 (1836). "V. spp. Am. Bor.?" Rooks county. Collected by Mr. E. Bartholomew.

MUHLENBERGIA Schreb. Gen. 44 (1789). No species assigned. This is often cited as "Schreb. Gram. t. 50."

M. gracillima Torr. Pac. R. R. Rep. IV (Bot. Whipple) 155 (1856). Llano Estacado, and near the Antelope hills of the Canadian river. Hamilton, Grant, Morton, Stevens, Stanton, Russell.

M. mexicana (L.) Trin. Unifl. 189 (1824). Agrostis mexicana L. "Mant. 1: 31 (1767)." West to Rooks and Ness.

M. minutiflorum (Michx.) Hitchc. Dilepyrum minutiflorum Michx. Fl. 1: 40 (1803). "In apricis, pratensibus regionum Kentucky et Illinoensium." Muhlenbergia diffusa Schreb. Besch. Graes. 2: 143, t. 51 (1810). This is often quoted as "1772-79"; but the title-page and Pritzel's Thesaurus agree on the date 1810. The title-page of the first part (pp. 1-154, pll. I-XXI) is dated 1769; but the plates are dated variously from 1766-1768. The second part, in the copy I possess, has no separate title-page (pp. 1-88, pll. XXII-XL). This is said by Pritzel to have been issued 1772-1779. It was apparently issued in three parts, the signatures for pp. 1-20 reading "II Th.;" for pp. 21-56, "II Th., 2 Ausg.;" for pp. 57-88, "II Th., 3 Ausg." The dates of the plates vary from 1760-1778. The third part is designated on the title-page as "Zweiter Theil", and seems to be a continuation after a long interruption (pp. 89-160, pll. XLI-LIV). Riley, Chase, Pawnee, Saline.

M. racemosa (Michx.) B.S.P. Cat. 67 (1888). Agrostis racemosa Michx. Fl. I, 53 (1803). In ripas subulosis inundatis fluminis Mississippi. West and south to Rooks and Hodgeman.

M. sobolifera Trin. Diss. Gram. Un. & Ses. 189 (1824). Agrostis sobolifera Muhl. Gram. 70 (1817). In sylvis. Penns. Riley, Geary, Morris, Wabaunsee, Ottawa.

M. sylvatica A. Gray. N. A. Gram. and Cyp., No. 13 (1834). This is a set of exsiccatae with printed labels, bound in book form and with a printed title-page. Agrostis sylvatica Torr. Fl. N. U. S., I, 87 (1823). Mountains of New Jersey. Pottawatomie, Riley, Shawnee, Clay.

Phleum pratense L. has escaped from cultivation along roadsides.

ALOPECURUS L. Spec. 60 (1753); Gen. Pl., Ed. 5: 30 (1754). Includes four species, none of which are credited to America; A. pratensis, geniculatus, hordeiformis, monspeliensis.

A. geniculatus L. Spec. 60 (1753). In Europae uliginosis. Republic, Pottawatomie, Riley.

SPOROBOLUS R. Br. Prod. Fl. Nov. Holl. 169 (1810). "Obs.—Genus affinitate agrostidi praesertim A. virginicae L. proximum, ad quod praeter sequentes referenda est agrostis diandra." Three species are described, S. indicus, elongatus, pulchellus.

S. airoides (Torr.) Torr. Pac. R. R. Rep. 7: part 3, 21 (1856). Agrostis airoides Torr. Ann. Lyc. N. Y., II, 151 (1826). "On the branches of the Arkansas, near the Rocky Mountains." East and north to Hamilton, Barton, Reno.

S. asper (Michx.) "Kunth. Gram. 1, 68." Ex Kunth, Enum. 1: 210 (1833) Agrostis aspera Michx. Fl. I, 52 (1803). "In collibus rupibusque regionis Illinoensis." West to Clark, Gove, Phillips.

S. asperifolius (Nees and Meyen) Thurb., in Wats. Bot. Calif. 2: 269 (1880). Vilfa asperifolia Nees and Meyen, in Trin. Mem. Acad. St. Petersb., Ser. VI, 5: 95 (1840). Chile; Rio Magno. Clark, Rice, Barber, Cloud, Republic, Rooks, Trego.

S. brevifolius (Nutt.) Scribn. Mem. Torr. Bot. Club, 5: 39 (1894). Agrostis brevifolius Nutt. Gen. 1: 44 (1818). "In sterile, naked plains and arid, argillaceous soils, near Fort Mandan, on the Missouri." Riley, Saline, Rooks.

S. cryptandrus (Torr.) Gray. Man., Ed. I, 576 (1848). Agrostis cryptandrus Torr., in Ann. Lyc. N. Y., II, 151 (1826). On the Canadian river. Common in sandy soil.

S. depauperatus (Torr.) Scribn. Bull. Torr. Bot. Club, 9: 103 (1882). Vilfa depauperata Torr. ("Mst.") in Hook. Fl. Bor. Am., 2: 257 (1840). N. W. America. Barren, sandy parts of the Columbia, from Menzies island upwards. Douglas. Finney county.

S. heterolepis (Gray) Gray, Man. 576 (1848). Vilfa heterolepis, Gray, "Ann, Lyc. N. Y. 3: 233 (1835)." Pottawatomie, Riley, Morris.

S. minor Vasey, in Gray Man., Ed. 6, 646 (1890). Nemaha county.

S. pilosus Vasey. Bot. Gaz. 16: 26 (1891). Hamilton, Rush, Lane.

S. texanus Vasey. Contr. Nat. Herb. 1: 57 (1890). Rice county.

S. vaginaeflorus (Torr.) Vasey. Cat. Grasses U. S. 45 (1885). Vilfa vaginaeflorus Torr., in Gray Gram. et Cyp. 1: No. 3 (1834). New Jersey. Agrostis virginica. Muhl. Gram. 74 (1817). "Habitat in aridis, floret Sept. Penns., Carolina, Georgia. A. virginicae L. Affinis sed ab. A. pungente diversa." West to Stafford and Rooks.

CINNA L. Spec. Pl. 5 (1753); Gen. Pl., Ed. 5: 6 (1754). One species as below.

C. arundinacea L. Spec. 5 (1753). In Canada. Miami, Pottawatomie, Riley, Labette.

AGROSTIS L. Spec. Pl. 61 (1753); Gen. Pl., Ed. 5: 30 (1754). Includes 12 species, only A. virginica being American.

A. alba L. spec. 63 (1753). In Europae nemoribus. West to Barber, Reno, Republic; introduced or escaped.

A. hiemalis (Walt.) B.S.P. Prel. Cat. N. Y. 68 (1888). Cornucopiae hiemalis Walt. Fl. Car. 74 (1788). "Culmo erecto, paniculo diffusa verticillata foliis augustis subteretibus." West to Rooks and Cowley.

CALAMAGROSTIS Adans. Fam. Pl. 2: 31 (1763). No species described.

C. canadensis (Michx.) Beauv. Agrost. 15 (1812). It is doubtful if Beauvois should be cited as the author of this combination. He gives as a synonym of his genus Calamagrostis, "Arundinis Spec. Linn., Juss., etc.," and ends with a list of species, "Cal. canadensis, confinis," etc., with no description or synonymy. Arundo canadensis Michx. Fl. 1: 73 (1803). In Canada. Hamilton county.

CALAMOVILFA Hack. True Grasses, 113 (1890). Includes C. brevipilis and the following, both from N. A.

C. longifolia (Hook.) Hack. True Grasses, 113 (1890). Calamagrostis longifolia Hook. Fl. Bor. Am. 2: 241 (1840). Saskatchewan, Drummond. Riley, Barber, Stevens, Jewell, Republic, Rice, Morton.

SPARTINA Schreb. Gen. 43 (1789). No species described.

S. cynosuroides (L.) Willd. Enum. I, 80 (1809). Dactylis cynosuroides L. Spec. 71 (1753). In Virginia, Canada, Lusitania. Wet places throughout the state.

S. gracilis Trin. Mem. Acad. St. Petersb., Ser. VI, 5: 110 (1840). "Amer. Bor." Hamilton county, collected by Mr. C. H. Thompson.

CHLORIS Sw. Prod. 1 and 25 (1788). Includes five West Indian species.

C. verticillata Nutt. Fl. Ark., in Trans. Am. Phil. Soc., N. S., V, 150 (1837). On the sandy banks of the Arkansas, near Fort Smith. Throughout the state.

SCHEDONNARDUS Steud. Pl. Gram. 146 (1855). Based upon one species, S. texanus, which is

S. paniculatus (Nutt.) Scribn. Mem. Torr. Bot. Club 5: (1894). Lepturus paniculatus, Nutt. Gen. I, 81 (1818). On dry saline plains, near Fort Mandan, on the Missouri. Prairie; common.

BOUTELOUA Lag. "Var. Cienc. y Litter. 2: Part 4, 134 (1805)."

B. curtipendula (Michx.) Torr. Bot. Emory Exped. 153 (1848). "Valley of the Gila, rare. This plant agrees pretty well with Kunth's description of B. (Eutriana) racemosa, except in the pubescent lower palea, and the minute bristles at the base of the neuter flower. Whether it be the plant of Lagasca or not is very difficult to determine from his brief character. It certainly is very different from B. racemosa of the United States, which has a large, three-awned neuter flower, and if distinct from Lagasca's, must receive another name. That of B. curtipendula would be appropriate." Chloris curtipendula, Michx. Fl. I, 59 (1803). "In aridis regionis Illinoensis ad Wabash et in rupibus ad prairie du rocher, perennial." Prairie; common throughout the state.

B. hirsuta Lag. "Var. Cienc." l. c.; Nov. Gen. 5 (1816) as follows: "Glumae valvula exteriore dorso tuberculis piliferis muricato-hirsuta. Lag. Varied. de Cienc. Liter. y Art, An. 2, Num. 25, pag. 141. H. in Imp. Mex. Annual." East to Pottawatomie, Marion, Sumner.

B. oligostachya (Nutt.) Torr. In Gray, Man., Ed. 2, 553 (1856). Atheropogon oligostachyum Nutt. Gen. I, 78 (1818). On the plains of the Missouri. East to Wabaunsee, Chase, and Barber.

ELEUSINE Gaertn. Fruct. et Sem. 1: 7 (1788). Includes E. coracana and indica.

E. indica (L.) Gaertn, l. c. 1: 8 (1788). Cynosurus indicus L. Spec. 72 (1753). In Indiis. Johnson, Miami, Linn, Bourbon, Riley, Labette.

LEPTOCHLOA Beauv. Agrost. 71 (1812). "Spec. Cynosurus capillaceus; Eleusine filiformis, virgata."

L. fascicularis (Lam.) Gray, Man. 588 (1848). Festuca fascicularis Lam.

Tabl. Encycl. 1: 189 (1791). "Ex. Amer. Merid. Comm., D. Richard." Johnson, Jackson, Riley, Jewell, McPherson, Harper, Ford.

L. mucronata (Michx.) Kunth. "Gram. 1: 91 (1829-35.)" Eleusine mucronata Michx. Fl. Bor. 1: 65 (1803). In cultis Illinoensibus. Bourbon, Labette, Greenwood.

BULBILIS Raf. Am. Month. Mag. 2: 190 (1819). A review of Nuttall's Genera, "18. Sesleria dactyloides must form a peculiar genus by Mr. N.'s own account. It may be called Bulbilis."

B. dactyloides (Nutt.) Raf. in Kuntze, Rev. Gen. Pl. 763 (1891). Sesleria dactyloides, Nutt. Gen. I, 65 (1818). On the open grassy plains of the Missouri. "This species appears on the one hand allied to Atheropogon, and on the other to Dactylis. Though rather a Sesleria than any other genus, it recedes from it in having the valves of the corolla entire at the apex, and thus it approaches Dactylis, at least the D. glomerata." East to Republic, Riley, Cowley, Chase.

MUNROA Torr. Pac. R. R. Rep. 4: 158 (1856). Based on the following species:

M. squarrosa (Nutt.) Torr. l. c. Crypsis squarrosa Nutt. Gen. I, 49 (1818). On the "plains near the Grand Detour of the Missouri, almost exclusively covering the thousands of acres, and as pungent as thorns." East to Barber, Ellsworth, and Rooks.

PHRAGMITES Trin. Fund. Agrost. 134 (1820). "Species: Communis (Arundo phragmites L.), etc."

P. Phragmites Karst. Deutsch. Fl. 379 (1880-1883). Arundo Phragmites L. Spec. 81 (1753). In Europae lacubus fluviis. Pottawatomie, Hamilton.

SIEGLINGIA Bernh. "Syst. Verz. Pfl. Erf. 40 (1800)."

S. pilosa (Buckl.) Scribn., in Litt. Uralepis (Tricuspis) pilosa Buckley, Proc. Acad. Phil. 1862, 94 (1862). Middle Texas. Triodia acuminata Vasey. Special Report No. 63, U. S. Dep. Ag. 1883 (fide Prof. F. L. Scribner). Hamilton, Stanton, Stevens, Gove.

S. purpurea (Walt.) Kuntze. Rev. Gen. 789 (1891). Aira purpurea Walt. Fl. Car. 78 (1788). No locality. Riley, Rooks.

S. sesleroides (Michx.) Scribn. Mem. Torr. Bot. Club, 5: 48 (1894). Poa seslerioides Michx. Fl. Bor. 1: 68 (1803). In regione Illinoensi et in montosis carolinae. West to Rooks and Barton.

REDFIELDIA Vasey. Bull. Torr. Club, 14: 133 (1887). Based upon

R. flexuosa (Thurb.) Vasey, l. c. Graphephorum? flexuosum Thurber, Proc. Acad. Phila., 1863, 78 (1863). (In Gray's Enum. Pl. Parry, and Hall and Harbour.) "Dr. J. M. Bigelow collected this grass several years ago on the Canadian river. It is doubtfully referred to Graphephorum as that genus is defined by Doctor Gray in the Proceedings of the Botanical Society of Canada. But the joints of the rhachis are very short, and the tuft of hairs seems rather to belong to the palea." Seward and Logan.

ERAGROSTIS Beauv. Agrost. 70 (1812). "Spec. Poa cynosuroides? cyperoides? Eragrostis ferruginea, interrupta, pilosa, riparia, verticillata, etc."

E. capillaris (L.) Nees. Agrost. Bras. 505 (1829). Poa capillaris L. Spec. 68 (1753). In Virginia, Canada. Johnson to Cherokee, Greenwood, and McPherson.

E. caroliniana (Spreng.) Scribn. Mem. Torr. Bot. Club, 5: 49 (1894). "Poa caroliniana Spreng. Mant. Fl. Hal. 33 (1807)." Throughout eastern Kansas.

E. curtipedicellata Buckley. Proc. Acad. Phila., 1862, 97 (1862). Northern Texas. Barber county.

E. hypnoides (Lam.) B.S.P. Prel. Cat. N. Y., 69 (1888). Poa hypnoides Lam. Tabl. Encycl. 1: 185 (1791). Ex America Merid. Comm., D. Richard. Riley, Shawnee, Bourbon, Johnson, Republic, Jewell.

E. major Host. "Gram. Austr. 4: 14 (1809)." Briza Eragrostis L. Spec. Pl. 70 (1753). In Europa australi. Common in cultivated soil and waste places.

E. oxylepis Torr. Pac. R. R. Rep. IV, 156 (1856). Poa oxylepis Torr. Marcy's Rep. 288, t. 19 (1852). "Poa (Eragrostis) oxylepis, P. interrupta Nutt., in Trans. Amer. Phil. Soc. (N. Ser.) 5: 146, not of Lam. Wichita mountains; July. A very neat grass. The specimens of Captain Marcy are only about 18 inches high." Poa interrupta Nutt. l. c. (1837). In bushy prairies, near the sandy banks of the Arkansas. Stafford, Barber, Stevens, Stanton.

E. pectinacea spectabilis Gray. Man., Ed. 2, 565 (1856). Poa spectabilis Pursh. Fl. 81 (1814). "In dry barren sand-fields; New York to Carolina. Annual. July, v. v. A beautiful grass; the large panicle is purple, mixed with green stripes." Poa amabilis? Walt. Fl. Car. 80 (1788), not L. "Panicula diffusa virgata ramis nutantibus ramulo uno alterove, spiculis lanceolatis remotis quindecimfloris." West to Rooks and Trego.

E. pilosa Beauv. Agrost. 162 (1812). Roem & Sch., Syst. II, 575 (1817). Poa pilosa L. Spec. 68 (1753). In Italia. Throughout western Kansas.

E. sessilispica Buckl. Proc. Acad. Phila., 1862, 97 (1862). Near Austin, Tex. Seward county.

E. tenuis (Ell.) Steud. Pl. Gram. 273 (1855). Poa tenuis Ell. Sk. I, 156 (1821). From specimens brought from Greenville by Mr. Moulins. West to Barton and Jewell.

EATONIA Raf. "Journ. Phys. 89: 104 (1819)."

E. obtusata Gray. Man., Ed. 2, 558 (1856). Aira obtusata Michx. Fl. I, 62 (1803). In aridis, a Carolina ad Floridam. Common throughout the state.

KOELERIA Pers. Syn. 1: 97 (1805). Includes five species and four varieties, none credited to America.

K. cristata Pers. l. c. Aira cristata L. Spec. 63 (1753). In Angliae, Galliae, Helvetiae siccioribus. Republic, Clay, Riley, Saline, McPherson, Reno, Sedgwick, Cowley.

MELICA L. Spec. 66 (1753); Gen. Pl., Ed. 5: 31 (1754). Includes three species, one, M. altissima, credited to Siberia and Canada.

M. diffusa Pursh. Fl. 77 (1814). In sandy swamps, Virginia and Carolina. Riley and Cherokee.

KORYCARPUS "Zea, Act. Matrit. (1806)."

K. diandrus (Michx.) Kuntze. Rev. Gen. 772 (1891). Festuca diandra Michx. Fl. I, 67 (1803). In sylvis antiquissimis regionem Kentucky, Tennassee, etc. West to Riley and Butler.

UNIOLA L. Spec. 71 (1753); Gen. Pl., Ed. 5: 32 (1754). Includes two species, U. paniculata from Carolina, and U. spicata.

U. latifolia Michx. Fl. I, 70 (1803). In occidentalibus montium Alleghanis. Pottawatomie, Riley, Geary, Wabaunsee, Cherokee, Greenwood, Saline.

DISTICHLIS "Raf. Journ. Phys. 89: 104 (1819)."

D. spicata (L.) Greene. Bull. Calif. Acad. 2: 415 (1887). Uniola spicata L. Spec. 71 (1753). In Americae borealis maritimis. East to Rooks, Stafford, Barber, also Riley.

POA L. Spec. 67 (1753); Gen. Pl., Ed. 5: 31 (1754). Includes seventeen species, three of which are referred to America.

P. annua L. Spec. 68 (1753). In Europa. Pottawatomie, Saline, Douglas, Leavenworth, Cherokee.

P. arida Vasey. Contrib. U. S. Nat. Herb. 1: 270 (1893).

P. andina Nutt., in Wats. King's Exp. 388 (1871), not Trin. Riley, Rooks, Saline.

P. compressa L. Spec. 69 (1753). In Europae et Americae septentrionalis siccis, muris, tectis. Miami, Jackson, Shawnee, Riley, Morris, Seward, Clark.

P. pratensis L. Spec. 67 (1753). In Europae pratis fertilissimis. Commonly escaped from cultivation and naturalized.

P. wolfii Scribn. Bull. Torr. Club, 21: 228 (1894). Riley, Shawnee (in Herb. Popenoe).

PANICULARIA "Fabr. Enum. Pl. Host. Helmst. 373 (1763)."

P. nervata (Willd.) Kuntze. Rev. Gen. 783 (1891). Poa nervata Willd. Spec. I, 389 (1797). In America boreali. Pottawatomie, Riley, Trego.

FESTUCA L. Spec. 73 (1753); Gen. Pl., Ed. 5: 33 (1754). Includes eleven species, none American.

F. elatior L. Spec. 75 (1753). In Europae pratis fertissimis. Frequently escaped in eastern Kansas.

F. nutans Willd. Enum. I, 116 (1809). In America boreali. Shawnee, Riley, Pawnee.

F. octoflora Walt. Fl. Car. 81 (1788). "Panicula erecta, spiculis octofloris acuminatis." No locality. Throughout the state.

F. shortii Kunth, in Wood's Class-book, 794 (1861). "(F. shortii Kunth, when the grass is stouter and the spikelets about 5-flowered,)" after description of F. nutans. Johnson, Riley.

BROMUS L. Spec. 76 (1753); Gen. Pl., Ed. 5: 33 (1754). Includes eleven species, two American.

B. ciliatus L. Spec. 76, No. 4 (1753). In Canada; ex semine D. Kalm. Ottawa, Sumner, Riley, Pottawatomie.

B. hordeaceus L. Spec. 77 (1753). In Europae collibus aridissimis sabulosis. Riley county.

B. purgans L. Spec. 76, No. 3 (1753). In Canada. Wyandotte, Doniphan, Riley, Greenwood, Rooks.

B. secalinus L. Spec. 76 (1753). In Europae agris secalinis arenosis. A common weed.

LOLIUM L. Spec. 83 (1753); Gen. Pl., Ed. 5: 36 (1754). Includes the two following species.

L. perenne L. Spec. 83 (1753). In Europa. Republic and Douglas.

L. temulentum L. Spec. 83 (1753). In Europae agris inter Hordeum, Linum. Neosho county.

AGROPYRON "J. Gaertn. Nov. Comm. Petrop. 14, Part 1, 539 (1770)."

A. caninum unilaterale (Cassidy) Vasey. Contr. Nat. Herb. 1: 279 (1893).

A. unilaterale Cassidy. Bull. Colorado Exper. Sta. 12: 63 (1890). This species grows in stout tufts along the banks of streams at from 7,000 to 8,000 feet. Hamilton.

A. repens (L.) Beauv. Agrost. 102 (1812). Refers Triticum repens to this genus and in the index, p. 146, places repens under Agropyron. Triticum repens L. Spec. 86 (1753). In Europae cultis. McPherson, Wabaunsee, Wallace.

A. repens glaucum ("Desf.") Scribn. Mem. Torr. Bot. Club, 5: 57 (1894). Triticum glaucum Desf. Tabl. Bot. Mus. 16 (1804) will not hold for citation, for it is a nomen nudum. I am unable to determine with any certainty the name to be used for this form. Common throughout the state.

A. tenerum Vasey. Bot. Gaz. 10: 258 (1885). "Common throughout the Rocky mountains." Collected in Hamilton by Mr. C. H. Thompson. There is no specimen in the college herbarium, the only specimen gathered being in the herbarium of the U. S. Dept. Agriculture.

HORDEUM L. Spec. 84 (1753); Gen. Pl., Ed. 5: 37 (1754). Includes six species, one, H. jubatum, from Canada.

H. jubatum L. Spec. 85 (1753). In Canada. Common in waste places.

H. pusillum Nutt. Gen. 87 (1818). On the arid and saline plains of the Missouri. Common.

ELYMUS L. Spec. 83 (1753); Gen. Pl., Ed. 5: 36 (1754). Includes five species, two from America.

E. canadensis L. Spec. 83 (1753). In Canada. Common.

E. canadensis glaucifolius (Muhl.) Torr. Fl. U. S. 1: 137 (1823).

E. glaucifolius Muhl. in Willd., Enum. 131 (1809). In Pennsylvania. Common.

E. elymoides (Raf.) Swezey. Cat. Neb. Pl. 15 (1891). Sitanion elymoides "Raf. Journ. Phys. 89: 103 (1819)." East to Republic, Ellis, Barber.

E. striatus Willd. Spec. 1: 470 (1797). In America boreali. Pottawatomie, Geary, Riley, Shawnee, Greenwood, Barber, Rush, Hamilton.

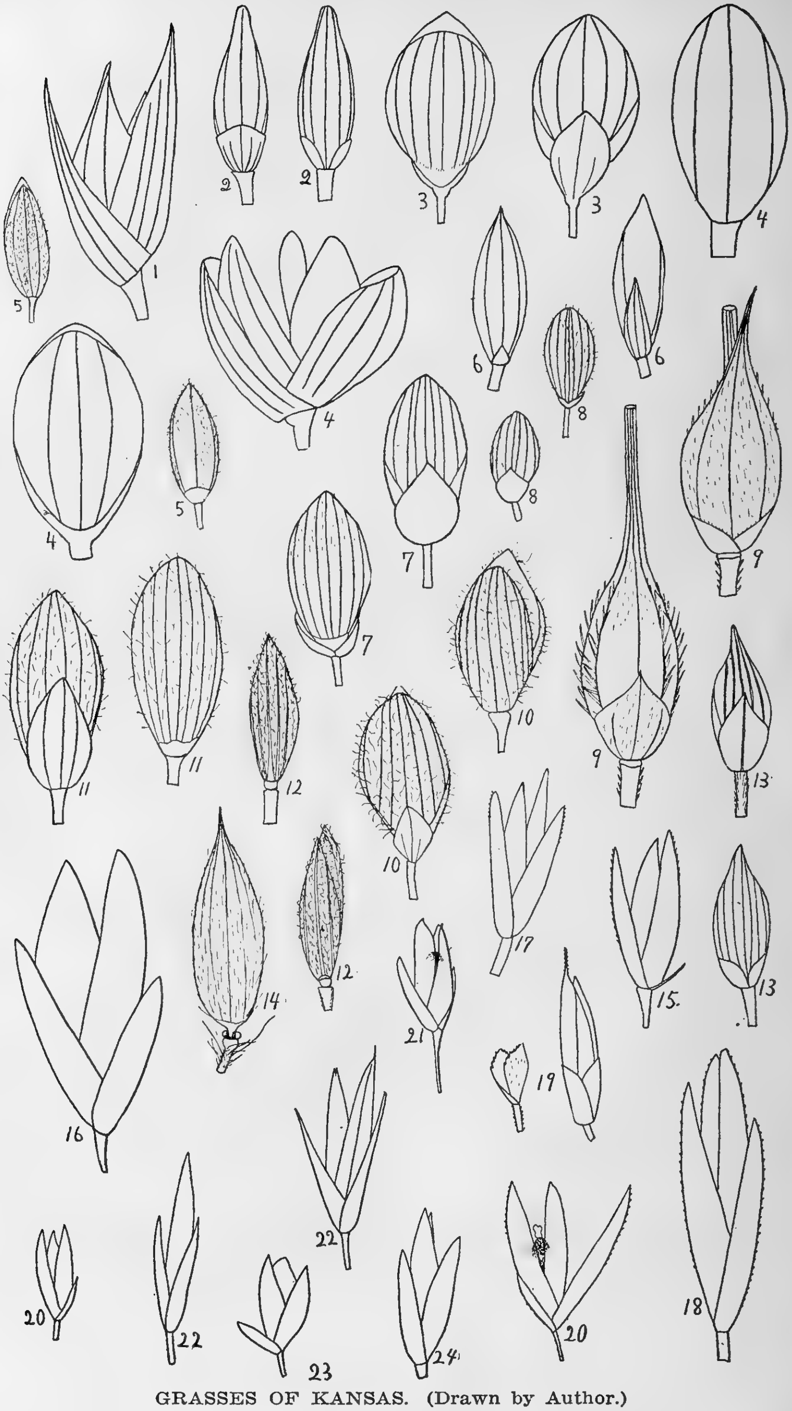
E. virginicus L. Spec. 84 (1753). In Virginia. West to Norton, Trego, Ness.

HYSTRIX Moench. Meth. 294 (1794). Founded on the following species: H. patula Moench.

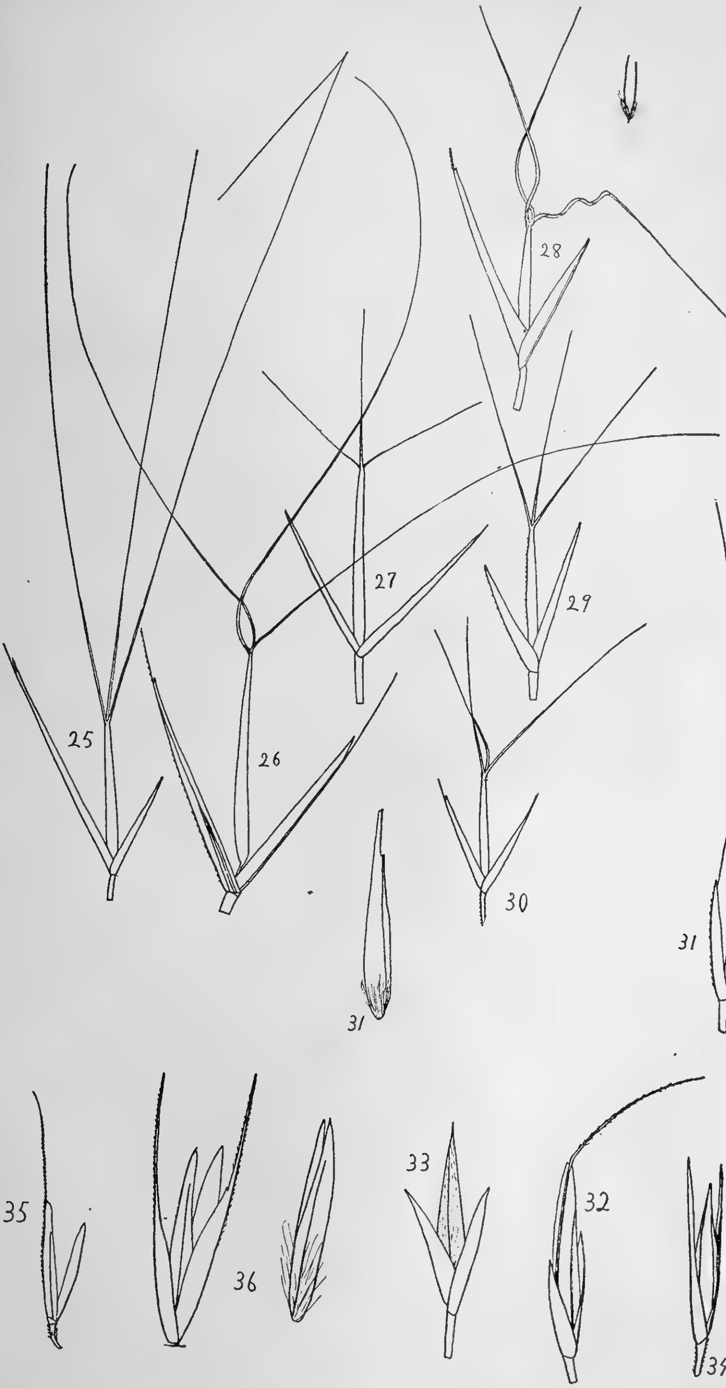
H. hystrix (L.) Millspaugh. Fl. W. Va. 474 (1892). Elymus hystrix L. Spec. 560 (1753). Locality not known. (Under Addenda, "pag. 84.") Wyandotte.

DESCRIPTION OF PLATES.

Fig. 1. Panicum virgatum x 8.
2. Panicum proliferum x 8. Two views.
3. Panicum scoparium x 8. Two views.
4. Panicum obtusum x 8. Three views.
5. Panicum lineare x 8. Two views.
6. Panicum sanguinale x 8. Two views.
7. Panicum depauperatum x 8. Two views.
8. Panicum dichotomum x 8. Two views.
9. Panicum crus-galli x 8. Two views, with base of awn.
10. Panicum clandestinum x 8. Two views.
11. Panicum waltheri x 8. Two views.
12. Panicum autumnale (var. pubiflorum) x 8. Two views.
13. Panicum capillare x 8. Two views.
14. Eriochloa punctata x 8.
15. Sporobolus texanus x 8.
16. Sporobolus asper x 8.
17. Sporobolus minor x 8.
18. Sporobolus pilosus x 8. Type specimen kindly loaned by Mr. Coville.
19. Sporobolus depauperatus x 8. Spikelet and glumes.
20. Sporobolus cryptandrus x 8. Two specimens.
21. Sporobolus asperifolius x 8.
22. Sporobolus brevifolius x 8. Two specimens.
23. Sporobolus arioides x 8.
24. Sporobolus vaginæflorus x 8.
25. Aristida fasciculata (purpurea) x 2.
26. Aristida oligantha x 2.
27. Aristida humboldtiana x 2,
28. Aristida basiramea x 2. Spikelet and callus.
29. Aristida dispersa x 2.
30. Aristida purpurascens x 2.
31. Muhlenbergia sylvatica x 8. Spikelet and flowering glume.
32. Muhlenbergia gracillima x 8.
33. Muhlenbergia sobolifera x 8.
34. Muhlenbergia mexicana x 8.
35. Muhlenbergia minutiflorum x 8.
36. Muhlenbergia racemosa x 8. Spikelet and flowering glume.



GRASSES OF KANSAS. (Drawn by Author.)



GRASSES OF KANSAS. (Drawn by Author.)

FERNS OF WYANDOTTE COUNTY.

By MINNIE REED, Argentine.

During my three years in Wyandotte county I have made many botanical excursions, and have always found some ferns. Indeed, ferns are very abundant on the eastern boundary of Kansas, especially on the wooded hills and bluffs near the Kansas and Missouri rivers.

One can soon gather an armful of beautiful fronds of either the Cystopteris fragilis or Adiantum pedatum in their favorite haunts in this vicinity.

The most common fern in Wyandotte county is Cystopteris fragilis, or dainty fern, as it is commonly termed. It grows upon every hillside and in every shaded ravine in the greatest luxuriance. I have often seen fronds of this species from 12 to 18 inches high and in dense masses of considerable area. It loves the wooded hillsides, especially the northern slopes, but it is found on every hillside, even on the southern slopes, where the soil is mellow and the leaf mold deep; yet it clings in the rocky crevices where there is but little soil of any kind.

This fern is well named Cystopteris fragilis, as it is very delicate in appearance, and for that reason is so much admired. Its dainty fronds furnish just the right green for cut oflwers, and as it bears transplanting well it is often cultivated in the garden.

Cystopteris bulbifera is not so abundant; is, in fact, somewhat rare. I have found but a few specimens that I was sure were this species. When the bulblets are present on the fronds there can be no doubt, but in other ways it resembles fragilis, and they are often found growing together; so for this reason are occasionally confused.

Adiantum pedatum, maidenhair fern, is perhaps next in abundance to Cystopteris fragilis, though not nearly so common. However, one very frequently finds a large mass of these graceful fronds. It is usually found in very shady, damp places, as the rocky ledges of deep ravines, or the north side of heavily wooded cliffs along a stream, and occasionally in an open glade of the woods. This species often grows 12 or 18 inches high, with fine large fronds spreading 12 to 15 inches.

Pellaea atropurpurea, or leather fern, is found upon the bare limestone or red boulders on eastern or northern bluffs or hillsides. It is usually shaded, but sometimes entirely exposed. It grows close and flat upon the rocks or in the crevices. The fronds are from three to eight inches long, but it is so dry and dull looking that it is not very handsome in appearance, so is not much sought after by amateurs, yet it is of course just as interesting to the botanist.

Camptosorus rhizophyllus, or walking fern, is less common than any of those previously mentioned. I know of but two localities where this species is found, and they are near Argentine. The specimens that I have in my collection vary from two to four inches in height. This species also clings to the rocky ledges of shady bluffs, usually on the east or north side.

Onoclea sensibilis (oak leaf fern), is also somewhat rare in this region, but I have been fortunate enough to find this beautiful fern in two localities, where I collected fronds from 12 to 15 inches high. It loves deep shady ravines, or heavy woods where the leaf mold is moist and deep. It is easily cultivated, and I wonder that it is not more often seen in gardens, as it is a very beautiful plant.

Botrychium virginica, or the grape fern, is found occasionally scattered through the woods, but it is not abundant. It seldom occurs in groups, but almost always the plants are solitary, or at most three or four plants grow near together. Specimens vary in height from 6 to 12 inches, and have but the one frond.

Notholaena dealbata, or the little silver fern, is the daintiest and the most beautiful of all our Kansas ferns. Its delicately cut leaves shine like silver on the lower surface, and are a pale ashen green above. Its fronds are from two to six inches high, but it is seldom six inches in height, being more often two to four. This fern is enthusiastically admired by all who are fortunate enough to discover the shy little fugitive. I know of but one place where it grows, and that is a bleak northern limestone cliff between Kansas City and Argentine.

All of the above-mentioned species have been collected in the vicinity of Argentine, though I have also collected most of them on my excursions further out in the county back from the river.

KANSAS MOSSES.

By Miss MINNIE REED.

The special study of *Musci*, as well as other Cryptogams, is of comparatively recent date, as scarcely anything was known of their anatomy, reproductive organs, or life history, until near the end of the last century.

This, the nineteenth, century is an age of specialists, who, during the last 25 years have made wonderful discoveries by their careful and thorough investigations. As a result of this specialization, all the sciences have made marvelous progress.

One man no longer tries to master the whole of natural history, nor even the whole of botany; but taking a single order or group, he devotes most of his time to it, until he understands its entire life history, with all its variations and affinities; and he becomes an authority upon that subject. Thus we have bryologists, or moss specialists; mycologists, or fungi specialists, etc.

The ancients scarcely noticed mosses, while none were distinguished individually from the general group Muscinae, except one about which there was a popular superstition. This moss was known as Muscus crani humani, or moss of the human skull; and was supposed by the old herbalists to be a certain cure for any disease of the head.

At this time plants of all kinds were only studied for their medicinal virtues, all other considerations being deemed unimportant.

For a long time mosses were confused with lichens and algae; even after they had been studied specially. Such forms as the ordinary brown sea weed (Fucoidae) and the so-called Irish moss (another alga), with many of the lichens that resemble mosses, were for a long time classed with Muscineae.

Before the sexual organs of mosses were discovered, many quaint ideas about their reproduction were held, even by the leading botanists.

Linnaeus had an entirely erroneous idea of these organs, and reversed the sexes; supposing the capsule containing the spores contained instead, the the pollen for fertilization; and that the antheridia, or real male organs, bore the seeds.

The first work written about mosses alone, was published in 1741, and called "Muscorum Dillenius." It contained many excellent engravings, though there were some lichens and algae included, because of their external resemblance.

Some writers credit Micheli with being the first to understand the structure of mosses, and make the drawings of their reproductive organs. These were made in 1729, over 50 years before Johannes Hedwig, the father of bryology, published his great book on Musci. There is reason to believe that Hedwig was really the first to fully understand the sexual organs, and distinguish the two kinds; and it is certain that his was the first great book on Musci. His work was very carefully done, and his identifications of both species and genera were very correct; so that many mosses still bear his name.

Bridel came soon after Hedwig, with his "Bryologia Universalis", and other books on Musci. He, too, was an authority, a keen observer, and discovered and described several new species.

Unger observed the spermatozoids as early as 1837; and Hofmeister in

1849 first propounded and explained the alternation of generation in his splendid book, "Die Entschung des Embryos der Phanerogamen", showing the whole course of development of Muscineae and vascular cryptogams; and the true relation between the asexually-produced spore, and the sexually-produced embryo or sporophore, as well as the genetic relation of Cryptogams and Phanerogams.

After these men came Prof. W. P. Schimper, also a German, who was, in his day, the greatest living authority on Music. His greatest work, "Bryologia Europaea", is a standard work of great value, adding very much to the knowledge of bryology.

Mueller, Hampe and Lindberg were all well-known bryologists and also Germans.

Of the English bryologists, the most prominent are: Wilson, now dead, Mitten and Doctor Braithwaite, who are still living and working. Doctor Braithwaite has just published a valuable book called "Handbook of English Mosses", which is very clear, concise, and accurate.

Renauld and Cardot are two French bryologists still working, who have identified and named most of the Kansas mosses thus far reported.

The first work on mosses in America was done by Doctor Muhlenberg, a Lutheran minister of Lancaster, Penn., who published a catalogue of over 170 species; principally named by Hedwig and Beauvois.

Later came Sullivant, who published his first edition of 205 species of mosses, and later, in the year 1856, the second edition, containing 410 species.

James and Lesquereux began their "Manual of North American Mosses"; but before it was completed James died (1882), so that Lesquereux finished it in 1884, with some aid from Watson, Renauld, and others. This manual describes 128 genera, and nearly 900 species; but only the northern and eastern states were thoroughly represented, as but little collecting had as yet been done beyond the Mississippi river, or in the gulf states.

There are a number of active bryologists in the United States now, though most of them are comparatively young. Of these older ones, Macoun, Eugene Rau and D. C. Eaton are best known, while of the younger ones, Mrs. E. G. Britton and C. R. Barnes are most prominent. Mrs. Britton is now writing a "Handbook of Mosses of Northeast America", which will be a very valuable addition to American bryology. This will be published soon, we hope.

Next in importance comes C. R. Barnes's "Artificial Key to North American Mosses", published in 1890. This is a very great help in identifying mosses, in connection with Lesquereux and James's Manual, making the latter twice as clear, and hence more valuable.

Recent additions to North American mosses have increased the number to something over 1,000 species; and still but little territory has been studied.

Kansas, like most of the western states, has had but little work done on her mosses. In 1884, the first list of Kansas mosses was published in the "Washburn College Bulletin", edited by Prof. F. W. Cragin. The collecting was done by Professor Cragin's students chiefly, while the specimens were sent to Eugene Rau for determination.

This list contained but 12 species, all from the immediate vicinity of Topeka. Additional species were reported from time to time, and the lists published in the "Washburn College Laboratory Bulletin", giving new localities for mosses previously reported, until the fourth and last list was published in 1886, numbering 53 species in all. These last lists included collections from various counties over the state, many specimens being collected in

Saline county, by Dr. Joseph Henry, who, though only an amateur and over 70 years old, was nevertheless an enthusiastic collector. He died in October, 1887. Renauld and Cardot determined Dr. Joseph Henry's collection of Saline county mosses, which extended through more than three years of careful work, and was published with Cragin's last list in the Botanical Gazette, vol. XVII, p. 81. There were 40 species added to the old list, making 93 species in all (besides eight varieties) reported from Kansas in 1892.

I find that with the addition of the mosses published in Smyth's Check-list last year, with the 30 additional species which I have collected, not previously reported from Kansas (besides one entirely new species), that we have a list of 165 species. This list will probably be increased when the remainder of my material has been identified. Most of my specimens were collected in the eastern third of the state. The larger part of the collecting has been done in Wyandotte, Riley, and Pottawatomie counties, with a few specimens from Bourbon county, collected by Rev. John Bennett; from Franklin county, by Grace R. Meeker; from Shawnee county, by J. W. Beede and B. B. Smyth; from Atchison county, by E. B. Knerr, and a few from Wilson county, collected by Frank McClung; I also have one specimen from Rooks county, sent by E. Bartholomew, and a few from Trego, Greeley, and Anderson counties, collected by myself. The kindly assistance of the above collectors has aided me very much in securing material for study and comparison.

Bryophytes, or mosses, rank fourth in the subdivisions of the vegetable kingdom, coming just above Fungi and below Pteridophytes, the vascular Cryptogams or ferns. The Bryophytes include two orders: the Hepaticae, or liverwort mosses, and Muscineae, or true mosses. The order Muscineae is characterized by two generations—sexual and asexual. The sexual generation contains abundant chlorophyl, and is the direct growth of the spore, or in mosses preceded by the more simple protonema, which, though chlorophyllose, does not bear the sexual organs, but produces buds for the leafy plant or stem, which leafy stem constitutes the moss plant proper, producing the sexual organs.

The female sexual organ, when fertilized, produces the sporophore, or asexual generation; which is very different from the sexual generation, and produces nothing but spores. This sporogonium, produced from the fertilized oospore of the female flower, is not organically connected with the first generation, but obtains its nourishment from it by absorption, its base being firmly embedded in the tissue at the apex of the stem. This sporocarp finally completes its growth, and develops the spores, ready to germinate and again produce the sexual generation, thus completing the cycle of growth.

The spores of mosses vary in size from one-fifth to 1-500 mm. in diameter; the very minute mosses often having the largest spores; there only being a few in each capsule, as in Ephemerum, Micromitrium, and others, while many of the larger species have the capsule filled with many very fine spores, as in Hypnum, Cylindrothecium, and others. See plates.

The size and surface-markings of the spore are often distinguishing characteristics between species and genera.

The color of spores varies from a dark reddish brown to a light greenish yellow, or almost hyaline, but the usual color is brown.

The surface may be smooth, papillose, verruculose, or slightly irregular. (See plates.)

The shape also varies from spherical to an irregular globoid or angular, the spherical being most common. (See plates.)

The contents of the spore consist of chlorophyl, starch granules, oil globules, mucus, and protoplasm. The spores of some species contain more oil than others, and some are considerably more dense than others.

The outer, thicker coat of the spore (primordial utricle, or moth cell) is termed the exospore, and consists of differentiated protoplasm somewhat similar to cellulose. It is thicker in some species than others. The inner part or contents of the spore is called the endospore.

Spores when placed under favorable conditions, with moisture and warmth, will germinate readily. First the exospore bursts and the endospore protrudes and begins to divide, continuing the division and growth until the long threads form the dense felt-like mat, resembling the light green filaments of conferva, and forming a green film over rocks and walls.

These green threads are termed the protonema, and correspond to the prothallium of ferns. This is the first stage of the development of the sexual generation, from the asexual spore. The long threads elongate by apical growth, forming oblique septa and long cells; and giving rise to branches just back of the septa. The septa are always inclined at different angles, usually in three ways.

The opposite side of the endospore sends out hyaline rhizoids, also obliquely septate, which soon becomes brown. These penetrate the soil and absorb nourishment; thus the protonema develops chlorophyl and supports itself by assimilation. It soon forms leafy buds behind or below the septa or node; the rhizoids develop below, firmly fixing it to the soil, where it soon grows into the leafy axis, or what is ordinarily termed a moss, which is the perfect stage of the sexual generation. (See plates 35 and 36.)

The size and persistence of the protonema varies greatly in different groups of mosses, it being very small in some species (less than a centimeter), while in others it grows quite large, covering several centimeters with its filaments, which live for some time, but it usually disappears when the leafy axis is developed. In very minute mosses that live but a short time, the protonema grows vigorously, so that all stages of development may be present on one individual, and genetically connected, as in Ephemerum, Micromitrium, and others. (See plates.)

The Sphagnaceae, Andreaeaceae and Tetraphidae differ from the typical mosses in the structure of the sporogonia and in the formation of the protonema. The Sphagnaceae, when growing on a firm substratum, expand into a flat plate of tissue, which branches at the margin, producing the leafy stem from its upper surface.

In Andreaea, according to Kuhn, the contents of the spore divide while still within the closed exospore into four cells, forming a tissue similar to that produced in the spores of some Hepaticae, as Radula and Frullania, and finally from one to two peripheral cells grow into filaments which extend over the sub-stratum. (See "Sach's Text-book of Botany," pp. 361-363, and "Goeble's Special Morphology," pp. 163-166.)

Thus the protonema may develop in three ways, as above described. Protonema may also be produced in numerous other ways, besides germinating from spores, of which further detail will be given later.

The rhizoids, or roots, are of three different kinds, the radical rhizoids, by which the plant absorbs nourishment from the soil, protonemal rhizoids serving the same purpose to the protonema, and lastly adventitious roots on the stem and branches, termed tomentum; which are used for clinging and absorbing moisture—chiefly the latter—and often forming a thick felt on stem and branches, as in Bartramia and Dicranum. (See plates.)

The color of the rhizoids varies from a light brown to a dark purple, the brown being most common. In the cellular structure of all three forms the cells are separated by oblique septa.

In the Sphagnaceae very few small rhizoids are to be found. There is a very close relationship between rhizoids and protonema threads, as each may develop into the other. The rhizoids are hyaline when first formed, but as they enter the soil they become brownish and contain oil drops and considerable protoplasm.

The buds of the protonema develop into the stem or leaf-bearing axis. In the simpler mosses, there is no differentiation in the stem tissue, except that three or four layers of cells are closer and firmer, with an inner axis of fundamental tissue, having larger, thinner-walled cells, as Gymnostomum glaucum, Hedwigia ciliata, and Hylacomium splendens. In others, more highly developed, there is besides, also, an axial bundle of very thin-walled and very narrow cells, and a central bundle or cylinder, as in Grimmia, Funaria, Bartramia, Mnium, Bryum, and many others. The cell walls of the central bundle are thickened perceptibly only in Polytrichum, Atrichum, and Dawsonia. Thus we have all the gradations, from scarcely a suggestion of a vascular system to signs of medullary rays in the most highly developed mosses, which is similar to that of some of the lowest vascular plants. (See "Sach's Botany," p. 365, and "Goeble's Special Morphology," p. 167).

The form of the stem ranges from very short and simple (less than one millimeter in length), as in Phascum and Buxbaumia, to large branched plants, from three to five decimeters long, as in various Hypnum, Polytrichum, Sphagnum, and others.

The diameter of the stem varies from one-tenth millimeter to one millimeter, and is always firm and elastic.

The manner of branching is very characteristic, as it may be dendroid or tree-like, simply or compoundly pinnate, fastigiately or irregularly branched, and either erect or creeping. Again the branching may be complanate or flattened so that the branches and leaves are all in one plane (in this case being usually creeping), or the plants may be pulvinate or closely compact and cushion-like, or simply a tangled mat. In a few cases the plants occur singly, as in Funaria and others.

The color of the stem may be either brownish, yellowish, or more often green and chlorophyllose; and the surface may be either rough and scaly or smooth and shining. The plants are either annual, as in Phascum and others, or perennial, as in Sphagnum, Polytrichum, etc.

Mosses bearing fruit on the apex of the stem belong to the Acrocarpi, while those bearing their fruit laterally belong to the Pleurocarpi. The acrocarpous mosses send out a branch each year, at the apex, just beneath the base of the seta, producing a continuation of the stem called an innovation. The pleurocarpous mosses send out true branches, and have symmetric stems.

The leaves of mosses are always simple, sessile, and arranged in two or more rows, according to the position of the successive segments. If they are arranged in two rows and flattened, they are said to be complanate, as in Fissidens (see plate IV), or they may be in three rows, as in Fontinalis; but in most mosses the leaves are arranged in spirals. The phyllotaxy varies from two-fifths to three-eighths, as in Sphagnum, Andreaea, and Polytrichum.

The leaves may be erect or spreading, turned back, reflexed, curved like a scythe, or falcate, and again turned to one side or secund.

The leaves in some species are large and broad (one-half centimeter long in Mnium and Fissidens), (see plates IV and XXI), or very minute (1 mm.) as in the pseudopodium of Tetraphis, and Aulocomnium.

In some species there are two sizes of leaves, a row of larger leaves on one side of the stem, and a row of smaller leaves on the other, as in Hypopterygium, Rachopilum, and Cyathoparum. Other species have their leaves larger and closer at the apex, termed rosulate, while they gradually grow smaller, until they become scale-like at the base of the stem, as in Funaria, Dicranella, Leptobryum, and others. The leaves may be very close, erect, and overlap, termed imbricate, as in some species of Leucobryum, Thelia, Leskea, and others (see plates V, XI, XXIV, and XXVIII); or the leaves may be very distant, as in Webera albicans, Bryum argenteum, and others (see plates XVIII and XIX). The leaves surrounding the floral organs usually differ from those of the stem in size, shape, color and position, being often crowded into a rosette, as in Mnium, Polytrichum, and others. Some leaves have stipular appendages at the base, called paraphyllia, which are thread-like and chlorophyllose, and probably aid in assimilation. Paraphyllia occur in many Hypna, and serve as distinguishing characteristics between its many subgenera. (See plate XXXIII.)

The leaves of mosses differ less in shape than in phanerogams, though there is considerable variation. They are usually ovate-lanceolate, varying to orbicular, and subulate or awl-shaped.

The base is often decurrent, auricled, or cordate, while the entire leaf may be recurved, very concave, or even carinate. (See plates XXVI, XXIX, XXVIII, and XXXI.)

The apex varies from broadly obtuse to long apiculate, hair- or awn-pointed, and occasionally emarginate, while the two edges of the upper half may be folded together, making it carinate; or the edges may be rolled in towards the center, making it involute, or even tubular.

The edges may be entire, serrulate, dentate, hispid, plane, revolute, involute, crenulate, or wavy; while the border cells may be of different size, shape, color, or thickness. (See plates.) The surface may be smooth on both sides, papillose on one side only, or on both, and hispid or hairy. When only one side is smooth, it is usually the upper. All these differences of arrangement, form, size, margin, nad surface of the leaves are used in identification. All the species blend into each other, making the intermediate forms very difficult to distinguish, even when closely studied with a microscope.

The leaves are sometimes ribbed or costate, and some are ecostate or nerveless; while still others are bicostate, having two rudimentary nerves. The costa may extend beyond the apex into an awn point, when it is called excurrent. If the costa extends only to the tip of the leaf, then it is percurrent, or it may end in the middle of the leaf.

The costa or nerve may be wide or narrow, thick or thin, round or flat, smooth or hispid, or spinulose. It may also vary in color from green to brown, or even purplish. In many species the costa is the distinguishing feature. (See plates.)

A peculiar form of leaf occurs in the genus Fissidens, in which the leaf seems to be vertical, and to have two laminae for part of its length. The split, or seemingly double part, is the true leaf; but the nerve or costa has developed a lamina both on the upper and lower surfaces; which extend beyond the true leaf more than its entire length, and faces horizontally. (See plate IV.)

In Polytrichum and Orthotrichum the nerves are made up of several erect lamellae on the upper surface, and vary in number from two to eight. These lamellae also vary in their height from 4 to 13 cells high, in some species.

The leaves of most mosses are but one layer of cells in thickness; some are two or even three layers thick; while the shape, size, and arrangement of the cells, termed the areolation, varies widely in different families, constituting a basis of classification used by all modern bryologists.

The shape and size of the cells may vary from minute hexagonal or rectangular to large hexagonal or rectangular, rhomboidal, or very long linear, flexuous, or vermicular, according as the areolation is dense or loose. Sometimes the cells are very densely chlorophyllose, as in Atrichum, Timmia, etc.; or the cells may contain but few large chlorophyl grains, as in Mnium, Bryum, and others; again others are without any chlorophyl (hyaline), as in Leucobryum and Sphagnum, having then a whitish appearance. (See plate V.) The basal cells very frequently differ from the upper cells, either in size, shape, color, or in being hyaline, when the upper cells are chlorophyllose, or the reverse. This variation of the basal cells is often used as a specific distinction, and Schimper uses this feature, especially in the genus Dicranum, dividing it into two sections.

When the ends of the cells are rectangular, they are termed parenchymatous, as in some of the Hypna. (See plate XXIV.) When elongated, and pointed or rhombic, the aerolation is prosenchymatous, as in Bryum, and some Hypna. (See plates XXX and XXXII.) Sometimes the walls are very much thickened, producing only a point or dot, as in Grimmiaceae.

Reproduction is accomplished both sexually and asexually. The asexual reproduction is accomplished in many ways; but in almost every case a new plant is preceded by a protonema. In some mosses the leafy buds, becoming detached, or the leafy branches broken from the stem, grow immediately into new plants upon striking the soil; as in Conomitrium julianum, and Cinclodotus aquaticus. A single protonema may produce many plants; or single cells of the protonema may become globular, separate from one another, and lie dormant until next season, as in Funaria hygrometrica, each then growing into a new protonema. The rhizoids, either the aërial or subterranean, may change directly to protonemal threads, as in Bryum, Mnium, Barbula, etc.; or by first forming tubercles containing stored food material, which remain dormant until exposed to light, heat, and moisture, when they develop into protonema, as in Barbula muralis, Funaria hygrometrica, Grimmia pulvinata, Trichostomum rigidum, and Atrichum. (See plates XIV and XXII; see also in Goeble, p. 172.) The aërial rhizoids may produce protonema, with chlorophyl in their cells, and leaf buds directly; and Schimper says the annual male plants are produced in this way by the perennial patches of female plants of Dicranum undulatum, thus accomplishing their fertilization. The cells of leaves may produce protonema by growing out into tubes which become segmented into propagula, as in Orthotrichum lyelli, O. obtusifolium, etc. Club-shaped penicillate tufts of protonema, with short cells, grow on the tips of the leaves of Orthotrichum phyllanthum, Grimmia trichophylla, Syrrhopodon, and Calymperes. Protonema may grow from some leaf tips, from the marginal cells of leaves, as in Buxbaumia aphylla, or from the tips of fertile plants, as in Leucobryum vulgare. The setae or cell walls of the capsule will produce protonema, and also the inner surface of the calyptra of Conomitrium julianum.

Gemmae as well as spores produce new protonema, hence new plants. The gemmae are little spherical cellular bodies containing chlorophyl, which are produced either on the leaves or stem. Aulacomnium androgynum and Tetraphis pellucida bear gemmæ upon the top of prolonged leafless branches, in a delicate cup formed by a few modified leaves. (See plate XXXVI.) There are no plants so well supplied with purely vegetative means of reproduction as the mosses; some never bear fruit; hence these provisions of nature to insure reproduction.

There is no doubt of the existence of sexual organs in mosses. The two organs of reproduction are now well understood.

Just as in Phanerogams the flowers of mosses occur in three forms. The male and female organs may occur in the same flowers, then it is synoecious; or the two organs may be in separate flowers on the same plant, when it is termed monoecious; but if on different plants it is dioecious. Of the synoecious mosses, Mnium cuspidatum and some Brya are examples; of the monoecious species, Atrichum, Polytrichum, and some Hypna, are good examples; while of the dioecious mosses, such common species as Funaria hygrometrica, some Brya and Hypna are examples. The most remarkable example of dioecious moss is found in Fissidens grandifrons; the male plant only being found in Europe, and the female plants only found in America; consequently it is always sterile. Sometimes the male flowers are on smaller, shorter lived plants, as Funaria hygrometrica or Dicranum undulatum, etc. (See plate XIV.)

In the species that are synoecious, all the plants look much like the female plants, but the male plants are usually quite different in appearance from either the female or synoecious plants.

When the plants are synoecious, both organs are in the same receptacle or perichaetium together, or they are separated by special leaves of the perichaetium, arranged in a spiral in the axis of the leaves surrounding the archegonia which are in the center. The female flower usually appears as a long almost closed bud; while the male flower is shorter and more blunt.

The male flowers are borne either terminally or laterally. When terminal the antheridia or male organs are surrounded by leaves variously modified and colored, termed the perigonium. The leaves of the male flower are usually shorter and more blunt than those of the female flower. In some species the lower perigonial leaves form a cup-like receptacle, colored red or orange; inclosing the inner leaves and antheridia, as in Polytrichum, Atrichum, and Pogonatum. (See plate XXII.) Sometimes they are bud-like or gemmiform, and the outer leaves colored red or green. These are always lateral; growing out of the axils of the leaves, as in Hypnum and Cylindrothecium; while in some species they have no perigonium but the leaf from whose axis they grow; and still others grow on a naked stalk, or prolonged stem, as in Tayloria and Splachnum. The perigonium consists of very small modified leaves, which grow smaller and more delicate, as they near the center, and vary in number in different species.

In both male and female flowers, many small filiform bodies, called paraphyses, grow up and help to protect the delicate antheridia and archegonia. In male flowers sometimes the paraphyses are club shaped, but they are always filiform in the female flower. (See plates XIV & XX.) The antheridium is a club-shaped or globose body covered by an outside layer, one cell in thickness, inclosing many free cells within. This outer membrane is chlorophyllose and green until the antheridium ripens; when it changes to a red, brown, or yellowish color. It opens at the apex and bursts the membrane, as in Sphagnum. (See in Goeble's, p. 175, and in Sach's Botany, p. 371.) The spermatozoids are analagous to pollen, hence the name antheridium for the organ containing them. The spermatozoids are also club-shaped bodies, spirally twisted, the pointed anterior end being furnished with two long delicate cilia, which serve as motile organs by vibrating rapidly. Thus they move about swiftly, as soon as freed from the antheridium; though they must always have water in which to float into the open archegonia, and for this reason the antheridia never bursts when dry; the antheridia and spermatozoids are best studied in Polytrichum, where they are comparatively large. (See plate XXII.)

The origin of the antheridium is not uniform, but differs in different species. In Sphagum it originates in the place of a new shoot, while in Fontinalis and most other mosses the origin varies: even being different in the same flower: (see "Goeble's Special Morphology," p. 175, and "Sach's Text-Book of Botany," p. 372.)

The female flower is inclosed in leaves called the perichaetium or perigynum. These leaves also are often much modified, becoming hyaline, delicately membranous, or much elongated into a hairlike point, in some species, while the base becomes sheathing or involute. The perichaetial leaves are usually larger, longer, and more pointed than the perigonial leaves.

The archegonia or female organs, which are analogous to the pistil of a flower, are flask-shaped bodies on a short, thick stalk or seta. The thick part or ventral portion resting on the seta is termed the venter or germen, and incloses the germinal cell or oöspore. The upper slender neck is usually twisted on its axis, and is called the neck or stylidium. The venter wall, before fertilization, is two cells in thickness, and extends up into the neck, which is only one cell thick. This neck or stylidium consists of four or six rows of cells inclosing a central row of cells, termed the canal cells. These canal cells become mucilaginous when the archegonium is mature and receptive; and swell, forcing apart the upper cells, making an open canal down to the oöspore, through which the spermatozoids enter for fertilization. The spermatozoids, as soon as they escape from the antheridium into the water surrounding them, move very rapidly until finding an open archegonium, which they enter, passing down the canal to the oöspore. Schimper and others have seen the spermatozoids in the canal. Usually but one archegonium in a flower is fertilized or develops; but in a few mosses several are matured from the same flower, as in Climacium dendroides, and others. (See plates.)

The origin of the archegonium varies as much as the antheridium; and in Sphagnum it originates at the apex of the female shoot; and also in the typical mosses (see Goeble's Special Morphology, p. 176, and Sach's Botany, p. 375). As the fertilized archegonium grows, the inner leaves of the perichaetium grow larger, forming a sheath around the base of the seta, as in Dicranum, Mnium, and others.

The fertilized oöspore now begins to grow down into the tissue of the apex of the stem, firmly imbedding itself; while it also grows upward, forming a seta or stalk, which bears the capsule or theca inclosing the spores.

The oöspore, in growing upward, tears away the upper part of the archegonium, carrying it upward, where it usually remains attached, forming the calyptra or veil; while the lower part forms a sheath inclosing the base of the seta, called the vaginule.

The sporogonium (sporophore or sporophyte), which the developed oöspore is called, almost reaches a perfect development in the venter of the archegonium of Sphagnum.

In Sphagnum, Andreaea, and Archidium, the seta is very short, but in most mosses it becomes quite long.

The calyptra entirely covers the young capsule, and is usually membranous, thin and smooth; but sometimes it is densely hairy, or hispid, as in Polytrichum and Orthotrichum. Sometimes the apex is straight, and again it is inclined; sometimes it is split up one side, or cucullate; or it may be cone-shaped, with a smooth or irregularly-lobed base, it then being termed mitriform. (See plates.) The capsule or theca varies much in size, shape, surface, and color; but the general form is cylindrical or globose. These forms are modified in many ways, into intermediate shapes, as very long cylindrical, pyriform, elliptical, oval, angled, straight or curved, erect or corneous, or pendulous. Again the capsule may be constricted or widened at the mouth or throat; having a very small or large lid; and sometimes the base is enlarged (called the apophyses); or if only one side is swollen it is termed strumose.

The walls of the capsule are always several layers thick, with a distinct epidermis, and frequently with stomata. Only a part of the central tissue of the sporophore is used in the growth of the sphores; except in Archidium, where it is all finally displaced by the matured spores.

The columella is the central tissue of the capsule, and the mother cells of the spores are formed around it; but the manner of this growth is characteristic in each group of mosses. (See "Goeble's Special Morphology," pp. 177–178, and "Sach's Botany," pp. 374–375.)

The interior of the capsule may develop in four different ways; and, upon this difference, mosses are divided into four divisions or orders.

The central cells of the theca are called the endothecium, and the peripheral cells, the perithecium The endothecium develops an outside layer of cells by division, called the archesporium, which is the spore-forming tissue. This archesporium divides into a mass of spore mother-cells, each of which divides into four spores.

The perithecium grows and forms by cell division, several layers of cells; two of these layers usually being next the archesporium, with an interior cellular space between the outer layers several cells in thickness. This outer layer is connected with the inner layer covering the archesporium (called the outer spore sac). (See Sach's Botany, p. 378.)

The four types or natural divisions of mosses, based upon the development of the spores in the capsules, are as follow: The first and simplest is Sphagnaceae, in which the endothecium forms the columella only, which does not pass through the archesporium, but is covered by it above.

The second type is Archidiaceae, in which the fertile and sterile cells are mixed together in the endothecium, and the spore sac is separated from the wall of the capsule by a bell-shaped intercellular space, and there is no columella.

The third type is Andreaeaceae, in which the endothecium is differentiated into archesporium and columella, but the columella does not pass through the archesporium. The inner layer of the amphithecium becomes the spore sac, which is not separated from the rest of the parietal tissue by an intercellular space.

The fourth type, Bryaceae, is similar to Andreaeaceae, except that the columella passes through the spore sac, which is separated from the walls of the capsule by an intercellular space in the shape of a hollow cylinder.

The operculum covers the top of the capsule, like the lid of a sugar bowl, assuming many shapes and sizes, and varying from the usual conical to long-beaked (rostellate), or plano-convex. The apex may be mamillate, apiculate, straight, or bent, while the surface may be either rough or smooth and the color the same as or different from the capsule, and in many cases forming a specific distinction between the species. (See plates.)

The operculum is forced off the capsule either by the shrinking of the annulus, or by the swelling of the spores, thus allowing their escape and dissemination.

In two subdivisions of the division Musci the operculum is not developed. Andreaea opens by the capsule splitting into four valves, allowing the spores to escape through the spaces. The other subdivision does not allow the spores to escape until the capsule has decayed and broken into fragments. This subdivision includes several genera—Ephemerum, Phascum, etc.; but the larger portion of the division Musci is furnished with a deciduous operculum.

In regard to the operculum the mosses are divided into three groups. The first, called Schistocarpi, are those splitting the capsule into four valves and having no deciduous operculum. The second group, Cleistocarpi, are closed-fruited mosses, those not freeing their spores until the capsule decays. The third group, Stegocarpi, are mosses whose capsules have a deciduous operculum or lid, which opens to free the spores when the capsule is ripe. The annulus is a ring, composed of a row or several rows of cells (from one to four rows), which grows between the lid and capsule. When the capsule is mature this ring of cells contracts on the inner surface, thus freeing the operculum from the capsule. The annulus is usually fugacious, but in some cases it is persistent, and is either simple, compound, or revoluble, as in Funaria; or it may be entirely wanting. The compound revoluble annulus of Funaria hygrometrica is especially good for studying. (See plate XIV.)

The mouth of the capsule when the lid is removed, may or may not have a peristome or teeth. If the mouth is naked or without a peristome, it is termed a gymnostomous moss; but most mosses have either a single or double peristome. When there are two rows of teeth it is said to have a double peristome; if only one row, a simple peristome.

Often the teeth are long and slender, and very sensitive to moisture, curling up in various ways either inward or outward when dry; but rapidly becoming erect when moistened. The simple peristome and also the outer row, when it is double, grows from the inner lining membrane of the capsule.

The number of teeth is usually constant in the same species; but varies in different species, from four to sixty-four; the number always being a multiple of four, doubling itself regularly, as four, eight, sixteen, thirty-two and sixty-four.

The teeth are of many sizes, shapes, and colors; and vary greatly in their surface and structure. They are sometimes long, slender, straight, and entire, as in Barbula; or lanceolate and closely articulate, or broadly triangular with few articulations; or perhaps blunt and irregular in shape. Sometimes they are smooth and again they are either granular or densely papillose or lined with plates, or lamellate on the inner surface. Again, they may be bordered by hyaline edges, and marked down the center by divisural lines, or be split down the medial line; thus giving the paired arrangement of the teeth. Their color is usually the same as the capsule; but it is frequently different, it often being bright orange, purple, yellow, or hyaline, but most commonly brownish like the capsule. Some teeth consist of a single elongated cell, as in Barbula and others; or of a row of cells transversely jointed (articulated), called trabiculate.

The inner peristome develops from the outer wall of the spore sac. It is often a short membrane reaching but a short distance above the edge of the capsule, and frequently it is a thin, plaited cone-like membrane, with cilia between the segments or processes. The cilia are usually opposite the interspaces of the outer teeth, and are from one to three in number, always being hyaline, and often spurred, or appendiculate, or papillose. The segments are usually opposite the outer teeth, and sometimes adhere to them. These inner teeth are often shorter than the outer, and usually thinner and paler. These are also often papillose, hygrometric, or hyaline. (See plates.)

In Tetraphis pellucida and the Polytrichaceae the peristome consists of agglutinated filaments. These differences in the teeth are used by Mitten, an English bryologist, as a basis of division, separating all mosses into two divisions—Arthrodonti, those with jointed teeth, and Nematodonti, those having filamentous teeth.

In the genus Polytrichum the top of the columella expands into a membrane, closing the mouth of the capsule, and joined to the top of the teeth, and is called the epiphragm, or tympanum.

The teeth are supposed by some writers to aid in scattering the spores by their hygroscopic properties, which cause them to make considerable motion, in curling back and forth into various positions as the amount of moisture varies.

At any rate the spores are dispersed in some way, and find a moist place in which to germinate. This finishes the cycle of development and brings us back to the spore, our former starting point.

Many mosses, mentioned above as illustrations of various points, do not occur in Kansas, nor have I examined all, but I quote from the authority of the greatest bryologists.

All species thus far reported from this state by reliable authorities are arranged below in a key, which is but an abbreviation of "Barnes's Artificial Key to North American Mosses," or, perhaps, more properly speaking, it is modeled from Barnes's Key. I have arranged this key for the convenience of other students of our Kansas mosses, knowing that it is very far from complete, but hoping to add to it myself at some future date, and feeling sure that whoever may take up this study will also add much more towards its completeness.

Many of the species included I have never collected or even seen; but they are reported by the best authority; and my list is mainly prepared from Renauld and Cardot's last list, published in the Botanical Gazette, March, 1892, with such additions as I have made from my own collection. All my identifications have been verified by Mrs. E. G. Britton; who has very kindly assisted and encouraged me in my work.

All species marked with a star or dagger I have in my collection and have examined closely; those marked with a small x were identified and studied by Renauld and Cardot, from specimens sent them by Dr. Joseph Henry, of Salina, and published in the Botanical Gazette, Vol. XVII, p. 82. All species not marked at all are reported in other lists, as "Washburn Bulletins," or "Smyth's Check List;" while those marked by a double dagger are new species.

The number following the name of a genus or species in this key refers to the page of Lesquereux and James's Mosses of North America, where the description is to be found.

ANALYTIC KEY TO THE GENERA OF KANSAS MOSSES.

ORDER I.—Sphagnaceae.

Capsule dehiscing by a deciduous operculum; peristome none; leaves composed of large hyaline cells, with intervening rows of small chlorophyllose ones. Genus single.....x Sphagnum molle Sulliv. 18

ORDER II.—Andreaeaceae.

?

ORDER III.—ARCHIDIACEAE.

Capsule bursting irregularly; spores few and very large. Genus single ....x Archidium Hallii Aust. 51

ORDER IV.—BRYACEAE.

Capsule bursting irregularly (spores numerous) or generally dehiscing by a deciduous operculum; in the latter case usually furnished with a peristome. Leaves not sphagnoid. Genera numerous, and as follow:

I. CLEISTOCARPI.—Capsule without a deciduous operculum.

A. Green protonema persistent.

Leaves ecostate.
Capsule colorless.................................. x Micromitrium, 37
Capsule colored.................................... x Ephemerum, 37
Leaves costate..................................... x Ephemerum, 37

B. Green protonema not persistent.

Margins of leaves flat or incurved.
Leaves linear-lanceolate to subulate or abruptly pointed.
Capsule cucullate.................................. x Pleuridium, 43
Margins of leaves more or less revolute.
Capsule short-pointed.
Calyptra mitrate................................... x Microbryum, 45
Calyptra cucullate................................. x Phascum, 41

II. STEGOCARPI.—Capsule with a deciduous operculum.

A. ACROCARPI. Flowers and fruit terminating the stem, either the main shoot or a branch.

1. Mouth of capsule naked.

* Leaf-cells isodiametric, at least above the middle of the leaf, often obscure.

Lid imperfectly formed, persistent.................. x Astomum, 51
Lid perfect, deciduous.
Capsule immersed.
Leaves lamellose.................................... x Pharomitrium, 100
Leaves not lamellose, ciliate....................... x Hedwigia, 152
Leaves with a hyaline hair-point.................... x Grimmia, 134
Capsule exserted, not ribbed when dry. Lid conic, beaked.
Pedicel long.......................................* Gymnostomum, 52

* * Leaf cells plainly elongated, distinct.

Lid small, convex or short-conic; capsule microstome.
Leaves subulate-dentate............................. x Bartramia, 53
Leaves broad, entire; calyptra inclosing capsule.... Pyramidula, 196
Lid large (rarely small); capsule macrostome.
Capsule dehiscing regularly above the middle, not covered by the calyptra...........................* Physcomitrium, 196

2. Mouth of capsule furnished with a peristome.

* Peristome single.

† Teeth articulate.

‡ Teeth eight.

Leaves thick and coriaceous.

[Orthotrichum and Ptychomitrium (S. Notarisia) may be found here.]

‡ ‡ Teeth sixteen; calyptra mitrate.

|| Calyptra plicate.

Teeth cribrose, purple .... x Coscinodon, 154
Teeth filiform, trifid .... Ptychomitrium, 156
Teeth approximate or connate in pairs.
  Lanceolate to subulate, papillose .... Ptychomitrium, 156
  Triangular-lanceolate, articulate quadrate.
    Basal leaf-cells hexagono-rectangular, hyaline.......... * Orthotrichum, 164

|| || Calyptra not plicate.

Terrestrial, or on rocks.
  More than 1 cm. high; leaf-cells small, quadrate or punctate, obscure; beak long or short, not clavate.
    Teeth lanceolate, flat, subentire or cribrose, or 2-3-fid to the middle .... * Grimmia, 134
    Teeth linear-lanceolate, 2-3-fid to below the middle, or cleft to base into filiform segments.......... Rhacomitrium, 147

‡ ‡ ‡ Teeth sixteen; calyptra cucullate.

|| Leaves distichous.

Leaves broad, with a prominent vertical wing .... * Fissidens, 81

|| || Leaves pluriseriate.

¶ Capsule unsymmetric, cernuous-inclined, or arcuate.

Teeth filiform, bifid from a membranous base .... x Desmatodon, 110
Teeth irregularly lacerate or bifid to the middle or below.
  Leaf-cells enlarged at the basal angles, oblong above, rectangular at base .... * Dicranella, 64
  Leaf-cells enlarged quadrate at the basal angles, linear at base, * Dicranum, 67
  Leaf-cells of two kinds, in two or three layers .... * Leucobryum, 90
Teeth bifid to near the base.
    Lid conic, leaves lanceolate .... * Ceratodon, 92

¶ ¶ Capsule symmetric, pendulous on a flexuous pedicel.

Teeth bifid to the middle .... x Campylopus, 77

¶ ¶ ¶ Capsule symmetric, erect.

Teeth bifid to the common membranous base.
  Leaves subulate to lance-subulate, from a broader base .... * Leptotrichum, 105
  Leaves lanceolate to linear-lanceolate.
    Lid elongated-conic.......... x Trichostomum, 108
    Lid short-conic or beaked .... x Desmatodon, 110
  Leaf-cells not enlarged at the angles.
    Teeth large, mostly cribrose.
      Pedicel little longer than the often hair-pointed leaves...... * Grimmia, 134
    Teeth small, often truncate or rudimentary; leaf-margins involute above .... * Weisia, 55
    Teeth entire.
      Capsule oval to subcylindric, not ribbed when dry; teeth linear-filiform, connate at base.......... x Didymodon, 104
      Capsule short-pyriform, turbinate when dry; teeth blunt...... Seligeria, 96
      Capsule globose; lid beakless, small.......... * Bartramia, 203

‡ ‡ ‡ ‡ Teeth thirty-two.

Teeth cancellate, filiform or linear; pedicel long, twisted to the left, * Barbula, 115

† † Teeth not articulate.

‡ Teeth thirty-two or sixty-four.

Calyptra cucullate; capsule symmetric or nearly............... * Atrichum, 255
Calyptra mitrate, densely hairy; capsule 4-6 angled, teeth 64, * Polytrichum, 263

* * Peristome double.

† Capsule symmetric, erect.

Teeth broadly or narrowly triangular-lanceolate; capsule ribbed, not twisted.
Leaf-cells at base hexagono-rectangular, hyaline ....* Orthotrichum, 164

† † Capsule unsymmetric, inclined, oblique, or pendulous.

‡ Inner peristome a membrane, carinate or cut into sixteen segments; these sometimes separated by cilia.

‖ Cilia very short, rudimentary or none.

Membrane latticed or cleft to the base into filiform appendiculate segments.
Pedicel none or very short, leaves ecostate..................* Fontinalis, 268
Membrane not cleft to the base.
Segments entire or interruptedly cleft along the middle line.
Shorter than the teeth or rudimentary.........................* Funaria, 200
Equaling the teeth in length; leaves not squarrose.
Leaf-cells narrowly rhombic-hexagonal, tending to linear, leaves narrower..................................* Webera, 215
Leaf-cells and leaf broader...............................* Bryum, 223
Segments bifid, divisions divaricate.
Leaves lanceolate to subulate, large......................* Bartramia, 203
Leaves lanceolate or broader, plants smaller .... x Philonotis, 208
Segments filiform, united by fours at their tips.................* Timmia, 254

‖ ‖ Cilia present.

Appendiculate.
Leaves lance-subulate, cells linear.......................* Leptobryum, 215
Leaves broader, cells rhombic-hexagonal ....* Bryum, 223
Inappendiculate; capsule not ribbed when dry.
Leaves lanceolate, glossy, cells narrowly rhombic-hexagonal, inclining to linear ....* Webera, 215
Leaves large, soft, oblong-ovate or broader, cells round-hexagonal, * Mnium, 241

B. Pleurocarpi. Flowers and fruit lateral, in the axils of leaves.

[Fontinalis may be found here.]

1. Peristome single (rarely none); teeth eight or sixteen.

Leaves distichous, with broad vertical wing...... ....* Fissidens, 81
Leaves serrate to ciliate-dentate ; capsule long pediceled.........x Fabronia, 294

2. Peristome double, the inner often imperfect.

* Segments none or short, or obscured by adhering to the teeth.

† Leaves papillose.

Entire, ovate to ovate-lanceolate.
Teeth ciliate-papillose .... * Leskea, 301
Teeth not papillose .... * Anomodon, 304
Spinulose-dentate to fimbriate (rarely entire), deltoid or round-ovate, * Thelia 298

† † Leaves not papillose; capsule straight; segments bifid or adhering to the teeth.

Plants small (1–2 cm.); capsules about 2 mm. long .... * Pylaisia, 308
Plants large (4–6 cm.); capsules 4 mm. long .... * Cylindrothecium, 310

* * Segments not distinctly keeled, narrow ; leaves costate ; cells roundish to oval rhombic.

Stem and branch leaves similar .... * Leskea, 301
Stem leaves much smaller than branch leaves .... * Anomodon, 304

* * * Segments distinctly keeled, often broad.

† Capsule symmetric, erect.

[Species of Hypnum with erect or suberect capsules may be found here.]

Leaves not papillose, ecostate ; annulus large.
Leaf-cells quadrate at basal angles .... * Cylindrothecium, 310
Leaves ecostate ; annulus small, narrow .... * Pylaisia, 308
Leaves costate ; plants dendroid .... * Climacium, 313

† † Capsule unsymmetric, often arcuate.

Leaf-cells small ; calyptra cucullate .... * Hypnum, 316

ANALYTIC KEY TO THE SPECIES OF KANSAS MOSSES.

SPHAGNUM, p. 12.

x S. molle Sulliv. 13.

Saline Co.; a very young and sterile form (Dr. Joseph Henry).

MICROMITRIUM, p. 37.

x Micromitrium sp. ?

Too young to determine. Saline Co. (Joseph Henry.)

EPHEMERUM, p. 37.

Leaves costate, costa excurrent; seta 0; capsule blunt-pointed.
Leaves with long hyaline spinulose arista .... x E. spinulosum B. & S. 3.
Leaves papillose on both sides .... x E. papillosum Aust. 4.
Both collected in Saline Co. by Dr. Henry.

PHASCUM, p. 41.

Capsule subglobose, apiculate.
Leaf-margins plane or incurved, denticulate.... P. carniolicum Web. & Mohr. 1.
Leaf-margins reflexed, quite entire .... x P. cuspidatum Schreb. 2.
Costa prolonged into a long filiform point,
x P. cuspidatum, var. piliferum B. & S.
P. carniolicum, in Western Kansas (Smyth's Check List). P. cuspidatum and var. piliferum were collected in Saline Co. by Joseph Henry.

PLEURIDIUM, p. 43.

Inflorescence autoecious; upper leaves long subulate.
Serrulate from the middle upwards .... x P. Bolanderi Muell. 5.
Saline Co., sterile, by Jos. Henry.

MICROBRYUM, p. 45.

x M. floerkeanum Sch., var. henrici Ren. & Card.

This differs from the typical form in the green color of the plant, and the excurrent costa, often hyaline at the point. Saline Co., on sandy ground (Henry, Bot. Gaz., Vol. XIV, p. 91).

ARCHIDIUM, p. 49.

Autoecious, costa often long excurrent .... x A. Hallii Aust. 5

Saline (Henry).

ASTOMUM, p. 51.

Capsule solitary.

Brown, globose, leaves crispate .... x A. crispum Hampe 1

Orange, subglobose, leaves crispate when dry .... x A. Sullivantii Sch. 3

A. crispum, Saline (Henry). A. Sullivantii, Saline (Henry).

GYMNOSTOMUM, p. 52.

Lid falling early; capsule thin walled, with 3–4 rows of transversely elongated cells at mouth.

Plants 1–7 cm. high, costa 70 micromillimeters wide at base with 4–6 guides ....* G. rupestre Sch. 2

Riley and Pottawatomie (M. Reed).

WEISIA, p. 55.

Inflorescence autoecious; teeth more or less perfect, or none.

Capsule wrinkled lengthwise when dry .... * W. viridula Brid. 1

Capsule narrower, lid long beaked, curved, teeth nearly entire.

* W. viridula, var. stenocarpa Muell.

W. viridula, Saline Co. (Henry); Wyandotte (Bennett & M. Reed); Riley, Pottawatomie, and Anderson (M. Reed). Var. stenocarpa, Wilson Co. (Cragin); Wyandotte and Riley (M. Reed).

DICRANELLA, p. 64.

I. Cells of exothecium rectangular quadrate; seta red; costa usually broad and indistinct below.

A. Leaves not sheathing, erect, spreading.

Costa percurrent, or excurrent; annulus none, peristome papillose.

Capsule cernuous, curved................................. * D. varia Sch. 6

Capsule erect, symmetric.................................. D. rufescens Sch. 7

II. Cells of the exothecium prosenchymatous; seta often yellow; costa narrow and well defined below.

Seta yellowish.

Capsule cernuous, not strumose...................... D. heteromalla Sch. 10

D. varia, Shawnee (Cragin & Becker); Saline (Henry); common. It differs from the type in having a long beaked lid, teeth pellucid at apex, reddish at base, bifid, vertically striolate; it is probably a variety. D. rufescens (Smyth's Check List). D. heteromalla, Saline (Henry), a sterile form with shorter leaves; rather doubtful species.

DICRANUM, p. 67.

"In this genus the structure of the costa is of diagnostic value. It is either composed of similar cells (homogeneous) or composed of large parenchymose cells and small sclerenchymose cells (stereides); it is then heterogeneous. The large parenchymose cells (called guides)[1] form a row (seldom double) in the middle of the costa, touching each other tangentially. They are comparatively large, but little thickened, and either empty or starch-bearing."[2]

Dioecious; stems radiculous (often densely); costa with guides; capsule more or less arcuate.

Leaf-cells pitted; costa percurrent; leaves not undulate; guides in one row.

Perichaetial leaves abruptly subulate............ x D. scoparium Hedw. 17

In Labette (Nelson); Saline (Henry); sterile form, with leaves often broken at point.

CAMPYLOPUS, p. 77.

Costa smooth at back, auricles none.

Upper leaves with hyaline points................... x C. henrici Ren. & Card.[3]

C. henrici, Saline Co. (Henry); sterile.

FISSIDENS, p. 81.

I. (Eufissidens.) Plants terrestrial or submersed, but not floating; leaves soft, of one layer of cells.

A. Fruit terminal.

1. Monoecious, male flowers axillary.

Leaf-cells larger, not densely chlorophyllose, nor in distinct rows, x F. bryoides Hedw. 2

2. Dioecious or monoecious, with male flowers terminal on a rooting branch at the base of the female stem.

Leaf-cells almost or quite isodiametric, often obscure; leaves with a narrow border, at least on vaginate lamina.

Margins of leaf-cells not papillose.................... x F. brambergeri Schw.

Serrulate at apex; auricles broadly margined................ x F. incurvus Schw. 3, var. minutulus Sulliv.

Short acuminate, lid rostellate.. x F. incurvus Schw., var. exiguus Sulliv.

Leaves without a border.

Obtuse, cells pellucid, operculum conic..............* F. obtusifolius Wils. 17

Broader border of elongated cells on margin of vaginate lamina; and a narrow, more or less distinct border on the dorsal wing, x F. obtusifolius, var. Kansensis Ren. & Card.

Apiculate, operculum with acicular beak .... x F. osmundoides Hedw. 18

B. Fruit lateral.

Leaves bordered by several rows of paler, often incrassate cells.

Capsule erect or inclined, flowers dioecious, leaf-cells obscure, x F. decipiens DeNot. 19

x F. bryoides, Saline (Henry). F. incurvus, var. minutulus (Smyth's Check List). x F. incurvus, var. exiguus (Smyth's Check List). x F. obtusifolius, var. Kansensis, Saline (Henry). F. osmundoides, Brown Co. (Becker). F. decipiens (Smyth's Check List).

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[1] Pringsh. Jahrb. f. Wiss. Bot., VI, 374.
[2] Cf. Limpricht: Die Laubmoose, p. 23.
[3] Renauld & Cardot: Bot. Gaz., XIII (1888), p. 197, pl. XIV.

LEUCOBRYUM, p. 90.

Capsule apparently lateral (by innovations).
Leaves erect, spreading, oblong-lanceolate ....* L. vulgare, Hampe 1
Plants smaller, half as long, leaves shorter and more crowded.
Capsule smaller, pedicel shorter..........................L. minus Sulliv. 2
L. vulgare, sterile, Bourbon Co. (Bennett). L. minus, in Smyth's Check List.

CERATODON, p. 92.

Stems 2–3 (sterile often 10) cm. long; teeth articulate for three-fourths of length.........................* C. purpureus, Brid. 1
Collected in Shawnee (Fields and Smyth); Ford (Cragin); Saline, sterile form (Henry); Riley (Kellerman); Wyandotte (M. Reed).

SELIGERIA, p. 96.

Seta straight when moist.
Leaves sharp pointed; cells above rectangular; spores measure 10–14 mmm............................S. pusilla, Br. & Sch. 1
Reported from eastern Kansas (Smyth's Check List).

PHAROMITRIUM, p. 100.

Capsule immersed, globose, without peristome, enlarged at orifice after the falling of the lid; leaves soft, loosely areolate.
Calyptra oblique, plurilobate.............................x P. subsessile Sch.
Saline (Henry), with young form named by Austin P. exiguum.

DIDYMODON, p. 104.

Leaf-cells below rectangular.
Leaf base red; margins above revolute...............D. rubellus, Br. & Sch. 1
Also a new species, D. species nova? Ren. & Card.[1] D. rubellus (Smyth's Check List); and D. species nova? Saline Co. (Henry).

LEPTOTRICHUM, p. 105.

Dioecious; leaves slightly twisted.
Stem leaves spreading; perichaetial leaves hardly sheathing.
x L. tortile Muell., var. vaginans Lesq. 1
Stem leaves imbricate; perichaetial leaves long, sheathing.
x L. vaginans Sch. 2
Monoecious; plants short (5 mm.)
Teeth cylindrical; nodose, articulate, leaves spreading.
* L. pallidum Hampe 5
L. tortile, var. vaginans (Smyth's Check List). L. vaginans, Saline (Henry). L. pallidum, Wilson (McClung); Saline, sterile form, with leaves often broken at tip (Henry); Labette, a doubtful sterile form (Newlon).

TRICHOSTOMUM, p. 108.

Lamina composed of one layer of cells, papillose.
Margins reflexed or undulate, entire; annulus none... x T. tophaceum Brid. 1
Margins plane or incurved; costa reaching apex, or excurrent, serrate above; base of leaf yellowish, with thick-walled rectangular cells .... x T. crispulum Br. 3

[1]Botan. Gaz., Vol. XVII, p. 81 (1892).

T. tophaceum (Smyth's Check List). T. crispulum, sterile, Pottawatomie (M. Reed); Saline (Henry).

DESMATODON, p. 110.

Capsule erect or nearly so; leaves without a thickened or hyaline border, papillose.
Costa excurrent into a hair.
Capsule cylindric (1:5-6); teeth divided half way or entire, dioecious,
x D. plinthobius S. & L. 6
Costa vanishing at apex, or forming a short point; leaves hyaline at base, margins revolute.
Capsule long cylindric, leaves crenulate........... x D. arenaceus S. & L. 3

D. plinthobius, Saline, sterile (Henry). x D. arenaceus, sterile, Saline (Henry).

BARBULA, p. 115.

I. Leaves with jointed dichotomous filaments on costa.

Costa narrow, round; leaves thin, broad..................... § I. Chloronotae.

II. Leaves not filamentose.

Teeth from a low membrane scarcely projecting from the mouth.
Plants small; leaf cells small.
Perichaetial leaves little different from the foliage ..... § II. Unguiculatae.
Perichaetial leaves long, sheathing or convolute......... § III. Convolutae.
Plants robust (except B. cespitosa).
Leaves entire; stems radiculous....................... § IV. Tortuosae.
Teeth from a high tesselate membrane.......................... § V. Syntrichiae.

§ I. Chloronotae.

Leaves with hair points; tip of leaf concolorous; hairs serrate; leaves rounded, obtuse .... x B. henrici Rau.

§ II. Unguiculatae.

Teeth plainly twisted; leaves blunt, or mucronate by the excurrent costa; cells at base rectangular and pellucid; capsule oblong-elliptic to subcylindric; sub-incurved......................* B. unguiculata Hedw. 13

Leaves gradually pointed, papillose; cells at base roundish, quadrate, or short-rectangular; costa 70 micromillimeters wide at base, and tapering gradually... x B. fallax Hedw. 13

§ III. Convolutae.

Leaves plane on margins, or recurved; capsule smooth; costa percurrent............................ x B. convoluta Hedw. 32

§ IV. Tortuosae.

Leaves long-linear, acute, abruptly mucronate........... B. caespitosa Schw. 37

§ V. Syntrichiae.

Leaves not bordered; cells smooth.............. B. mucronifolia Br. & Schw. 43

x B. henrici (?), sterile (probably is Phascomitrium sessile, say Renauld & Cardot), Saline (Henry). B. unguiculata, variable, Shawnee, Wilson (Cragin); Brown (Becker); Saline (Henry); Riley (Kellerman). x B. caespitosa, Wabaunsee (Baldwin); Saline (Henry). B. mucronifolia (Smyth's Check List).

GRIMMIA, p. 134.

Seta shorter than capsule; lid falling with columella.......... § I. Schistidium.
Seta longer than capsule, arcuate.............................. § II. Eugrimmia.
Seta straight.. § III. Guembelia.

§ I. Schistidium.

Leaves without hyaline points; capsule ovate-globose.
In small dense cushions, soft lurid green................ G. conferta Funck. 1
Leaves shorter, broad, obtuse........... G. conferta, var. obtusifolia Sch. 1
In loose cushions, coarse, fuscescent.................. * G. apocarpa Hedw. 3
Loose, leaves blunt; capsule turbinate, wide mouthed when empty,.....G. apocarpa Hedw. 3, var. rivularis Nees & Hornsch.

§ II. Eugrimmia.

Capsule not costate (or obscurely) when dry; leaves not reflexed; margins plane; capsule elliptical; collum 0..G. olneyi Sulliv.? 17

§ III. Guembelia.

Lamina above 2–4–stratose; calyptra mitrate.
Leaf margins plane................................ x G. leucophaea Grev. 24
Leaf margins recurved; walls of basal cells sinuate........... .... x G. Pennsylvanica Schw. 22
Only the margins 2–4–stratose; leaves hair-pointed; annulus 0; calyptra mitrate, covering the whole capsule... ....G. calyptra Hook. 23

G. conferta, var. obtusifolia (Smyth's Check List). * G. apocarpa, Saline, sterile (Henry); Riley and Pottawatomie (Reed). Specimens blackish brown, and leaf points often broken; fruiting specimens common. G. apocarpa, var. rivularis (Smyth's Check List). x G. olneyi? sterile and stunted form, Saline (Henry). G. Pennsylvanica (Smyth's Check List). G. calyptrata, Saline (Henry).

RACOMITRIUM, p. 147.

Leaves muticous; costa not lamellose; leaves not auricled nor decurrent, obtuse...........................R. aciculare Brid. 2

HEDWIGIA, p. 152.

Leaves falcate or curved at apex, pale green.
Capsule globose, lid broadly convex........................H. ciliata Ehrh. 1
A stunted form, Saline (Henry).

COSCINODON, p. 154.

Costa forming a rough hyaline point, twice as long as the leaf... .... x C. Wrightii Sulliv. 2
Monoecious; leaves ovate lanceolate, abruptly acuminate; teeth cribrose................................ x C. Renauldii Card.

x C. Wrightii, Saline (Henry); x C. Renauldii Card., Saline (Henry). Bot. Gaz., XV (1890), p. 41, plate VI B.

PTYCHOMITRIUM, p. 156.

Plants small (1 cm.); leaves acuminate, nearly or quite entire.
Collum 0.
Teeth subulate (1:10); entire .... P. incurvum Sulliv. 2
Collum equaling one-third sporangium......... P. pygmaeum Lesq. & James 4
P. incurvum, and P. pygmaeum, Southeast Kansas (Smyth's Check List).

ORTHOTRICHUM, p. 164.

A. Stomata superficial.
Peristome double; capsule strongly costate.
Leaves not gemmiferous; teeth with punctulate areoles; capsule including collum subcylindric.
Leaves apiculate, minutely papillose .... O. brachytrichum Schimp. 18
Capsule ribbed only near the mouth; peristome opaque, very papillose, reflexed when dry .... O. speciosum Nees 12
B. Stomata immersed.
Peristome simple; capsule faintly costate, bands (8, rarely 16) cinnamon red.............................. O. anomalum Hedw. 1
Capsule 16-costate, bands (16, rarely 8) yellow....... * O. cupulatum Hoffm. 3
Plants shorter, blackish; capsule shorter, urceolate.......
.... * O. cupulatum, var. minus Sulliv.
Peristome double; capsule costate when dry, half immersed, obovate, contracted below mouth.
Leaves simple, often slightly papillose; neck not cupped......
.... x O. strangulatum Beauv. 19
O. brachytrichum, O. speciosum, O. anomalum (Smyth's Check List); * O. cupulatum, and * O. cupulatum, var. minus, Riley (M. Reed); x O. strangulatum, Saline (Henry).

PYRAMIDULA, p. 196.

Calyptra large, inclosing capsule, dehiscent by a lateral cleft; orifice naked.................................. x P. tetragona Brid.
Saline (Henry).

PHYSCOMITRIUM, p. 196.

Capsule exserted.
Leaves entire or nearly so.
Seta short, little exceeding leaves..................... * P. Hookeri Hampe 4
Seta much longer (5–10 mm.)
Leaves linear-lanceolate; collum 0................x P. turbinatum Mich. 6
Leaves ovate-lanceolate; collum distinct....... * P. acuminatum B. & S. 5
Leaves serrate; cells at mouth of capsule transversely elongated, 5–7 rows; leaves acute, not bordered, P. pyriforme Linn. 2
Costa excurrent; seta short; annulus small, simple, falling in pieces .... * P. Kellermani Mrs. Britton

* P. Hookeri, Riley (Kellerman & M. Reed); Wyandotte and Pottawatomie (M. Reed); Franklin (Meeker); x P. turbinatum? sterile, Saline (Henry); P. pyriforme, Shawnee (Cragin); Brown (Becker); Labette (Newlon). * P. Kellermani, Riley (Kellerman); Wyandotte and Pottawatomie (M. Reed). * Physcomitrium Kellermani, Mrs. Britton, n. sp. Plants 3–5 mm. high; stem short, simple or with basal innovations; leaves few, rosulate, 3 mm. long, ovate triangular acuminate, vein excurrent; margins coarsely serrate, cells very lax, basal scarcely elongated; inflorescence monoecious; seta short, 1–2 mm. long, scarcely

exceeding the leaves, tapering into the neck, or even apophysate; capsule pyriform, 1-15 mm. long, bright golden brown; lid small, dense; beak short, sharp, mouth not broadly flaring when old, often contracted below it, bordered by 5-7 rows of elongated transverse cells and a persistent orange-colored annulus of smaller square, undifferentiated cells; neck short, stomata immersed, walls of the theca dense, regular; spores rough (25-30 mmm. in diameter), maturing in March or April. Manhattan, Riley Co., Kan., W. A. Kellerman, April 26, 1889, and March 6, 1889. (No. 38.) In moist sandy banks, near streams. Differs from Drummond's specimens of P. Hookeri in the smaller size of the plants, the lax, coarsely-serrate leaves, the shorter seta, more pyriform capsule, and especially in the annulus.

FUNARIA, p. 200.

Annulus large and revoluble; capsule distinctly striate — costate; leaves short-acuminate; lid large; spores 12-17 mmm............................* F. hygrometrica Hedw. 8

* F. hygrometrica, Shawnee (Cragin); Labette (Newlon); Saline (Henry); Riley, Pottawatomie, and Wyandotte counties (M. Reed); usually small, very common.

BARTRAMIA, p. 203.

Capsule curved; lid oblique; peristome double; seta exceeding stems.

Leaves papillose only on upper surface................ x B. radicalis Beauv. 8

Base not white, margins revolute, autoecious........* B. pomiformis Hedw. 6

B. radicalis, sterile, Saline (Henry), B. pomiformis Labette (Newlon); Franklin (Herrick).

PHILONOTIS, p. 208.

Leaf cells rectangular to linear; plants short (1-3 cm.)

Costa thick, rusty; leaves erect, spreading; capsule horizontal, x P. Muhlenbergii Brid. 1

Not uncommon, but sterile, Saline (Henry).

LEPTOBRYUM, p. 215.

Leaves narrow, flexuous, subulate, glossy; capsule inclined or pendent; lid apiculate; annuluslarge....* L. pyriforme Schimp. 1

Collected in Pottawatomie county by Minnie Reed.

WEBERA, p. 215.

A. Annulus present; segments of endostome split and gaping along the keel; cilia well developed.

Inflorescence paroecious.

Capsule horizontal or pendent, not touching the seta; contracted below the mouth..................W. nutans Hedw. 5

Inflorescence dioecious.

Uppermost leaves lanceolate (1:4-6); costa reaching apex..W. annotina Schw. 9

B. Annulus 0.

Leaves sharply serrate; stem red; leaves glaucous green...... W. albicans Schimp. 18

W. nutans (Smyth's Check List); W. annotina, Shawnee (Becker); W. albicans, Brown (Becker); Wilson (Cragin); Saline (Henry); Riley, sterile, common (M. Reed).

BRYUM, p. 223.

Upper leaf cells rhombic to hexagonal; plants not from stolons.
Cilia 0, or if any inappendiculate.................................. § I. Cladodium.
Cilia 2–4, appendiculate .... § II. Eubryum.
Plants from stolons .... § III. Rhodobryum.

§ I. Cladobryum.

Synoecious or heteroecious, costa long excurrent; endostome attached to peristome; spores smooth, about 30 mmm..................................B. pendulum Sch. 4

§ II. Eubryum.

A. Synoecious.
Costa long excurrent; endostome attached to peristome; spores smooth, about 30 mmm.................x B. bimum Schreb. 14
B. Dioecious.
Leaves pointed; costa percurrent or excurrent; capsule longer (1–3+), tapering at base, yellowish brown, slightly constricted below mouth; leaf margins revolute, serrate at apex.. x B. pseudotriquetrum Schwaegr. 38
Leaves pointed; costa vanishing, silvery; plants small; leaves closely appressed, imbricate; capsule purple, pendent ....* B. argenteum Linn. 29
Costa excurrent; leaves long cuspidate; capsule long (1–3); leaves erect and straight when dry; collum one-half the sporangium.................* B. caespiticium Linn. 30

§ III. Rhodobryum.

Costa excurrent; margin revolute ⅔ to ¾ length; collum one-half sporangium, curved ....B. ontariense Kindb.

*B. pendulum (Smyth's Check List); Pottawatomie (M. Reed). B. bimum Saline (Henry); Shawnee (Cragin). x B. pseudotriquetrum, Saline (Henry); Southeast Kansas (Smyth's Check List). B. argenteum, Shawnee (Fields); Wilson (Cragin); Saline, sterile (Henry); Wyandotte, Riley, Pottawatomie and Anderson counties (M. Reed); Franklin (Meeker). * B. caespiticium, Saline (Henry); Riley, Pottawatomie and Wyandotte counties (M. Reed). B. ontariense, Saline, sterile (Henry). Torr. Bull., XVI, p. 96.

MNIUM, p. 241.

Leaves serrate; teeth of leaves single; stems simple or branched; not dendroid; basilar branches stoloniform.
Leaves acuminate, serrate to middle; lid convex, or mamillate; membrane of endostome lacunose, * Mnium cuspidatum Hedw. 1
Leaves acuminate, serrate to base; lid mammiform........x M. affine Bland 7
Stems slender; leaves pale-margined; capsule shorter and solitary ....M. affine, var. elatum B. & S.

* M. cuspidatum, Shawnee (Cragin, Smyth and others); Wabaunsee (Baldwin); Brown (Becker); Labette (Newlon); Wyandotte (Bennett and Reed); Riley, Pottawatomie and Anderson (M. Reed); Atchison (E. B. Knerr). Very common in the eastern half of the state.

x M. affine, Shawnee (Cragin); Saline (Henry). M. affine, var. elatum, sterile, found in Saline Co. (Henry).

TIMMIA, p. 254.

Capsule irregularly plicate when dry; segments appendiculate.. * T. megapolitana Hedw. 1

Shawnee (Smyth and J. W. Beede); Riley and Pottawatomie (M. Reed).

ATRICHUM, p. 255.

Costa lamellose on upper side only; lamellae 2–6, entire; lamina with teeth on lower surface.

Leaves acute, serrate for ¾ length.................. * A. undulatum Beauv. 1

Lamellae of leaves higher; capsule narrower and erect...... x A. undulatum, var. alticristatum Ren. & Card.

Leaves bluntish; serrate above middle only.

Teeth double, aculeate............................ * A. angustatum Brid. 2

Teeth single, short......................... * A. xanthopelma Lesq. & James 4

* A. undulatum, Saline (Henry); Bourbon (Bennett); Franklin (Meeker); Pottawatomie, Wyandotte and Riley (M. Reed). None of these specimens had clustered capsules, as described in Lesquereux's and James's Manual. * A. angustatum, Shawnee (Cragin); Labette (Newlon); Wyandotte (M. Reed); Saline (Henry). * A. xanthopelma, Saline (Henry); Wyandotte and Riley (M. Reed). x A. undulatum, var. alticristatum, Saline (Henry).

POLYTRICHUM, p. 263.

Leaves entire; margins inflexed, aristate at apex.

Awn hyaline, long.................................. P. piliferum Schreb. 3

Awn colored, short; leaves spreading when moist, subrecurved............................. * P. juniperinum Willd. 4

Leaves serrate; marginal cells of lamellae semilunar, with two prominent papillae at corners.............. P. commune Linn. 6

* P. juniperinum, Pottawatomie Co. (M. Reed), and in Western Kansas (Smyth's Check List). P. piliferum, Western Kansas (Smyth's Check List). P. commune, Northeast Kansas (Smyth's Check List).

FONTINALIS, p. 268.

Perichaetial leaves abruptly pointed, entire.

Leaves not decurrent; teeth lacunose........... * F. dalecarlica Br. & Sch. 4

FABRONIA, p. 294.

Leaves ciliate-dentate.

Peristome of 8 geminate teeth; leaves costate nearly to middle.............................. x F. octoblepharis Schw. 3

Sterile, Saline (Henry).

THELIA, p. 298.

Papillae 2-4, furcate, usually bifurcate; teeth 1:17-20..... * T. asprella Sulliv. 2

Shawnee (Cragin); Brown (Becker); Franklin (Meeker); Riley and Anderson (M. Reed).

LESKEA, p. 301.

I. Costa reaching to or beyond the middle.

Not percurrent; leaves entire.

Endostome divided into segments.

Cleft between articulations; leaves bluntish........... L. obscura Hedw.? 2

Not cleft; leaves acute.................................. *L. polycarpa Ehr. 1
Endostome a short undivided membrane................ x L. Austini Sulliv. 6

II. Costa very short or none.

Leaf-cells rhombic.
Leaves of primary stem acute.......................... *L. pulvinata Wahl. 7

*L. obscura, specimen scant; unable to determine positively; leaves not papillose; if L. obscura, it is probably a variety. Pottawatomie and Riley (Reed); Saline (Henry). x L. Austini, Saline (Henry). *L. polycarpa, Clay (Cragin); Shawnee, Brown (Becker); Wyandotte and Bourbon (Bennett); Pottawatomie, Riley and Anderson (M. Reed). This is a very common species; but varies considerably. *L. pulvinata ? differs from the type form considerably; it may be a new species or variety; collected in Pottawatomie and Riley counties by M. Reed.

ANOMODON, p. 304.

Leaves papillose; base not auricled, filiform-acuminate..*A. rostratus Schimp. 1
Leaves obtuse or apiculate; branches attenuate........ *A. attenuatus Hartm. 2
Branches not attenuate; leaves open, erect; teeth nodose...
*A. obtusifolius B. & S. 3

*A. rostratus, Wabaunsee (Baldwin); Wilson (Cragin); Franklin (Meeker); Riley, Pottawatomie, Anderson, and Wyandotte (M. Reed); Saline, sterile (Henry). *A. attenuatus, Wyandotte (Bennett); Riley (M. Reed). *A. obtusifolius, Shawnee (Fields); Brown (Becker); Saline (Henry); Wyandotte (Reed); common.

PYLAISIA, p. 308.

Segments half adherent to teeth; spores 19–20 mmm.
Leaves long-acuminate; margin not recurved ...... x P. intricata B. & S. 4
Leaves short-acuminate; margins recurved ....* P. Selwyni ? Kindb.
Segments wholly adherent; spores 28 mmm............* P. velutina B. & S. 5

x P. intricata, Jefferson (Cragin); Saline (Henry). P. Selwyni ? Kindberg (Ottawa Naturalist, II, 1889, p. 156); Riley (M. Reed). Could not be sure of this species, as it differed somewhat from the manual description; it may be a variety P. velutina, Riley (Reed).

CYLINDROTHECIUM, p. 310.

Capsule solitary.
Leaves acuminate-apiculate; teeth with 14–17 articulations; capsule 1:3.5–4 ....x C. cladorrhizans Sch. 1
Leaves abruptly short-apiculate; teeth with 6–8 articulations; capsule 1:5–5.5.....................C. seductrix Sulliv. 2
Leaves not apiculate; teeth with 22–26 articulations; capsule 1:2.5–3......................... * C. compressum B. & S. 5
Distinctly serrulate; all basal cells rectangular; annulus large; teeth vertically striolate............ * C. Sullivantii Sulliv. ? 7

C. cladorrhizans, Saline (Henry), with a form much resembling C. brevisetum by its stems and branches less compressed, and pedicel shorter. C. seductrix, Shawnee (Cragin and Becker); Wabaunsee (Baldwin); Brown (Becker). * C. compressum, Saline

(Henry); Wyandotte, Riley, Pottawatomie, and Anderson ([M.] Reed). * C. Sullivantii ? very doubtful; poor material; Wyandotte Co. (M. Reed).

CLIMACIUM, p. 313.

Capsule straight; lid rostrate, ovate-oblong (1:2.5-3); leaves slightly decurrent, and hollowed at basal angles.
C. dendroides Web. & Mohr. 1

Saline, sterile, (Henry); Shawnee, sterile (Smyth).

HYPNUM, p. 316.

I. Leaves spreading.

A. Leaf-cells short (1:3 or less).
1. Leaves papillose; paraphyllia present.
Costa strong.
Capsule cylindric, or if oval-oblong, then operculum long rostrate.
Plants small (5 cm.), delicate, creeping, 1-2-pinnate; stem leaves long acuminate, cilia 1.......... H. gracile (?) B. & S. 10
Plants large (10 cm.), creeping; 2-3-pinnate; forming wide, flat mats.
Perichaetial leaves not ciliate; apical cells of branch leaves round............................ x H. recognitum Hedw.? 13
Plants large (10 cm.), erect; 1-pinnate, in wide tufts; capsule narrowly cylindric. (1:5-6)............ * H. abietinum Linn. 15
2. Leaves not papillose; unicostate or ecostate.
Leaves entire; plants creeping.
Ecostate or with obscure traces of a nerve.
Cilia 1-2, plants minute filiform, leaves ovate; long acuminate................................ * H. confervoides Brid. 118
Cilia 1-2, plants large, in wide, flat mats.......... * H. adnatum Hedw. 124
Leaves costate to apex; plants in loose tufts or mats, acuminate.
Basal cells much enlarged..................* H. irriguum Hook. & Wils. 122
Basal cells not enlarged ....H. irriguum, var. spinifolia Lesq. & James.
Annulus triple....................................* H. radicale Beauv. 120
Annulus simple...............................* H. orthocladon Beauv. 121
Leaves not acuminate..............................* H. fluviatile Swartz 123
Costa ceasing above the middle; cells alike throughout.
Inner perichaetial leaves with a short (1/4 length) point.
Capsule long-cylindric, arcuate; annulus triple...... * H. serpens Linn. 119
Capsule oblong, oblique; annulus simple............* H. Kochii Br. & Sch.
Inner perichaetial leaves subuliform-acuminate; cells vermicular......................... x H. porphyrrhizum Lindb.
Cells enlarged, rectangular at basal angles.
Cilia appendiculate, equaling segments...........* H. riparium Linn. 127
Plants slender, creeping; leaves narrow, serrulate at apex.
H. riparium, var. serratum Ren. & Card.
x H. riparium, var. cariosum Sulliv. ?
B. Leaf-cells elongated (1:5 or more).
1. Leaves costate half way or more.
a. Seta rough.
Lid convex-conic to long-conic; cells of basal angles scarcely different.

Leaves very short acuminate, glossy, not decurrent.... x H. rivulare Bruch 56
Leaves gradually acuminate, autoecious............... H. rutabulum Linn. 52
Lid (more or less long) rostrate; leaves acute or acuminate; cilia 2–3; leaf points not filiform.
Leaves serrulate all around; not decurrent nor excavate; acute segments perforate........................ x H. praelongum L. 75
Leaves entire at base; lid nearly as long as capsule.......* H. hians Hedw. 77
b. Seta smooth.
i. Lid (more or less long) rostrate.
Leaves apparently two ranked; plants of dry woods, * H. serrulatum Hedw. 89
Leaves spreading every way, ovate, acute, rarely slender-pointed; in water...................* H. rusciforme Weis. 90
Leaves deltoid, with long, slender points; points straight; spreading branchlets attenuate........ H. strigosum Hoffm. 70
ii. Lid convex to conic.
* Leaves acute or acuminate, serrulate.
Capsule symmetric, erect.
Dioecious, large (branches 3–4 cm.)............ * H. acuminatum Beauv. 36
Capsule unsymmetric, inclined.
Capsule short (1:1.5) monoecious; leaves straight when dry, * H. salebrosum Hoff. 37
Stems long; leaves shorter, and short acuminate, indistinctly serrate................. H. salebrosum, var. longisetum B. & S.
Capsule longer (1:3) dioecious; leaves straight when dry.... * H. laetum Brid. 35
Leaves short, broader, more strongly dentate and more loosely areolate .... H. laetum, var. dentatum Lesq. & James
* * Leaves acute or acuminate, entire.
† Capsule strongly constricted under mouth when dry.
Leaves widest just at base, tapering equally; concave, smooth, cells plain...........................* H. polygamum Wils. 132
Leaves widest above base, long-acuminate.........* H. chrysophyllum Brid. 30
† † Capsule slightly or not constricted; plants whitish, yellowish or bright green; cilia 2; Monoecious, leaves open, H. salebrosum Hoffm. 37
2. Costa very short, or none or double.
a. Alar cells, abruptly enlarged, often inflated and colored.
Leaves not falcate, filiform-acuminate; alar cells few, large orange; plants stout, 7-10 cm. long; leaves quite entire..............................* H. stellatum Schreb. 131
b. Alar cells scarcely different, or quadrate, not abruptly enlarged.
Leaves complanate; lid rostrate; leaves not undulate, quite entire, H. sylvaticum Huds. 109
Leaves serrulate to base, bicostate; annulus large......* H. geophilum Aust. 87
Leaves equally spreading; capsule inclined or horizontal, often arcuate, and smooth when dry; leaves squarrose; abruptly long-acuminate............ * H. hispidulum Brid. 129

II. Leaves secund.

A. Costa single, reaching to middle or beyond.
Cells elongated; seta rough; leaves entire............... H. plumosum ? Swz. 58
Seta smooth; leaves not rugose, often plicate; paraphyllia none; annulus large.
Dioecious, leaves striate; teeth brown or dark orange, bordered; alar cells pellucid ....* H. aduncum Hedw. 132

B. Costa double, short, or none.

Lid conic, often apiculate; capsule oval to oblong (1:1–2.5); alar cells pellucid, short, yellow, thick walled...........H. curvifolium Hedw. 159

x H. recognitum? Saline, sterile, (Henry); (Thuidium delicatulum). * H. abietinum, sterile, Bourbon (Bennett). * H. confervoides ? bright green areolation slightly chlorophyllose, leaves on young branches almost hyaline, Rooks (E. Bartholomew). * H. adnatum, Saline (Henry); Riley, leaves entire, costate to apex (M. Reed). * H. irriguum? with erect stem leaves, semitransparent in upper half, thick celled and chlorophyllose, the cells quadrangular but not enlarged at the base; capsule not constricted below the mouth; upper half of teeth hyaline; annulus two-celled; Riley (M. Reed). * H. irriguum, var. spinifolium? Riley (M. Reed). * H. radicale, differs from the type by being quite closely cespitose; plants small (½-1 cm.); areolation in some specimens nearly the same as base, cells rhomboidal, chlorophyllose, and more rectangular at base. The costa extends to below apex in some, and in others it is percurrent; segments entire and cilia as long as teeth; teeth closely articulate with a medial line distinct either half or entire length. This may be simply a local variation, or it may be a variety; or it may be a form of H. serpens, instead of H. radicale; found in Riley Co. (M. Reed). * H. orthocladon (H. varium); Saline (Henry), common; Riley (M. Reed). * H. fluviatile, branches attenuate, leafy to base; costa faint; leaves thin and delicate; found in a well curb, Riley (M. Reed). * H. serpens, very common and somewhat variable. Wyandotte, Riley and Pottawatomie (M. Reed); Saline (Henry); Brown (Becker); Jefferson (Cragin); Shawnee (Fields and Cragin). * H. Kochii[1], Saline (Henry); Riley (M. Reed); * H. porphorrhizum[2], Saline (Henry); Wyandotte (M. Reed). This is perhaps identical with H. hygrophyllum. H. riparium, Brown (Becker); Saline (Henry); Wyandotte (M. Reed). x H. riparium, var. serratum[3], Saline (Henry). Plants slender, creeping, and leaves narrow; serrulate at apex. x H. riparium, var. cariosum[3] ? Saline (Henry). x H. rivulare ? Saline (Henry); Wyandotte (Bennett). H. rutabulum, var. ? (Smyth's Check List). x H. praelongum, Saline (Henry). * H. hians, Shawnee (Fields); Wabaunsee (Baldwin); Jefferson (Cragin); Saline, sterile (Henry); Wyandotte (M. Reed). * H. serrulatum, Shawnee and Jefferson (Cragin); Wabaunsee (Baldwin); Franklin (Meeker); Wyandotte and Riley (M. Reed). * H. rusciforme (Smyth's Check List); Riley (M. Reed). H. strigosum, Wabaunsee (Baldwin). * H. acuminatum, Shawnee (Fields); Brown (Becker); Wilson (Cragin); Saline (Henry); Riley and Pottawatomie (M. Reed); common but sterile. H. salebrosum, var. longisetum (Smyth's Check List). * H. laetum, Shawnee (Becker); Wabaunsee (Baldwin); Labette (Newlon); Bourbon (Bennett); Saline, sterile (Henry); Pottawatomie, Riley, and Wyandotte, sterile (M. Reed). x H. laetum, var. dentatum, Saline, sterile (Henry). * H. polygamum?, Riley, specimens not quite mature (M. Reed). * H. chrysophyllum, Labette (Newlon); Wyandotte and Riley (M. Reed). H. sylvaticum, Saline (Henry), sterile. * H. geophilum ?, Wilson, immature (McClung). * H. hispidulum, Shawnee (Cragin); Brown (Becker); Saline (Henry); Riley (Reed). Basilar cells of leaves but slightly granulose; seta four times as long as branches, operculum but slightly apiculate. H. plumosum?, Shawnee (Fields); Saline (Henry). * H. aduncum, Saline, sterile, (Henry); Pottawatomie and Riley (M. Reed). H. curvifolium (Smyth's Check List).

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[1] Bot. Gaz., XIV, p. 99.

[2] Bot. Gaz., XIV, 1889, p. 99. Ren. & Card.

[3] Ren. & Card. Bot. Gaz., XIV, 1889, p. 98.

In looking over the entire list of Kansas mosses, I find there are 165 distinct species, besides about 10 varieties, reported up to the present date. This list is necessarily very incomplete, as but a small portion of the Kansas mosses have been collected and studied.

Of the 23 tribes found in North America, 14 only are represented in this list. They are the following: Phasceae, Weisiae, Pottieae, Grimmieae, Orthotricheae, Tetraphideae, Physcomitrieae, Bartramieae, Bryeae, Polytricheae, Fabroneae, Leskeaceae, Orthothecieae, and Hypneae.

The 128 genera found in North America are represented by 50 genera in Kansas. Forty-five of the 165 species are found in the immediate vicinity of Manhattan; while about 30 have never been reported from Kansas before.

Nearly all collecting has been done in the eastern third of the state, so that the mosses of the remaining two-thirds are unknown, except for a few scattering specimens.

Almost one-fifth of the moss flora of Kansas belongs in the great genus Hypnum; about one-half are distinctly eastern species; 10 are southern; 3 are Rocky Mountain species; 2 are Californian; about a dozen are central; 10 are distinctly Kansan; and the remainder are cosmopolitan species.

This shows that our moss flora is composed of vagrants from every region in North America, as here is the middle ground where the different flora meet, or overlap; Kansas being the extreme limit of many species.

When the mosses of the western part of the state are more thoroughly studied, no doubt some entirely new species will be added to the present list, while the conclusions may be quite different from those now reached, for there is reason to believe that mosses, as well as other plants of the western plains, are quite characteristic. However, there is no doubt that as we go further west on the arid plains, the number of mosses decreases with the moisture until we reach the Rocky Mountains, where there is both shade and moisture to favor their growth.

Manhattan, Kan., June, 1893.

EXPLANATION OF PLATES.

NOTE.—All measurements in the plates are one-third that given in the explanation.

PLATE I.

(a) Weisia viridula Brid. var. stenocarpa Muell., x 25. (b) Part of the peristome showing teeth in pairs, x 500. (c) Spore showing papillous surface, x 500. (d) Cells of the leaf at apex. (e) Cells of base of leaf. (f) Comal leaf much enlarged. (g) Male flower showing antheridia and paraphyses, and perigonial leaves. (h) Tip of leaf, showing the incurved edges. (i) Antheridium greatly enlarged. (j) A dry plant of Weisia viridula Brid., x 2. (k) Capsule showing the peristome. (l) Peristome many times magnified, with two spores. (m) A leaf, x 20. (n) Cells at apex of leaf. (o) Cells at base of leaf.

PLATE II.

(a) Plant of Dicranella varia Schimp., with fruit. (b) Dry capsule more enlarged, showing the curved beak of the operculum. (c) Spores equivalent to 27 mmm. (d)Bifid tooth with a part of the edge of the capsule. (e) Tip of leaf, showing the cells. (f) Leaf enlarged considerably. (g) Basal cells of the leaf.

PLATE III.

(a) Dicranum scoparium Hedw. from a New York specimen, x 5. (b) Capsule with operculum, dry, x 5. (c) A part of a male plant showing antheridia in the axils of the leaves. (d) Leaf greatly magnified. (e) Basal cells of leaf. (f) Apical cells. (g) Two trifid teeth with spores. (h) Spores equivalent to 18 mmm. x 500. (i) Antheridium.

PLATE IV.

(a) Fissidens bryoides Hedw., from Switzerland, x 5. (b) Capsule and peristome, dry, showing constriction under the mouth. (c) Tip of branch more enlarged. (d) Perichaetial leaf enlarged, showing leaf cells. (e). Basal cells. (f) Cells at apex. (g) Ordinary branch leaf, much enlarged, showing cells and dorsal lamina. (h) Basal cells. (i) Apical cells and projecting costa. (j) Cross section near the base of leaf, showing the dorsal lamina and both halves of the true leaf. (k) Part of the peristome, showing one pair of teeth and the base of another. (l) Spore diameter, 10-14 mmm. (m) Fissidens obtusifolius Wils., Kansas, x 4. (n) leaf. (o) Capsule. (p) Spores.

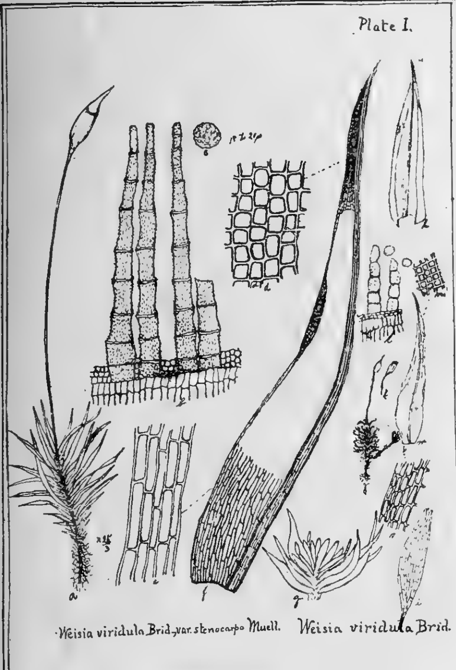


Plate I.
Weisia viridula Brid, var. stenocarpa Muell.
Weisia viridula Brid.

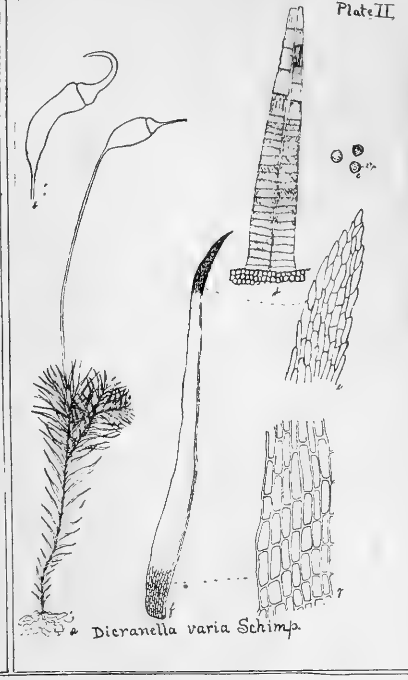


Plate II.
Dicranella varia Schimp.

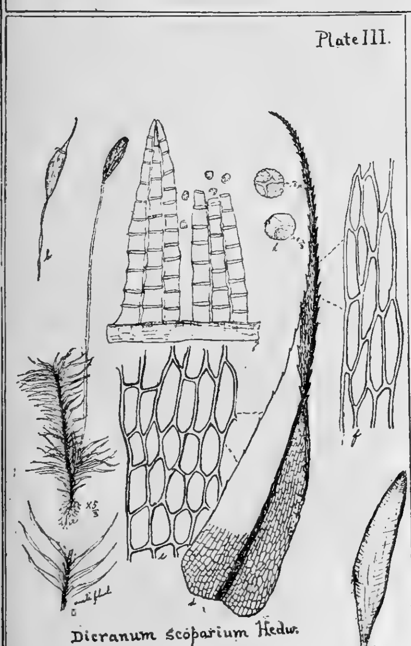


Plate III.
Dicranum scoparium Hedw.
M. Reed, Del.

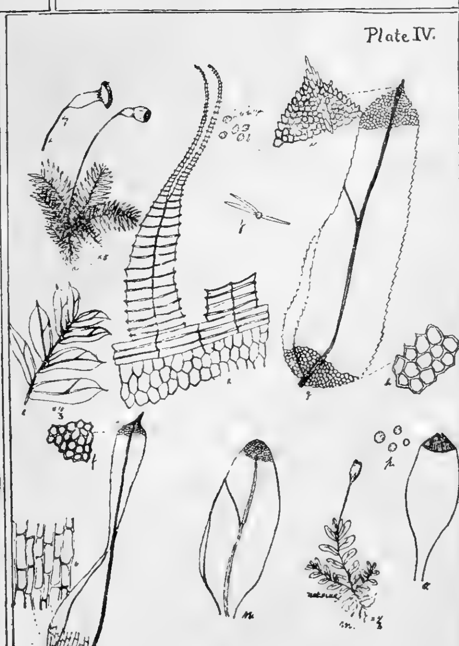


Plate IV.
Fissidens bryoides Hedw.
Fissidens crassifolius, Wils.

PLATE V.

(a) Sterile plant of Leucobryum vulgare Hampe, x 2. (b) A leaf, x 10. (c) Cells at edge of leaf, x 500. (d) Outer layer of leaf cells, x 500. (e) Inner leaf cells, showing water pores and chlorophyl grains, x 500. (f) Cross section of the leaf. (g) Cross section of one-half of the leaf, showing the outer cells with their water pores and the inner narrow chlorophyl cells between, x 500.

PLATE VI.

(a) Ceratodon purpureus Brid., x 6, showing the fruit with the cucullate calyptra, and conical lid. (b) The same dry, showing the angular shape of the capsule, with twisted seta and curled leaves, x 6. (c) Stem leaf near apex. (d) Basal cells. (e) Apical cells. (f) Perichaetial leaf. (g) Basal cells. (h) Apical cells. (i) Two teeth of the peristome, showing papillose surface, with upper edge of the capsule and a portion of the annulus. (j) Portion of the annulus. (k) Spores equal to 8-12 mmm. (l) Operculum. (m) Cells of the edge of operculum. (n) Plant of C. purpureus, from Switzerland.

PLATE VII.

(a) Leptotrichum pallidum Hampe, x 3. (b) Dry capsule, showing ridges and slightly twisted peristome and seta. (c) Verruculose spores, diameter 18-20 mmm. x 500. (d) Obliquely rostrate operculum. (e) A portion of the peristome capsule, and annulus, showing the papillae on the slender teeth. (f) Stem leaf, x 15. (g) Basal cells, x 500. (h) Apical cells, x 500. (i) Outer perigonal leaf, x 100. (j) Middle cells, x 500. (k) Apex of same, x 500. (l) Inner perigonal leaf, x 100. (m) Basal cells, x 500. (n) Awn point, x 500. (o) Young fruit and plant of same, showing male flowers in axils of leaves, x 6.

PLATE VIII.

(a) Trichostomum tophaceum Brid., x 5, from California. (b) Dry capsule, showing lines and twisted seta, x 35. (c) Stem leaf. (d) Basal cells, x 500. (e) Apical cells, x 500. (f) A portion of peristome and edge of capsule, showing nodular and irregular forms of the teeth, with the large papillae, x 500. (g) The long rostellate operculum, x 35. (h) Spores, showing oil drops, diameter equal to 9-13 mmm., x 200.

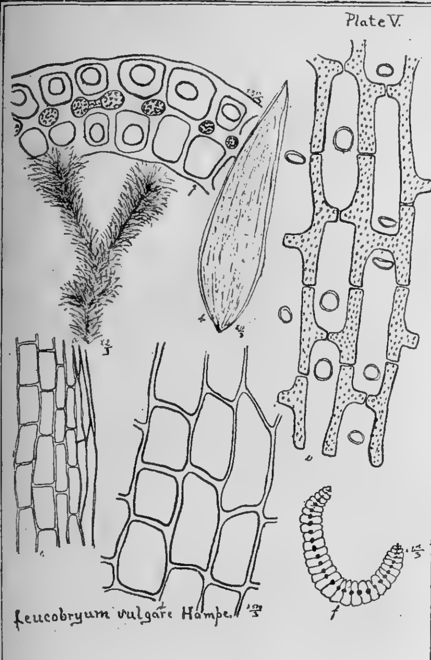


Plate V.

Leucobryum vulgare Hampe.

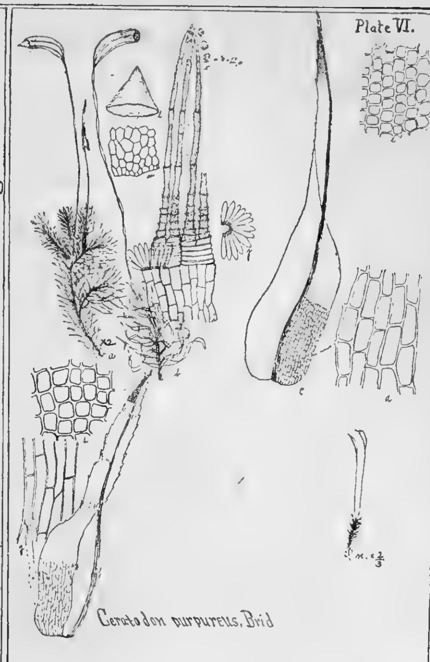


Plate VI.

Ceratodon purpureus, Brid.

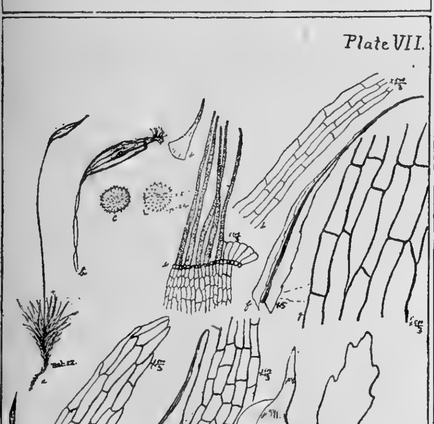


Plate VII.

Leptotrichum pallidum Hampe.

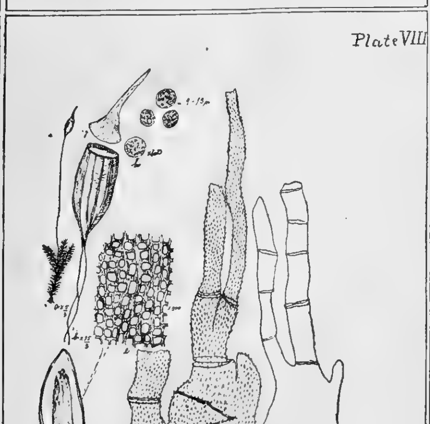


Plate VIII.

Trichostomum tophaceum, Brid.

PLATE IX.

(a) Barbula unguiculata Hedw., x 15. (b) Dry plant of same, showing the twisted leaves, seta, and peristome, also the projecting columella, x 15. (c) Stem leaf, x 100. (d) Basal cells, x 200. (e) Apical cells, showing the papillae, x 200. (f) Cucullate calyptra. (g) Operculum. (h) Partly twisted teeth, showing the papillae, x 100. (i) Perichaetial leaf, x 60. (j) Basal cells. (k) Inner perichaetial leaf. (l) Spores, diameter equivalent to 9-11 mmm., x 200.

PLATE X.

(a) Ptychomitrium incurvum Sulliv., x 10, from New York. (b) Comal leaf, x 100. (c) Basal leaf, x 100. (d) Basal leaf, x 500. (e) Upper cells. (f) Part of the peristome and upper edge of the capsule, teeth bifid and densely papillose, x 200. (g) Part of the annulus, x 200. (h) Operculum. (i) Calyptra. (j) Spores, diameter equivalent to 9-12 mmm., x 500.

PLATE XI.

(a) Orthotrichum cupulatum Hoff., var. minus Sulliv., x 20. (b) The hairy calyptra. (c) Moist capsule, showing colored stripes and incurved peristome. (d) Dry capsule, showing recurved peristome. (e) Operculum. (f) Spores, diameter equivalent to 10-14 m., x 500. (g) Part of capsule, showing the square cells and one of the bifid teeth. (h) Enlarged leaf showing areolation. (i) Border cells. (j) Apical cells. (k) Stomata of capsule.

PLATE XII.

(a) Physcomitrium Kellermanii Mrs. Britton, x 1. (b) Plant of Physcomitrium pyriforme Brid., x 15. (c) Young capsule. (d) Cucullate calyptra. (e) Operculum. (f) Papillose spores, diameter equivalent to 25-30 mmm. (g) Comal leaf. (h) Basal cells. (i) Upper cells, showing chlorophyllose grains. (j) Cells of edge near apex of leaf. (k) Dry capsule. (l) Plant of Physcomitrium Hookeri Hampe, x 10. (m) A portion of the compound annulus and upper edge of capsule, showing the transversely elongated cells. (n) Papillose spores, diameter equivalent to 18-23 mmm. (o) Leaf, x 20. (p) Basal cells. (q) Apex of leaf. (r) Male plant, with the blossom.

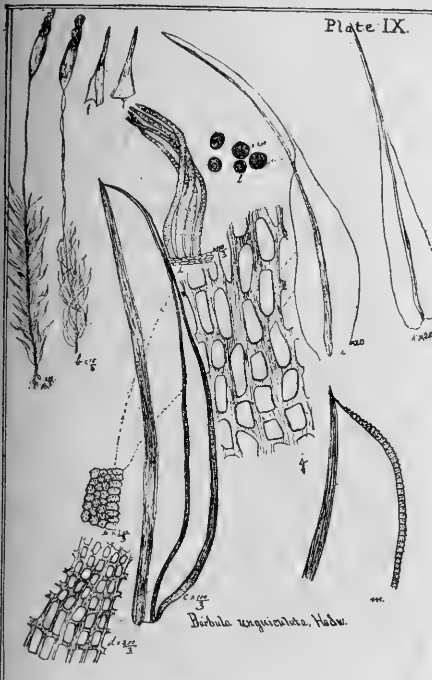


Plate IX.
Barbula unguiculata, Hedw.

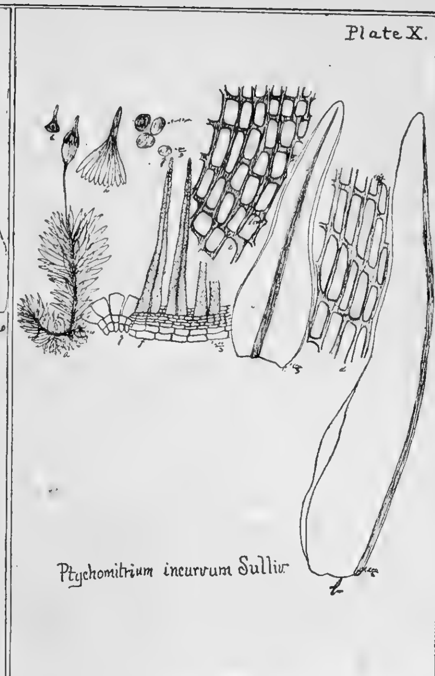


Plate X.
Ptychomitrium incurvum Sulliv.

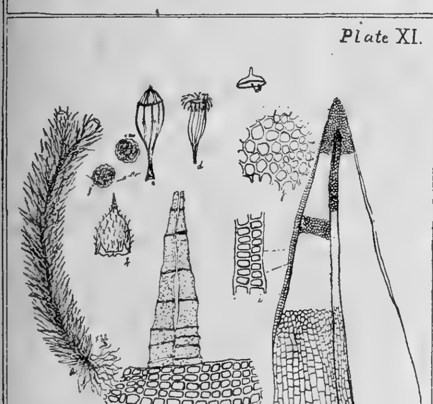


Plate XI.
Orthotrichum cupulatum, Hoffm. var. minus, Sulliv.
M Reed, del.

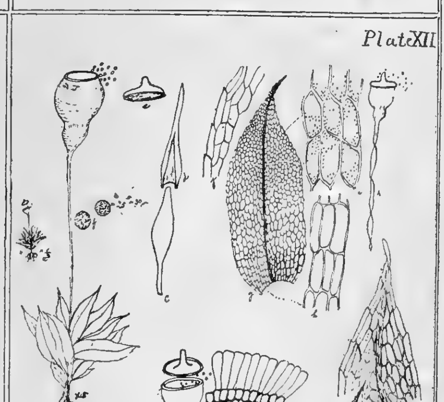


Plate XII
Physcomitrium pyriforme, Brid.
Physcomitrium Hookeri, Hampe.

PLATE XIII.

(a) Physcomitrium Kellermanii Mrs. Britton, x1. (b) Same, x 10. (c) Operculum, x 10. (d) Base of seta, showing the vaginule, x 350. (e) Papillose spores, diameter equivalent to 25-30 mmm. (f) Calyptra inverted. (g) Leaf, x 35. (h) Apex of leaf, showing serrulate edge and apex, with excurrent costa, x 100. (i) Basal cells, x 100. (j) A portion of the annulus and capsule, showing transversely elongated cells. (k) Leaf cells from base, x 500. (l) Cells from Apex of leaf, x 500. (m) Part of capsule, showing stomata cells.

PLATE XIV.

(a) Funaria hygrometrica Sibth., x 8, showing the incurved peristome. (b) Dry plant of the same, x 10. (c) Young capsule, with calyptra, x 12. (d) Comal leaf. (e) Basal cells. (f) Apical cells, showing chlorophyl grains. (g) Operculum, showing thickened rim and spiral lines. (h) Side view, showing mamillate top. (i) Annulus. (j) Spores, diameter equivalent to 18-23 mmm. (k) Rim of lid, much magnified. (n) Base of seta, with undeveloped female flowers and paraphyses. (o) Archegonium. (p) Part of the outer and inner peristome, showing one tooth of each.

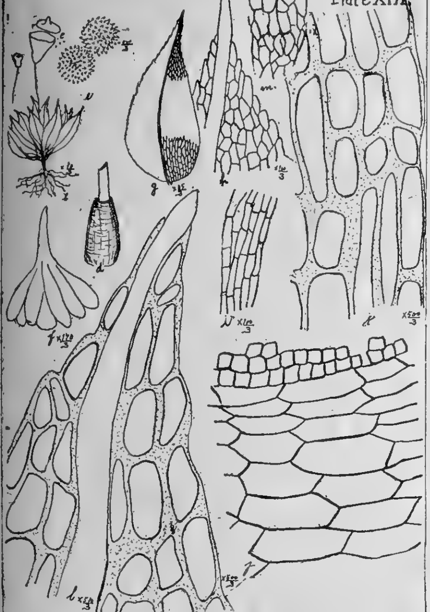
PLATE XV.

(a) Bartramia pomiformis Hedw., from Iowa, x 5. (b) Dry capsule with seta, x 15. (c) Operculum. (d) Leaf showing areolation, and serrate excurrent costa. (e) Basal cells. (f) Cells near apex. (g) Part of peristome and upper part of capsule, showing the projecting membrane which bears the peristome, also the divisural line on two teeth, with two cilia dividing each segment. (h) Papillose spores, diameter equivalent to 98-23 mmm.

PLATE XVI.

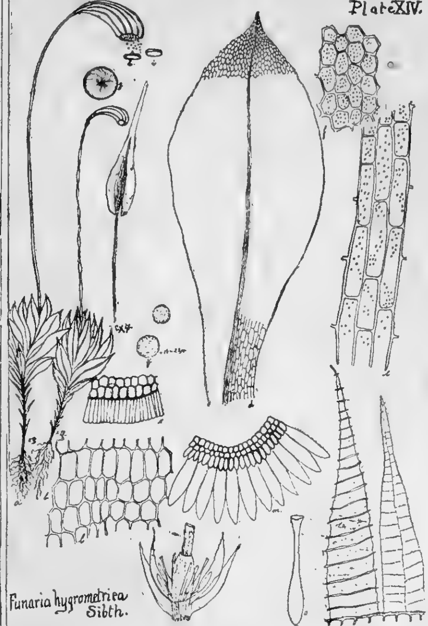
(a) Philonotis Muhlenbergii Brid., x 2, from Massachusetts. (b) Dry capsule, x 5. (c) Stem leaf, x 50. (d) Basal cells, x 500. (e) Apical cells, x 500. (f) Perichaetial leaf, x 50. (g) Branch leaf, x 50. (h) Basal cells, x 500. (i) Part of edge near apex, showing cells, x 500. (j) Part of inner and outer peristome. (k) Spores, diameter equivalent to 22 mmm., x 500.

Plate XIII.



Physcomitrium Kellermanii Mrs. B.

Plate XIV.

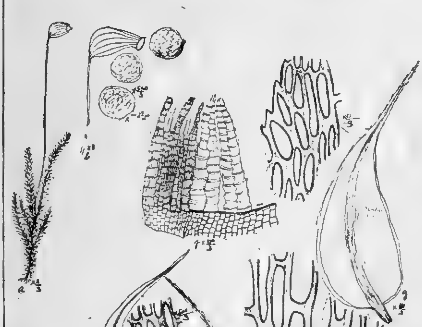


Funaria hygrometrica Sibth.

Plate XV.

Bartramia pomiformis Hedw.

Plate XVI.



Philonotis muhlenbergii Brid.

M. Reed, Del.

PLATE XVII.

(a) Leptobryum pyriforme Linn., x 10, from Nebraska. (b) A dry capsule. (c) The base of seta, with unfertilized archegonia and paraphyses. (d) Operculum. (e) Part of the edge of lid. (f) Part of the peristome, showing two outer teeth, one carinate segment, with cilia between. (g) Part of annulus. (h and i) Leaves. (j) Basal cells. (k) Apex. (l) Male plant. (m) Female. (n) Calyptra. (o) Perichaetial leaf. (p) Apex enlarged. (q) Middle cells. (r) Basal cells. l, m, n, o, p, q and r from an immature Kansas specimen.

PLATE XVIII.

(a) Sterile plant of Webera albicans Sch., x 3. (b) Stem leaf. (c) Upper branch leaf. (d) Apex of upper leaf. (e) Cells of the leaf. (f) Fruiting specimen of Webera albicans, from California, x 2. (g) Leaf. (h) Basal cells. (i) Upper cells. (j) Capsule and operculum, x 4. (k) Perichaetial leaf. (l) Apical cells. (m) Part of Peristome, both inner and outer. (n) Spores showing oil drops, diameter 18-23 mmm.

PLATE XIX.

(a) Bryum argenteum Linn., x 5. (b) Branch, with male flower. (c) Operculum. (d) Part of both inner and outer peristome. (e) Annulus cells. (f) Branch leaf. (g) Stem leaf. (h) Perichaetial leaf. (i) Cells. (j) Bryum caespiticium Linn., x 4. (k) Male plant of the same, x 5. (l) Capsule, x 8. (m) Part of peristome. (n) Part of annulus. (o) Comal leaf. (p) Basal cells. (q) Middle cells.

PLATE XX.

(a) Timmia megapolitana Hedw., x 3. (b) Tip of fruiting branch, showing young capsule with calyptra. (c) Filiform stoloniferous branch. (d) Calyptra on a younger capsule. (e) Capsule, with peristome. (f) Stem leaf. (g) Basal cells. (h) Apex of leaf. (i) Synoecious flower, showing base of seta, antheridia, paraphyses, and undeveloped archegonia, with the perigonial leaves inclosing them. (j) Latticed inner peristome, and two of the outer peristome. (k) Spores, diameter 18 mmm., x 500.

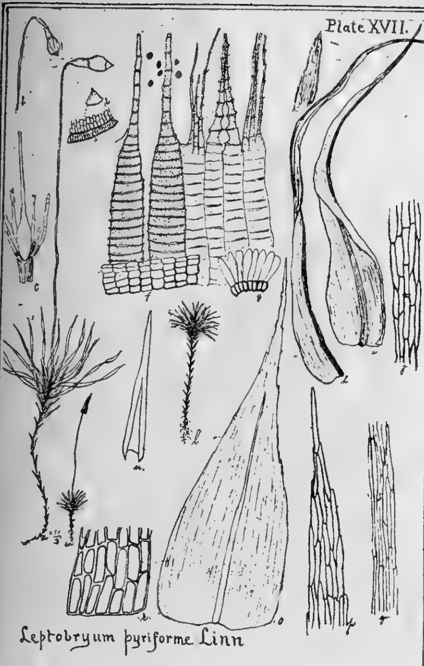


Plate XVII.

Leptobryum pyriforme Linn

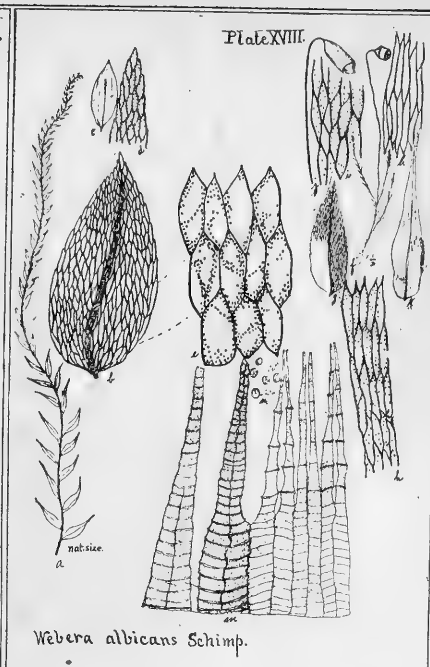


Plate XVIII

Webera albicans Schimp.

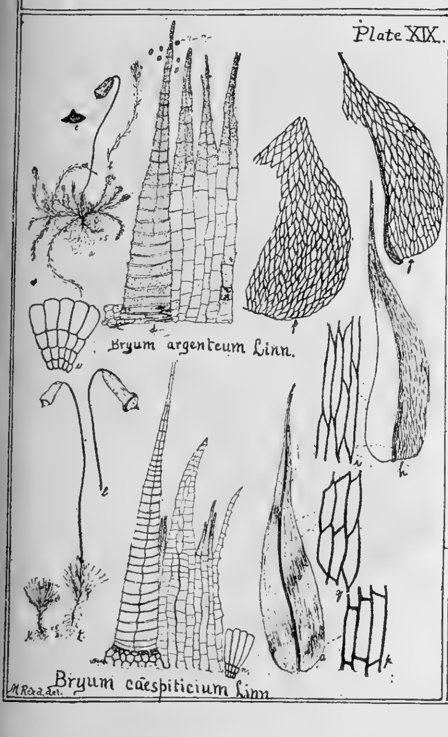


Plate XIX.

Bryum argenteum Linn.

Bryum caespiticium Linn

M Reed, del.

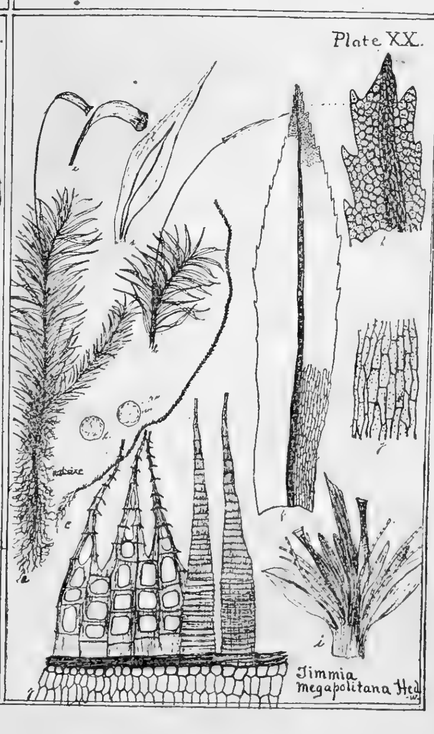


Plate XX.

Timmia megapolitana Hed.

PLATE XXI.

(a) Mnium cuspidatum Hedw., x 8. (b) Comal leaf. (c) Basal cells and border. (d) Part of border cells near apex, showing chlorophyl grains. (e) Base of seta showing vaginule, antheridia, paraphyses and unfertilized archegonia. (f) Calyptra. (g) Spores, diameter 30-35 mmm., x 500. (h) Two outer teeth and part of upper edge of capsule. (i) Part of inner peristome. (j) View of peristome from above. (k) Operculum.

PLATE XXII.

(a) Atrichum undulatum Beauv., x 3. (b) Dry plant, natural size. (c) Male plant, x 3. (d) Male flower greatly magnified, showing antheridia in the perigonium. (e) Calyptra and capsule. (f) Operculum. (g) Upper leaf, x 60. (h) Basal cells, x 500. (i) Apical cells and border, x 500. (j) Basilar leaf. (k) Cross section of upper leaf, showing the laminae. (l) Perigonial leaf. (m) Part of peristome and upper part of capsule. (n) Spores, diameter 18 to 22 mmm., x 500. (o) Antheridia.

PLATE XXIII.

(a) Pylaisia Selwynii?, x 5. (b) Dry capsule. (c) Operculum. (d) Tip of male branch. (e) Part of the peristome, showing the inner adherent segments, and divisural line down the center of teeth; also part of the inner membrane, and upper edge of capsule. (f) Verruculose spores, diameter 17 to 22 mmm. (g) Branch leaf. (h) Cells of leaf. (i) Stem leaf. (j) Cells of leaf. (k) Perichaetial leaf. (l) Basal cells. (m) Upper cells. (n) Pylaisia velutina B.&S., x 2. (o) Stem leaf. (p) Perichaetial leaf. (q) Capsule. (r) Operculum. (s) Calyptra.

PLATE XXIV.

(a) Thelia asprella Sulliv., x 5, from a Wisconsin specimen. (b) Operculum. (c) Spores, showing oil drops, x 500. (d) Part of inner and outer peristome and edge of capsule, x 100. (e) Tip of papillose tooth, x 500. (f) Stem leaf, x 100. (g) Leaf cells and ciliate border of same, x 500. (h) Border and cells at base, x 500. (i) Upper rim of the capsule, much magnified. (j) Perichaetial leaf, x 100. (k) Tip of cilia on apex, x 500. (l) Basal cells, x 500. (m) Base of cilia from upper edge, x 500.

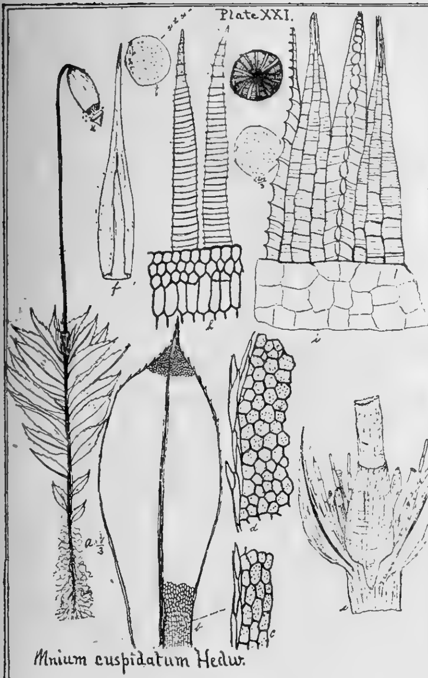


Plate XXI.
Mnium cuspidatum Hedw.

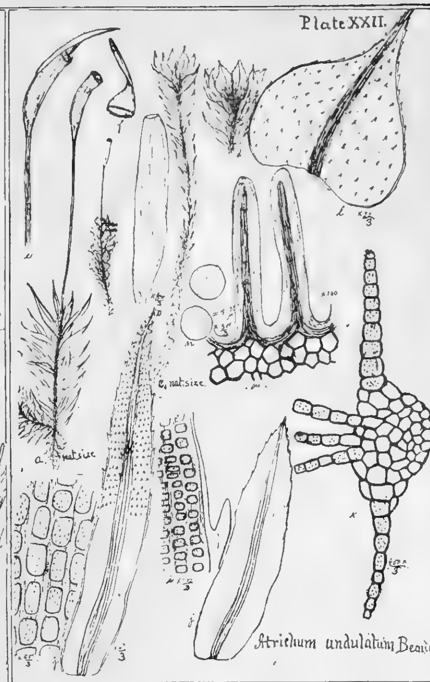


Plate XXII.
Atrichum undulatum Beauv.

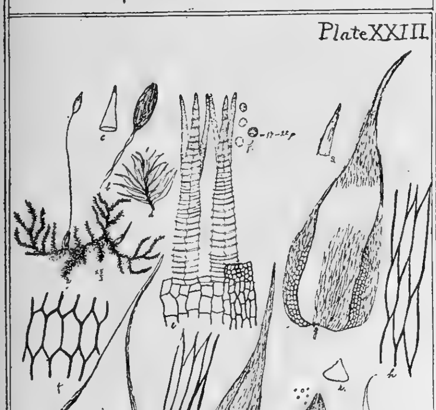


Plate XXIII.
Pylaisia selwyni?
Pylaisia velutina B. & S.
H. Reed Del.

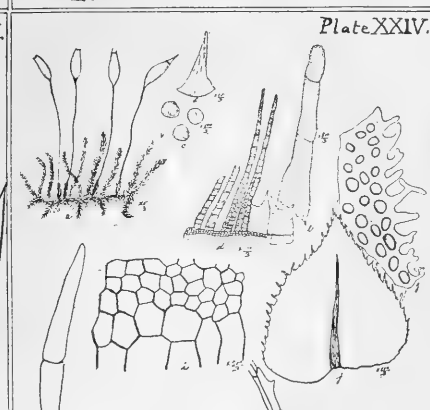


Plate XXIV.
Thelia asprella Sull.

PLATE XXV.

(a) Leskea pulvinata Wahl. (b) Capsule and part of twisted pedicel. (c) Operculum. (d) Part of inner and outer peristome, with part of capsule. (e) Spores, diameter equivalent to 13-18 mmm., x 500. (f) Archegonia. (g) Archegonia much magnified. (h) Stem leaf. (i and j) Perichaetial leaves.

PLATE XXVI.

(a) Leskea polycarpa Ehrh., x 3. (b) Capsule enlarged more. (c) Operculum. (d) Calyptra. (e) Part of inner peristome. (f) Two teeth of outer peristome. (g) Part of annulus. (h) Spores, diameter equivalent to 11-13 mmm., x 500. (i) Stem leaf. (j) Border and inner cells of leaf. (k) Perichaetial leaf.

PLATE XXVII.

(a) Anomodon rostratus Sch., x 5. (b) Branch leaf. (c) Perichaetial leaf. (d) Part of inner and outer peristome. (e) Irregular spores, diameter equivalent to 8-10 mmm. (f) Anomodon obtusifolius Br. & Sch., x 5. (g) Inner and outer peristome. (h) Spores, diameter equivalent to 16-18 mmm. (i) Branch leaf. (j) Perichaetial leaf.

PLATE XXVIII.

(a) Leskea obscura Hedw., x 3. (b) Young fruit in calyptra. (c) Operculum. (d) Capsule much enlarged, x 40. (e) Tooth greatly magnified. (f) Stem leaf. (g) Spores, diameter equivalent to 9-12 mmm., x 500. (h) Stem leaf. (i) Branch, showing young fruit, young branch, and male bud.

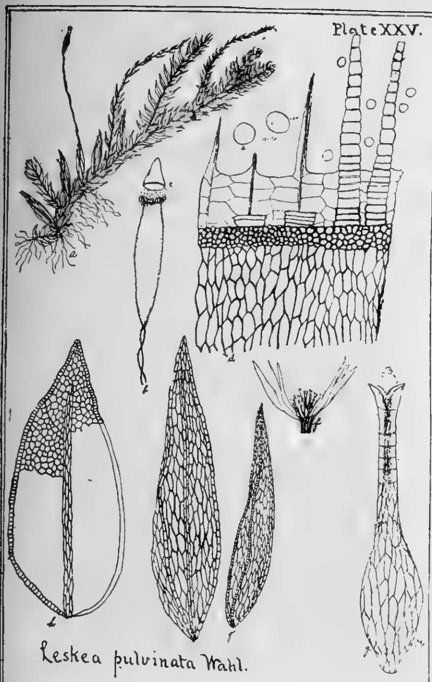


Plate XXV.
Leskea pulvinata Wahl.

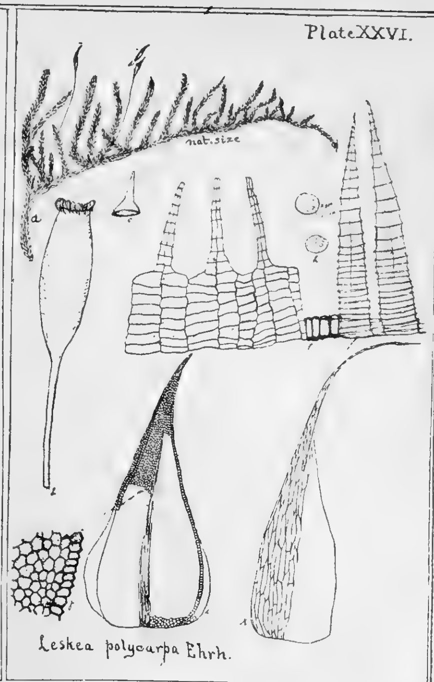


Plate XXVI.
nat. size
Leskea polycarpa Ehrh.

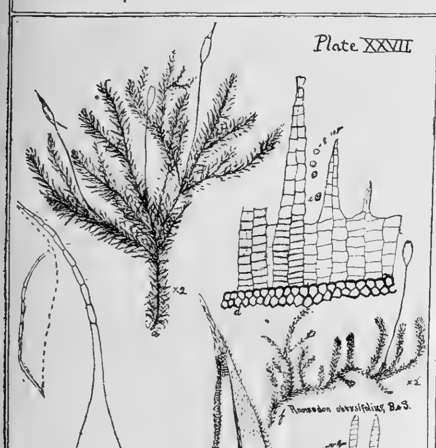


Plate XXVII.
x2
Anomodon obtusifolius, B. & S.
Anomodon rostratus Sch.
M. Reed. Del.

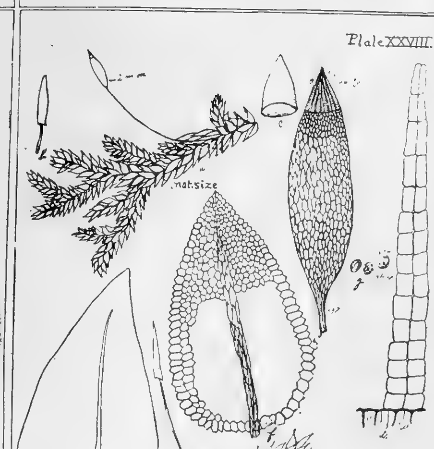


Plate XXVIII.
nat. size
Leskea obscura Hedw.

PLATE XXIX.

(a) Cylindrothecium compressum B. & S., x 6. (b) Concave leaf from stem. (c) Basilar cells, x 500. (d) Cells from upper part of leaf, x 500. (e) Dry capsule. (f) A tooth of the peristome. (g) Spores, diameter equivalent to 9-13 mmm., x 500. (h) Perichaetial leaf. (i) Calyptra.

PLATE XXX.

(a) Hypnum porphorrhizum? Lindb., x 3. (b) Young capsule with calyptra. (c) Capsule. (d) Dry capsule more magnified, with apiculate operculum. (e) Part of inner peristome, showing carinate segments and cilia between. (f) Part of outer peristome. (g) Spores, diameter equivalent to 9 mmm. (h) Branch leaf, x 75. (i) Basilar cells, x 500. (j) Perichaetial leaf, x 70. (k) Cells of leaf, x 500. (l) Stem leaf, x 100. (m) Cells of stem leaf, x 500.

PLATE XXXI.

(a) Hypnum serpens Linn., x 2. (b) Part of branch, much enlarged. (c) Stem leaf. (d) Cells of leaf. (e) Part of peristome and upper edge of capsule, also part of annulus. (f) Spores, diameter 18 mmm., x 500. (g) Perichaetial leaf.

PLATE XXXII.

(a) Hypnum laetum Brid., with mature fruit. (b) Peristome, inner and outer. (c) Perichaetial leaf. (d) Stem leaf. (e) Operculum. (f) Spores, diameter 14-18 mmm., x 500. (g) Hypnum hians Hedw., x 2. (h) Capsule. (i) Calyptra. (j) Peristome. (k) Leaf. (l) Apex.

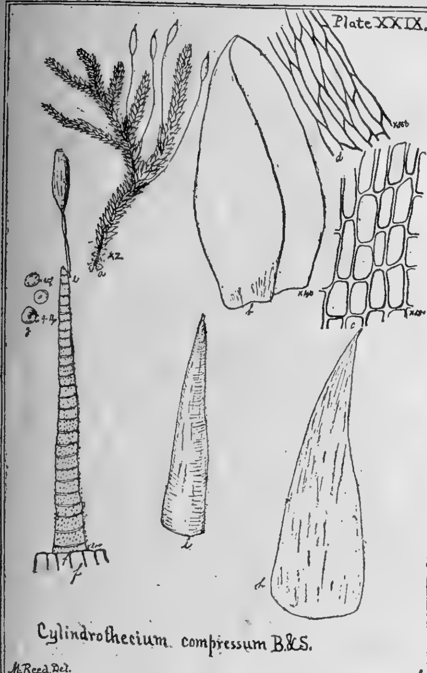


Plate XXIX.

Cylindrothecium compressum B.&S.

M. Reed, Del.

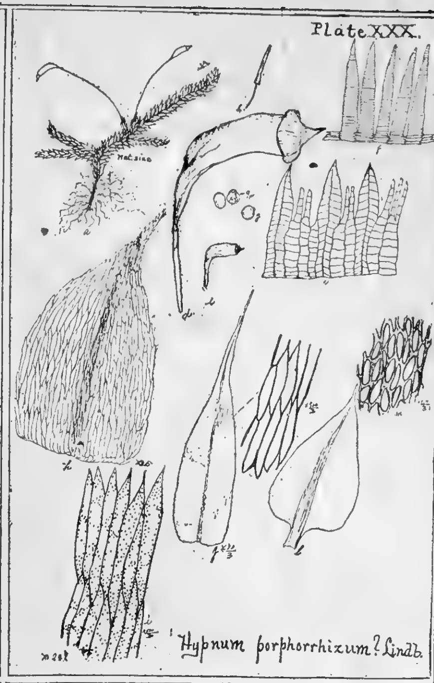


Plate XXX.

Hypnum porphorrhizum? Lindb.

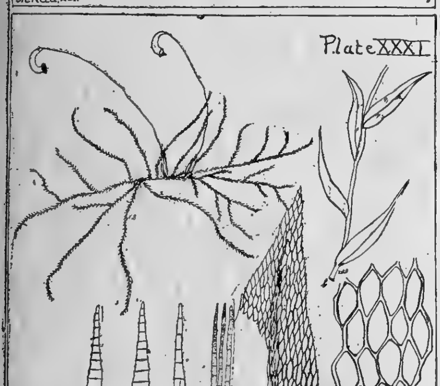


Plate XXXI.

Hypnum serpens, Linn.

M. Reed, Del.

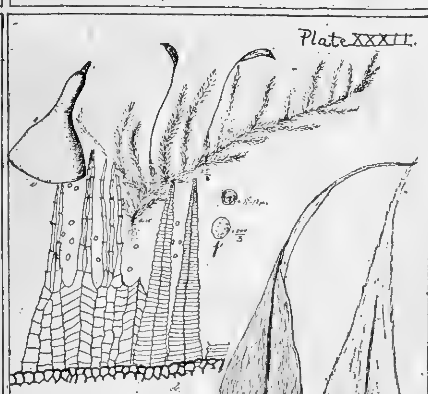


Plate XXXII.

Hypnum laetum, Brid.

Hypnum hians Hedw.

PLATE XXXIII.

(a) Hypnum abietinum Linn., x 3, sterile. (b and c) Stem leaves. (d) Papillose cells. (e and f) Paraphyllia, x 500. (g) Long paraphyllum, x 500.

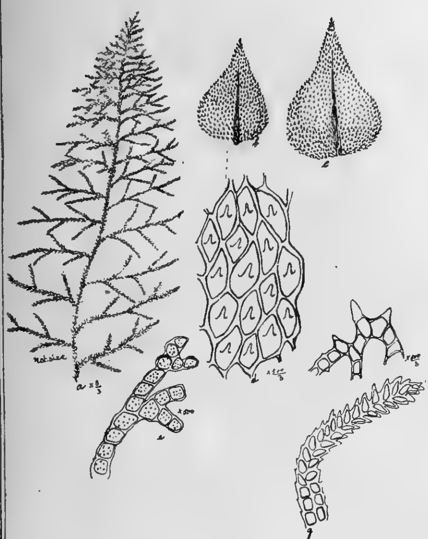
PLATE XXXIV.

(a) Hypnum hispidulum Brid., x 5. (b) Leaf, showing areolation. (c) Branch, x 45. (d) Perichaetial leaf. (e) Female flower. (f) Part of inner and outer peristome, also upper edge of capsule. (g) Spores, diameter equivalent to 7-10 mmm.

PLATES XXXV AND XXXVI.

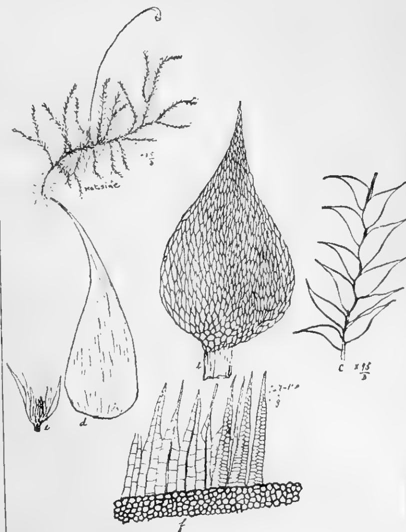
(a) Protonema of Pogonatum brevicaule Beauv., x 100. (b) Tip of same, x 500. (c)Gemmae of Tetraphis pellucida, x 500. (d) Pseudopodium of Tetraphis pellucida, x 6. (e) Cup containing the gemmae of same, x 20. (f) Spore germinating. (g) Same, in later stage. (h) Protonema, developed from spore, with leaf buds just starting; drawn from picture.

Plate XXXIII.



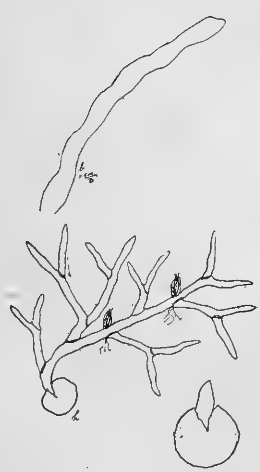
Hypnum abietinum Linn.

Plate XXXIV.



Hypnum hispidulum Brid.

Plate XXXV.

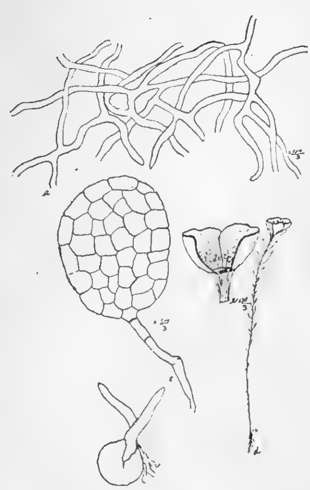


Pogonatum brevicaule Beauv.

Protonema.

M. Reed. Del.

Plate XXXVI.



Tetraphis pellucida Hedw.

Gemmae and pseudopodium.

ERYSIPHEAE OF RILEY COUNTY, KANSAS.

By LORA L. WALTERS, Manhattan.

Erysipheae, commonly known as "white mildews," or "blights," may be easily recognized by the white dusty or web-like coating on the outside of leaves or stems or other parts of many common plants. This white coating, the mycelium, consists of numerous slender colorless threads, branching and intercrossing, pressed close to the host plant. At short intervals they send out special branches, called haustoria, that penetrate the epidermal cells, serving to attach the fungus to the host, and also to extract nourishment.

Erysiphae are reproduced both asexually by conidia and sexually by sporidia. Chains of conidial cells are formed at the ends of short branches of the mycelium, called fertile hyphae or conidiophores. Under favorable conditions these conidia germinate rapidly, sending out slender tubes and forming new mycelium.

The perithecia containing sporidia are globose, sometimes depressed, bodies seated singly on the mycelium. At first they are colorless, then yellow, becoming dark brown or black when mature, bearing thread-like appendages. These perithecia contain delicate, thin-walled sac-like bodies called asci. These are colorless, more or less oval in shape, usually pedicillate, containing from two to eight sporidia. The sporidia are simple spores, colorless, granular, oblong or oval. The perithecia usually appear late in summer and remain on the fallen leaves over winter. They are not provided with any opening, and the spores escape only by the decaying of the perithecium.

Linneus, in Species Plantarrum, p. 1186, 1753, describes all powdery mildews as one species of fungi, under the name of Mucor Erysiphe. He describes it as follows: "Mucor albus capitulis, fuscis sessilibus. Habitat in foliis Humuli, Aceris, Lamii, Galeopsidis, Lithospermi."

In all descriptions the original has been consulted, where it was accessible, and copied. These descriptions are inclosed in quotation marks and follow the citation. The citations not consulted are inclosed in quotation marks. Where the original description could not be obtained the next oldest is given.

This work has been done in the botanical laboratory of the Kansas State Agricultural College. The list is based upon specimens contained in the herbarium of the college.

SPHAEROTHECA, Lev. Ann. Sci. Nat. 3d S. XV, p. 30 [138] (1851). "Mycelium arachnoideum floccosum effusum plerumque persistens. Conceptacula globosa, sporangio unico vesiculoso, octosporo farcta; sporae ovatae. Appendiculae numerosae floccosae cum mycelio intertextae."

S. Castagnei. Lev. Ann. Sci. Nat. Ser. III, Tome XV, p. 31 [139] (1851). "Bifrons. Mycelio effuso arachnoideo plerumque evanido. Conceptaculis minutis sparsis globosis. Appendiculis numerosis brevibus sursum flexis." Leville gives a large number of different host plants of widely separated orders. Perithecia abundant 80-100 mmm, appendages usually colored throughout, asci elliptical, sporidia usually eight, variable in size. On Bidens cernua L., B. connata Muhl., Taraxacum Taraxacum (L.) MacM.

ERYSIPHE Hedw. in DC. Flore Franc. II, p. 272 (1805); Lev. (Emend.) Ann. Sci. Nat. 3d S. XV, p. 53 [161] (1851). The following is the original description from DC. as cited above: "Les erysiphes ont un receptacle charm qui renferne plusieurs pericarpes ovoides, aigus, dont chacun contient deux graines; ce receptacle est entoure d'une pulpe blanchatre qui se prolonge en plusieurs rayons articules, simples ou rameux." "Perithecium containing several asci, appendages simple threads similar to and frequently interwoven with the mycelium." (Ellis & Everhart.)

E. communis (Wallr.) Link Spec. Pl. 105 (1824) as Erysibe. "E. hyphasmate demum effuso, floccis, arachnoides, sporangiis sphaericis sparis numerosissimis tandem nigro-fuscis capillitio albo adfixis. Alphito morpha communis, Wallr. Verhandl. Naturf. Frde. 1, p. 31. Habitat in variis Europae plantis, Diagn. Flocci albidi aut cinerei tenerrimi initio hyphasmata subrotunda formantes tum effusa. Sporangia primum alba tum flava, tandem nigro-fusca. Capillitii flocci simplices albi hyphasmati affixi." Asci 4-8 or more. Sporidia usually 4-8. On Scutellaria lateriflora, L. Astragalus carolinianus L. Falcata comosa (L.) Kuntze.

E. cichoracearum DC. Flore Franc. II, p. 274 (1805). "J'ai trouve cette espece a Bagneux, a la fin d'un ete eres-sec; elle attaque les deux surfaces des feuilles de la scorzonere d'Espagne, et du salsifix a feuilles de poireau; ses tubercules sont noirs, epars globuleux, un peu deprimes; de leur base partent des filamens blancs, rayonnans, nombreux, articules et souvent rameux on anastomoses; ces filamens prennent beaucoup d'accroissement avant la naissance des tubercules, et couvrent quelquefois la feuille entiere d'un fin reseau blanc, avant de porter ancun fruit; a la fin de leur vie, ceux qui avoisinent les tubercules deviennent roussatres." Perithecia 100-160 mmm. On Helianthus tuberosus L., Carduus altissimus L., Dysodia papposa (Vent.) Hitchc., Ambrosia trifida L., Parietaria pennsylvanica Muhl., Verbena stricta Vent., Solidago missouriensis Nutt.

E. graminis DC. Flore Franc. VI, p. 106 (1815). "J'ai trouve cette belle espece d'erysiphe sur les feuilles du froment, mais je ne lui en ai pas donne le nom; parce que je crois l'avoir retrouvee sur d'autres especes de gramens a feuilles larges et planes; elle croit sur les deux surfaces, mais principalement sur la superieure; ses pustules sont petites, d'abord rousses, puis noiratres: les filets qui partent de leur base sont nombreux, longs, entre croises, et tellement abodans, qu'ils forment des touffes oblongues, d'un duvet cotonneux, blanc ou roussatre, epais, et dans lequel les tubercules sont plonges de maniere a imiter les loges de certaines spheries." Perithecia 150-200 mmm. On Poa pratensis L., Hordeum pusillum Nutt, Triticum vulgare L.

UNCINULA Lev. Ann. Sci. Nat. Ser. III, Tome XV, 43 [151] (1851). "Mycelium epi-vel hypophyllum, floccosum, sub membranaceum, evanidum vel persistens. Conceptacula globosa sporangiis 8-16 subpyriformibus, 2-4 sporis ovatis repleta. Appendiculate rigidae, simplices bifidae vel raro dichotomae apice uncinatae radiato-patentes demum sursum flexae."

U. neceator (Schw.) Burrill in Ellis & Everhart N. A. Pyren. 15 (1892) Erysiphe necator Schw. Syn. N. A. Fung. No. 2495 in Trans. Am. Phil. Soc. N. S. 4: 270 (1834). "Multo rarius in uvis Vitis labruscae varietatibus cultis in vineis nostris. E. Hyphasma, tenuissimum albidum, floccis valde tenuibus orbiculatum, on constringens. Sporangiolis minutissimis—raris fusco—nigris, globosis. Ubi omnino evoluta, etiam haec species destruit uvas." Perithecia 85-120 mmm. Appendages (½-3) x diameter of perithecia colored one-half of length, frequently septate, tips spirally coiled. Asci 4-6. Very short pedicillate; sporidia 218, long, filling the ascus. On Parthenocissus quinquefolia (L.) Planch.

U. flexuosa Pk., Trans. Albany Inst. VII, p. 215 (1873). "Mycelium thin, web-like, evanescent; conceptacles minute, .0035 inch in diameter; appendages 15-25, about as long as the diameter of the conceptacle, the apical half wavy flexuous and sometimes slightly thickened; sporangia 8-10, ovate or elliptical; spores 8, elliptical, .0007-.0008 inch long. Figs. 10-12. Lower surface of horse-chestnut leaves. Buffalo. September. G. W. Clinton. The flexuous appendages are characteristic of this species. They sometimes appear as if twisted like the blade of a screw auger." The above description was kindly communicated by Professor Peck. The number of spores for this species are described as 8-10, but all specimens examined showed only six. On Aesculus arguta Buckl.

U. macrospora Pk. Trans. Albany Inst. VII, p. 215—25th Rep. N. Y. State Mus. p. 96 (1873). "Mycelium effused, persistent, conceptacles subglobose; appendages numerous, 30 or more, about equal in length to the diameter of the conceptacle; sporangia 8 to 12; spores two, very large, elliptical, .0012 to .0015 inch long. Leaves of elm trees." Tips of appendages sometimes septate and coiled. On Ulmus americana L.

U. parvula C. & P. Erysiphe of the U. S. Jour. Bot. X, p. 170 (1872). "This is very distinct from Uncinula polychaeta, B. & C., which is found also on Celtis. Not only is the mycelium thinner and more evanescent, but the conceptacles are not half the diameter of those in that species, and the appendages are shorter and far less numerous. Hypophyllous, mycelium effused, delicate, evanescent; conceptacles scattered, globose, minute; appendages simple, numerous, scarcely as long as the diameter of the conceptacles; sporangia elliptical, rostrate; sporidia 6. On leaves of Celtis occidentalis L. Poughkeepsie, N. Y. (C. H. P. n. 189)." On Celtis occidentalis L.

U. salicis (DC.) Winter, Die Pilze, II, p. 40 (1887). Erysiphe salicis, DC. Flore Franc. II, p. 273 (1805). "Cette plante n'est peut-etre qu'une variete de l'erysiphe du frene, a laquelle elle ressemble absolument a l'oeil nu; ses tubercules passent de meme du jaun pale a l'orange, au brun et au noir; de la base du tubercule partent plusieurs fils blancs simples qui s'etaient sur la feuille, s'y entre-croisent avec ceux des autres tubercules, et y forment la croute blanche dont la surface de la feuille est recouverte. Cette espece croit sur les feuilles du saule-daphne." Perithecia 120-160 mmm. Sporidia 4 or 5, usually 20-25 mmm long. On Salix amygdaloides Anders., Populus monilifera Ait.

PHYLLACTINIA Lev. Ann. Sci. Nat. Ser. III, Tome XV, 36 [144] (1851). "Mycelium amphigenum; conceptacula hemisphaerica demum depressa receptaculo membranaceous-granuloso persistente vel evanido insidentia, sporangiis 8 et ultra in pedicellum protractis 2 vel 4 sporis farcta; sporae ovatae. Appendiculae 8-16 restae, rigidae, aciculatae demum retroflexae."

P. corylea (Pers.) P. suffulta Sacc. Mich. II, 50 (1882). Erysiphe coryli DC. Fl. Fr. II, p. 272 (1805). Sclerotium suffultum Reb. Fl. Neom. 360 (1804). Sclerotium erysiphe *B* corylea Pers. Syn. 124 (1801). Decandolle's description (l. c.) evidently refers to Phyllactinia. Pers. name is quoted as a synonym and from the description given below is evidently the same, in which his variety name would have precedence over the name of Rebentisch. "Sclerotium erysiphe: Epiphyllum, granulis aggregatis fusco-nigris, tomento albo insidentibus. Obs. myc. 1, p. 13. Mucor erysiphe, albus capittilis, fuscis sessilibus. Linn. Syst. Veg. 15, p. 1020.

B Corylea: tomentum tenuissimum fungillis in disco impresso subvillosis. Hab. autumno in variarum herbarum foliis, *B* in aversa, folii Coryli avellanae parte crescit." If the specific name used by Linnaeus (Mucor erysiphe) be taken up, it should probably be applied to the mildew of the hop, as that plant is the first host mentioned under that species (L. Spec. Pl. 1186 (1753).

PODOSPHAERA Kunze Mycol. Hefte II, p. 111 (1823). "Perithecium subglobosum; processubus radiculiformibus horizontalibus excentricis, apice in laminan dilatato radicantibus. Ascus solitarus, thecis ovalibus sporidigeris octo repletus."

P. oxycanthae (DC.) "D'By. Morph. und Phys. der Pilze III, p. 48." Erysiphe oxycanthae DC. Flore Franc. VI, p. 106. "On trouve cette erysiphe sur les deux surfaces des feuilles de l'aubepine: elle ressemble a celle de l'ancolie par sa maniere de croitre, c'est-a-dire, que ses tubercules sont noirs, epars, tres-ecartes, et ne forment pas, par leur entre croisement, une croute visible; la seule circonstance qui puisse faire distinguer cette espece, est l'extreme brievete des filamens blancs qui sortent de ses tubercules. M. Cauvin me l'a envoyee des environs d'Angers, et M. Chaillet, de Neufchatel. Je l'ai trouvee en Bretagne. M. Bosc me l'a fait observer en grande abondance sur les plants d'aubepine des pepinieres de Versailles; il observe que cette parasite retarde sensiblement lur croissance." Amphigenous, mycelium scant or abundant, persistent. Perithecia 65-110 mmm, dark, opaque, appendages sometimes septate, 1-4 times, diameter of the perithecium, 3-5 times dichotomous, branches short, tips recurved, ascus broadly elliptical or orbicular, sporidia usually 8. On cult. plums, leaves of cult. cherry.

MICROSPHAERA Lev. Ann. Sci. Nat. Ser. III, Tome XV, p. 381 (1851). This is under list of corrections to the body of the work (pp. 109-179). He substitutes Microsphaera for Colocladia, hence all the Colocladiae become Microsphaeriae Colocladia, Lev. l. c. 46 [154] (1851). "Mycelium arachnoideum subcontextum evanidum vel persistens conceptacula sporangiis 4-8, ovatis, rostratis, 4-8 sporis repleta. Appendiculae rectae dichotomae, ramulis apice turgidis vel filiformibus."

M. grossularia (Wallr.) Lev. Ann. Sci. Nat. Ser. III, T. XV, p. 160 (1851). "Alphitomorpha penicillata var. Grossulariae, Wallr. Verh. Naturf. Freunde I, p. 40." The following is from Lev. l. c.: "Bifrons. Mycelio arachnoideo fugaci vel persistente. Conceptaculis sparsis vel gregariis globosis minutis Sporangiis 4-8 ovato-rostratis 4-5 sporis. Appendiculis 10-15 vage dichotomis, ramulis ultimis bidentatis." On Sambucus Canadensis L.

M. symphoricarpi, Howe Bull. Torr. Bot. Club, V, p. 3. "Mycelium effused, subpersistent, conceptacles scattered or crowded; appendages 8-16, 2-4 times the length of the diameter of the conceptacles, 3-5 times dichotomous, ramuli divaricate, tips variable, often truncate, never curved, sporangia 4-6 with 3-5 spores. Leaves of Symphoricarpus. Nov." On Symphoricarpus symphoricarpus (L.) MacM.

M. euphorbiae (Peck) B & C. Grev. IV, p. 160 (1875). 26th Rep. N. Y. State Mus., p. 80. "Mycelium thin; conceptacles small, .0035 in. in diameter; appendages few, long, flexuous, colored; sporangia broadly ovate, 3-4; spores 3-4, large, .001 x .00065 in." Long tips often trifid or 4-6 x dichotomous, asci pedicillate, sporidia 4-6. On Euphorbia corollata L., E. marginata Pursh.

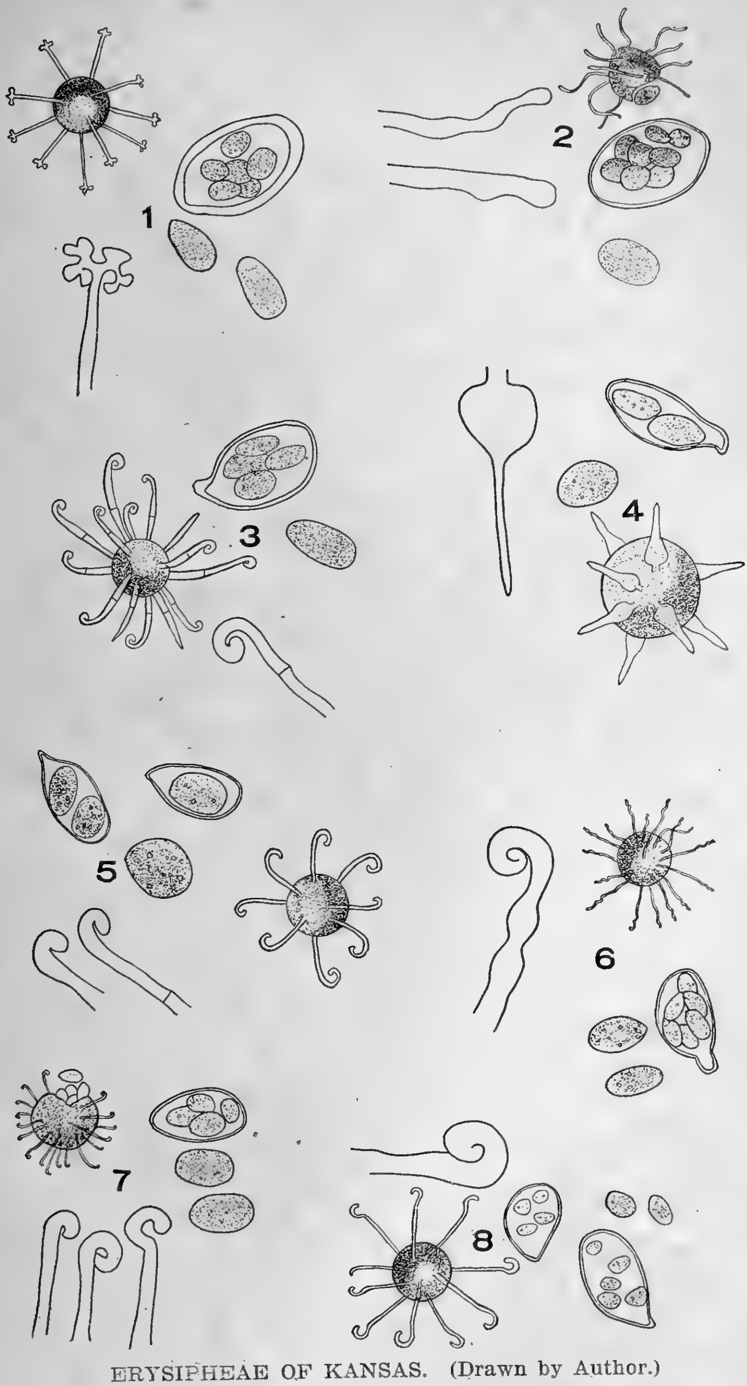
M. alni (Lam. and DC.) Winter Die Pilze II, p. 38 (1892). Erysiphe alni Lam. & DC. Syn. Pl. Gall. 57 (1806). "Hypophylla, filamentis plurimis expansis longissimis liberis—Sclerotium erysiphe alnea. Schl. cerat. exs. n. 68. In Alno incana. Perithecia 80-100 mmm, abundant, appendages 1-2 times diameter of perithecia, 3-4 times dichotomous branched, tips strongly recurved. Asci orbicular, sporidia usually eight, variable. On Platanus occidentalis L.

M. quercina (Schw.) Burrill, Bull. Ill. State Lab. Nat. Hist. II, p. 424. Erysiphe quercinum Schw. Syn. N. Am. No. 2492 in Trans. Am. Phil. Soc. N. S. 4: 270 (1834). "Hyphasma occupans fere totum folium expansum candicans, tenuissimum, floccis vix distinctis sporangiolis raris minutissimis sparsis nigris. Praesertim loco distinguenda species." Perithecia 90-100 mmm. Appendages 1-4 times diameter of perithecium, hyaline, much interwoven with mycelium, 4-6 times dichotomous, branches short, tips recurved, sporidia variable 3-8. On Quercus velutina Lam., Q. macrocarpa Michx., Q. Muhlenbergii Engelm.

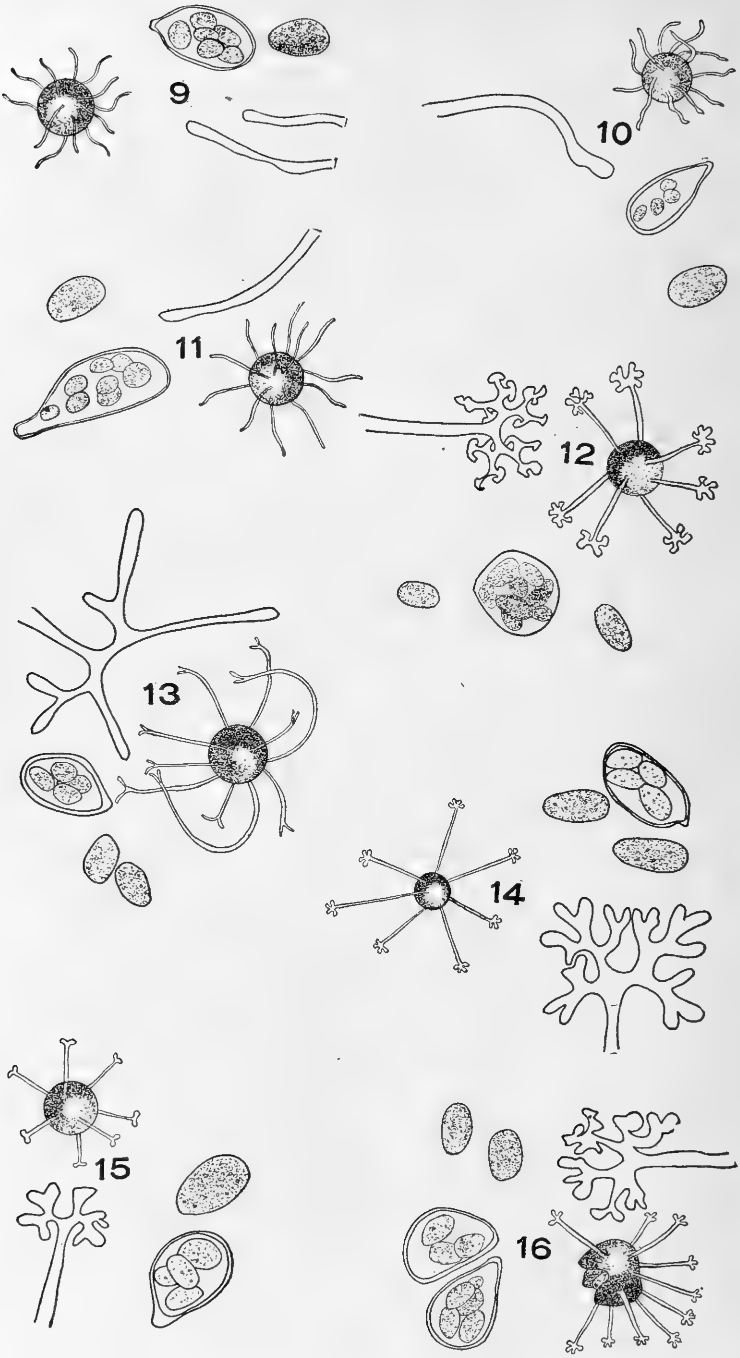
DESCRIPTION OF PLATES.

Unless otherwise indicated all magnifications are as follows: Perithecia, x 62; asci, x 225; sporidia, x 500; tips of appendages, x 500.

Sphaerotheca castagnei, Fig. 2.
Erysiphe communis, Fig. 9.
Erysiphe cichoracearum, Fig. 10.
Erysiphe graminis, Fig. 11.
Uncinula necator, Fig. 4. Sporidia and tips, x 225.
Uncinula flexuosa, Fig. 5.
Uncinula macrospora, Fig. 6.
Uncinula parvula, Fig. 8.
Uncinula salicio, Fig. 7.
Phyllactinia suffulta, Fig. 3. Tips, x 225.
Podosphaera oxycanthae, Fig. 1. Tips, x 225.
Microsphaera grossulariae, Fig. 15. Tips, x 225.
Microsphaera symphoricarpi, Fig. 14. Tips, x 225.
Microsphaera euphorbiae, Fig. 13. Tips, x 225.
Microsphaera alni, Fig. 12. Sporidia and tips, x 225.
Microsphaera quercina, Fig. 16. Tips, x 225.



ERYSIPHEAE OF KANSAS. (Drawn by Author.)



ERYSIPHEAE OF KANSAS. (Drawn by Author.)

THE TOPEKA COAL HOLE.

By B. B. SMYTH.

I am indebted to Col. Wm. Tweeddale for the use of the blue print from which the following measurements and section were taken, also for much of the data connected with the digging of the well.

In 1886 a contract was made between the city of Topeka and the American Diamond Rock-Boring Company of New York, for the digging of a well 2,000 feet deep, the company to receive, when the well should be completed, a stipulated sum therefor. Payments as the work progressed were agreed upon, and some payments were made by the city, which were withheld from the company by its bondsmen, who were not assured that the well would ever be completed, and who were liable to the city for the amount paid in case the well should not be completed.

The work was done mostly during the summer of 1886, though owing to inadequate machinery, the work progressed under many difficulties, and various accidents interfered with its progress.

The apparatus used was a diamond drill. The first casing, 4½ inches in diameter, was put down through surface soil, sand and gravel to clay, a depth of 82½ feet. Boring was then done with the drill through the strata indicated below. After passing the surface soil, the diameter of the well was 3½ inches to a depth of 260 feet; 3 inches to a depth of 500 feet, and 2½ inches the remainder of the distance.

On one or two occasions the point, with considerable of the coupling rods, was lost in the well, could not be pulled out, and the boring resumed from a point near the top of the broken rods, necessitating a redigging of portions of the well. This was probably owing to deflection, in both instances, placing the lower portions of the two borings at some distance apart, as they undoubtedly deflected in different directions.

On one occasion when the steam was discovered to be too high, the engineer passed from the drill to the engine house to open the door of the furnace; but, before reaching it, steam from the boiler passing through a small aperture into the fire-box, blew open the door and blew into his face, injuring him so that he died in two days, and blew down two apple-trees, eight inches in diameter, at distances of 30 and 45 feet. The force of the escaping steam against the ground was so great as to move the boiler endwise toward the north. On reaching a distance of 150 feet from the engine house, the forward end of the boiler became elevated, and the force of the escaping steam raised it past the front gable of a house that stood near the street and carried it over the tops of some young trees about 30 feet high and 300 feet to the north. Here the force of the steam became spent and the boiler fell down on the ground, after breaking some of the branches at the tops of the trees, showing its course through the grove. The steam had all escaped through a four-inch aperture into the fire-box, and the force of the escaping steam suddenly let loose against the ground raised the boiler from its foundations and sent it up like a rocket to a height of fully 30 feet above the ground.

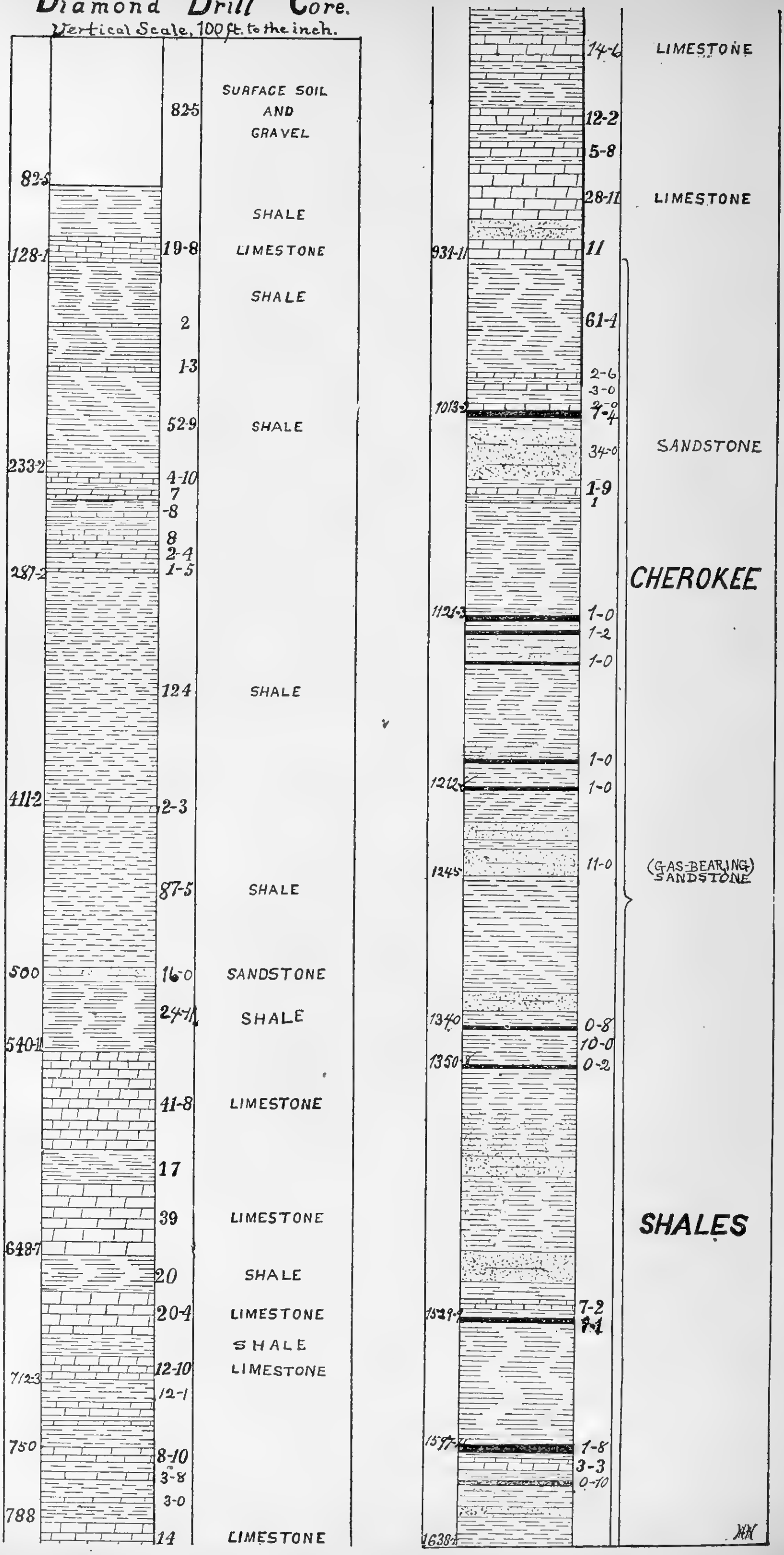
On another occasion, the tower took fire, impeding the progress of the work for some time.

After two or three years, efforts were renewed to sink the well still lower;

TOPEKA WELL.

Diamond Drill Core.

Vertical Scale, 100 ft. to the inch.



but after much difficulty and fruitless labor, the work was finally abandoned, forfeiting the amount the company was to have received from the city, something like $12,000.

The well was located on Lawrence street, near the Shunganunga creek, between Third and Second streets. The eighty-two and a half feet of surface soil and gravel indicates the depth to which the creek was excavated during the ice period, as the earth to that depth is entirely composed of drift and surface soil.

The zero of depth, or top of the casing, was 974 feet above sea level.

Col. W. Tweeddale was superintendent for the city and M. E. Harrington was superintendent for the contractors.

The following table shows the total depth, the number of strata, the thickness of each stratum, the color of the strata and the character and composition of each stratum as shown by the cores brought up. The cores are deposited with the Kansas Academy of Science.

Total depth. ft. in.	No. of stratum.	ft. in.	Color.	Kind of stratum.
27—6	1	27—6	Dark	Soil, clayey loam.
30—0	2	2—6	Lighter	Soil, clayey loam.
42—0	3	12—0	Still lighter	Soil, clayey loam.
58—0	4	16—0	Gray	Fine sand.
80—6	5	22—6	Gray	Coarse sand.
82—6	6	2—0	Red	Coarse sand.
101—0	7	18—6	Blue	Mud, small p's of core.
108—6	8	7—6	Light blue	Laminated fireclay.
111—6	9	2—6	Dark	Conglomerate limestone.
123—3	10	11—9	Dark	Limestone mixed with clay.
124—3	11	1—0	Blue	Fire clay.
128—1	12	3—10	Dark	Limestone.
137—8	13	9—7	Blue	Clay and mud.
142—6	14	4—10	Blue	Laminated fireclay.
150—0	15	7—6	Dark	Laminated fireclay.
152—4	16	2—4		Gain in measuring rods.
154—10	17	2—6	Blue	Clay.
156—10	18	2—0	Gray	Hard limestone.
161—10	19	5—0	Blue	Clay or shale.
174—1	20	12—3	Blue	Mud.
179—0	21	4—11	Blue	Soft clay.
180—3	22	1—3	Gray	Fossil shell limestone.
185—3	23	5—0	Blue	Laminated fireclay.
189—9	24	4—6	Blue	Mud.
193—9	25	4—0	Blue	Clay.
194—2	...	0—5	Dark	Clay.
198—2	26	4—0	Light	Clay.
201—8	27	3—6	Light	Mud.
202—2	28	0—6	Dark	Clay.
211—6	29	9—4	Light	Laminated fireclay.
211—9	30	0—3	Dark	Laminated fireclay.
219—2	31	7—5	Light	Laminated clay.
233—2	32	14—0	Blue	Mud (struck water).
238—0	33	4—10	Gray	Hard limestone.

243—7	34	5—7	Light	Hard fireclay.
249—11	35	6—4	Gray	Hard limestone.
254—7	36	4—8		Gain in measure of rods.
255—3	37	0—8	Light	Limestone.
262—4	38	7—1	Black	Hard slate or fireclay.
270—4	39	8—0	Light	Limestone.
270—11	40	0—7	Light	Fire clay.
276—11	41	6—0	Black	Hard fireclay.
279—3	42	2—4	Gray	Limestone.
285—7	43	6—4	Black	Hard fireclay.
287—2	44	1—7	Gray	Limestone.
292—2	45	5—0	Light	Fire clay.
297—0	46	4—10	Light	Fireclay conglomerate, mixed with sand.
	47			
318—8	48	21—2	Light	Hard stratified fireclay.
322—8	49	4—0	Light	Stratified fireclay, disintegrated.
325—8	50	3—0	Light	Hard laminated fireclay.
337—6	51	11—10	Light	Very hard laminated fireclay, mixed with sand.
342—0	52	4—6	Light	Hard laminated fireclay.
346—8	53	4—8	Light	Hard laminated fireclay, mixed with sand.
351—8	54	5—0	Dark	Hard laminated fireclay, with black streaks.
357—8	55	6—0	Dark	Mud.
365—0	56	7—4	Black	Soft laminated fireclay.
372—6	57	7—6	Black	Hard laminated fireclay.
377—6	58	5—0	Black	Soft fireclay.
387—6	59	10—0	Dark	Mud.
396—8	60	9—2	Black	Hard laminated fireclay.
411—2	61	14—6	Dark	Soft fireclay.
	62			
413—5	63	2—3	Gray	Crystalline limestone.
425—5	64	12—0	Dark	Hard fireclay.
433—3	65	7—10	Dark	Hard laminated fireclay.
443—11	66	10—8	Dark	Hard fireclay.
448—11	67	5—0	Dark	Hard laminated fireclay.
454—7	68	5—8		Gain in measurement of rod.
469—4	69	14—9	Black	Compact fireclay, mixed with sand and grit.
484—0	70	14—8	Dark	Hard laminated fireclay.
500—0	71	16—0	Dark	Hard laminated clay, mixed with lime.
515—5	72	15—5	Dark	Hard laminated fireclay, mixed with lime.
538—5	73	23—0	Dark	Compact laminated fireclay.
540—11	74	2—6	Dark	Hard fireclay.
546—7	75	5—8	Light	Conglomerate limestone, containing shells.
553—9	76	7—2	Gray	Hard limestone.
578—0	77	24—3	Light	Hard limestone, streaked with clay.

581—6	78	3—6	Black	.... Hard limestone, fossils.
585—1	79	3—7	Gray	.... Hard limestone, shell fossils.
592—7	80	7—6	Dark	.... Limestone, clay streaks.
599—7	81	7—0	Dark	.... Hard laminated fireclay.
609—7	82	10—0	Blue	.... Hard laminated fireclay.
612—7	83	3—0	Light gray	.... Limestone.
617—7	84	5—0	Dark gray	.... Limestone.
627—3	85	9—8	Gray	.... Limestone.
630—3	86	3—0	Black	.... Clay, mixed with lime.
636—3	87	6—0	Gray	.... Limestone.
639—5	88	3—2	Blue	.... Clay, mixed with lime.
640—2	89	0—9	Gray	.... Limestone.
641—0	90	0—10	Blue	.... Clay.
642—4	91	1—4	Gray	.... Limestone.
643—2	92	0—10	Blue	.... Clay.
645—2	93	2—0	Gray	.... Limestone.
648—7	94	3—5	Blue	.... Clay, mixed with limestone.
653—9	95	5—2	Blue	.... Mud.
663—7	96	9—10	Blue	.... Clay.
668—7	97	5—0	Blue	.... Clay.
672—11	98	4—4	Gray	.... Limestone.
688—11	99	16—0	White	.... Limestone.
699—5	100	10—6	Dark	.... Soft clay and mud.
706—3	101	6—10	Gray	.... Limestone, streaks of clay.
712—3	102	6—0	Gray	.... Limestone, small pieces.
715—3	103	3—0	Blue	.... Mud.
718—3	104	3—0	Dark	.... Hard laminated fireclay.
724—4	105	6—1	Dark	.... Mud.
731—4	106	7—0	Gray	.... Hard limestone.
733—9	107	2—5	Black	.... Hard fireclay.
735—6	108	1—9	Gray	.... Hard limestone.
740—0	109	4—6	Black	.... Hard laminated fireclay.
747—8	110	7—8	Dark	.... Hard laminated fireclay.
750—0	111	2—4	Gray	.... Hard limestone.
755—0	112	5—0	Gray	.... Hard limestone.
756—6	113	1—6	Gray	.... Hard limestone.
761—3	114	4—9	Dark	.... Hard fireclay.
762—8	115	1—5	Light	.... Limestone.
763—8	116	1—0	Dark	.... Limestone.
764—11	117	1—3	Light	.... Limestone.
770—2	118	5—3	Blue	.... Soft clay.
774—5	119	4—3	Dark	.... Fire clay.
777—6	120	3—1	Light	.... Limestone.
788—0	121	10—6	Dark	.... Slate, mixed with limestone.
789—3	122	1—3	Dark gray	.... Limestone.
793—3	123	4—0	Dark gray	.... Limestone containing fossil shells.
802—0	124	8—9	Light	.... Hard limestone.
811—0	125	9—0		.... Gain in measuring rods.
815—3	126	4—3	Dark	.... Clay, mixed with limestone.
826—3	127	11—0	Light	.... Limestone.
829—9	128	3—6	Dark	.... Conglomerate limestone.
835—3	129	5—6	Very dark	.... Laminated clay or slate.

838—6	130	3—3	Mottled	Hard conglomerate fossil limestone.
840—8	131	2—2	Very dark	Laminated clay.
841—6	132	0—10	Very dark	Conglomerate fossil limestone.
854—2	133	12—8	Dark	Laminated clay, mixed with limestone.
864—10	134	10—8	Gray	Hard conglomerate fossil limestone.
866—4	135	1—6	Dark gray	Hard conglomerate fossil limestone.
871—2	136	4—10	Dark	Clay, mixed with limestone.
878—3	137	7—1	Light gray	Hard limestone.
880—7	138	2—4	Black	Hard slate.
882—7	139	2—0	....	Mud.
883—11	140	1—4	Black	Hard clay.
890—5	141	6—6	Gray	Hard limestone.
895—7	142	5—2	Light gray	Hard limestone.
899—1	143	3—6	White	Hard limestone.
900—3	144	1—2	Black	Hard limestone.
901—3	145	1—0	Gray	Limestone.
908—6	146	7—3	Gray	Hard limestone.
912—10	147	4—4	Gray, ch'g bl'k,	Hard limestone.
915—10	148	3—0	Gray	Sandstone.
917—7	149	1—9	Blue	Laminated clay.
919—1	150	1—6	Blue	Laminated clay, small pieces.
920—11	151	1—10	Blue	Mud.
923—11	152	3—0	Blue	Slate.
934—11	153	11—0	Light gray	Hard limestone.
938—11	154	4—0	Dark	Fire clay.
940—9	155	1—10	....	Increase of measurement.
953—1	156	12—4	Blue	Hard fireclay.
954—9	157	1—8	....	Increase.
968—7	158	13—10	Dark	Medium hard laminated clay.
981—7	159	13—0	Dark	Laminated fireclay or shale.
982—9	160	1—2	....	Mud.
986—5	161	3—8	Dark	Laminated fireclay.
994—9	162	8—4		
996—3	163	1—6	Dark	Bituminous shale.
998—9	164	2—6	Dark	Conglomerate limestone, mixed with clay.
1000—0	165	1—3	Dark	Laminated clay or shale.
1003—0	166	3—0	....	Limestone.
1011—2	167	8—2	Light	Laminated shale.
1013—2	168	2—0	....	Limestone.
1014—6	169	1—4	....	COAL.
1018—2	170	3—8	....	Laminated shale.
1053—0	171	34—10	Light	Laminated sandstone.
1056—4	172	3—4	Light	Laminated shale.
1058—1	173	1—9	....	Limestone.
1063—1	174	5—0	Light	Laminated shale.
1064—1	175	1—0	....	Limestone.
1072—10	176	8—9	Light	Laminated shale.
1080—10	177	8—0	Dark	Shale.
	178			
1084—6	179	3—8	Light	Laminated shale.
1092—1	180	7—7	Dark	Laminated shale.

1102—1	182	10—0	Light	Laminated shale.
1103—11	183	1—10	Light	Sandstone.
1105—11	184	2—0	Light	Shale.
1111—3	185	5—4	Dark	Shale.
1121—3	186	10—0	Light	Laminated shale.
1122—3	187	1—0	....	COAL.
1122—6	188	0—3	Black	Shale.
1129—4	189	6—10	Light	Laminated shale.
1130—6	190	1—2	....	COAL.
1132—2	191	1—8	Dark	Shale.
1140—6	192	8—4	Light	Shale.
1144—2	193	3—8	....	Sandstone and shale.
1146—2	194	2—0	Black	Shale.
1147—2	195	1—0	....	COAL.
1154—2	196	7—0	Light	Shale.
1170—2	197	16—0	....	Laminated shale, with flint.
1173—2	198	3—0	Black	Shale.
1183—1	199	9—11	....	Laminated shale, with flint.
1185—1	200	2—0	Blue	Hard blue clay, small pieces.
1189—2	201	4—1	Blue	Hard blue clay shale.
	202			
1197—0	203	7—10	....	Laminated shale, with sand.
1198—0	204	1—0	....	COAL.
1212—8	205	14—8	....	Laminated shale, with sand.
1213—8	206	1—0	....	COAL.
1217—8	207	4—0	....	Fire clay.
1219—1	208	1—5	....	Shale.
1220—2	209	1—1	....	Lost.
1223—2	210	3—0	....	Soft shale.
1226—9	211	3—7	Light	Shale.
1227—9	212	1—0	Very dark	Shale slate.
1228—0	213	0—3	Light	Slate.
1228—4	...	0—4		
1231—4	214	3—0	Light	Shale.
1236—4	215	5—0	....	Mica sandstone.
1242—4	216	6—0	Blue	Sandstone, running into hard blue clay.
1245—0	217	2—8	Blue	Hard blue clay.
1248—7	218	3—7	....	Porous limestone, clay washed out. (GAS found in this formation.)
1249—5	219	0—10	....	Clay.
1258—5	220	9—0	Variegated ...	Variegated sandstone.
1258—8	221	0—3	Dark	Shale.
1259—0	222	0—4	....	Sandstone.
1261—8	223	2—8	Dark	Shale.
1262—11	224	1—3	Black	Shale.
1263—2	225	0—3	....	COAL.
1270—9	226	7—7	Light gray	Shale.
1271—9	227	1—0	Black	
1272—1	228	0—4	Dark	Limestone.
1272—9	229	0—8	....	
1274—2	230	1—5	....	Lost.
1276—6	231	2—4	Dark	Shale.

1277—0	232	0—6	Gray	Limestone.
1278—9	233	1—9	Black	Shale.
1279—3	234	0—6		Limestone.
1284—6	235	5—3	Dark	Shale.
1287—2	236	2—8		Lost.
1299—7	237	12—5	Blue	Hard fire clay, in pieces.
1304—3	238	4—8		Shale, mixed with limestone and sulphur.
1305—0	239	.....		Good clay.
1308—3	240	3—3		Fireclay.
1312—11	241	4—8		Shale.
1317—11	242	5—0		Fireclay in pieces.
1318—10	243	1—0	Dark	Shale, small pieces.
1322—7	244	3—8		Lost.
1325—7	245	3—0		Shale, mixed with oxide of iron.
1334—6	246	8—11		Sandstone.
1339—7	247	5—11	Black	Shale (rotten).
1340—0	248	0—5	Dark	Shale.
1340—8	249	0—8		COAL.
1350—8	250	10—0	Black	Shale.
1350—10	251	0—2		COAL.
1351—7	252	0—9		Sandstone.
1351—10	253	0—3		Lost.
1352—9	254	0—11		Hard sandstone, irregular pieces.
1360—6	255	7—9		Fireclay, mixed with limestone.
1369—6	256	9—0		Clay shale and dark clay, running into shale.
1370—6	257	1—0	Dark	Fireclay and sandstone mixed.
1372—0	258	1—6	Gray	Sandstone.
1380—6	259	8—6	Dark	Shale, some limestone.
1382—6	260	2—0		Fireclay, small pieces.
1390—6	261	8—0	Dark	Clayey shale, mixed with mica sandstone.
1393—7	262	3—1		No core.
1394—5	263	0—10		Sandstone.
1406—5	264	12—0	Dark	Shale, mixed with sandstone.
1418—5	265	12—0	Dark	Clay, mixed with sandstone.
1427—4	266	8—11	Gray	Sandstone.
1427—8	267	0—4	Light	Limestone.
1434—3	268	6—7		Sandstone shale.
1435—5	269	1—2	Gray	Sandstone, variegated.
1443—1	270	7—8	Gray	Sandstone.
1449—7	271	6—6	Gray	Sandstone.
1450—1	272	0—6	Dark	Shale.
1453—10	273	3—9	Gray	Variegated sandstone.
1454—10	274	1—0		Shale.
1466—10	275	12—0		Sandstone, with shale bands.
1500—0	276	33—2	Dark	Laminated shale.
1504—7	277	4—7	Light	Sandstone and shale.
1513—7	278	7—9	Light	Broken shale with sand.
1520—9	279	7—2	Light	Limestone.
1521—9	280	1—0	Dark	Shale.
1523—9	281	2—0	Light	Shale.

1529—9	282	6—0	Dark	.... Shale.
1530—10	283	1—1		.... COAL.
1596—10	284	66—0	Light	.... Shale.
1597—4	285	0—6	Dark	.... Shale.
1599—0	286	1—8		.... COAL.
1599—6	287	0—6	Dark	.... Shale.
1602—9	288	3—3	Light	.... Crystalline limestone.
1606—9	289	4—0	Dark	.... Shale.
1607—7	290	0—10		.... Coal sediment.
1610—7	291	3—0	Light	.... Variegated sandstone and shale.
1611—1	292	0—6	Light	.... Shale.
1621—1	293	10—0	Dark	.... Shale.
1625—7	294	4—6	White	.... Sandstone.
1638—1	295	12—6	Dark	.... Shale.
1638—4	296	0—3	Light	.... Soft shale.

The accompanying section, drawn to a scale of 100 feet to the inch, was prepared by Miss Hattie Huntsman, under the direction of Prof. E. Haworth, of the State University, Lawrence.

COAL IN ATCHISON COUNTY, KANSAS.

By E. B. KNERR.

In August, 1893, an interesting vein of coal was found exposed in the bed of a narrow ravine between two bluffs facing the Missouri river, about two miles south of the city of Atchison. At the point of discovery the vein measured 16 inches, and on trial the coal was at once recognized to be of good quality. Within a few days hundreds of people visited the spot, and as almost every one carried back with him some of the coal for exhibition and trial, a colored man by the name of O'Connel, who had formerly mined coal at Leavenworth, was encouraged to open up the vein. He brought a few wagon-loads to the city and paraded the streets.

Some months after this, the Atchison horse-car line was abandoned preparatory to the introduction of an electric system, and the car drivers were thrown out of employment. One of their number, Mr. Ada, conceived the idea of working the coal field south of town, and with the help of several of the former car drivers, with shovels and picks and wheelbarrows, they went to work. The coal is so favorably situated that their mine, now known as the Ada mine, has paid all its expenses from the very beginning in coal taken out.

Shortly after this enterprise was undertaken, the Donald Bros. dry-goods firm opened up the vein in the bluff about a half mile south of the Ada mine. The Donalds at once invested considerable capital, employed a body of expert miners and made quite an extensive entry. They have now been at work less than two years, but have removed the coal from an area of more than 500,000 square feet. At the present time they are operating their mine with electric machinery.

This vein of coal varies in thickness from 16 to 20 inches, and is very hard for a bituminous coal. A chemical analysis gives the following results:

Water	3.43
Volatile gas	30.02
Fixed carbon	55.79
Ash	10.76
	100.00

The specific gravity of the coal is 1.17. The heat units were calculated to be 6642 gram calories. The coal contains very little sulphur, and this is combined as calcium sulphate, and therefore is unobjectionable. There is no iron sulphide, pyrite, mixed up with the coal. This is further proven by the fact that the ash is a light gray—almost white. Iron in the coal would color the ash reddish. The objectionable form of sulphur in coal is as iron sulphide, for when this is present it readily combines with the fire grates of stoves, etc., burning them out. Hence it is fortunate that pyrite is absent from Atchison coal.

The natural facilities for mining this stratum of coal are the best, with the exception that the strata of soapstone above and below the coal are very hard. At the Donald mine the vein lies about 30 feet above the water of the Missouri river, and about 15 feet above the road bed of the Missouri Pacific railroad. In the process of mining, the coal does not have to be lifted a foot. It is placed on the low trucks and drawn out by small mules, weighed and dumped into the cars.

After the discovery of this vein other localities were reported at various places in Atchison and Doniphan counties, and the traditions of former coal mining in the neighborhood were recalled. I have examined several of these localities, and am convinced that, with possibly an exception in Doniphan county, they belong to a different stratum entirely. On the state grounds of the Soldiers' Orphans' Home, about three miles north of Atchison, there is a coal outcrop measuring six to eight inches. This stratum is about 150 feet above the Donald vein. I have traced it to a point about five miles south of the orphans' home, where it thins out to only a half inch in thickness. This smaller vein is much softer than the other, and is the one to which the traditions of Atchison coal mining refer. It is curious to observe how these traditions have magnified the thickness of the vein. It was a two-foot vein when worked 30 years or more ago, according to traditions. I have opened up two of the former drifts and find that the stratum measures only eight inches at the most, and in this fact we find the explanation of the abandonment of these first mining efforts.

Encouraged by these traditions, a company was formed in Atchison some years ago to prospect for coal. This company did a very foolish thing in selecting a locality for their prospecting. They did not begin operations in the native rocks of the bluffs, but went off near to the Missouri river and sunk a hole some 800 feet. Of course they missed the Donald vein, for it had been removed from where they were working by the Missouri river. Had they operated closer to the bluff, beginning in bed rock, the 18-inch vein would have been struck, and in all probability Atchison would have rivaled Leavenworth by this time as a coal-mining locality.

ROCK EXPOSURES ABOUT ATCHISON.

By JOHN M. PRICE, Jr.

The vicinity of Atchison presents some very interesting exposures of rock formation. Within a radius of a few miles there are three or four well-developed rock quarries besides numerous quarries only partially developed.

For the sake of convenience I have prepared a section showing the geological position and order of the various formations exposed, and these I have numbered from 1 to 18, beginning with the lowest and numbering up.

Our first expedition was to the Waggener quarry, one mile south of Atchison, and situated on one of the bluffs overlooking the Missouri river. Here the lowest formation exposed was No. 8, the 20-foot limestone. Just above this came No. 9, a layer of soapstone shale, four feet in thickness. Above this was a band of limestone eight inches wide. This band of eight inches appeared only in one place, and decreased on both sides, and on one side it completely disappeared into the shale. Above this was more shale for a distance of about 20 feet. Then appeared a ridge of limestone four feet in thickness, and then more shale for a distance of from 20 to 25 feet.

From here we went to the Atchison coal mines. Here we find No. 8, the 20-foot limestone, as the highest formation. Hence it is called the cap-rock. Below this came No. 7, slate, or rather a slaty shale, having a thickness of four feet. Next was found a band of limestone 21 inches thick, and below this shale for a distance of 12 feet. A layer of limestone 10 feet came next, and beneath this was No. 3 shale for a distance of about 25 feet. Next came No. 2, the coal, averaging between 16 and 18 inches. Below this was more shale, but its depth we could not determine—it was at least 30 feet.

Returning from the coal mines, we passed an old deserted quarry on the opposite side of the hill from the Waggener quarry. Here we obtained exposures of Nos. 14, 15, and 16. This last is composed of a three-foot band of solid limestone covered by about 15 inches of disintegrated limestone. Below the limestone comes a layer of soapstone shale measuring four feet, and below this lies the sandstone. This, however, was not sufficiently exposed to obtain any measurement.

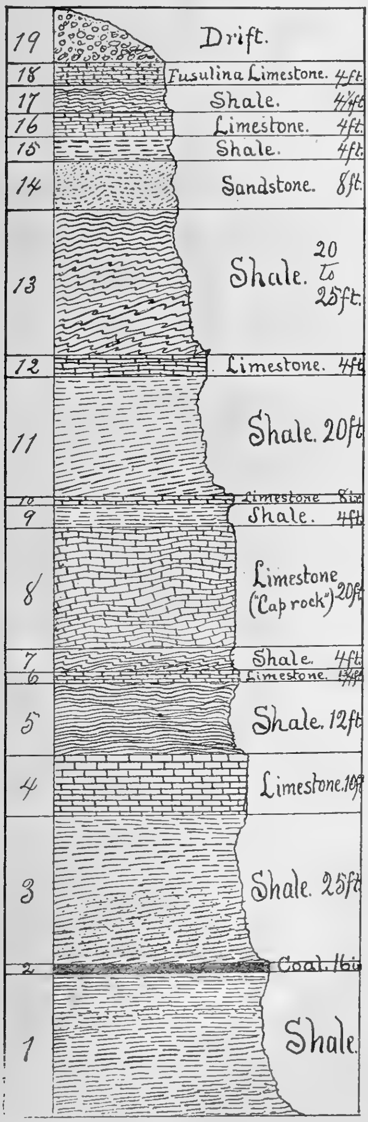
This measurement, however, we obtained in an exposure near the Gaffney brick yards. In one place it measured eight feet, but within less than half a mile it had disappeared entirely. No. 10 did not appear here, nor in any of the other exposures; and the 24 feet of shale of Nos. 9 and 11 had dwindled to only seven feet. No. 13 is the clay used by the Gaffney Brick Company, and makes the finest vitrified brick manufactured in the state.

Many other exposures were visited, but all gave substantially the same results. One in particular, about two miles north of town, gave exposures of all the formations from No. 16 down to No. 3, inclusive. All of these formations are very persistent, and especially the different limestones.

I could obtain no exact measurements of Nos. 17 and 18. The two measure approximately 12 feet. The latter is a limestone abundant in fossil Fusulina.

The measurement of all these exposures, from the level of the river to the drift, gives a total of 180 feet. The drift measures all the way from nothing to about 50 feet.

One interesting feature of the hills around Atchison is the frequency of terraces. These are formed by the washing away of the soil down to a layer of limestone and the gradual wearing back of this when exposed. The same process is repeated with the clay and limestone beneath. Thus a series of terraces are formed, each resting upon a layer of limestone and sustained in place by it These terraces are very frequent along the bluffs bordering on the river bank, but are also found further inland.



THE TERMINAL BOULDER BELT IN SHAWNEE COUNTY.

By B. B. SMYTH, Topeka.

Stretching across the southern part of Shawnee county there occurs a line of red rocks, more or less rounded by the action of water and abrasion. This line is very noticeable, because the rocks in it are unusually hard and of a different color from all other rocks that are found *in situ*, and lie loosely upon the surface in such a way as to give the impression that they were thrown there and had subsequently sunken slightly into the earth.

This line is a part of a line stretching across the United States for a distance of more than 2,000 miles; reaching from the British line in northwestern Montana, entirely across the states of Montana, North and South Dakota, and Nebraska, one corner of Kansas, across the states of Missouri, Illinois, Indiana, Ohio, Pennsylvania, and New Jersey. It continues eastward from end to end over Long Island, and still continues eastward over the bottom of the shallow ocean south of Rhode Island and Massachusetts.

This line is not, however, in Shawnee county, at least, a moraine in truth; it is a distinct and well-defined border belt of boulders, with slight morainic tendencies. The boulders in this line are from one to ten feet in diameter, and from close together to thirty or forty feet apart. Four of the largest in the line are six or seven feet high and ten feet across. These are about seven miles apart, one in a place. Three of them are within ten feet of the very front; a fourth is a little further back. One of them, six feet high and ten feet across is split vertically into three parts; the parts have sunken into the ground somewhat, and are separated from each other far enough to permit a cow to pass through. The interior parts are well covered with lichens of very slow growth. A fifth, about 600 feet back of the line, is three feet high and twelve by eight feet across. It stands in ground that is sometimes springy and soft, and probably rests on the bed-rock, which is two feet below the surface. Several others, somewhat larger, stand on the high ground north of the Kaw, and about twelve miles back from the moraine. One, about the same distance further back, is said by Professor Hay, who has seen it, to be twenty-seven feet across. These are all in Shawnee county.

The boulders are mostly on hilltops and southern exposures. There seem to be all varieties of granitoid, gneissoid, quartzose, and schistose rocks, conglomerates, and metamorphic sandstones. They are red, pink, purple, gray, green, black, and striped with pink and yellow; but red is the predominating color. They are usually very hard, especially those exposed; sometimes one that is covered is decomposed, like these samples (Nos. 1 and 2) in my hand.

COURSE OF THE MORAINE.

This train of boulders traverses the county from east to west, as indicated on the map, commencing near the southeast corner, about two miles north of Richland. It follows the southern crest of the bluffs north of the Wakarusa, until Linn creek is reached, which it crosses, passing up tne creek to Berryton, continues the same course to Pauline, and on to the westward three miles. Here it makes a sharp turn to the north for two miles until the banks of the Shunganunga are reached; it then disappears.

A recent attempt to trace the continuance of this boulder train, in company with Dr. Wm. Smith, of Topeka, resulted in finding it to make a sharp detour around to the southwest, in the bottom of the Shunganunga valley. It reappears south of the Shunganunga, at a point two miles southwest from its disappearance. Over that portion of its course the train of boulders, with a large amount of accompanying drift, rests on the naked bed-rock at the bottom of the Shunganunga valley. Its thickness here, wherever it could be seen, by reason of the creek cutting through it, is from four to sixteen feet. It is covered with ten to twenty feet of native prairie earth washin in from the surrounding high lands. The drift debris at the bottom of the valley has considerable clay and small pebbles of various soft rocks, a feature not observable on the surface. Here is an excellent opportunity for studying the character of the original deposit, where it has been buried since its deposit and left undisturbed to the present day. The upper portion of this buried deposit gradually changes in its character to that of native prairie earth, showing that the drift material and the earth from the prairies were being washed down together, at first the former predominating, as the headwaters of the creek are either on the line of the moraine or entirely within the glaciated district; and later the prairie earth predominating, finally being alone, as the drift material became gradually covered up, and was being washed no more.

Thus there is a bay or sinus opening to the southwest, about two miles deep and two miles wide. Within this embayment stands Burnett's mound, a hill half a mile wide and two miles long, and about 150 feet high, projecting northward from some high lands to the south. Except on the northwest side of the mound, where the moraine approaches to a distance of about one-third of a mile, there is not a sign of any glacial material within half a mile of the hill. North of the line indicated, all over the county, there are to be found on the high lands boulders in plenty, and hidden in occasional hollows beds of drift material that have not yet been washed away. South of that line there is not a particle of boulder clay and not a boulder, save here and there one whose presence there can readily be accounted for. This is also true within that bay; but here there is no exception. There is yet to be found the first sign of glacial material within the bay.

On the east side of the mound the two miles of the boulder train run along the crest of a native ridge parallel with the hill, with a slight valley intervening. On the north and west sides of the mound the moraine is covered up in the Shunganunga valley, as stated. This, Prof. T. C. Chamberlin, of the University of Chicago, says, in the Journal of Geology for November-December, 1894, "affords a criterion of age that is new, so far as we know."

This conclusion is irresistible: That on the east side, and partly on the other sides, the reflection of the sun's rays from the hill kept the ice from approaching closer; and on the northwest side, where the reflected rays would be the least powerful, the torrent of the Shunganunga creek, passing around the north end of the mound, heavily washed the base of the ice, and aided the sun's rays in keeping the ice from approaching closer.* From the place where the moraine reappears above ground south of the Shunganunga, it continues its general course of north 67 degrees west across the county with very little deviation. Valleys crossing its course do not seem to affect it. It crosses hills and valleys in a straight line, except that in the Mission creek valley the moraine is advanced two miles, making a lobe two miles deep and several miles wide.

*Later studies of the region show that a swift-flowing river, half a mile wide, passed around the mound and flowed southward into the Wakarusa, effectually preventing the ice from reaching the mound, and having more influence in that direction than the sun's rays.

HEIGHT OF THE ICE.

This ought to give some clew to the height of the ice at its front. Another clew is obtained in Martin's Hill, west of Topeka, the hill west of the sugar mill, and the hill at Valencia, all overlooking the Kaw, and none of them covered by the ice, but standing as islands surrounded by fields of ice, since the ice that passed up the valley on either side spread out and met a short distance south of these hills. In Kansas, too, some idea may be had of the total height of the ice in this way: The front of the ice in this state was the arc of a circle, as shown by that terminal boulder train. The focus of the arc is a little above White Cloud, Doniphan county. The main glacier came straight down the Missouri valley, or a little east of it, and spread out to the south and westward like the radiating lines of an hepatic or the venation of a maidenhair fern. It must also have spread to the southeastward, until held in check by vast fields of ice in that direction.

A field of ice that failed to touch Burnett's mound, though it passed two miles further south on either side, could not have much exceeded the height of the mound, say 150 feet. At Martin's hill the ice could not have exceeded 400 feet in height, else it could easily have passed over the hill; since it passed over lands of equal height wherever the northern slopes were more gentle. If we assume, then, that the height at Martin's hill, six miles north from the ice front, was 400 feet, and allow an average of 40 feet to the mile as the slope of the surface of the ice, it will indicate 3,000 feet as the height of the ice at White Cloud. The elevation of the uplands at White Cloud is 1,000 feet above sea level, the same as at Topeka. The elevation of the highest intervening lands is 1,150 feet.

SOURCE OF THE ROCKS.

It has always been a question where these rocks could have come from. We find no rocks just like them in any of the states mentioned. Hence they are not local rocks. Similar rocks are to be found *in situ* in Keewatin, north of Lake Winnipeg, in eastern Manitoba, northeastern Minnesota, and in Ontario, north and east of Lake Superior, along what is known as the Laurentian range of mountains.

These stones, Prof. Ulysses S. Grant, of Minneapolis, writes me, are found *in situ* nearly all over Minnesota. They are not found this side of Minnesota, except these (Nos. 17 to 22, and 24), which are found in the Sioux quartzite, in the valley of the Big Sioux and farther east. This specimen (No. 20) contains evidence of glaciation in itself. Look at these pebbles. Waterworn, are they not? They are worn exactly the same as similar pebbles are worn by ice and water at the present day. Yet immeasurable ages have passed over this earth since the formation of these pebbles. Here is a specimen (No. 24) from the same formation that contains evidences of water and no ice. How do you account for those beautiful lines except on the hypothesis that these particles were laid in water in which the currents were regularly reversed, intermittent, or otherwise changed? This specimen (No. 23), a red jasper, Professor Grant says, "is known to form pebbles in the base of the Sioux quartzite, near New Ulm, Minnesota." He says further: "This is the most probable source for your specimen. Exactly similar rocks are found in the iron ranges on both sides of Lake Superior."

How came these rocks in our boulder train so far from their native home? The question as to whether they were washed there by ocean waves would be at once decided in the negative. The question as to whether they were transported by icebergs across seas of open water has been considered; and the question as to whether they were transported by glaciers coming from the north has received serious consideration. The iceberg question must be decided in the negative, because icebergs scatter and deposit their loads everywhere over their courses in warmer seas. These stones, on the contrary, are scattered in a very definite line, a line which is continuous in all its course of more than 2,000 miles, except where it can be shown to be broken through local causes.

CAUSES OF THE ICE PERIOD.

Whether these stones have been carried by ice from the north, over dry land, raises the question as to what the climate must have been in past ages to cause such a degree of cold as to allow glaciers to accumulate to an extent sufficient to reach as far southward as Kansas and southern Illinois.

The question of change of position of the poles and consequent change of all latitudes on the earth is too absurd to merit serious consideration. That there is a very small change going on I will not deny. But the oblateness and fixity of the earth will preclude the possibility of a change of latitude at any place sufficient to affect the climate.

The question of land elevation as a cause of the glacial epoch has received serious consideration and some believers. But the arguments are specious; they are based on false premises. Elevation and depression of the northern hemisphere is a regular result of the earth's astronomical changes, not a cause. If elevation were a cause, the greatest extent of ice should be looked for in the highest regions. But the greatest extent of ice occurred in the low lands of Illinois and Indiana, while the elevated regions of the northern peninsula of Michigan and of Cattaraugus county, New York, proved an effectual barrier to the passage of the ice over them; and the elevated region of the "great plains" had free running streams every summer, while Iowa, north Missouri, and all the low plain region east to western Pennsylvania was covered with ice for a thousand years.

If glaciation of the northern hemisphere is not brought about by terrestrial causes, it is well to consider the astronomical changes that could tend to bring about such a result:

First. Ellipticity of the earth's orbit and precession of the equinoxes. If the earth's orbit were a true circle, the summer and winter would be equal in length. As it is, the six months of summer is now six days longer than the six months of winter. The perihelion point of the earth is reached about the first of January. This point recedes in the orbit a little, so that the earth reaches it 50 seconds of space earlier each year, and makes the complete round of the earth's orbit in 25,868 years. This is called a platonic year. Progression of the perihelion point of the earth's orbit (11 seconds per year) is added to this, making 61 seconds of space each year and reducing the platonic year to 21,408 years.

The heat at present received in the northern hemisphere in summer, compared with that received in winter is as 176 to 100. In 13,000 years more, when the earth reaches its perihelion on the 4th of July, and the platonic winter comes to the northern hemisphere, the amount of heat received in the summer season as compared with that received during the winter season will be as 160 to 100. Thus, comparing 176 with 160 the northern hemisphere receives 10 per cent. less heat each summer during the platonic winter than during the present summers. This 10 per cent. distributed over the northern hemisphere would vary from nothing at the equator to 10 per cent. in the latitude of Kansas and 23 per cent. around the north pole. Ten per cent. of reduction of summer temperature in Kansas would reduce the summer temperature from 78 degrees to 73 degrees, and the annual mean temperature from 55 degrees to 53 degrees. A reduction of 23 per cent. around the north pole would move the isothermal line of 32 degrees annual mean temperature 10 degrees to the south, as its heat is about all received in the six months of summer; and, inasmuch as the reduction would be greater over the land than over the ocean, we might safely look for the limit of permanent ice to be removed to the south of James bay, and even to approach Lake Superior. However, this cause would be insufficient to bring permanent ice into Minnesota. But it would become an important factor in aid of other causes.

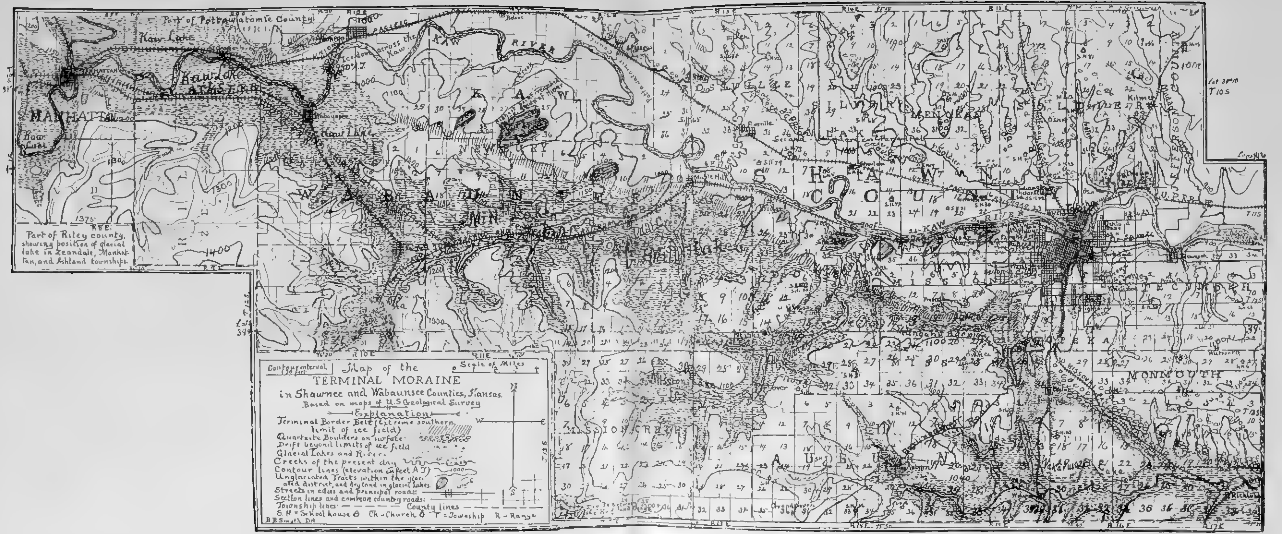
Second. Variation of ellipticity of the earth's orbit. It has been calculated that the ellipticity of the earth 100,000 years ago was two and one-half times what it is now. If that were true, the difference between summer and winter would be 15 days instead of six days; and the amount of heat received by the northern hemisphere each summer during the platonic winter would be 25 per cent. less instead of 10 per cent. less, as at present. This at the north pole would be 58 per cent. less than the amount of heat received there during the summer season at the present time. This is a very important amount, and might or might not be sufficient to push the ice from British America down into Minnesota.

These two variations, having different periodic times, would sometimes neutralize each other to some extent, and at other times reinforce each other. It may be possible to calculate the effects at each particular period; but I have not the data necessary to attempt it.

But there is a third astronomical cause more important than either of the others, namely: Changes of obliquity of the earth's axis. It has been calculated by Laplace that the variation in obliquity amounts to 1 degree 33 minutes 45 seconds. Drayson, of England, as clearly shown by Gen. J. C. Cowell (see Science, December 22, 1893), has demonstrated that the change of obliquity of the earth's axis is caused, not by a nutation of the earth's axis, but by a revolution of the pole of the heavens around a point six degrees removed from the pole of the ecliptic. This, if true, is a very important point. It would cause the obliquity of the earth's axis (since that always points to the pole of the ecliptic) to vary from 23 degrees 25 minutes 47 seconds to 35 degrees 25 minutes 47 seconds. The length of this period is said to be 31,682 years. The time of least obliquity is placed at 400 years hence, and the period of greatest obliquity is placed 13,544 years ago. Thirty-five degrees obliquity would carry the tropic of Cancer up into Oklahoma, Arkansas, and Tennessee; and bring the arctic circle down into Saskatchewan and south of Hudson bay. This cause would be amply sufficient to account for all the glacial epochs that have ever existed on the earth; and they seem to have existed in varying degrees for all past time, even down to the Huronian.

INFLUENCE OF THE OCEANS.

Another thing to be considered in connection with this is the form of the oceans. It is well known that great currents of warm water are flowing northward through the Atlantic ocean near the Atlantic coast, and through the Pacific near the Asiatic coast. After the lapse of a long period of time, when the increasing cold of the platonic winter causes the ice of the Arctic ocean to spread so as to cover a large part of the northen Atlantic ocean and close Bering strait, the warmer currents are entirely shut off from reaching the polar seas, and there is nothing to prevent an increased accumulation of the ice around the pole. The ice naturally spreads farthest in


Map of the
TERMINAL MORAINE
in Shawnee and Wabaunsee Counties, Kansas.
Based on maps of U.S. Geological Survey
Contour interval 50 feet
Scale of Miles
Explanation
Terminal Border Belt (Extreme southern limit of ice field)
Quartzite Boulders on surface
Drift beyond limits of ice field
Glacial Lakes and Rivers
Creeks of the present day
Contour lines (elevation in feet A.T.)
Unglaciated Tracts within the glaciated district, and dry land in glacial lakes
Streets in cities and principal roads:
Section lines and common country roads:
Township lines
County lines
S. H. = School house
Ch = Church
T = Township
R = Range
B. B. Smyth, Del.
Part of Riley county, showing position of glacial lake in Zeandale, Manhattan, and Ashland townships.
Part of Pottawatomie County
MANHATTAN
Kaw Lake
KAW RIVER
KAW
WABAUNSEE
MISSION CREEK
AUBURN
MONMOUTH
TECUMSEH
MENOKEN
SOLDIER
TOPEKA
NEWBURY
Wakarusa Lake

the direction of least resistance, which is over the continents. The warm oceanic currents prevent the ice from reaching very far to the south in either ocean. But there is nothing to prevent the ice from reaching very far to the south in the region of Hudson bay and westward of that.

NECESSITIES OF AN ICE PERIOD.

Two features necessary to the accumulation of a large amount of ice are the contiguity of large bodies of water and an increase in the summer heat. These were obtained in the Gulf of Mexico, which in past times reached farther north than at the present day, and the short hot summers that occur during the platonic winter. Large quantities of water were raised from the Gulf of Mexico and carried northward by the south winds until the ice was reached, where it became quickly converted into snow or rain. Then, too, the melting of the ice in the summer season furnished plenty of water close to the ice; so that a three-day blow from the south could carry much moisture far to the north.

The north winds blowing over the ice fields had a temperature far below freezing; and, supposing that changes in direction of wind occur as they do at the present day, they would present this feature: A very warm south wind heavily laden with moisture, met by a very cold north wind, causing precipitation of a large amount of moisture in the form of heavy snows in the region of Hudson bay, and heavy rainfall on the plains south. Thus the snow accumulated and was piled up higher and higher. This snow, by reason of its great height and pressure, became packed solidly into ice and did as glaciers always do, pushed its foot away from the region of greatest accumulation toward the warmer regions. Hence it was pushed to the south until the melting power of the sun exceeded the rate of travel of the ice.

RATE OF TRANSIT.

As to the length of time required to bring these rocks here. It is by no means necessary to consider that they should be brought from Ontario to Kansas during a single epoch. These stones, you will observe, are a very enduring kind. Indeed they seem even to become harder by exposure to our southern sun; and, as Doctor Smith and I noticed in examining them, they are mostly polished on the southwest side, apparently by attrition of the dust particles raised during the few dust storms that we have. It is a higher polish than is received by abrasion during transit. If they have been here long enough to become so highly polished by so infinitesimal a cause, they have been here long enough for all accompanying softer rocks, except in the buried portions of the moraine, to have become entirely disintegrated and carried away. Indeed, they have been here long enough for some of these granitoid rocks to have become decomposed since their arrival, as is shown by this specimen which I dug up from the buried portion of the moraine, which, when I found it six weeks ago, was a shapely round boulder, but which broke to pieces by the pressure necessary to remove it from the earth, and which I now crumble in my fingers before you. It was a solid stone when it was deposited in the bottom of the Shunganunga; but became decomposed by the small amount of alkali or other deleterious material in the surrounding soil. Many a story of time, temperature, travels, and attending conditions is written in the bottom of that old Shunganunga, yet to be read by the intelligent glacial geologist.

How can we know where these stones were picked up by ice during the Kansan epoch from the place where they were deposited during the last preceding epoch? If the front of the ice during any epoch should advance farther than it did at the culmination of the last preceding epoch it would leave enough of these rocks accompanied by other debris to form a distinct moraine, possibly composed largely of rocks collected in the last few miles. Such moraine would lose its morainic character after the lapse of a sufficiently long time; and there would be nothing left but these hard rocks, ready to be moved forward if need be at the culmination of the next succeeding epoch. We may find out, approximately, perhaps, where any of these stones came from originally; but can we tell how many times they rested for 20,000 years, more or less, at a time, before they reached here?

At the ordinary rate of travel of ice in a glacier, this piece of jasper could easily have been moved from New Ulm, Minn., to Topeka, Kan., in a single epoch; but, as this piece is unconnected with any quartzite, and as Prof. U. S. Grant says that at New Ulm it forms pebbles in the base of the Sioux quartzite, but is found in mass on both sides of Lake Superior, it is more reasonable to suppose it came originally from north of Lake Superior, and that it reached here by stages.

TIME OF THE ICE EPOCH.

If the height of the last platonic winter occurred say 11,350 years ago, and the obliquity of the earth at that time was 30 degrees, it is easy to see that there would be no great trouble in the ice being pushed from Hudson bay down into southern Minnesota, even though the ellipticity of the earth's orbit were no greater than at present.

And whenever the greatest obliquity of the earth's axis coincided with the greatest ellipticity of the earth's orbit, and both coincided with the earth reaching its perihelion about the 4th of July, the greatest glacial epoch would take place; and this was when the ice was pushed to its utmost extension in Kansas, and was what Prof. T. C. Chamberlin calls in Geikie's Great Ice Age the "Kansan" epoch, to indicate and individualize the epoch during which the ice reached its greatest extent toward the south, and to individualize the deposit made during that epoch, as is clearly shown in this boulder train through Shawnee and other counties of Kansas. The number of platonic years that have passed since then has not yet been accurately calculated; neither has the number of ice periods, only approximately, and supposed to be five; which would place the Kansan epoch, as this is the middle of the platonic summer in the northern hemisphere, between 110,000 and 125,000 years ago.

Further study will be given this subject.

ON THE EASTERN EXTENSION OF THE CRETACEOUS ROCKS IN KANSAS AND THE FORMATION OF CERTAIN SANDHILLS.

By ROBERT HAY, Junction City, Kan.

Twenty years ago I obtained from the sandy bed of the creek at St. George, in Pottawatomie county, the cast of an Inoceramus of a Dakota form. I decided at the time that it had been brought there by the ice from Nebraska or Dakota. Two years later I obtained, in glacial gravel in Jackson county, cretaceous sharks' teeth and a fragment of an ammonite of the genus Placenticeras. This confirmed my previous conclusion as to the Pottawatomie specimen. In 1883 I ascertained that water of Arrington spring came from a highly ferruginous coarse sand, which seemed to be the debris of Dakota sandstones not far removed from its original site. Again, the suggestion of Nebraska was made by the direction of the ice movement; but whether it might not be Kansas was a question. The most easterly outcrop of the Dakota then known in the state was in the northeast of Washington county. Its full development there, and the fact since ascertained that glacial boulders lie on it in that county, suggested the idea that it might have been in force much further east up to the glacial erosion. These facts suggest that outliers of the Dakota, patches of what was once a continuous area, may be found some time in Marshall and Pottawatomie counties, and even in Nemaha or Jackson, perhaps quite to the river.

In 1887 I found, in the well of the waterworks at Junction City, a bed of ferruginous sand, as my note book of the date says "almost sandstone," that shows that its origin was the Dakota, not far away. At the same time, on the top of the hill by the Catholic cemetery (in sec. 14, T. 12, R. 5 E.) I found a small deposit of gravel composed entirely of the hard nodules of the dark ferruginous Dakota sandstones. Again I found fragments of the sandstone itself, turned up by the plow, near the Dickinson county line, seven miles west of Junction City. But still the most eastern outcrop in the region that I know of was just on the west side of the city of Abilene, or 15 miles north on the Clay-Dickinson county line, near Industry. There was no outcrop in Geary county.

In November of 1893 I was bid to make a closer examination of a district southwest of Junction City, where some accumulations of sand had often puzzled me. I had attributed the sand, at that elevation, 200 to 300 feet above Smoky river, to the prevalence of the south wind. But the condition of the river alluvium in that direction was such as always to make me dissatisfied with the conclusion. Now I obtained a better solution. In a shallow ravine, where the grass is always long, I found an outcrop, or rather outlier of Dakota sandstone, of the softer yellowish red variety, and a quarter of a mile away another patch of the harder ferruginous qualities. I had crossed these depressions before, but had not hit the right places, and the grass concealed them from all but close vision. Then, north of these, the sand accumulations, which I had taken to be exceptionally hard packed dunes, showed, by digging at their southern ends, that they were the packed sand, or loose sandstone, that is conspicuous about Industry. It is unmistakably the Dakota, and several parallel ridges are of it, and the loose sand at the north is wind-blown only to a small extent. As far as there are dunes here, they are nearly on the site of the sandstones, more or less incoherent, of which they are the debris. These appearances are on sections 21, 16, and 17, of town 12, range 5 east, the two harder rock patches being on section 21. The region to the west of these has largely a sandy soil for several miles, and though both to the north and west, and conspicuously to the south, the Permian rocks are at greater elevations, here is an area of eastern prolongation of the Dakota, resting on an eroded hollow of the older formations. The prolongation of a Dakota tongue on the south of Dickinson county suggests that the phenomena I have described might be expected. Till now, however, they have not been recorded. The geological map of the state should now show Dakota in Geary county.

The consideration of all these facts suggests other inquiries. Has the the erosion of the Kaw valley spared other patches that may testify to the former existence of the cretaceous further east? Is the sand mass—stone or otherwise—at St George a relic of the Dakota?

Five years ago I found, under the sandhills of the northern part of Reno county, that the red beds were well developed. Over in Rice county the Dakota is in force; but a remarkable erosion makes it absent where the first gas well was bored at Lyons. Further north and east, the thin limestones of the Benton are also found.

In Rice county, near the Reno county line, nearly straight north of Hutchinson, there is a region of sandhills, a large area of which is inclosed as pasture. In this pasture on section 10, township 21, range 6 west, is a continuous sandy ridge with hard ferruginous rock appearing through it in small patches for from a quarter to half a mile from west to south of east. It is the Dakota sandstone with the vitreous surfaces, and people in the district say it is of volcanic origin. Breaking the ferruginous surface, which has the vitreous coat, I found under it only soft, dark yellow or red, somewhat incoherent sandstone. It could be cut by the spade. The ferruginous streak has hardened and protected it till now at this spot, while all around the agencies of the weather have broken up the body of soft sandstone, and the winds have piled up the incoherent mass into sand dunes, which grass is now again rendering stationary. In the cut on the Rock Island railway, a few miles northeast of Hutchinson (sec. 33, T. 22, R. 5 west), similar soft sandstones are exposed, and the district to the east and west is made of grass-grown sandhills. A small patch of the vitreous, ferruginous nodular stone is also just north of the Reno-Rice county boundary in 33, 21, 6; and this, with the one in section 10, is in the sandhill region, most of which has been redeemed by grass. The county in the neighborhood of these two is practically level, except the irregularity of the sandhills, and there is descent to the north and east to the Little Arkansas and its tributaries, and southward to the Arkansas, and the sheet of the Dakota was thin before its weathering into sandhills began.

Sandhills thus formed from subjacent sandstones might be described by a term taken from a description of soils similarly formed, and called sedentary sandhills; and it is probable that a large proportion of the sandhills of the world are so formed. It is remarkable that while sand travels with the wind, a region of sand dunes is stationary. The mass remains; the molecules are in motion. There are regions where the wind, persistent in one direction, has caused an arenaceous desert to encroach on the regions beyond; but it will be found that large areas are like those described above, and some tertiary regions I have described elsewhere, and composed of sedentary sand dunes. Besides those mentioned above, the sandhill region west of Abilene belongs to this class.

I will make here a further note on easterly extension of the cretaceous and refer briefly to some beds higher than the Niobrara, which are well developed in northwestern Kansas. Eleven years ago, in this Academy, I drew attention to some shale in Norton county in that position. I have now no doubt that these higher shales belong to the Fort Pierre group. At the mouth of Prairie Dog creek, just over the line in Nebraska, they are developed strongly, and all the way from this west up the Republican valley and all its forks, as well as the Sappa and Beaver valley. In the former, this goes way into Colorado; on the South Fork, to its very head; and they are developed very strongly north of the Union Pacific road from Hugo to Limon. The eastern front in Kansas is not all shown; but it may be presumed there is some in the northwest of Phillips county, and on the Prairie Dog-Solomon watershed, and in Graham county and northern Gove. They show well above the Niobrara on the slope to the Smoky south of Winona, in Logan county. There are abundant outcrops on both forks of the Smoky, but the east front on the south is over on Butte creek, and is shown again on the White Woman, in Greeley county. I am not certain that here I have found its further extension; but, as it does not show in the Arkansas valley in Kansas, it may be assumed that its trend south of latitude 38 degrees 30 minutes is west.

The general direction of this trend of the easterly front is roughly parallel with what we have understood usually is the direction of the east front of the other cretaceous formations.

One or two paleontologic facts are in evidence as to the age of these shales. I have before me, as I write, specimens of Baculites ovatus, which were obtained in what is now Logan county, 20 years ago. This year I have obtained Inoceramas crispii, var. barabini, from the shales of the Republican valley, just east of Benkelman, Neb.; and in Cheyenne county, Kansas, I have obtained both the Baculite and the Inoceramus. These are characteristic Fort Pierre fossils. Lucina is also in the shales in Colorado.

THE RIVER COUNTIES OF KANSAS.

SOME NOTES ON THEIR GEOLOGY AND MINERAL RESOURCES.

By Robert Hay.

TOPOGRAPHICAL INTRODUCTION.

The counties on the Missouri river are the oldest settled counties in Kansas. In the counties next west and south the phrase "to go to the river" meant to go to Leavenworth, Quindaro, White Cloud, Atchison, or other places where there was a landing place on the Missouri river. From the steamboats on the river came the immigrants and their supplies.

By the construction of the acts of Congress settling the boundary of the state of Missouri, the bed of the great river from the fortieth parallel to the mouth of the Kaw is in Kansas. The east bank is the west line of the state of Missouri.

The windings of the stream make the river front of Kansas of great length. It is not less than 145 miles, of which nearly 20 belong to Wyandotte, 23 to Leavenworth, about 21 to Atchison, and over 80 to Doniphan. If the shores of the permanent islands were included this water frontage would be increased. The front to the river mainly consists of high bluffs, and where there is a broad expanse of bottom land, as at Island creek, Kickapoo, and elsewhere, the bluffs still abruptly bound the river valley, rising steeply from the water or from the fertile alluvia which the water has in time passed deposited against them.

The bluffs are mostly covered with timber, but there are districts in each county where the rocks rise bare and bold, and where the height is increased by precipices of yellow clay which is 20 to 50 feet deep.

The precipitous front to the river is broken in many places by narrow openings which allow the discharge of small tributary streams, and in some places by wider ones, as that of Salt creek, near Fort Leavenworth, and Wolf creek, in Doniphan county. Many of the narrower openings become wider behind the bluffs, which there become narrow ridges, and the ravine-like openings is seen to be the outlet of an amphitheatre which extends north and south and some distance west. This topographical form is noticeable at Atchison and Quindaro, and is more strongly marked at Leavenworth and the Soldiers' Home.

In many parts of the river front the rocky walls are distinctly terraced. Mostly two terraces are well marked, but in many places five can be traced, and some of them can be followed round into the creek valleys and the amphitheatres. These terraces indicate a greater depth and a vastly broader expanse of the waters of the great river in past ages when it stood at higher levels, while obstructions far to the southeast were being removed.

Wyandotte and Leavenworth counties have a frontage also to the Kaw river of 25 and 22 miles respectively, and the southern Wolf creek and the Stranger there discharge from valleys that cut deep into the table-land. This table-land in Wyandotte and eastern Doniphan counties is scarcely recognizable as such, so numerous are the depressions and so round the elevations; but in the western parts of Doniphan, Atchison and Leavenworth the plateau character is distinctly seen, the level top in many parts being floored with persistent beds of limestone, whose flatness gives a marked difference to the landscape from the large areas which are covered with the yellow clay. At the mouth of the Kaw the water line is just below the elevation contour of 750 feet, and at the Nebraska line the water level is below the 850 foot contour. Yet everywhere within a mile or two of the river the surface rises to over 1,000 feet, and at Pilot Knob in the city of Leavenworth, and another Pilot Knob at Atchison, the elevation reaches over 1,100 feet. West of the Stranger in Leavenworth and Atchison counties, and in the western part of Doniphan, stretching into Brown county, the plateau keeps the higher elevation.

Where the yellow clay has not covered up the subjacent rocks, there is found in the ampitheatres and other valleys a lower plateau or step to the higher one whose base is of sandstone and of sandy shales, at an elevation from 1,000 feet down to 850 feet, and its curved slopes have more affinity to the yellow clay topography than to the limestones, and hence its character is not as readily detected. It shows, however, very plainly around Leavenworth, and in the valley of the Little Stranger, in the higher lands of Wyandotte county, and far away in Brown county. More details of it will be given further on, and we may speak of it distinctly as the sandstone plateau, or the sandstone horizon.

There is one topographical feature that is important only in limited areas. That is the accumulation of great masses of boulders. Resting on the bed-rock, under the yellow clay, red quartzite, granite, and greenstone boulders, and gravel, may be found nearly everywhere wherever a stream, however small, has cut down to the older formations. This may be seen within the limits of Kansas City, at Leavenworth, Atchison, Muncie, and elsewhere. On the Missouri front the boulders are, however, very rare, though they are frequently abundant in ravines only a few rods within the bluffs. Though widely distributed, they only prominently mark the surface at few localities, and these are back from the river. The divide west of Salt creek and the Little Stranger is one continuous string of boulders from north to south, overlaid on the higher ridges with the yellow clay. They form rough piles in the timbered slopes to the Big Stranger, and some are over a ton in weight.

The bluffs of the Missouri, as has been remarked, are largely covered with timber, and the appearance of much of the four counties is similar. But it is found that a great proportion of the timber, especially at the higher elevations, is young, the growth that has sprung up since the prairie fires have been kept down. In this is an example of the influence of man in determining topographical forms.

All along the Missouri front, from Wyandotte to Doniphan, landslides have been numerous. In places it seems that nothing but loose earth and vegetation had been moved, but in others, e. g., southeast of Connors station, great masses of rock have slid and turned on their edges, and trees have grown on their flanks. Near Kickapoo and elsewhere this is a constant menace to the safety of the railway roadbed, and therefore a constant expense. The cause of this will appear further on. Landslides have occurred on the inland creeks, but much more rarely than on the Missouri. The drainage system of these counties may be largely inferred from what has been said of the contour of the land, and will be verified by looking at the map. The northern Wolf creek in Doniphan county and the north-south trough of the Stranger cut off the narrow region to the east of them from the general Kansas and Nebraska drainage, and so leave it a region of very short streams, mostly with deep valleys, which in many instances converge and pass through the Missouri bluffs by the narrow openings before referred to, and leaving the bluffs in the form of long ridges with narrow tops, parallel to the river. This is also true, though not so marked, in the subsidiary drainage to the Kaw river, Turkey creek, Muncie creek, Wolf creek, Wild Horse creek and others doing their share in varying the upland and making narrow ridges of the river bluffs.

Proportionally there is more bottom land on the Kaw front than on the Missouri front of these counties; but, owing to the sandy nature of the alluvia, the assumed malarial influences of bottom lands are minimized, while their proverbial fertility is not diminished. The increased elevation of the bottoms for the Missouri valley has been given. For the Kaw valley it will be seen in these figures, which show the railway elevations in westward order: Armstrong, 757; Edwardsville, 785; Lenape, 783; Linwood, 791; Fall Leaf, 811.

The gradual rise of the Stranger valley northward will be seen by comparing the elevation of Linwood, near the mouth, with that of Easton, near the Atchison county line, which is 904 feet; but east and west of which the thousand foot contour is reached in a short distance. The railway elevations for Kansas City, Kan. (760 feet), Leavenworth (770 feet), and Atchison (795 feet), may be noted, but it should be remembered that within a mile or so from the depots these cities run up close to the thousand foot contour, and at a little distance beyond the level is that of the sandstone plateau or the higher limestone table-land. White Cloud is 848 feet above sea level; Troy, 1,095.

With this general topographical introduction we proceed to the consideration of the geology, taking, first, the details from and near the city of Leavenworth, where they have been more completely studied. With it the geology of the other counties may be compared, and some probable inferences made.

LEAVENWORTH COUNTY.

GEOLOGY.

The bed-rock of this county is everywhere of the geologic period we know as the coal measures. This bed-rock is not always hard rock. It is sometimes a soft clay shale (commonly called soapstone) or it is a sandy shale that splits into fine laminae and breaks into square or oblong blocks, as seen in the cut where the Kansas Central and Santa Fe railways cross the ridge in the west part of the Fort Leavenworth military reservation. Sometimes there is a hard black shale that will burn, which in places is salable as coal, e. g., near Kickapoo. Again the bed-rock is a compact though nowhere a very hard sandstone, in which wells find water and near the outcrop of which there are some springs. And lastly, the bed-rock is limestone, sometimes in regular jointed beds of good building stone, but often in irregular layers forming massive beds 12 to 20 feet thick.

THE COAL MEASURES.

The bed-rock described above, if its covering of yellow marl and the alluvia, which we will describe later, were removed, would present a very uneven surface. Probably its hills and valleys would have as great differences of elevation as there are now, and many slopes would be more precipitous. But in that case it would be much easier to see than it is now that the various rock formations lie in a regular order one upon another, and the same ledge of rock often persists with little change of character or thickness for many miles. But though erosion of the valleys in pre-glacial times had cut out vast bodies of the rock material, yet opposite sides of the same valley would show the same layer of rock nearly at the same level. An example of this is seen in the fact that the same limestone that is being quarried on the reservation west of Fort Leavenworth was excavated at Pilot Knob for the reservoir, though in most of the country between it has been eroded out, and materials that were once below it are now at the surface of the lower levels.

Again deep down in the ground the same seam of coal is being worked at North Leavenworth and Lansing, and the same bed of hard shale is above it and bastard limestone below it, with intervening fire-clay. At that depth the strata are persistent for long distances. Great gashes have been cut in them by the wearing of the streams near the surface.

The coal measures at Leavenworth may be said to be about 1,500 feet thick, measured from the top of Pilot Knob to the last black shale, 450 feet below the coal seam now being worked. They are coal measures; that is, they contain coal, but only a very small fraction of this thickness is coal. Six, and in some places seven, thinner seams are passed through before the Leavenworth vein is reached. But one vein of 22 inches thick, at a depth of 700 feet, constitutes this a coal region, without reckoning the workable veins below.

In 1881, Mr. Oscar Lamm, manager of the shaft at the State Penitentiary, published the record of the strata passed through. It is as follows:

Strata Passed Through.	Thickness of strata.		Depth.		Strata Passed Through.	Thickness of strata.		Depth.	
	Ft.	In.	Ft.	In.		Ft.	In.	Ft.	In.
1. Surface clay, bowlders, etc	35	5	35	5	43. Shale, black	1	0	532	0
2. Limestone, gray	12	0	47	5	44. Limestone, gray	3	2	535	2
3. Shale, black	3	11	51	4	45. Shale, black, etc	7	5	542	7
4. Limestone, blue	2	5	53	9	46. Limestone, light gray	3	5	546	0
5. Soapstone, light drab	23	6	77	3	47. Shale, black		6	546	6
6. Limestone, gray-dark	15	8	92	11	48. Limestone, light gray	2	0	548	6
7. Shale, green-gray, etc	23	0	115	11	49. Sandstone, brown-gray,	8	3	556	9
8. Limestone, brown, etc.	6	8	122	7	50. Shale, black	12	0	568	9
9. Limestone, gray, etc.	7	10	130	5	51. Limestone, brown	3	3	572	0
10. Soapstone, light drab	37	0	167	5	52. Shale, black	2	6	574	6
11. Limestone, brown, etc.	17	10	185	3	53. COAL		8	575	2
12. Shale, black, etc	11	8	196	11	54. Fire-clay		6	575	8
13. Limestone, gray-dark	4	10	201	9	55. Sandstone, gray	4	0	579	8
14. Shale, gray-black	3	2	204	11	56. Shale, drab	2	2	581	10
15. Limestone, brown	1	1	206	0	57. Shale, bituminous	1	8	583	6
16. Shale, gray-purple	8	0	214	0	58. Shale, buff	1	9	585	3
17. Limestone, gray	6	5	220	5	59. Limestone, light gray	4	0	589	3
18. Shale, green	1	6	221	11	60. Shale, drab-purple	9	6	598	9
19. Limestone, gray	2	5	224	4	61. Limestone, light gray	2	2	600	11
20. Shale, gray, etc	15	6	239	10	62. Shale, black	4	9	605	8
21. Limestone, drab	10	2	250	0	63. COAL, black		7	606	3
22. Shale, gray, etc	18	4	268	4	64. Fire-clay, drab	5	1	611	4
23. Limestone, gray	2	6	270	10	65. Limestone, light gray	3	3	614	7
24. Shale, gray, etc	4	3	275	1	66. Shale, drab	2	3	616	10
25. Limestone, dark gray	1	11	277	0	67. Limestone, light gray	1	10	618	8
26. Shale, black, etc	5	10	282	10	68. Shale, drab		4	619	0
27. Limestone, light gray	1	7	284	5	69. Limestone, light gray	2	7	621	7
28. Shale, gray, etc	1	6	285	11	70. Shale, black	2	4	623	11
29. Limestone, gray, etc.	21	0	306	11	71. Fire-clay, dark	3	7	627	6
30. Limestone, black, etc.	4	0	310	11	72. Shale, light, sandy	24	0	651	6
31. Shale, black, etc	10	1	321	0	73. Shale, dark drab	8	0	659	6
32. Limestone, gray	18	8	339	8	74. Limestone, dark gray		6	660	0
33. Shale and limestone, drab, etc.	9	0	348	8	75. Shale, drab, etc.	10	1	670	1
34. Limestone, light gray, etc.	12	3	360	11	76. COAL		10	670	11
35. Shale, gray, etc	142	8	503	7	77. Fire-clay, drab		2	671	1
36. Limestone, brown		6	504	1	78. Sandstone, black	6	0	677	1
37. Shale, drab	7	10	511	11	79. Slate, drab, etc	7	1	684	2
38. COAL, black		2	512	1	80. COAL		2	684	4
39. Shale, drab	9	2	521	3	81. Fire-clay and shale	1	4	685	8
40. Limestone, light brown	5	0	526	3	82. Shale, dark	3	0	688	8
41. Shale, black, etc	3	9	530	0	83. Slate, drab and black	23	4	712	0
42. Limestone, gray	1	0	531	0	84. COAL	1	9	713	9

Of the 713 feet passed through, Mr. Lamm gives this summary:

Surface clay	35 feet 5 inches.
Limestone strata	191 feet 6 inches.
Sand rock	18 feet 6 inches.
Shale, soapstone, slate	452 feet 6 inches.
Fire-clay	11 feet 10 inches.
Coal (seven seams)	4 feet 3 inches.
Total	713 feet 9 inches.

The last 21 inches of this is the workable vein at the Lansing shaft. It is a little thicker further away from the shaft. Of the other coal seams the thickest is 10 inches.

The record of the drill hole made at Leavenworth in 1887 shows that there are below the Leavenworth seam 453 feet of coal measures, thus:

Shales, various	281 feet.
Sandstones	168 feet.
Coal (two seams)	4 feet.
Total	453 feet.

The Leavenworth Coal Company have bored beneath their vein to a total depth of 1,170 feet, with the following result:

9.0 feet of coal in 12 seams.
191.8 feet of shale, slate and fire-clay, 29 beds.
240.1 feet of sandstone in 23 beds.
18.8 feet of limestone in 6 strata.

They have since sunk their second shaft several hundred feet distant from the drill hole to a depth of 999 feet, which on the whole verifies the drill record, but varied in a remarkable way in two or three instances, showing in two cases 19 inches and 17 inches of coal respectively where the drill showed limestone, and in another place gives coal 13 inches for three thinner seams and shale.

These summaries show that in the lowest part of the coal measures the coal veins are thickest and that sandstones predominate over limestones, and shales still form the largest part of the thickness. This is precisely the condition of things shown in southeast Kansas—Bourbon, Crawford and Cherokee counties—where the lowest beds of the coal measures are at or near the surface.

They also illustrate variations at short distances. The Leavenworth Coal Company's boring shows no coal at 20 to 40 feet below the Leavenworth vein, but their second shaft shows it at 32 feet below, with a thickness of nine inches. The city boring shows it 24 inches at 25 feet below the main seam. The sump at the Home mine shows it 18 inches at 25 feet below, and at the Brighton sump it is reported 16 inches at 30 feet. The city boring gives 24 inches of coal at a depth of 270 feet below the main seam, while the Leavenworth company's shaft shows 26 inches at 290 feet below, with 10 inches more 4½ feet above, the intervening bed being sandstone, while above this is a black bituminous slate for several feet.

Here we have correspondences and variations. From this it would seem that the next coal below the Leavenworth vein has been proven at four of the mines and may be relied on at an average of not less than 18 inches from Brighton to Leavenworth, and that a paying vein has been proved at 270 to 290 feet below the main vein at two places. The main vein has often been called the 21 inch vein, chiefly owing to Mr. Lamm's statement that at the penitentiary shaft it had that thickness. But in that mine away from the shaft, also in the three mines to the north, it is thicker. The average of 15 measurements in all the five mines gives 22 and five-twelfths inches for the thickness in the whole worked field, with enough variation to suggest slight thinning off to the south and west.

Returning to the consideration of the rocks near the surface we get this section as a succession of strata at Ryan's quarry, south of the sugar factory:

7. Yellow marl slope.		
6. Weathered limestone	5	feet.
5. Yellowish and greenish shale ...	3	feet.
4. Irregularly bedded limestone ...	14½	feet.
3. Black laminated shale	5	feet 6 inches.
2. Dimension rock	2	feet.
1. Gray shale below.		

This succession is very persistent on the Missouri river. It is seen down near the Soldiers' Home, and shows at the Home mine, and partly at Fort Leavenworth. Owing to its surface sometimes being eroded off, No. 4 has been found thinner, and by some persons it is known as "the 13 foot."

The dimension rock, the black shale, and the 13 foot, rough limestone, are companions that give a key to the geology of this part of the county. At Fort Leavenworth the dimension rock is out of sight under water, and the black shales in the water, and the 13 foot is within two feet of the recent stage of low water. But there are variations. In most places the black shale does not exceed four feet, and in some places the yellow shale (No. 5) is reduced to two feet, and even to a mere shale parting of less than a foot. No. 6 is pierced with holes worn by the weather and water when the river was at a permanently higher stage. With shale partings between its irregular layers it runs up to 15 feet or more, 4, 5 and 6 having an aggregate thickness, where fully developed, of over 30 feet. This thickness is shown towards Fort Leavenworth.

Above this section we have shown at much higher levels in the different localities another series, which culminates at the top of Pilot Knob.

This series near the top is singularly like the section just given. We have it shown at Pilot Knob and in the government quarries west of the fort, thus:

Rough limestone, 10 feet. (14 feet at Pilot Knob.)
Laminated buff shale, 2.6 feet.
Laminated black shale, 3 feet.
Dimension rock, 2 feet. (1 foot 10.)
Shale.

Here are dimension rock, black shale and rough limestone just as at the river bank. It is a repetition. There are 250 feet between the two similar sections, and that space is filled mostly with sandstone and shale, with a few thin layers of limestone and a heavy, limy, yellow sandstone, of which the governor's house at the Home is built. In this horizon of over 200 feet sandstones prevail as at Brighton over 30 feet thick, and elsewhere shales. But the shales are often laminated and have flaggy and other sandstones among them, as may be seen in the railway cut on the reservation. They are also black and carbonaceous, and in places develop into coal, as on Salt creek and South Stranger.

The complete section would be about thus:

10. Rough limestone (Pilot Knob)...........	10 feet.
9. Black and lighter shale	6 feet.
8. Dimension rock (upper)	2 feet.

7. Shales and sandstones with some limestone ledges	250 feet.
6. Rough limestone ledges and some intercalated shales	6 or 8 feet.
5. Yellowish, green shale	3 feet.
4. Rough limestone	14 feet.
3. Black shale	5 feet.
2. The dimension rock	2 feet.
1. Shales.	

No. 7 may be divided about as follows, beginning at the bottom, but the thicknesses vary greatly within the limits from Lansing to the fort:

a. Brick shale, and in places two beds of limestone	40 feet.
b. Sandstone and sandy shale, and the yellow limestone	65 feet.
c. Brick shale	20 feet.
d. Sandstone	20 feet.
e. Shales and sandstone with layer of limestone near the top, and thinner ones lower	100 feet.

At the Soldiers' Home immediately above the No. 6 lies the shale out of which the vitrified bricks are made. Its lowest parts are blackish (carbonaceous). The middle is sandy laminated, the upper part is more marly clay shale; that is, the brick shale is the lowest part of No. 7. It shows, lying in the same position, on No. 6, north of the Riverside mine, and again north of the Home mine, and again as far north as Kickapoo. Further south on Island creek, sandstone rests directly on limestone which is perhaps No. 6. The brick shale in other places will be referred to further on. Shale of a very similar texture is seen in the bottom of the cut on the reserve, and probably will be found at various levels from 40 to 100 feet above the lower dimension rock, or at similar distances below the Pilot Knob rough limestone.

I have said that the rough limestone of Ryan's quarry appears on the bank of the river near Fort Leavenworth, but there is a remarkable change between the two places. South of the sugar factory this limestone is many feet above the railway track, and so shows itself from the Home mine to Spruce and Olive streets. But from there northward it is no more seen on the railway track till we reach the mouth of Two Mile creek. Under the waterworks bank and further north there crop out shale with ledges of flaggy sandstone. These ledges have a decided dip toward the south. Going down to the water's edge at one spot there is sufficient freedom from debris to see the outcrop of No. 4. The top of it is just 14 feet above the water at the day I measured it, which was just at the time the ice was breaking up. This would carry its base down into the water. North of the bridge its base at the same time was several feet out of the water, and the black shale above water level, so that it comes up more rapidly than the slope of the water surface. There must be a great depression of strata northwest from Olive street to the north limit of the city, which is changed about there to a northerly rise. The absence of hard rock in the bluffs north of the depot is accounted for by this, for the sandstone would more readily wear away, and loess has filled in the lower levels.

It is remarkable that in the Leavenworth Coal Company's mine there is a decided change of dip some distance northeast of the shaft. It dips northerly by east at an angle of 13 degrees for over 400 feet, and then the continuity of the coal seam is interrupted by a "trouble"—not like a trap dike common in some coal regions, which is igneous rock protruded from below, but this trouble is a broken mass of stratified rocks apparently dropped in from above. After the trouble is passed through the coal seam is continuous beyond, but rises to its former level. It was probably some seismic action that opened a gap and let the upper strata fall in, but the gap was closed before any great fracture had occurred at the surface. Only a sag took place there, represented by what we now notice only as a comparatively slight change of dip. And yet there may be more change, even fracture, near the surface than we can discover, as the heavy cap of loess hides the bed-rock all through the northern part of the city.

There also appears to be a slight difference in the level of some strata on both sides of Five Mile creek, but this I could only be sure of by actual leveling. It is, however, probable that all watercourses more or less correspond to the breaks or changes in the direction of the dip of strata.

At the south side of Three Mile between Second and Third streets, and also at the rock expose, south of the railway yard, it is seen that the rock dips to the west. This westerly dip, combined with the northerly, gives a general west by north dip which, with some exceptions, carries down the various strata out of sight as we go away from the river, and others come in on the top. This is true probably for the whole thickness of the coal measures. The westerly dip is well illustrated by the position of the coal at Brighton, as compared with that at Lansing. The distance between the two shafts is 2¼ miles, almost due west. The coal at Lansing is 714 feet deep; at Brighton it is 811 feet. The difference of level of the tops of the two shafts, as determined by the railway survey, is 67 feet 9 inches, which leaves a depth of 29¼ feet to be accounted for by the dip between the two mines. This gives a westerly dip of 13 feet per mile for the main coal. As the dimension rock is 29½ feet lower at Brighton than at Lansing, this practically gives the same dip at the surface.

The northerly dip of the district is seen in the difference above sea level of the dimension rock and the Leavenworth coal vein at the penitentiary and the Leavenworth Coal Company's shaft:

	Elevation Penitentiary shaft.	Elevation Leavenworth Coal Co.	Difference.
Top of shaft	828.0 feet.	810.0 feet.	18.0 feet.
Dimension rock ...	774.9 feet.	776.9 feet.	
Vein coal	116.6 feet.	103.5 feet.	13.1 feet.

This gives a dip at the dimension rock which is near the surface of only a foot and a half and the vein coal of two feet four inches per mile. The two mines are five and one-half miles apart, and the more northerly one is nearly a mile further west than the other. There are local dips in the two mines which lie between which exceed this amount, but they recover themselves in short distances.

That this northerly dip is changed into a northerly rise north of the waterworks has already been noted. The dip westerly is, however, more continuous, though there are local easterly dips in several of the mines.

The westerly dip carries all strata of the eastern part of the county downwards considerably in a few miles, so that in the valley of Little Stranger and Salt creek none of the strata of our lower dimension rock series are visible there, and the sandstones and shales that lie high up on the west of Pilot Knob ridge are found in the bottom of the valley. Some of the carbonaceous shales of eastern uplands there become more like coal, and at the southern part of the divide between Big and Little Stranger there is one seam of good coal.

THE DRIFT.

Under date of August 27, 1868, Wilder's Annals of Kansas has this passage: "Prof. Louis Agassiz, Roscoe Conkling, Ward Hunt, and other eastern men, visit Leavenworth. Agassiz said he had never seen such good soil as he had seen in Kansas and Missouri." This is part of a much longer passage, which is an abbreviation of an article a column and a half long in the Leavenworth "Conservative" of the same date. Professor Agassiz was the apostle of the drift. It was he who by study of the glaciers in his native Switzerland rose to the scientific explanation of the drift deposits of northern Europe and northeastern America. He converted to his theory every distinguished geologist of his day, including Sir Charles Lyell. In addition to recording the fact of the visit of Agassiz to Leavenworth, D. W. Wilder has told the writer an interesting incident of that visit which I think I am violating no confidence to repeat. Agassiz said to Wilder, "Have you any boulders here?" "Our Web", though not a geologist, said he thought there were, remembering a stone somewhere about the city that he guessed was what the scientist wanted, and they went out from the assembly of railway magnates to look at a rock. Agassiz was overjoyed. He was delighted, and said he had found here, 5,000 miles from his home, the confirmation of the theory he had worked out in Switzerland. If we could only find that particular stone we would set it up in front of the Leavenworth high school and imbed in it a tablet of enduring brass to record its interview with the arch-interpreter of boulders.

That boulder was one of many that may be seen within the civic boundaries of Leavenworth—one of multitudes that are scattered over the county, that in some places are like great streams of stones on the prairie, that on some high tops are so close together as to suggest artificial pavement. These red, gray and green boulders with associated gravels and some forms of clay and some markings of the bed rock constitute the phenomena which we include in the term drift. These boulders have come from far. Though much older here than Regis, Loisel, or Coronado, they are not native Kansans. They were brought here by a force tremendously in excess of their own inertness. They were brought by the ice that overspread all the continent to the northeast, which ground its way over the granites and greenstones and hard limestones of British America and Minnesota, tearing huge masses from their beds and doing the same with the hard red quartzites of Minnesota and Dakota, and bearing the accumulation, with scarcely more than the sharpest edges worn off, to be dropped out in Kansas and Iowa when the ice melted under the returning geniality of climate.

The boulders are of all sizes, from that of a nut to a mass of several tons. In Leavenworth county there are comparatively few along the Missouri river front. They are found in great numbers along the sides and top of Pilot Knob ridge and the valleys of Seven and Nine Mile creeks, and still more numerous on the other side of the ridge toward Little Stranger and Salt creek. On the watershed between the two Strangers they are in great force. The ice containg the boulders probably ground down the surface of that slope to the south, and in time of melting rested there while its stony burden was strung along the surface. Gravels as separate deposits with few boulders are scarce, but they may be seen near Lansing and northwest of Tonganoxie and in some of the valleys in the north part of the county. West of Salt creek, passing the Eight Mile House, going west, there is a fine succession of boulder deposits. They are of all sizes up to more than a ton, and occur in the road cuts below the tops of the hills on every successive ridge for four miles. They are seen on every road south to beyond Boling, and constitute a fine example of a glacial moraine. The mineral well on Little Stranger comes from below a mass of this morainic material which has been made into a heavy conglomerate by ocherous cement.

In places there is a tough, sticky, dark colored clay, with pebbles and small boulders resting on bed rock, which is the product of the ice action in grinding up the shales, sandstones and limestones over which it passed. It is called hardpan or boulder clay. I have seen but little of this in Kansas, and usually the plainest drift products are the accumulations of boulders and pebbly gravels.

In the absence of hardpan, these rest on the bed rock of the district. For long ages the Missouri river and its tributaries had been washing the surface of the coal measures and had carried away in this region the last vestige of any newer formations that might have been above them, and the valleys nearly on the present lines were cut out. Then came the ice planing down the surfaces, widening the valleys and narrowing the ridges. All river courses were dammed, and the great streams of the Missouri, Platte and Kaw were sent in new channels around the ice front or scattered in great lakes, and in these lakes and streams ice floated from the edge of the glacier, both at its greatest southern extent and when it was melting away and retreating northward. These icebergs carried boulders and dropped them far away in the deposits of sand and clay that settled from the cold waters.

In Dakota, churches are built of some of these boulders. Most of them here are the red, hard quartzites, which will take a beautiful polish. The time will come when these troubles of the farmer will find a utility and a place in ornamental building.

In the region south of the limit of the ice the rivers and lakes were laying down a yellowish deposit, very like the present mud of the Missouri river, and as the ice melted this followed up the retreating glacier, and the yellow marl lies over the deposits of boulders, which are exposed where modern erosion has thinned out or entirely removed the marl, as in some of the localities mentioned.

Both boulders and marl are found on the highest land in this region, testifying to the mass of ice and the flow of water, whose action was probably aided by some changes of level the extent of which we cannot at present even guess in this region. Of the marl we shall now more particularly speak.

THE YELLOW MARL—LOESS.

Nearly everywhere in Leavenworth county this bed-rock shale, sand or limestone is covered with a coating of yellow marl before referred to. It is is shown in the bluffs of the Missouri river 30 feet high. Sometimes it is only three to five feet thick, and caps bluffs of limestone or shale. It is in places nearly 100 feet thick, and is so prevalent that bed rock is only seen in the precipitous bluffs of the river, the higher ridges and ravines. The name loess is from the German (loss), as a similar formation so named is found in Rhineland. It is sometimes called the bluff formation because it is so conspicuous in the Missouri river bluffs from below Kansas City to Yankton.

The name yellow marl describes its color and composition. It is a limy, sandy clay with streaks of sand and gravel, and its color is a little brighter than the recent deposits of Missouri river mud, which, in its mechanical structure and chemical composition, it greatly resembles.

The yellow marl was deposited from the waters of streams or lakes of fresh water which covered the country in front of the ice of the glacial period and which followed the ice as the melting at the southern edge caused its retreat to the north. It covered the whole of Leavenworth county. It has been eroded from part, but it is the subsoil of the high, rolling prairie and is under the smooth bottom land of Stranger creek.

As in Kansas the ice came down as far as the south side of the Kaw river and as far west as the Blue, all the valleys of northeastern Kansas, as well as eastern Nebraska and eastern Dakota, were filled, and the great streams of the Missouri, Platte and Kaw were scattered on the western plains, and the loess was deposited at levels up to 1,500 feet. But on the retreat of the ice the drainage that had been stopped began again, and the soft yellow mud that had smoothed over the rugged ravines of the pre-glacial time began to be washed out, and the modern drainage channels were probably established before the prairie grass obtained its hold or the trees began to grow in the ravines.

Men lived somewhere near while the loess lakes were in existence. We find their weapons in the loess, and very likely from the first drying up of the land they hindered forest growth by fires.

The loess in its deposit to a very great extent smoothed over a very rugged country, in some cases adding height to bluffs that would be conspicuous without its aid. The economic value of the loess will appear further on.

Every valley has in its draws and slopes land that has been made by the material washed by rain and stream from the higher levels. This is called alluvium. The various kinds of alluvia are gravels, sand, clays, gumbo or modifications of these and are sufficiently well known not to need particular description. They are the latest geological product, belonging entirely to the present stage of surface changes.

ECONOMIC GEOLOGY.

It will be recognized that many of the facts previously stated have a commercial value. I shall now more succinctly put together the economic results of this investigation.

COAL.

In the early history of Leavenworth county coal was mined by drifts from several veins of coal near the surface at or near the same geological horizon, at Kickapoo, on Little Stranger creek below Boling, and on Big Stranger near Tonganoxie. The Little Stranger mines were the most numerous and apparently worked most systematically, and they supplied coal in considerable quantities until the opening of the Leavenworth deep mine in 1870, shut off their principal market. This seam furnished a large supply to the city and county. Mr. Peet worked it back in the fifties, and Mr. James Orr and Mr. Hyde began later. These persons owned the land, and sometimes mined themselves and sometimes they gave it to others on royalty. As many as 12 drifts were made into the side of the bluff, those furthest south being at the level of the coal, four feet above the creek bed. Further north the creek was diverted and several acres at and below the water level were stripped and the coal taken out. Higher up some drifts were made into the bluff sloping down to the coal and the water was dammed out. Mr. Orr sunk a shaft 14 feet and worked chambers to the northwest to a distance of over

200 feet. It would appear from such records as I have seen that in 1867 and 1868 not less than 50,000 bushels were taken out each year, and the aggregate was probably not less than 250,000 bushels. The coal as seen now at the outcrop is from 18 inches to two feet thick. The upper third is decidedly inferior quality, but the lower part is as good coal as is obtained in the region. It was used in early days by the blacksmiths and by the gas company as well as by mills and foundries. It is easily accessible by a railway switch a mile long and can be cheaply mined. It cannot afford to be carried on country roads in competition with Leavenworth coal with railway rates. The area underlain by this coal is several hundred acres and may be more.

There is still a body of coal in that district which, notwithstanding some disadvantages, can be cheaply mined. Its extent cannot well be less than 500 acres, and it is possible it may be three or four times as great. Worked on the long-wall system an acre of coal one foot thick would give 44,000 bushels, and it is within bounds to say that the Little Stranger coal would average 16 inches of high quality, though it has the disadvantage of being associated with six or eight inches of less value that would have to be mined with it. It is covered with shales and clay to a depth of 30 to 50 or 60 feet. The thicker coverings include a bed of limestone four feet thick.

There is a coal on Salt creek and on Big Stranger near Tonganoxie at somewhere near this horizon, but the weather prevented my determination of its exact relations or its thickness.

The time will come when these upper seams at Big Stranger, Little Stranger, Salt creek and Kickapoo will again become important parts of the resources of the county, though they may not rank in value with the output of the coal from the Leavenworth deep vein.

These coal seams are accompanied by shales some of which will certainly make vitrified brick, and it may be that exposition of the problem of their use lies in this association, and we may have successful brick, tile and pottery yards in the central section of the county where the clay and the coal will be on the same land.

The story of the development of the deep coal at Leavenworth has been often told. I only refer to it to express my own appreciation of the perseverance and spirit of Major Hawn in not giving up when the depth was greater than he had at first anticipated. To him the city of Leavenworth is indebted for the principal factor of its prosperity.

The seam of coal which I call the Leavenworth main coal is now being mined in five places. From the Leavenworth company's shaft in the north to the penitentiary shaft the distance on a north and south line is 5½ miles, the latter being about a half mile to the east. Add to this the distance of the southern face in the Lansing mine and the northern face in the Leavenworth mine from their respective shafts and we have a north and south extension of proved coal of fully seven miles. The distance of the penitentiary and Brighton mines in the same way gives us a proved existence of three miles east and west. We have then an area of 21 square miles in which the coal is known, having been proved by the successive sinking and successful working of the

Leavenworth Coal Company's shaft	1870
Penitentiary shaft	1881
Riverside mine	1886
The Home mine	1889
The Brighton mine	1889

I have carefully weighed 10 specimens—two from each mine in the district—and find the average specific gravity of Leavenworth coal to be 1.283. This gives 80 pounds 3 ounces as the weight of a cubic foot of Leavenworth coal. That is, a cubic foot is almost identical with a bushel.

This may be compared with some English and Pennsylvania coal, whose specific gravities are as follows:

Newcastle coal (Hartley mine)	1.29
Wigan "four feet"	1.20
Pennsylvania	1.40
Leavenworth	1.283

If we estimate that the length of the coal vein be extended to 10 miles and the breadth of it as now known be increased one mile, which is an extremely low estimate, we should have an area of 40 square miles, which, with the average thickness before given of 22 5-12 inches, would give a total of 2,083,136,000 bushels. This, at the rate of output for 1891 (7,479,406 bushels) would last 280 years, or if the rate of output were doubled would hold out 140 years, which might be reckoned from 1885.

I have previously stated that a lower coal vein has been proved at four places within the district. If its average thickness were taken at 18 inches over the same area the present output might be doubled and the coal would still last over 200 years. It is probably safe to predict that before that time other fuels will be largely used. Of these we shall speak further on.

In 1888 a boring was made at Tonganoxie to a depth of 852 feet. The last 22 inches is given in the drill record as coal of the best quality, and it is claimed that it is Leavenworth coal. The upper part is very different in its succession of strata from the Brighton mine, which is the nearest of the Leavenworth mines, but the lower part shows some similarity in the occurrence of sandstones, black shales, thin coal and fire clay; so that there is no good reason to doubt that coal is there, and if not actually a continuation of the Leavenworth main coal it is not far from the same horizon. If it were the same seam the area of the coal field would have to be taken at double or treble the estimated area given above. A consideration of the south by west trend of the elongation of the other veins of coal in Kansas is in favor of expecting continuity of the Leavenworth vein in the direction of Tonganoxie.

It is a well known fact that coal seams run out in the course of a few miles in given directions, and are replaced by shales or other deposits. The converse of this is also true, that in the opposite direction the shale sometimes becomes coal. If then a seam of coal should be found very thin at some spot and it were known not to exist at all in a given direction, it might possibly be found a vein of workable thickness and high quality in the opposite direction. If, then, in the future it should be desirable to make a test with a diamond drill in the valley of Little Stranger, besides the coal near the surface, already described, the 8-inch, 7- and 10-inch veins of the penitentiary shaft (at 575, 606 and 670 feet, respectively) might possibly be found each about 100 feet deeper, and one or more of them might give a workable coal, before the horizon of the main vein was reached.

Of the heat-producing power of the coals of Kansas, Professor Blake, of the state university, has made a full comparative report, in which he says: "The coals depreciate in their steam-producing powers from the southeastern part of the state toward the north and west," but Leavenworth coal is so far an exception to this rule that in the tables it is bracketed with the Cherokee upper vein and comes before Osage and Franklin county coals. The best Indiana block coal is shown for comparison.

Pounds of water evaporated per pound of coal used:

Place.	10 per cent. correction.	30 per cent. correction.
Leavenworth	12.54	14.80
Indiana (Clay county)	14.53	17.03

The methods of this determination are carried out in apparatus that assures nearly perfect combustion, and Professor Blake remarks that, "about one-half the evaporative powers here given under the 10 per cent. correction will be obtained in practice" in steam boilers.

Prof. E. H. S. Bailey gives an analysis of Leavenworth coal as follows:

Water	2.69
Volatile	39.21
Fixed carbon	47.41
Ash	10.69

And arranging the coals of Kansas as to their value, as shown by analysis in five groups, Professor Bailey places that of Leavenworth in the second group.

The black bituminous shales of the surface and down in the mines will some day be sources of heat and illumination to the larger populations of the future. They will all yield oil and gas by distillation, and when supplies of petroleum, now constantly decreasing in the eastern states, are exhausted these shales will everywhere be a source of wealth to the communities that have them. It will pay better to mine them then than to mine coal to-day.

MINERAL PAINTS.

The bed of shale immediately above the 13 feet of limestone has a yellow streak near the bottom that in many places is a good bed of ochre. It is seen at Ryan's quarry and at the soldiers' home. Other parts of the shale beds have similar deposits. There is also purple brown shale at a higher level that shows on Salt creek, Little Stranger and near the Wyandotte county line, that apparently would make a paint of the umber class. The yellow ochre calcines a beautiful brown. These shales all belong to the coal measures.

In a great many places the bottom of the yellow marl is a rich red clay, free from sand, which from the quantity of iron in it will make a good pigment for outdoor painting. It will have to be sought for and may be found where the superincumbent marl is not very thick, and the paint-bed itself may be found sometimes two or three feet thick. Under the circumstances of frost and snow in which this examination has been made it is impossible to get at the thickness of these soft deposits. This rich clay has, however, been seen in the western part of the city and on slopes of Salt creek and Little Stranger.

CLAYS.

Leavenworth county is rich in clays for all kinds of bricks and moulded blocks. The most prominent feature of the region, the loess or yellow marl, is over a large part of its area fit for the best kinds of common bricks. It can be found sufficiently porous for draining-tiles and also of quality suitable for compact pressed bricks. The loess is everywhere. Experiment determines its value. If inferior bricks are made it is usually the fault of the maker, either in selection of his clay, or in its manipulation and baking.

The bricks that are now claiming so much attention are the vitrified bricks for paving.

These paving bricks are made of shale (or shales) of the coal measures. The outcrop that has become best known is at the soldiers' home, where it shows from 20 to 30 feet in thickness. It forms the lowest part (a) of No. 7 in the section on page 236. It is mainly a clay shale called by the workmen soapstone, but it changes into luminated sandy shales in parts of its thickness. Sometimes the best results are obtained by selecting a particular part of the thickness of the bed. At others the proper proportions of sand in the clay are obtained by mixing all the parts of the entire stratum. The iron that seems to be a necessary part of a clay for vitrified bricks is found in some parts of the shales as bands of limonite nodules or concretions, which are ground up with the rest of the material, but elsewhere there are no concretions, yet sufficient iron is distributed in streaks and ocherous stains through the substance of the shale.

It is a feature of these brick shales that they contract considerably in burning, to the extent sometimes of one-eighth of the linear dimensions of the bricks, which in the cubic contents is a diminution of bulk in the ratio of 512 to 343. This must be allowed for in the making of the bricks, and the heat of the drying shed and the kiln must be so regulated that the contraction shall be regular. The proper time for tempering the material before use is also important, and the use of winter frosts for this purpose should have attention. With care on all these points and attention to results of previous experience the brick shales of Leavenworth will produce as good results as anywhere. It seems that one of the solutions of the problem of the pavement of the city streets is found in the use of vitrified bricks.

The material for making them is abundant. The geologic position which we will call No. 7a, is easily found, and where not eroded it is of the brick shale quality very extensively. It may be seen cropping in the

1. River bluff near the railway-yard limits, northwest of Riverside mine.
2. River bluff under the South Esplanade, north of Home mine.
3. River bluff near Fort Leavenworth.
4. River bluff at Kickapoo.
5. Santa Fe cutting south of crossing of Fourth street, near soldiers' home.
6. Santa Fe cut northwest of Fourth street crossing.
7. Santa Fe and Southwestern cut near linseed-oil mills.
8. On street cut in the city on Shawnee street.
9. On bank of Three Mile creek on West Cherokee street.

There are places where the brick shale shows only a little, as under the loess at Geiger's quarry, where going back into the hill would probably show it of considerable thickness, and above Ryan's quarry, where it does not show at all in the outcrop. Similar beds are found in the higher parts of No. 7 (c and e) which show at the railway cut on the military reservation, on the flanks of Pilot Knob ridge, in the bluffs of Little Stranger and on Seven and Nine Mile creeks. The shales immediately above the coal on Little Stranger have great similarity to the proved qualities of brick shale.

The experience already attained in the making of paving brick, flooring tiles, curb blocks and Roman bricks from these brick shales warrants the expectation of still greater successes, and that terra cotta of the best quality may be made for use in ornamental architecture. At one of the brick yards an improvement of the common bricks has been made by an admixture of loess clay with the brick shale, and this admixture has also been made by nature where the loess and the brick shales come together, a greenish clay with red streaks being the result.

It may be stated that many blocks on Broadway have been curbed with the moulded blocks, and they have worn well.

There is another source of material for bricks. It is the dump piles of shale at the various coal mines.

The brick works at the penitentiary use this material exclusively. The hard "slate" which forms the roof of the coal is brought to the surface when it has been cut out to form the main entries of the mine. There are streaks of limestone or limy shale in this roof slate that do not improve the quality of the bricks, but if these are thrown out the material makes a fair vitrified brick. It is extensively used for sewers and paving, and will have still further development.

CEMENT.

I have not recognized here any gypsiferous deposits that would be suitable for plasters, but some of the shales are probably sufficiently calcareous to have some utility in that direction. The bed of limestone elsewhere mentioned as being in the shales lying over the coal on Little Stranger creek has considerable resemblance to the Fort Scott limestone, which is the only Kansas bed which so far has produced an hydraulic cement which has withstood competition and has obtained an established place on the market. It is probable that some shale beds and some other limestones may yet be found with hydraulic properties that may take a place among the regular products of the district. But the value of these can only be determined by actual experiment.

MINERAL SPRINGS.

There are no springs in this region that are noted by their force and large volume of water. But the numerous creeks of the district are fed by constant seepage from the sandstones, sandy shales and occasional gravels of the region, and wells varying in depth from 20 to nearly 100 feet have plenty of water in all parts of the county.

There are, however, in the region of the outcrop of the various parts of No. 7 of our section springs with a perennial flow of water. And several of these have decided mineral qualities. Coming out of sandstones that are charged with iron as carbonate or oxide, or from shales that besides iron have alum and other salts as well as sulphur in pyrites, the waters are charged more or less with these minerals, and some of them have without doubt valuable medicinal properties. I have visited three localities where such springs are found. One is on the Doctor Marshall place, near the Wyandotte county line, on Island creek. The water comes out near the contact of sandstone and limestone. There is certainly some iron in the water, but only a chemical analysis can determine its quality and medicinal value. Its quantity can only be found by having it cleaned out, as much debris has recently fallen into it and obstructed its flow.

Other springs are on the Ramsey farm, less than one mile northwest from the last. One of these is said to taste and smell strongly of sulphur, but it now fills a small pool for cattle that makes it difficult to obtain the water direct from the spring. Much of this has been taken away by the country people at different times.

The third region is on the Little Stranger creek, west of the Brewer farm. The bed-rocks in place here are a soapstone shale at and a little above the creek bed and a yellow sandstone on the shale in several low bluffs, the whole capped by loess on the slopes.

At the spring the yellow sandstone is missing and an immense mass of boulders—some way worn—imbedded in an ochreous cement, rests directly on the shale. The morainic mass is, like the rest of the outcrop, capped with loess. The boulders are of all kinds, the quartzites, greenstones and granites being accompanied by a much larger proportion of local rocks than is usual. There are two local limestones that are larger than any I have elsewhere seen in the drift. Some of the boulders are blocks of shale that have probably not been carried many rods from where they were torn out of their parent beds. Some of the shale here tastes strongly of alum, and all the coatings of the surfaces of the various rocks testify to the presence of iron. It is said that iron pyrite cubes have been dug out of the spring. The whole is at present choked up with recently fallen debris, but the surroundings are such that after a proper analysis of the quality of the water were made known a health resort here might well be made popular, as there is an abundance of shade and breezy heights, more than 300 feet above the Missouri river. The surroundings of the springs previously mentioned are also favorable for making them places of resort.

Chalybeate waters, sheltered valleys, breezy uplands form a conjunction desirable for the resort of those who seek health and those who are desirous of rest.

SOIL.

From what has been said it will be inferred that the loess is the subsoil of much of this county. This is true, and though it is yellow and in many places a heavy clay, yet it is a good soil as soon as broken by the plow. It is not bad for wheat, the vines love it, and all trees flourish in it.

In the Stranger valley the loess lies under several feet of black soil, which probably has been produced through the change of the subsoil by long production of vegetation, but there are black soils in some upland valleys—on Salt creek and both the Strangers—which it seems hard to explain in the usual way. It would, however, take both a chemical and mechanical analysis to prove a different origin. Enough, however, has been observed of them to suggest that possibly they may owe their origin and blackness to the breaking down of the carbonaceous shales of the coal measures. So their color would still be due to vegetation, but of Paleozoic time. It will need, however, much and special work to determine this. Suffice it that the soils of this county, black or gray or yellow, are all fertile, and will repay culture by plenty.

BUILDING STONES.

The rough limestone of the "13-foot" and the similar Pilot Knob stone yield but an inferior building material, though there is one layer of each that is of a better quality. They will all, however, make lime.

The two limestone layers we have called the upper and lower dimension rock, on the other hand are both hard and compact and yield little to the influence of frost in buildings. They can be quarried in blocks of almost any size and of even thickness. The lower dimension (No. 2 of this section) is only accessible in ravines and on the river south of the city. The upper one in ravines to the west, on Salt creek, on the Stranger near Easton, and probably on Little Stranger. In the southern part of the county there is much limestone, and some of the beds cropping on Wolf creek are identical with strata that have been quarried at Kansas City.

The sandstone that crops at Brighton and on Five Mile creek shows solid beds in the cuts on the Topeka & Southwestern railway as well as on Salt creek and near the crossing of the Santa Fe and Wyandotte railways on Wolf creek, and there must be many places where it would serve well for building purposes. There are a few small houses built of it near the head of Little Stranger, and there may be more. It is, however, mostly very friable, and the harder beds must be looked for.

Finally, the resources of Leavenworth county may be summed up thus: Abundance of coal, that will last for several generations; practically inexhaustible quantities of brick shales that will pave a hundred cities, brick clays for all classes of buildings, some building stones, both limestones and sandstones, mineral waters in various parts, and soils of unsurpassed fertility, all of which only await his bidding to be of service in "the amelioration of man's estate."

WYANDOTTE COUNTY.

This county is sub-triangular in form, and two of its sides are bounded by the Missouri and Kaw rivers. Though narrow from north to south, the rise from each river to the central upland is rapid, and the elevation reached is in places over 1,000 feet above sea level. A considerable portion of the northwest forms part of the sandstone horizon previously described.

The geology is not very different from that of Leavenworth county. The bedrock belongs to the coal measures. Thirty years ago Professor Mudge said that the dimension rock, which figures so conspicuously about Leavenworth, was found on the river at Quindaro. It is now impossible actually to trace the continuity of stratum from one place to the other, or to say that it is not continuous, owing to the covering of the lower beds of the river outcrop by the debris of the railway embankment and by landslides. It would take a very close and long-continued observation to determine the continuity or otherwise of the limestone strata through the river front of these counties. It ought to be done, but the present writer has not had the time at his disposal to accomplish it. I will repeat here the section at Leavenworth with which to compare the following rock sections in Wyandotte county:

A.

10. Rough limestone (Pilot Knob)....................10 ft.
9. Black and lighter shale....................6 ft.
8. Dimension rock (upper)....................2 ft.
7. Shales and sandstones with some limestone ledges.....250 ft.
6. Rough limestone ledges with intercalated shales.....6 to 8 ft.
5. Yellowish green shale....................3 ft.
4. Rough limestone....................14 ft.
3. Black shale....................5 ft.
2. The dimension rock....................2 ft.
1. Shales to the river.

The lower part of No. 7 contains the brick shale of the soldiers' home.

On the Missouri front, east of Quindaro, we get this section:

B.

g. Rough limestone with shale partings....................20 ft.
f. Shale (brick)....................12 ft.
e. Limestone, with fossils and intercalations of shale........5 ft.
d. Shale....................5 ft.
c. Limestone, with layers of chert....................10 ft.
b. Laminated shale (limy)....................2 ft.
a. Dimension rock (?)....................3 ft.

In one place the lower layers of (e) are consolidated into one and simulate the dimension rock. Which of these, (a) or (e), did Professor Mudge identify with the Leavenworth rock? Probably the lower, as the series (a), (b), (c), has more resemblance to the Leavenworth series than any other part of the section. The thicknesses of the upper part of this section suggest similarity to the section at Fort Leavenworth. The dimension rock (a) at the ravine half a mile east of Quindaro, where it is best seen, is at the railway level. There is a northerly dip here which carries it out of sight at the old Quindaro ravine. At Connors, a slope yielded little distinct outcrop; but at 75 feet above the railway a quarry is worked in 15 feet of limestone, and 70 feet higher, limestone is again seen 8 or 10 feet thick on top of the ridge. A little west of Pomeroy the following section was obtained:

C.

i. Limestone in several rough layers	10 ft.
h. Slope (shale ?)	20 ft.
g. Limestone	6 or 8 ft.
f. Shale	17 ft.
e. Limestone	10 ft.
d. Shale	16 ft.
c. Limestone	5 ft.
b. Black laminated shale	2 ft.
a. Layer of limestone	1½ ft.

Further west more precipitous bluffs show that the limestones are thicker, upper and lower soft layers having in the section been weathered and hidden in the stopes. (g) Shows fully 15 feet. (a) Is 10 feet above the railway track; but nothing shows below. Nearly all stopes are topped with the yellow clay —the loess. It is almost impossible to trace any bed of rock inland, owing to the great erosion and the covering of loess. At the quarry, where the shale is obtained for the Adamant brick works, and the ravine below, this section was obtained with some approximation to certainty:

D.

Loess.	
Limestone	1½ ft.
Shale, brownish	2 ft.
Blue shale (brick)	15 ft.
Limestone, three or four layers	2½ ft.
Greenish blue shale	4 ft.
Limestone ledge, top just seen.	

In the Kaw valley, the following section is obtained at Armstrong:

E.

h. Rough limestone, about	20 ft.
g. Shale (brick)	10 ft.
f. Limy ledge	1 ft.
e. Shale or shaly rock	3 or 4 ft.
d. Layers of limestone, flinty, 2 or 3 ft., thickening westward to 9 to 11 ft.	
c. Shale, carbonaceous, and clay	2½ ft.
b. Massive limestone	6 ft.
a. Limestone	1 ft.

This is not unlike the Quindaro section, and may be taken as the prevalent arrangement of the bed rocks up to the elevation it reaches all over the city area and some distance west. Something else comes on at higher levels. (d), In the above section, is at the railway level at Martin's dairy; but (e) is above that level a little further west.

A section further west, where the river and railway come close under the bluffs, and the highroad is on a shelf above, is as follows:

F.

Flaggy, ferruginous limestone above, becoming thick and white below, with a thick shale parting near top	18 ft.
Shale	4 ft.
Limestone ledge	1 ft.
Carbonaceous shale	3 ft.
Limestone—the top foot flaggy	13 ft.
Stratum, with some limestone	8 ft.
Stratum and 2 feet of limestone, to railroad track	10 ft.

A little further west there is this outcrop:

G.

Limestone rock, lower half rough	25 ft.
Shale	12 ft.
Ledge	1 ft.
Shale	2½ ft.
Limestone ledge	1½ ft.
Shale	4 ft.
Limestone in layer, with flints, (d) of the Armstrong section	8 ft.
Shale	2 ft.
Limestone, thick bed at railroad level, thin layers below	11 ft.

River is about 10 feet below.

Across the river at Argentine, street excavators in progress at the water-works hill, exposed the section following:

H.

Fusulina limestone	8 ft.
Sandstone and sandy shale	20 ft.
Fusulina limestone	6 ft.
Shale	4 ft.
Limestone, upper half oolite	12 ft.
Soapstone (shale)	7 ft.
Rough limestone	11 ft.
Rough layers, with thick shale partings	5 ft.
Rough limestone	16 ft.
Laminated sand shale, in parts almost sandstone	25 ft.
Limestone	10 ft.
Shale	12 ft.
Limestone	10 ft.
Shale	4 ft.
Limestone	10 to 15 ft.

At Turner, two miles west of Argentine, occurs this section:

I.

Limestone, several layers	2 ft.
Limestone, massive oolite	8 ft.
Limestone like the Quindaro "dimension"	2 ft.
Rocky ledge, about	2 ft.
Shale, greenish, with a ferruginous limestone streak in middle, about	8 ft.
Rock, with black chert	4 ft.
Layer limestone, shaly and laminated above	5 ft.

At the quarries one mile west of Edwardsville the section is thus:

J.

Loess, slope, with gravel below	30 ft.
Limestone, five or six layers	10 ft.
Limestone, massive, oolite	6 ft.
Limestone, thin layers, 3 to 5 inches each, and shale partings,	5 ft.
Limestone, two and three layers	7 ft.

Limestone, shale	6 ft.
Limestone, cuboidal blocks to bottom of quarry	15 ft.
Limestone ledge at tank, perhaps	3 ft.
Slope, mostly shale, but probably a hard ledge	30 ft.
Ledge, two or three layers	3 ft.
Shale	6 ft.
Main spillway rock (limestone) at Forest lake	16 ft.
Shale, with a hard ledge	6 ft.
Bottom of spillway rock	4 ft.

It will be seen by a comparison of these various sections that it is not easy to make a generalized statement of the succession of limestones and shales that would be correct for any large part of the county. There has not been a sufficiently extensive examination of the fossils of the strata at any one place to make them a reliable means of identification in other districts. The changing of shale to limestone, and vice versa, is so common that the thickness of a given layer is scarcely any guide to its identification elsewhere. At the old cement quarries at Armstrong a layer of shale which on the southeast side is five feet thick, on the northwest it is diminished to three feet, and is more argillaceous and less calcareous there. The chert beds are more or less persistent, but, notwithstanding their remarkable eastward dip at Armstrong, it ceases to be a guide, by disappearing westerly in the Kaw valley. On the other hand the oolite mentioned in the last three sections is a guide by some of its fossils as well as by its oolitic structure. Myalina Swallovii, Athyris bovidens, and fine specimens of Productus cora are nearly always there. The shells are white lime, and this is characteristic of all the invertebrate fossils in the oolitic limestone, including occasional trilobites (Phillipsia). This oolite is found, besides the places already mentioned, in a cut of the Santa Fe railway in Leavenworth county a few miles northwest from Bonner Springs, and lies below the cement bed at Armstrong.

The section at Argentine shows sandstone below a limestone, and still lower sandstone shales. On the divide, in the middle of the county, between Edwardsville and Pomeroy, sandstone is found at the same level as limestone, as shown in exposures at and south and north of schoolhouse in district No. 36. The contact of sandstone and limestone is not actually seen, but the same horizon is plainly inferable. Nearly the same is seen in a road-cut east of White Church.

The bottom then of the sandstone plateau is certainly irregular. So far the writer has seen no evidence that there is erosive unconformity of the strata. It would appear that by gentle oscillations of level, some deep water formations began to give place to shore-line deposits in the old carboniferous seas. The reverse of this brought on the conditions favorable for the deposit of the heavy limestones at the top of the sandstones in west Leavenworth county and Atchison.

Back in the seventies a boring was made at Wyandotte to a depth of 600 feet, and it was said a three-foot seam of coal was passed through. At what depth there is no record to tell. It is also said that the gas well at Armstrong brick works passed through three feet of coal at a depth of 175 feet. A boring was made in 1887 on the bottom south of the Kaw, at Kansas City, to a depth of nearly 2,000 feet. More recently a shaft was sunk at Rosedale to a depth of 700 feet. The records of these prospectings were, at the time, kept secret, and are now probably lost, so that it is not possible to compare the deeper strata with those in Leavenworth county. Still, as there is no very great dip of the surface rocks, and in Leavenworth comparatively little in the deep seated strata, we may assume that the coal measure formations extend as far down under Wyandotte as in the neighboring county.

THE LOESS.

As in Leavenworth, the surface, except of the river bottoms, is largely composed of the "bluff" or "loess" which forms the yellow subsoil of all the high land of the county, and also is found in a few places beneath the alluvium of the valleys.

DRIFT.

On the bed-rock, under the loess, nearly all over the county, there are glacial boulders and gravel, but in no place is the deposit very heavy. It may be seen up the ravines in the city, up the dairy ravine near Armstrong, on the creek bed at Muncie, in the ravines at Quindaro, Pomeroy, and Connors, as well as in the shallower depressions that hold the headwaters of Wolf creek from Piper to the county line. In only a few places is seen the pasty clay, or hardpan, which the glacier ground out of the terraces it passed over. The marks of the glacier called striae are also scarce. The writer is not sure of any. A few have some resemblance to them; but, though some of the surface limestones are hard, yet water, carbonic acid and iron in the loess mud have been operating so long that the surface under loess is usually softened, and all markings obliterated; and where the loess is gone, the weathering has altered the impressions both in form and direction so that certainty is scarcely possible. Striae may perhaps always be scarce, but some polished surface may sometimes be revealed which will indicate the work of the glacier.

ECONOMIC GEOLOGY.

COAL.

The surface vein of coal which belongs to the sandstone plateau in Leavenworth county does not seem to have been found in Wyandotte county. It is, however, quite possible that a similar vein in nearly the same horizon might be found in any part of the high land of the west and northwest of the county. It would seem that such a vein has actually been proved in the higher part of Kansas City. The erosion has been so great, both before and after the deposit of the loess, that such coal will hardly be found over any large area. Still, as a cubic foot of coal is just about a bushel, a few acres of it 18 inches thick could be valuable, if the cost of getting it is not too great.

It is more to the purpose, perhaps, to discuss the possibility of obtaining deep coal, as at Leavenworth. From what has been said, it is seen that there is no actual evidence on the subject, as the records of borings have either been suppressed or lost.

In Leavenworth county and in southern Kansas the workable coal beds are associated with shales and rocks of sandstone horizons. The Leavenworth record shows no coal or sandstone at the horizon given for the coal at Armstrong (75 feet); still, it might be at the latter place, as the distance from the Leavenworth field is enough to allow for such changes. Again, it is known of many veins of coal that they extend more in their meridional direction than east and west; that is, they are elongated from north of east to south of west. The Leavenworth deep vein is proved to extend entirely across the river bed into Missouri. If, then, a north by east to south by west line be drawn from the known easterly extension of the Leavenworth vein southerly, it would pass through the northwest corner of Wyandotte county, and it is possible that a mine in that region would, at about 900 feet deep, be a paying investment. Again, the Leavenworth record shows thin veins before the main seam is reached, and some veins below. Any one of these might develop thickness in any direction, and there would be a fair chance, even at Kansas City, Kan., for a paying vein to be found at from 600 to 1,100 feet deep. It would certainly pay for a boring to be made to the bottom of the coal measures to determine honestly what there is to be found.

GAS AND OIL.

Both rock gas and oil have been found in the county and north in the precincts of Kansas City, Kan. Several wells—on Jersey creek, the brick yard at Armstrong, and Northrup's mill, etc.—found bodies of gas that were for a long time useful. It does not appear that any great effort was made to develop these wells or preserve them. The gas was found at from 340 to 380 feet deep. It is quite likely there is more of it. Nearer the bottom of the coal measures, as at Neodesha, might prove a better horizon. The well that used to flow on Jersey creek might probably be developed into a paying producer of lubricating oil.

LIMESTONE AND SANDSTONE.

The heavy beds of limestone shown in the sections of the river fronts of this county give abundance for all the purposes for which limestone is used—building, lime-burning, road making, and the manufacture of cement. The more argillaceous shales and limestones may be more plentiful in counties to the west, and they can easily be imported to mix with the limestone here when the business of the Missouri valley becomes once more a growth. There is no place better situated for distributing a large cement product than Kansas City.

The higher parts of the county have some sandstones, but they have not yet been sufficiently exploited to test their value as building stones. Here, and in neighboring parts of Leavenworth county, they are sufficiently well developed to be worth more examination as to their availability for bridges and other purposes.

CLAY.

There are clays and clays. The usual suggestion when the word clay is used is that of a surface deposit easily accessible. In Wyandotte and the other counties of this district there is abundance of this surface deposit, good for making either pressed or common bricks. It may be said that the supply of such clay is inexhaustible by a much larger demand for several generations than has yet been made upon it in this or other counties. The yellow deposit we have described as the loess has everywhere in it beds of workable clay.

There are, however, older beds, sometimes lying deep among the stratified rocks of the coal measures that are more or less argillaceous. They are clay shales. It is these stratified beds of greater age that have been used for making

VITRIFIED BRICKS

for paving. These clay shales of the coal measures contain some iron—sometimes as concretions, elsewhere as streaks or stains; and this iron, in connection with the silica, when properly treated in the making and burning of the brick, gives the glassy luster and hardness that makes the value of this paving material. There is abundance of these shales in Wyandotte county. They are shown in sections B, C, D, and E (ante). In places they are somewhat difficult to reach; but, in the eastern part of the county, almost any long slope having a hundred feet of vertical height would show them under the loess or in the rock outcrops. There are differences of quality, easily determinable by trial. It would appear, from the proved character of vitrified bricks, that they will be a standard pavement of the future. Wyandotte will have its share of this important industry.

Pottery clays are not so common; but they may be found, and that suitable for drainage tiles and sewer pipes is abundant.

In this midcontinental region, far removed from the roofing slates of the mountains, why should not a light roofing tile be manufactured and used? The clays of the river counties are sufficient to roof all the cities of the Mississippi valley.

The metallic base of clay is the metal

ALUMINUM,

which has of late years become familiar in medals, pencil holders, etc. In clay it is mostly in the form of alumina, which is the metal combined with oxygen. Abundant in all clays, the separation of the metal is, as yet, an expensive process. A particular kind of clay, found mostly in two small districts in England, and called fullers' earth, has long been used for cleansing by woolen manufacturers. It has also been used in refining lard, and much of it has been imported for that purpose by the packinghouses of Kansas City. For some time past a bed of surface clay at Turner has been subjected to a peculiar process by Mr. Schwann, in which the percentage of alumina is increased and other matters eliminated. The resultant product has the same effect in the refining of lard that fuller's earth had, and it is now supplanting that material in the packinghouses of this county.

This artificial fuller's earth, containing a large percentage of alumina, may be called, in miners' language, a concentrated ore of aluminum; and it has occurred to Mr. Schwann that it may so be regarded, and that processes akin to the common methods known to the assayer and refiner of the precious metals would reduce the ore and produce aluminum at less outlay than that of the present costly electrical process of extracting the metal from the bauxite. His experiments have been perfectly successful, and there is now lying before the writer a small button of the metal thus made at the Turner smelter from Wyandotte county clay. The only step now to take is the making available, on a large scale, of the proper appliances for extracting the metal from the ore, and Wyandotte county will add another metal industry to the already large one of the silver smelter at Argentine, which has already refined over 9,000,000 ounces of silver.

GRAVEL.

There is, in the Neosho and in other valleys of southeastern Kansas a gravel, not made of rounded pebbles, but of stony fragments, more or less angular, but covered with a brown coat having a vitreous luster. The fragments are made mostly of limestone, but some are chert or flint. But all have the same ferruginous vitrified coating. They make better road material than any crushed stone in Kansas. This gravel is found in some of the watercourses of Wyandotte county, and in places it is found cropping as a thin stratum under the loess, and on some slopes. It has been quarried to some extent near Edwardsville, and search would probably reveal it about Bonner Springs and northward.

The gravels of the drift, composed of quartzite and granite pebbles, are found under the loess in all parts of the county, but probably the deposits are nowhere very thick. The larger boulders of quartzite—the well-known pink and reddish masses—are, however, sufficiently numerous to be worth collecting, and their hardness would make them useful for macadam roads.

MINERAL WATERS.

All springs are more or less impregnated with the minerals over or through which they run. Brown and reddish sands and sandstones and clays have often iron in them; and that will impregnate the water. Water percolating through limestone takes up some lime, and the vegetable matter in some shales supplies iron and sulphur from the decomposition of iron pyrites. The cap of loess also has iron and lime and alum capable of being absorbed by percolating waters; and therefore mineral springs are to be expected in the county. The beautiful rolling surface, the abundance of timber, the softness of the air, and the presence of mineral waters, makes it possible for the county to have more than one delightful health resort.

SOIL.

The loess is the principal subsoil of the county. Its surface, modified by the vegetation it has supported, is therefore the principal soil. It is mostly a marl, and is lighter than clay soils of some regions and in places it inclines to be sandy. The influence of the limestones and shales in forming direct sedentary soils is very limited; but, in the smaller valleys the detritus from the various outcrops has made itself felt in the gumbo and other clay soils of some bottom lands. The bottom lands of the Kaw valley and of the Missouri are largely composed of sandy alluvium. All the soils are fertile and mostly deep.

RAINFALL AND IRRIGATION.

The rainfall of Wyandotte county is abundant for the growth of crops. It exceeds 30 inches per annum. But dry seasons occur here; and the recurrence of drought from time to time in Ohio, New York, and even the western countries of Europe is causing attention to be given everywhere to the suggestion that irrigation may be adopted with benefit in the countries of abundant rainfall, for use at the critical period of crop-growing when "precipitation is procrastinated."

Wyandotte county (and with it all the river counties) is favorably situated for so using water as to ensure crops. The two rivers can be available for the bottom lands by pumping with gasoline or other engines. The topography and geological structure are favorable to the construction of reservoirs, both large and small, for the storage of the run-off waters in all parts of the county. A good example of this is seen in the 39 acres of water at Forest Lake, an artificial sheet shut in by a strong dam a few miles east of Bonner Springs. A pumping plant has been used this year (1894) on the south of the Kaw river near Kansas City.

ATCHISON COUNTY.

TOPOGRAPHY.

The topography of Atchison county is much the same as the other river counties. It has the same steep bluffs to the river; the same narrow openings in the bluffs for the exit of small streams; the same amphitheater forms behind the bluffs; the same rolling upland in the interior of the county. The Stranger does not give so marked a valley; but in one way it is peculiar, its whole depth is in the loess; scarce an outcrop on its sides or stony riffle in its bed to tell of the presence of bedrock. On the other hand, the western part of the county is trenched, by the Delaware and its tributaries, deep into the limestones. In some respects, this valley is much like that of the Big Stranger in Leavenworth county. The loess is over most of the county, and gives the rounded forms and smooth slopes to the topography of the central plateau; and there is scarcely any outcrop of the bedrock from near the Missouri bluffs to the valley of the Delaware.

GEOLOGY.

The bedrock of this county is of the coal measures. The connection of particular strata with those of the neighboring counties has not been worked out; but it would seem that some of the coal measures limestones might be traced through from Leavenworth county. At the mouth of Whiskey creek, a mile south of the city of Atchison, this section overlooks the valley:

Clay, slope.	
a. Dimension limestone	18 in. to 2 ft.
b. A whitish brick shale	4 to 6 ft.
c. A quarried limestone, somewhat irregular	16 to 20 ft.
d. Black shale	4 ft.
e. Dimension rock	2 ft.
f. Another quarried rock below	2 ft.

There is here a resemblance to the Leavenworth city section; but if the two dimension rocks are the same, it would indicate the absence of the whole series of sandstones and sandy shales of the Wyandotte-Leavenworth plateau. It is more likely that (a) represents one of the limestone ledges below the plateau that are not there of the "dimension" character; and that the sandy shales are hidden above under the loess. A mile further south this outcrop occurs also near the Missouri river:

Slope.	
Quarried limestone	10 ft.
Shale	10 to 20 ft.
Rock (limestone)	10 ft.
Clay shale	15 ft.
Coal	1 ft. 6 in.
Black shale	6 in.
Clay (shale)	10 ft.

The shale that has been used for several years southwest of the city, in the manufacture of vitrified bricks, is under a bed of limestone, and is probably one of the layers shown in one of the river sections; but concretions of limonite found in the original brick-bed are not so conspicuous elsewhere. Away from the river the sandstone shows and is given in the following record of a deep boring, made several years ago by the city:

Record of strata passed through in Atchison deep boring:

	Thickness of strata.	Total depth.
Sandrock	24	24
Limestone	10	34
Red shale	10	44
Soapstone	5	49
Limestone	2	51
Soapstone	20	71
Sandrock	5	76
Soapstone	64	140
Limestone	2	142
Soapstone	90	232
Limestone	2	234
Black shale	1	235
Soapstone	7	242

Limestone	4	246
Black shale	5	251
Soapstone	12	263
Limestone	7	270
Soapstone	12	282
Limestone	8	290
Soapstone	10	300
Sandrock	3	303
Limestone	30	333
Soapstone	15	348
Limestone	8	356
Sand shale	4	360
Limestone	3	363
White shale	12	375
Soapstone	4	379
Limestone	38	417
Dark shale	5	422
Green shale	8	430
Limestone	8	438
Soapstone	6	444
Green shale	10	454
Limestone	3	457
Dark shale	20	477
Limestone	2	479
Gray shale	6	485
Limestone	27	512
Gray shale	9	521
Limestone	21	542
Dark shale	2	544
Limestone	21	565
Flinty limestone	3	568
Soft sandrock	30	598
Soapstone	45	643
Soapstone	22	665
Yellow clay	8	673
Red and purple shale	5	678
Limestone	5	683
Red and purple shale	20	703
Conglomerate	17	720
Limestone	4	724
Conglomerate	71	795
Limestone	4	799
Soapstone	11	810
Limestone	3	813
Soapstone	20	833
Limestone	4	837
Conglomerate	* 20	867
Limestone	2	869
Soapstone	36	905
Limestone	5	910
Soapstone	12	922
Limestone	5	927
Soapstone	53	980
Limestone	4	984
Soapstone	18	1,002
Sandrock	23	1,025
Soapstone	24	1,049
Sand shale	64	1,113
Sand rock	4	1,117
Sand shale	87	1,204

There is an inaccuracy in this record at the item marked (*). It is not possible from any information I have, to correct it. It may be that addition of errors in measurements of strata sum up ten feet. There is a term used several times in the record that is of doubtful intepretation, as drillers do not use it in its strict technical sense. It is the word conglomerate. It is more than probable that it is here used for a dark shale containing hard nodular masses which contain lime crystals and iron as limonite or pyrite. The term soapstone is the drillers' usual designation of lavender-colored soft shale.

It does not appear that any coal was found in the boring; but the sand horizons of the lowest 200 feet suggest that they are near the bottom of the coal measures, where the chance for coal is greatest. It is a matter of regret that the drill did not continue its work until the examination of an expert decided that the coal measures had been entirely passed through.

CRETACEOUS.

I have already referred to the fact that the loess covers the greater part of the county. It in places has some sand and gravel, and boulders are occasionally seen at the bottom of it; but there seems to be no other formation in this or the neighboring counties between the age of the coal measures and these pleistocene deposits. There is, however, one fact in Atchison county that seems to point to the existence, at no great distance from this region (perhaps in this county itself), of cretaceous rocks once overlying the coal measures.

Arrington Springs, in the western part of the county, comes out of the debris that partially fills a preglacial valley. It is a chalybeate spring, and its iron is undoubtedly derived from the fine gravel, or coarse sand, through which it flows to the surface. The deposition of the coarse sand is probably of the glacial period, though it may be older. An examination of this sand suggests at once to any one familiar with the cretaceous formations, that it is the debris of the ferruginous Dakota sandstones. That it would keep that Dakota facies improbable if it had been transported far from place of degredation. I have seen such Dakota debris sand in the lower valley of the Smoky, where the propinquity of the original sandstone is not a matter of conjecture. Less than 20 miles further west than Arrington, I have found sharks' teeth and fragments of Ammonites in the glacial gravels, which could not have been transported far from their original Mesozoic beds, but such debris as these Arrington sands and such well preserved fossils are now all the evidence to suggest that a great thickness of strata once covered the carboniferous beds that have now only a covering of pleistocene or more recent deposits.

PLEISTOCENE.

It has already been stated that there is a covering of loess over most of this county. Its texture and general appearance are not unlike those in the other river counties. But there seems a difference in all these from that on the east side of the river, which is worthy of more attention than I have been able to give to it. In the Stranger valley the loess hides all bedrock. Wells over 50 feet deep do not reach the bottom of it. It is mostly a clay; but to the west, near the Jefferson county line, there is sand and gravel.

The occurrence of boulders has not been sufficiently observed to warrant any description of the morainic deposits which are mostly buried under the loess.

ALLUVIUM.

The present valleys, as well as the upland depressions, have some recent alluvial formations of sand, gravel, and joint clays and humus, the product of the present agencies of running water, wind, rain, and frost on the older formations. But what are properly called bottom lands are of very limited extent in this county. There are here and there some soils that are black like humus soils, but probably owe their color and character to black shales of the coal measures, out of which they were formed in or soon after the ice age, and are not, therefore, true modern alluvia as they seem to be.

ECONOMIC GEOLOGY.

COAL.

While the borings made in the county have not revealed the presence of deep-seated veins of coal, yet the one seam near the surface, indicated in one of the sections given on a previous page, has turned out to be of great economic value as a local fuel near Atchison. It is also quite probable that it may be discovered, or another near the same horizon, further inland, where by means of shallow shafts, it may be cheaply lifted to the surface. Shallow borings in different parts of the county would early determine this. The thin seam at Arrington will probably not be found thicker if traced any distance.

LIMESTONE.

The bluffs on the river, and outcrops in the west part of the county, furnish abundance of this material both for burning and for building. It has been so far but little exploited.

CLAY.

The loess everywhere yields good material for common or pressed bricks; and, as population increases, the building of brick houses and the making of the bricks will constitute an important permanent industry.

SHALE.

It was Atchison that first made vitrified bricks in Kansas. These are made of coal-measure shales, of which there is abundance down the river front of the county. The selection of the best qualities and the proper manipulation of these shales constitute an art in which some citizens of Atchison are now experts. The miles of streets paved in their own city and the millions of bricks exported for the streets of other cities, are in evidence as to the value of this pavement, which is destined in the future to hold an important place in the comfort and sanitation of urban communities. The enterprise that began the industry will always keep a large share of it in Atchison county.

Terra-cotta ware and other molded forms of blocks are among the future products of these clay shales in the river counties. Why not tiles for roofing?

MINERAL WATERS.

Small seepings of water, more or less mineralized, come from the gravels and sands in various places under and in the loess. It is quite possible that some time others of more volume may be obtained. In the meantime Arrington springs furnishes a valuable iron water, and the surroundings are such as to make it, in times of denser population, a pleasant health resort. Its elevation of over 1,000 feet above sea level is another fact of value.

SOIL.

The soil is the last made geological product. Most of the soil of this county is formed of the loess by the action of the vegetation itself. The loess is the subsoil. Some of it is heavy from the prevalence of clay, but elsewhere a greater proportion of sand makes the soil more tractable. In either case it is fertile. Where shales are near the surface, gumbo soils of more or less tenacity have been found, but the areas of such soils are limited. The lighter soils of bottom lands also occupy but a small part of the county. The soil is probably the most valuable mineral product of the county. With the proper treatment it will grow all the products of the region.

N. B.—Since the foregoing was written, the writer has had the privilege of reading two papers which, with illustrations, were submitted to the Kansas Academy of Science and is allowed to make excerpts therefrom. They give definiteness to one or two points mentioned in the foregoing pages.

Prof. E. B. Knerr, in describing the Atchison coal field, says: "The vein of coal lies between two veins of brick shale or soapstone, as it is sometimes called, the material from which the excellent Atchison vitrified brick is made, and it is the purpose of the Donald firm (the coal company) to operate a brick plant in connection with the coal industry. The vein of shale over the coal is 25 feet thick." The coal measures 16 inches thick and its value, as indicated by chemical analysis, is "on an equality with the best from any other part of the state." The analysis is as follows:

Ash	7.30
Water	3.46
Gas	36.84
Coke	52.38
	99.98

The coal is worked from the outcrop which is two miles south of the city, and has been continuously worked since August, 1893. The area that has been excavated is 700 by 400 feet, which gives a total output of over 373,000 bushels, or about 15,000 tons. This is no mean addition to the resources of the county. Prof. J. M. Price of Atchison has worked out the succession of the formations in the neighborhood of the city completely, and so gives the coal horizon its proper place. The geological succession is thus indicated by Professor Price:

Boulder drift from 0 to	50 ft.
Fusulina limestone, about	3 ft.
Shale	10 ft.
Limestone	4 ft.
Shale	4 ft.
Sandstone	6 to 8 ft.
Brick shale	20 ft.
Limestone	4 ft.
Shale	20 ft.
Limestone	8 in.
Shale	4 ft.
Cap limestone	20 ft.
Slate (shale)	3 ft.
Limestone, heavy jointed	1 ft. 9 in.
Shale	12 ft.
Limestone	10 ft.
Shale	25 ft.
COAL	1 ft. 4 in.
Shale, to river level	30 ft.
Total	231 ft.

DONIPHAN COUNTY.

TOPOGRAPHY.

The third county in the state for "smallness," Doniphan, has a remarkably extensive river front. It has the same rolling loess topography as the other river counties, and the same limestone and loess bluffs to the river.

GEOLOGY.

The geology is similar to that of Atchison and Leavenworth counties. The bedrock, limestone, or shale, is of the coal measure period, and the cap of lœss and the lower gravels and boulders are of the ice age. It was intended to have given all the river counties as full treatment as that given to Leavenworth county, but lack of means made this impossible, and Doniphan county is only mentioned to show that a good intention has not been carried out, and to suggest that, if a state survey were set on foot, this fruitful corner of Kansas would have the attention that its position as a river county demands.

In view of the fact that the elevations above sea level of Kansas City, Leavenworth, and Atchison, are usually given as those of the railways that skirt the river, the following table showing elevations inland for comparison, will be of interest:

ELEVATIONS ABOVE SEA LEVEL.

Riverside elevations:	
White Cloud	848 ft.
Atchison	795 ft.
Leavenworth	766 ft.
Kansas City, Kan	750 ft.
Kansas City, Mo	750 ft.
Argentine	750 ft.
Armstrong	757 ft.
Bonner Springs	786 ft.
Linwood	791 ft.
Inland elevations:	
Severance	904 ft.
Troy	1,097 ft.
Effingham	1,137 ft.
Pleasant Ridge	1,082 ft.
Leavenworth waterworks	1,120 ft.
Piper	976 ft.
Bethel	1,017 ft.

A BIBLIOGRAPHY OF KANSAS GEOLOGY,

WITH SOME ANNOTATIONS.

BY ROBERT HAY.

INTRODUCTORY NOTE.

When the idea of compiling this bibliography was becoming an intention, I remember that Capt. Vogdes, of the Fifth U. S. Artillery, had told me that he was collecting books on Kansas geology, and I therefore wrote asking him to assist by giving me a list of the books he had, or knew about, bearing on the subject. He very kindly complied and sent me a list of no less than seventy titles, including nearly all the earlier works, and forming a very good start for my somewhat lengthy talk. In the progress of the work I have had valuable assistance from the librarians of the Academy of Science, State Historical Society, the State Library, and the State University, as well as from my honored friend, Mrs. Mudge of Manhattan. It is possible that some important papers may have escaped me, and I have purposely omitted newspaper articles, although there are some of an interesting character. The order is that of Capt. Vogdes's list. First come U. S. Government publications; then Kansas official papers, and afterward reports of other states and societies, miscellaneous magazines, etc. Text-books and maps are at the end. I have thought it would aid future investigators if they knew where, in Kansas, the books and pamphlets named might be consulted, and have therefore indicated their presence in the Academy library by the letter A; in the Historical Society by H; State Library by the letter S; and in the State University by U. The letter V indicates the list of Capt. Vogdes. It is hoped the compilation will serve as a valuable check-list, and I shall be obliged if friends will communicate to me additional titles for future publication.

I. UNITED STATES GOVERNMENT REPORTS.

History of the Expedition, under the command of Captains Lewis and Clarke, to the sources of the Missouri river, thence across the Rocky Mountains and down the Columbia river, performed during the years 1804-5-6.
Philadelphia, 1824. Vol. I, xxvii and 470 pp. Vol. II, ix and 522 pp., map. (H S V).

Account of an Expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819, 1820, etc., by S. H. Long, 2 volumes. Philadelphia, 1823. (H S V).

An Exploration of the Country lying between the Missouri river and the Rocky Mountains, on the line of the Kansas and Great Platte rivers, by J. C. Fremont. Washington, 1843, 207 pp. and map, 6 plates. (H U V).

Report of the Exploring Expedition to the Rocky Mountains, in 1842, and of Oregon and North Carolina, in the years 1843-44, by Capt. John C. Fremont. Washington, 1845, 693 pp., 24 plates and 3 maps. (H S U V).
Gives figures of Kansas Fossils.

Exploration and Survey of the Valley of the Great Salt Lake of Utah, including a reconnoissance of a new route through the Rocky Mountains, by Capt. Howard Stansbury, U. S. Army. Washington, 1853, 495 pp., 58 plates, and atlas of two maps. (H V).

Exploration of the Red river of Louisiana, in the year 1852, by Capt. R. B. Marcy, U. S. Army. Washington, 1854, xiv and 286 pp., 66 plates and sections, and atlas of two maps. (A H S U V).

Refers to the gypsum north of the Arkansas river in Kansas.

Geological Report of the country explored under the 38th and 41st parallels of north latitude, in 1853-54, by James Schiel. Pacific R. R. Reports, Vol. II. Washington, 1855, Chap. X, 3 plates. (H V).

Kansas Fossils.

Report of the Geological Exploration from Fort Leavenworth to Bryan's Pass, made in connection with the survey of a road from Fort Riley to Bridger's Pass, under command of Lieut. F. T. Bryan. Washington, 1856. Also in 35 Cong., 1st Sess., Sen. Ex. Doc. 2, pp. 489-520. (H V).

Geology, by H. Englemann.

United States Preliminary Field Report of Survey of New Mexico and Colorado, by F. V. Hayden, 1869, p. 14. (H V).

Gives occurrences of cretaceous rocks on line of Kansas Pacific railway at Hays City and Fort Wallace, Kansas.

Geological Report of the Yellowstone and Missouri rivers, by Dr. F. V. Hayden, under direction of Capt. W. F. Raynolds, in 1859-60, printed in 1869. (V).

Chapter XII, entitled "Geological Explorations in Kansas," gives the succession of strata up the Kaw valley from Lawrence to Fort Riley and thence to Salina, being an account of the exploration in 1858. Article on fossil plants collected in the expedition is by Dr. Newberry, who names several Kansas localities. (A).

United States Geological Final Survey of Nebraska, Hayden and Meek, 1868. Printed in 1872. (H S V).

Chapter IX, pp. 66-69, is a sketch of the "Geological Formations along the Union Pacific railway, eastern division, from the Missouri river to Fort Riley, Salina, and Fort Wallace," Kansas.

Preliminary Report of the U. S. Geological Survey of Wyoming and portions of contiguous territories, being a second annual report of progress conducted under the authority of the Secretary of the Interior, by F. V. Hayden. Washington, 1872, 511 pp. (A H S V).

Contains report on fossil reptiles and fish of the cretaceous rocks of Kansas, by E. D. Cope, pp. 385-424. Also Kansas cretaceous invertebrate fossils, by F. B. Meek, pp. 304-7. Also Kansas plants, by Lesquereux, 370, et seq.

Preliminary Report of the U. S. Geological Survey of Montana, and portions of adjacent territories, being a fifth annual report of progress, by F. V. Hayden. Washington, 1872, 538 pp. (A H S U V).

Contains a report on the geology and paleontology of the cretaceous strata of Kansas, by E. D. Cope, pp. 318-349.

Geological Report of B. F. Mudge. Notes on the Tertiary and Cretaceous periods of Kansas. Bulletin U. S. Geol. Survey of the Territories, Vol. II, No. 3, 1876, pp. 211-221. (H S).

U. S. Geological and Geographical Survey of the Territories. 6th Annual Report. Hayden, 1872. (H S).

Contains "Lignitic formation and fossil flora," by Leo Lesquereux. Describes several Dakota leaves from Saline and Ellsworth counties, Kas.

U. S. Geological and Geographical Survey of the Territories. Ninth Annual Report. Hayden, 1875, printed 1877. (A H S).

Contains, p. 277, "Geological Report, by B. F. Mudge. Notes on the Tertiary and Cretaceous Periods of Kansas;" reprinted from Bulletin, Vol. II, No. 3, with much additional matter.

Contributions to the Fossil Flora of the Western Territories, Part I, The Cretaceous Flora, by Leo Lesquereux, U. S. Geol. Surv. Territories, Hayden, Vol. VI. Washington, 1874, 136 pp., 30 pll. (A V).

Contributions to the Fossil Flora of the Western Territories by Leo Lesquereux. Vol. VIII of U. S. G. Survey of the Territories, Hayden, 1883; plates. (A H S V).

Describes many Kansas specimens and identifies the "Cretaceous formation at the base of the Rocky Mountains with that of Kansas."

Invertebrate Cretaceous and Tertiary Fossils, by F. B. Meek, Vol. IX, U. S. G. Survey of the Territories. Hayden, 1876; plates. (A H S).

Refers to cretaceous beds of Central Kansas.

Vol. II, U. S. G. Survey of the Territories. "Cretaceous Vertebrata," E. D. Cope. Hayden, 1875; plates. (A H S).

Describes Kansas specimens. This volume refers to Kansas specimens over sixty times, to B. F. Mudge twenty-eight times, and dedicates three specimens to him and several to Prof. Merrill, of Topeka, and Surgeons King and Shearer of Fort Wallace. Describes, on pp. 43 et al., cretaceous beds of western Kansas and says that thirty-seven species of reptiles found in Kansas varied from ten to eighty feet in length and represented ten orders.

Vertebrata of the Tertiary Formations of the West, E. D. Cope. Vol. III, U. S. G. Survey of the Territories. Hayden, plates. (A H S V).

Locates Loup Fork and Pro-camelus beds in N. W. Kansas.

Course of Sciences applied to Military Art, Part I, Geology, by A. W. Vogdes, Fort Monroe, Va., 1884, 176 pp., 22 plates and maps. (V).

The name of Kansas series to the Lower Permian of Prof. Swallow's Section, as defined in his Preliminary Report on the Geology of Kansas. These rocks consist of limestones, shales, conglomerates, sandstones, and gypsums, outcropping along the banks of Cottonwood, Cary, and Fancy creeks, and includes the limestones, blue shales and marls of Fort Riley and Manhattan, Kansas.

Tenth U. S. Census, Vol. X, pp. 274-277. "Kansas Building Stones." G. C. Broadhead, with geological section. (H).

Eleventh U. S. Census, Bulletin No. 43, March, 1891. "Coal product west of the Mississippi." Gives area of Kansas coal measures much too small. See also Bulletin No. 75, on Gypsum. (H).

United States Geological Survey, J. W. Powell, Director:

Third Annual Report, 1881-82. (A H). Contains:

Birds with Teeth, by O. C. Marsh.

Says (p. 50) that the first bird remains were found in 1870, near the Smoky Hill river in western Kansas, and remains of 100 individuals have since been obtained there.

Sixth Annual Report, 1884-85. (A H). Contains:

Topographic work in Kansas, pp. 10, 11.

Geological work in Kansas, pp. 32, 39, 72.

Geologic features of Kansas, p. 314.

Seventh Annual Report, 1885-86. (A H). Contains:

Geography of Kansas, p. 45.

Atlas sheets of Kansas, p. 59.

Work in Kansas, pp. 110, 111.

Eighth Annual Report, 1886-7, Part I. (A H). Contains:
Area surveyed and atlas sheets of Kans., pp. 70, 71, 169, 170, et al.
Kansas gas field, p. 89.
Part II contains Fossil Plants in Kansas, by Lester Ward, pp. 667, 899, 900, et al.
Ninth Annual Report, 1887-8. (A H). Contains:
Surveys in Kansas, pp. 3, 49, 56.
Geologic work in Kansas, p. 104.
Tenth Annual Report, 1888-9. (A H). Contains:
Topographic Survey in Kansas, pp. 6, 8, 84, 89, 95, 103.
Geological work at Fort Riley, pp. 31, 154.
Eleventh Annual Report, 1889-90, Part I. (A H). Contains:
Topographic work in Kansas, pp. 5, 7, 34, 39, 46.
Kansas rock gas and oil, p. 598.
Twelfth Annual Report, 1890-91, Part I. (A). Contains:
Atlas sheets of Kansas, p. 7.
Topographic work in Kansas, pp. 4, 6, 7, 24, 29, 30, 47.

United States Geological Survey, J. W. Powell, Director:

Bulletin No. 7, 1884. A catalogue of geological maps relating to N. and S. America, by Jules Marcou. (A H).

Gives maps of Kansas of Hayden and Mudge, Nos. 56, 623, 772.

Bulletin No. 32. Mineral Springs of the United States, by Albert C. Peale. (A H).

Gives analyses of several mineral waters of Kansas.

Bulletin No. 57, Washington, 1890, 49 pp., 2 pll. A Geological Reconnoissance of Southwest Kansas, by Robert Hay. (A H).

Bulletin No. 76. Washington, 1891. A Dictionary of Altitudes, by Henry Gannett, 2d edition [1st ed. was Bulletin No. 5.] (A H).

Gives most of Kansas railway altitudes.

Bulletin No. 80, 1891. Correlation papers, Devonian and Carboniferous. (A H).

Chapter IX discusses "Permian problem in Kansas and Nebraska" and locates productive coal measures in Kansas.

Bulletin No. 82, 1891. Correlation Papers, Cretaceous, by C. A. White. (A H).

Gives Hill's Texas Trinity sands in southern Kansas, and refers to work on the cretaceous formations of the state by Hay, Hayden, Lesquereux, Meek, and Mudge.

Bulletin No. 84, 1892. Correlation Papers, Neocene, by Dall and Harris. (A H).

Cites Hay on western Kansas Tertiaries, pp. 299-301.

United States Geological Survey, J. W. Powell, Director:

Monographs, Vol. XVII. The Flora of the Dakota group. A posthumous work by Leo Lesquereux, edited by F. H. Knowlton, 256 pp., 66 pll., 1892. (A H S).

States that the Dakota group has 460 species of fossil plants and gives over 300 found in Kansas. New species are described of which many are named in honor of J. E. West, and some for Profs. Mudge and Snow, and for R. Hay, S. Mason, A. Wellington, and C. Sternberg.

United States Geological Survey, J. W. Powell, Director:

Mineral Resources of the United States, 1882-3, by Albert Williams, Jr. (A H).

Mentions Kansas lead, p. 312. Zinc, p. 368. Coal and other minerals, p. 682.

Mineral Resources for 1883-4, by Albert Williams, Jr. (A H S).

Mineral Resources for 1885, by David T. Day. (A H).

Mineral Resources for 1886, by David T. Day. (A H).

Mineral Resources for 1887, by David T. Day. (A H).

Mineral Resources for 1888, by David T. Day. (A H S).

Mineral Resources for 1889, by David T. Day. (A S).

Mineral Resources for 1890, by David T. Day. (A S).

Mineral Resources for 1891, by David T. Day. (A H).

Mineral Resources for 1892, by David T. Day. (A).

All these have some notice of Kansas minerals and the volume for 1892 has Kansas minerals under these heads: Cement, Clay, Coal, Coke, Gypsum, Lead, Limestone, Mineral Waters, Salt, Sandstone, and Zinc.

Coal, by Chas. A. Ashburner. Washington, 1888, is a separate of the Report on Mineral Resources for 1887.

Gives coal in Kansas, pp. 253-256.

Smithsonian Institution reports and papers:

Proceedings of U. S. National Museum for 1879, Vol. II. (S. M. C. Vol. XIX.) Washington, 1880, p. 292 et seq. (A H S).

Description of new Cretaceous invertebrate fossils from Kansas and Texas, by C. A. White. Says "Two aviculids were discovered by Prof. B. F. Mudge in strata of the Dakota group, Saline Co., Kansas, and sent by him to the National Museum." Refers to others from the same locality, described in Vol. IX of the U. S. G. Survey of the Territories. One is named Gervillia Mudgeana (p. 290). Says the discoveries of Prof. Mudge have done more than all the others to show the molluscan fauna of the Dakota group.

An account of the Progress in Geology in the years 1887-88, by W. J. McGee. Washington, 1890. Extract from the Smithsonian Report for 1888. (A H).

Refers to work of Kansas Academy of Science and Washburn College.

Preliminary Handbook of the Department of Geology in the U. S. National Museum, by Geo. P. Merrill, from Report Nat. Mus., 1889. (A H).

Appendix E states (p. 34) Kansas has 63 specimens of building stones, and (p. 38) 21 specimens of zinc and lead ores, marcasite, rock salt, and pumice dust, in the Museum.

Report Smithsonian Institution, 1885-6, Part II. Collection of Building and Ornamental stones in the U. S. National Museum: A Handbook and Catalogue, by Geo. P. Merrill.

Describes more fully the stones in the Museum.

U. S. Department of Agriculture:

Artesian Wells of the Great Plains. Report of Commissioners C. A. White and Samuel Aughey. Washington, 1882. (A H).

Gives some cretaceous geology near the Kansas, Colorado, Nebraska line.

Letter from Secretary of Agriculture (J. M. Rusk) transmitting a report on location of artesian wells west of the 97th meridian to the eastern foothills of the Rocky Mountains. Washington, 1890. Pp. 37-47, Sen. Ex. Doc. No. 222, 1st Sess., 51 Cong.

Gives tertiary and cretaceous geology of western Kansas in report of R. Hay.

Artesian, Underflow, and Irrigation Investigation: Progress report. Washington, 1891, Sen. Ex. Doc. No. 53, 2d Sess., 51st Cong., pp. 142, 143. (A H).

Alludes to water-bearing strata in western Kansas.

Artesian, Underflow, and Irrigation Investigations: Final report. Washington, 1892. Part II, by E. S. Nettleton, Chief Engineer. (A H S).

Gives several topographic profiles showing depths to water-bearing strata in western Kansas.

Part III, Report of Chief Geologist, Robt. Hay. Senate Ex. Doc. No. 41, 1st Sess., 52d Cong.

Gives diagrams of geologic sections from Rocky Mountains to 98th meridian in northern Kansas, and north-and-south sections on 100th and 102d meridians, and map showing distribution of tertiary formations in western Kansas and adjoining states.

Same work, second edition, 1893. The four parts bound in one volume.

United States Geological Exploration of the 40th parallel. Clarence King, by order of Secretary of War. Washington, 1880. Vol. VII, 201 pp., 34 plates. Odontornithes, a monograph on the extinct toothed birds of North America, by O. C. Marsh. (H S).

Type specimens from western Kansas Cretaceous are described and figured, and credited to Prof. Mudge, S. W. Williston, and H. Brous, pp. 192 to 199, pll. I, XX, XXI, XXVI-XXXIV, et al.

Under Ichthyornis dispar, Marsh says "The type specimen of this species was found in 1872, by Prof. B. F. Mudge, near the Solomon river in northwest Kansas;" and makes the following references to other descriptions:

"Marsh, Am. Jour. Sci., Vol. IV, p. 344, Oct., 1872; Vol. V, p. 161, Feb., 1873; p. 230, Mar. 1873."

"Jour. de Zoologie, Tome IV, p. 494, pl. XV, 1875; VI, 161." (S).

"Colonosaurus mudgei. Am. Jour. Sci., Vol. IV, p. 406, Nov., 1872."

"Coues. Key to North American Birds, p. 350, 1872."

"Owen. Jour. Geol. Soc. of London, Vol. XXIX, p. 520, 1873."

"Woodward. Pop. Sci. Review, Oct., 1875, p. 349."

"Huxley. N. Y. Lectures. Pop. Sci. Monthly, 1876. Vol. X, pp. 215-218."

"Huxley. American Addresses, pp. 54-55. London, 1877."

In the appendix, pp. 191-201, Marsh says: The list comprises nine genera any twenty species, nearly all of which were found in western Kansas.

II. Kansas Official Reports.

Report of the Geological Survey of Miami Co., Kansas, by G. C. Swallow, State Geologist, Kansas City, 1865, 24 pp., map. Republished without the map in Preliminary Report Geology of Kansas, 1866, pp. 70-94.

(Wanting.) (H V).

First Annual Report (for 1864) on the Geology of Kansas, by B. F. Mudge, State Geologist. Lawrence, 1866, 56 pp. (A H S V).

Preliminary Report of Geological Survey of Kansas, by G. C. Swallow, State Geologist. Lawrence, 1866, 198 pp. (A H V).

Kansas State Board of Agriculture:

Annual volumes for 1872, 1873, 1874, 1875, had geological papers of the Kansas Academy of Science, which will be given under "Transactions of Academy."

Vol. III, 1874, had extracts by Secretary from Mudge's Report as State Geologist, in 1866. (A).

Fourth Annual Report for 1875 had also Geology of Kansas, by B. F. Mudge, pp. 107-127. (A H).

The Report of the Eighteenth Annual Meeting of the State Board of Agriculture for the year 1889, contains: Artesian wells in relation to irrigation in western Kansas, by Robert Hay, pp. 24-33. (A H S V).

The Report of Proceedings of the Nineteenth Annual Meeting, January, 1890, contains: Some New Kansas Industries, by Robert Hay. (A H).

Refers to business based on mineral resources, cement, vitrified bricks, salt, etc.

Report of Proceedings of Annual Meeting, January, 1891, contains: Irrigation in western Kansas, its possibilities and water supply, by Robert Hay. (A H).

Gives geology of the underground waters.

Report Twenty-first Annual Meeting for 1892, contains: The Water Conditions of Western Kansas, by Robert Hay, pp. 51-57. (A H S V).

Report of Twenty-second Annual Meeting, 1893, contains: The Geology of some Kansas soils, by Robert Hay, pp. 143-146. (A H V).

Report of Twenty-third Annual Meeting, January, 1894, contains: A Chapter of Kansas Geology, by Prof. S. Z. Sharp. (A).

Refers to geologic structure of McPherson county.

Kansas Minerals at the World's Fair, by Robert Hay. (A).

Quarterly Report of the State Board of Agriculture, December 31, 1883, contains: The Lower Coal Measures of Southeastern Kansas, by Orestes St. John, with section and map. (A H).

March 31, 1886, contains: Water Supply of western Kansas. (A H).

Kansas State Board of Agriculture:

First Biennial Report for the years 1877-78, contains: Geology of Kansas, by B. F. Mudge, pp. 46-88, with map, 2 sections, 6 plates. (A H S V).

Third Biennial Report for the years 1881-82, contains: Sketch of the geology of Kansas, by O. St. John, pp. 571-599, sections and maps. (A H V).

Fourth Biennial Report for the years 1883-84, contains: Geological Summary, presumably by the Secretary, pp. 499, 504. (A H S).

Fifth Biennial Report for the years 1885-86, contains: Notes on the Geology of Southwest Kansas, by Orestes St. John, pp. 132-152. Natural Gas in Eastern Kansas, with appendix on Oil, by Robert Hay, pp. 198-208, with illustrations. What constitutes a good soil, by E. H. S. Bailey, pp. 181-184. (A H S).

Sixth Biennial Report for the years 1887-88, contains: Northwest Kansas, its topography, geology, climate, and resources, by Robert Hay, pp. 92-116, 2 sections. (A H S V).

Composition and Evaporation power of Kansas Coals, by E. H. S. Bailey and L. I. Blake, pp. 157-163. Salt, its discovery and manufacture in Kansas, with suggestions for its use in agriculture, by Robert Hay, pp. 192-204. (A H V).

Seventh Biennial Report, for the years 1889-90, contains: Geology of Kansas salt, by Robert Hay, pp. 83-96, 2 sections. (A H S V).

Eighth Biennial Report for the years 1891-92, contains: Geology and Mineral Resources of Kansas, by Robert Hay, 66 pp., and map. (A H S V).

Also issued separately as a World's Fair Edition, Topeka, 1893.

Transactions of the Kansas Academy of Science, printed by the state.

In annual volume of the State Board of Agriculture for 1872. (A H V).

Coals of Kansas, by W. H. Saunders, p. 387.

Limestone and Coal, by B. F. Mudge, p. 392.

Geology of Arkansas, by B. F. Mudge, p. 408.

In annual volume for 1873: (A H V).

Recent Discoveries of Fossil Footprints in Kansas, by B. F. Mudge.

In annual volume for 1874: (A H V).

The Pliocene Formation of Kansas, by B. F. Mudge.

A Geological Survey of Kansas, by B. F. Mudge.

Analysis of Kansas Clays, by Wm. H. Saunders.

Analysis of Soils, by W. K. Kedzie.

In annual volume for 1875: (A H V).

Kansas Chalk, by G. E. Patrick.

Analysis of Kansas Soils, by G. E. Patrick.

Calamities, by M. V. B. Knox.

(Remarks on some characteristic fossils of western Kansas, by B. F. Mudge were not printed.)

Transactions of the Kansas Academy of Science, separately printed.

Vol. V, 1876, contains: (A H).

On Bison Latifrons in Kansas, by B. F. Mudge, p. 9.

Report on Geology, by B. F. Mudge, p. 4.

Iola Gas Well, by G. E. Patrick, p. 13.

Vol. VI, 1877-8, contains: (A H S).

Cretaceous Forests and their Migrations, by B. F. Mudge, p. 46.

Dermal Covering of a Mosasauroid Reptile, by F. H. Snow, p. 54.

On a Fossil Tusk found in Franklin Co., by Wm. Wheeler, p. 11.

Iola Mineral Well, by W. K. Kedzie, p. 58.

Mastodon Remains in Douglas Co., by Jos. Savage, p. 10.

Vol. VII, 1879-80, contains: (A H S).

The Great Spirit Spring, by G. E. Patrick, p. 22.

List of Kansas Minerals, by B. F. Mudge, p. 27.

Metamorphic Deposit in Woodson Co., by B. F. Mudge, p. 12.

Memorial of Professor Mudge, by J. D. Parker, p. 7.

Sink-holes in Wabaunsee Co., by Jos. Savage, p. 26.

Vol. VIII, 1881-82, contains: (A H S V).

The Coal Fields of Cherokee Co., by Erasmus Haworth, p. 7-11, map of Cherokee Co.

Preliminary list of Fossils in Riley Co., by S. C. Mason, pp. 12-13.

The Igneous Rocks of Kansas, by Robert Hay, pp. 14-18.

Vol. IX, 1883-84, contains: (A H S V).

The Age of Kansas, by B. B. Smyth, p. 129.

Octohedral Limonite, by E. Haworth, p. 25.

A new Kansas Mineral, by J. T. Willard, p. 25.

Preliminary Report on Geology of Norton Co., with map and section, by Robert Hay, p. 17.

Notes on Fossil Jaw of Bison, by Robert Hay, p. 98.

In the Dakota, by Robert Hay, p. 109.

"Is a Geological Survey a Necessity?" by Robt. J. Brown, p. 49.

Some Kansas Mineral Waters, by G. H. Failyer, p. 114.

Last Submergence and Emergence of Southeastern Kansas from the Carboniferous Seas, by J. P. West, p. 106.

Utilization of Mineral Waters, by E. H. S. Bailey, p. 28.
Fort Scott Artesian Well, by E. W. Walter and E. H. S. Bailey, p. 96.

Vol. X, 1885-6, contains: (A H S V).
Discovery of a Fossil Bird Track in the Dakota sandstone, by F. H. Snow, pp. 3-6.
A Geological Section in Wilson Co., Kans., by Robert Hay, pp. 6-7, section down Fall River valley.
Report on Geology, by Robert Hay, pp. 21-22.
Historical Sketch of Geological Work in Kansas, by Robert Hay and A. H. Thompson, pp. 45-52.
Coal Measures of Lyon Co., by D. S. Kelly, p. 45.
Natural Gas in Eastern Kansas, by Robert Hay, pp. 57-62.
Notes on a Remarkable Fossil, by Robert Hay, pp. 128-129, plate.

Vol. XI, 1887-88, contains: (A H S V).
Newly Discovered Salt Beds in Ellsworth Co., Kans., by E. H. S. Bailey, pp. 8-10.
The Geology of Kansas, by Robert Hay, pp. 35-37.
On the Discovery and Significance of Stipules in certain Dicocyledonous Leaves of the Dakota Rocks, by F. H. Snow, pp. 34-35, plate.
Geology of the Leavenworth Prospect Well, by E. Jameson, pp. 37-38.
Triassic Rocks of Kansas, by Robert Hay, pp. 38-39.
Evaporating Power of Kansas Coals, by L. I. Blake, pp. 42-46.
Composition of Kansas Coals, by E. H. S. Bailey, pp. 46-49.

Vol. XII, 1889-90, contains: (A H S).
Artesian Wells in Kansas, by Robert Hay, p. 24.
Notes on Kansas Salt Marshes, by Robert Hay, p. 97.
Barite in Concretionary Rocks, by E. H. S. Bailey, p. 45.
Some Kansas Mineral Waters, by E. H. S. Bailey, p. 25.
Structure of Kansas Chalk, by S. W. Williston, p. 100.
New Plesiosaur from the Niobrara Cretaceous, by S. W. Williston, p. 174.
Mammoth Remains in Franklin Co., by O. C. Charlton, p. 74.

Vol. XIII, 1891-92. (A H S). Contains:
Notes on a Pink Barite, by E. B. Knerr, p. 76.
Composition of Building Stones, by E. H. S. Bailey, p. 78.
On some new Cephalopods, by Robert Hay, p. 37.
Glaciated Area in Northeastern Kansas, by Robert Hay, p. 104.
Granite in a Deep Boring, by Robert Hay, p. 75.
In Memoriam—Joseph Savage, by Robert Hay, p. 65.
Minerals of Kansas, by G. H. Failyer, p. 76.
A Food Habit of Plesiosaurs, by S. W. Williston, p. 121.
Memoir of J. P. West, by S. W. Williston, p. 68.
Niobrara Cretaceous of Western Kansas, by S. W. Williston, p. 107.

Reports of State Inspector of Coal Mines:

First annual, for 1884. Topeka, 1885, by E. A. Scammon. (A H V). Gives location of Kansas coal fields.

Second annual, for 1885. Topeka, 1886, by Jno. R. Braidwood. (A H V). Has a chapter, "The coal deposits of Kansas."

Third annual, for 1886-7. Topeka, 1888, by G. W. Findlay. (A H V). Statistics up to date.

Fourth Annual, for 1890. (A H V). Contains:
The Coal Deposits of Kansas, pp. 85-91.
References to the localities of zinc and salt.
Fifth Report (1st Biennial), 1891-92. (A H V).
Usual statistics and location of salt mines.

Kansas State Penitentiary, Henry Hopkins, Warden. Special report, Jan. 19, 1881, O. F. Lamm, Supt. (H).

Supplemental Report, Jan. 1st, 1883.
Describes the different strata passed through in sinking the Penitentiary coal shaft. (H).

Mineral Resources of Kansas, 23 pp. Topeka, 1893. (A H V).
A Compilation of the Kansas World's Fair Commissioners. Has a valuable array of statistics, but the geology is brief and inexact.

Bulletins of the Washburn College Laboratory, edited by F. W. Cragin, Topeka.
Vol. I, No. 2, January, 1885. Notes on the region of Crooked creek, by the editor. (A H S).
No. 3, March, 1885. Notes on the Geology of southern Kansas, by the editor. (A H S).
This refers the Barber Co. gypsum to the Dakota and Benton formations. Another note on same subject., Ed., p. 112.
No. 5, May, 1886. Further notes on the Dakota Gypsum of Kansas. Editor. (A H S).
No. 9. February, 1889. Geological notes on the region south of the Great Bend of the Arkansas. Editor. (A H S).
Retracts a former assertion as to certain concretions being fossils. Recognizes the Cretaceous as being above the red beds and gypsum. Gives a section and names some fossils and names the strata Comanche Peak beds.
No. 10, December, 1889. Contributions to the Paleontology of the Plains. Editor. (A H S).
No. 11, March, 1890. On the Cheyenne sandstone and the Neocomian shales of Kansas. Editor. (A H S).
Gives many details and several sections, and, as previously, calls the red beds Triassic.

Other Kansas Publications.

Agricultural Geology of Kansas, by W. K. Kedzie, 1877. (A H).

Catalogue of Minerals, Fossils and Birds in the Agricultural room, Capitol Building, Topeka, Kans., 1875. (H).
Probably the work of Prof. J. H. Carruth.

A contribution to the Geology of the Lead and Zinc mining region of Cherokee Co., Kansas, by Erasmus Haworth. A Master of Science thesis. Oskaloosa, Iowa, 1884.

Golden Rod, November, 1892. Edited by W. S. Newlon, Oswego, Kansas.
Notes on Kansas Glaciers, by Editor. (A).

Golden Rod, No. 6. November, 1893. Swallow's Hydraulic Limerock, by Editor. (A H).

Kansas University Quarterly, Lawrence, Kansas. (A H).
July, 1892, contains:
Kansas Pterodactyls. Part I, by S. W. Williston.
Kansas Mosasaurs. Part I, by S. W. Williston and E. C. Case.

October, 1892. (A). Contains:

The Waconda Spring Mound, by E. H. S. Bailey.

October, 1893. (A H). Contains:

Kansas Pterodactyls, II, by S. W. Williston.

In this article Doctor Williston objects to Marsh's generic name Pteranodon, on the ground that the genus was not new, and substitutes for it the older Ornithostoma.

Kansas Mosasaurs, Part II, by S. W. Williston.

Gives a complete restoration of a Clidastes.

January, 1894. (A H). Contains:

Report of Stratigraphic work in the field, southeastern Kansas, by Prof. Erasmus Haworth.

The New Kansas Magazine. Vol. I, No. 10. Atchison, 1892, contains:

The Salt of Kansas, by Robert Hay, pp. 5-6, map and section. (V).

Transactions of the Academy of Science of St. Louis.

Vol. I, 1858. (A V). Contains:

Descriptions of new fossils from the Coal Measures of Missouri and Kansas, by B. F. Shumard and G. C. Swallow, pp. 198-227.

Vol. II, 1868. (A H V). Contains:

Mr. Meek's notes on my Report of the Geology of Kansas, by G. C. Swallow, pp. 517-526.

The Rocks of Kansas, by Swallow and Hawn, p. 173.

Vol. IV, contains:

Carboniferous rocks of Eastern Kansas, by G. C. Broadhead, p. 481. (A).

This gives in considerable detail Professor Broadhead's idea of the line between Permian and Coal Measures.

F. B. Meek's Reply to Professor Swallow:

"On Certain Disputed Points in the Geology of Kansas and other Northwestern Localities." July, 1869. (A H V).

Annals New York Academy of Science, Vol. IV, 1887. (A V).

The Genera and Species of North American Carboniferous Trilobites, by A. W. Vogdes, p. 67, 2 pll.

Contains descriptions of Phillipsia cliftonensis Shum. and P. major Shum.

Bulletin Denison University, Vol. II, Part I, 1887. (A V).

A Sketch of the Geological History of Licking county, accompanying an illustrated catalogue of Carboniferous fossils from Flint Ridge, Ohio, by C. L. Herrick, 7 pll.

American Journal of Science and Arts.

Vol. XXII, 1851. Carboniferous Rocks of Southeastern Kansas, by G. C. Broadhead, p. 55. (S V).

Vol. XXVI, 1858. The Rocks of Kansas, by G. C. Swallow, p. 182. (H S V).

Vol. XXVII, 1859. On the so-called Triassic Rocks of Kansas and Nebraska, by F. B. Meek and F. V. Hayden, p. 31. (S V).

Vol. XXXIX, 1865. Remarks on the Carboniferous and Cretaceous rocks of eastern Kansas and Nebraska, in connection with a review of a paper recently published on this subject by Jules Marcou and F. B. Meek, p. 157. (H S V).

Vol. XLIV, 1867. Notes on the Geology of Kansas, by F. V. Hayden, p. 32. (H).

Vol. XLVI, No. 136, 1868. Memoir "On some Cretaceous fossil plants from Nebraska," by Leo Lesquereux, pp. 91-104. (H S).

Includes notice of some Kansas specimens.

American Journal of Science:

Vol. XXII, July, 1881. The Carboniferous Rocks of Southeastern Kansas, by G. C. Broadhead. (S).

Vol. XXXIX, May, 1890. "Notes of Cretacean Dinosaurs," by O. C. Marsh. Specimens from Pteranodon beds of Kansas.

Refers editorially (p. 166) to Kansas Academy of Science, Snow's Bird-track, and Hay and Thompson's Historical Sketch of Geology.

Vol. XLII, 1891, p. 517, refers to note on Kansas Trilobites in Kansas City Scientist. (S).

Vol. XLIII, 1892, Kansas Meteorites. Kunz, p. 65; Hay, p. 80. (S).

American Geologist, published at Minneapolis, Minn. N. H. Winchell, Editor:

Vol. II, 1888, p. 404. Preliminary description of a new or little known Saurian from the Benton of Kansas, by F. W. Cragin.

Pp. 433-436, "Mitchell Co., Texas," is the title of a letter from G. C. Broadhead, which describes salt deposits in several Kansas counties.

Vol. III, 1889, p. 199. Reviews "Northwest Kansas", by R. Hay.

Vol. IV, 1889, p. 309. Reviews "Salt in Kansas", by Robert Hay.

P. 389, notices scientific articles, including geologic papers, read at Kansas Academy of Science at Wichita.

Vol. V, 1890, p. 65. Notes on a Kansas Salt Mine, illustrated. Being the substance of a paper read at the Toronto meeting of A. A. A. S., by Robert Hay.

P. 296. Artesian wells in Kansas and the causes of their flow. Illustrated. By Robert Hay.

Vol. VI, 1891, p. 9. The Permo-carboniferous of Greenwood and Butler counties, Kans., by L. C. Wooster, Eureka, Kans. P. 224. Editorial describes "Snow Hall of Natural History, Lawrence, Kans.," with some notice of its fossils. P. 389. Reviews Bulletin No. 57, U. S. G. S., "Southwest Kansas," by Robert Hay. (A S).

Vol. V, p. 309, and Vol. VI, p. 370. Have "Brenham, Kiowa Co., Kansas, Meteorite," illustrated, by N. H. Winchell and J. A. Dodge. (A S).

Vol. VII, 1891, p. 23. On Cheyenne Sandstone and Neocomian Shales of Kansas, by F. W. Cragin. P. 179. Further notes on Cheyenne Sandstones and Neocomian Shales, by F. W. Cragin. P. 340. Megalonyx Beds in Kansas, illustrated, by J. A. Udden. (A S).

Vol. VIII, 1891, p. 171. New observations on the genus Trinacromerum, by F. W. Cragin, being a continuation of the description in Vol. II, *ante*. (S).

Vol. IX, 1892, p. 254. Observations on Llama remains in Colorado and Kansas, by F. W. Cragin. (H S).

Vol. X, 1892, p. 131. Glacial Striae in Kansas, by L. C. Wooster. P. 330. Notice of division of chair of geology at Kansas State University. (H S).

Vol. XI, 1893, p. 359. Review of Geology and Mineral Resources of Kansas, by Robert Hay. (H S).

American Geology. Letter on some points of the geology of Texas, New Mexico, Kansas, and Nebraska, addressed to Messrs. F. B. Meek and F. V. Hayden, by Jules Marcou, Zurich, 1858, 15 pp. (H S V).

Kansas City Scientist:

Trilobites of the Upper Coal Measures group of Kansas City, Mo.

Vol. V, No. 3, 1891, p. 33, plate. (A H V).

Phillipsia major Shum. P. cliftonensis Shum. He refers Pooetus longicaudatus Hall to Phillipsia major and remarks that the upper coal measures of Kansas extend westward to near the west county line of Greenwood Co., Kansas, whereas the trilobite in question was found some 25 miles east of this line at Madison.

Mammoth Sigillaria, by Edwin Waters. No. 9, September, 1891, p. 140, describes large specimens now in Snow Hall at Lawrence and at Yale College, and says that they were found almost at the top of the coal measures in Greenwood Co., Kansas.

Prospectus, Reports, and other information relating to Kansas Coal Belt Mining Company, Shenandoah, Penna., 1884, 31 pp., with map.

Geological Survey of Missouri:

The 1st and 2d Annual Reports of the Geological Survey of Missouri, by G. C. Swallow, State Geologist. Jefferson City, Mo., 1855, 209 and 239 pp., 15 pll., 19 sections, and 5 maps. (A H V S).

Refers to the position of the loess on the Missouri river and to the similarity of the rock strata on each side.

Report of the Geological survey of the State of Missouri, by G. C. Broadhead. Jefferson City, 1873, 323 x iv pp., 3 plates and sections and 9 maps. (A S V).

Contains observations on the geology of Kansas.

Geological survey of Texas. Second Annual Report. Austin, 1891. Cites R. Hay on "Red-beds," pp. 336-421. On Salt of Kansas, p. 445. Article on Carboniferous Cephalopods, by Alphaeus Hyatt, describes several new species from Geary Co., Kansas. (A H S).

This paper is also printed separately, pp. 329-356. Illustrated.

Second Geological Survey of Pennsylvania. Coal Flora of the United States, by Leo. Lesquereux, Vol. I, 1880, p. 109. (A H).

Vol. III, 1884, p. 880, gives six Kansas localities and describes 28 species of Kansas coal plants. (A H).

One locality given is Ellsworth, which, if correct, implies that a widely spread coal measures Neuropteris is found in Cretaceous strata.

Geological Survey of Illinois: Vol. VII, 1883, gives (p. 193) Range of Fossils in Kansas coal measures, and describes, pp. 214, 240, 249, fossils from Kansas, two being named after the finders, Professor Mudge and Mrs. St. John. (A S).

Catalogue of Pythonomorpha, found in the Cretaceous strata of Kansas, by E. D. Cope. (A H).

Read before the American Philosophical Society, Dec. 17, 1871. Transactions Am. Phil. Soc., Vol. XIV.

On a new Testudinata from the chalk of Kansas, by E. D. Cope. Transactions Am. Phil. Soc., Jan., 1872. (A H).

On two New Ornithosaurians from Kansas, by E. D. Cope. Trans. Am. Phil. Soc., March, 1872. (A H).

American Naturalist. May, 1887. Mesozoic and Cenozoic realms of the interior of North America, by E. D. Cope.

Refers to the existence of the Loup Fork formation in Kansas.

Syllabus of University extension lectures, by E. D. Cope.

Refers to coal measures and other strata of Kansas. Philadelphia, 1891.

American Geological Classification and Nomenclature, by Jules Marcou. Cambridge, Mass., 1888. Printed for the author.

Gives upper coal measures in the Dyas in Kansas.

Kansas in a Nutshell, by George P. Guerrier. Cambridge, Mass. 1889.

Cites R. Hay in "Atchison Champion" on extent of geological knowledge of Kansas.

Fifth International Congress of Geologists, "Geological Guide Book of the Western Excursion". (A).

Gives brief itinerary of the geology of Kansas from Phillipsburg to Kansas City. Washington, August, 1891.

"Kansas". A pamphlet issued by Missouri Pacific Ry. Co., 1892.

Reprints article on water supply of western Kansas from Annual Report of the State Board of Agriculture, which gives the geology of the water-bearing strata. (A H).

Kansas City Review of Science and Industry contains the following geological articles:

Kedzie, W. K. Iola, Kansas, mineral well. Vol. I, No. 5, July, 1877. (A H).

Case, Theo. S. Wyandotte, Kansas, gas well. Vol. I, No. 6, August, 1877. (A H).

Case, Theo. S. The mineral region of southwest Missouri and southeast Kansas. Vol. I, No. 7, Sept., 1877. (A H).

Parker, J. D. The river bluffs. Vol. I, No. 8, Oct., 1877. (A H).

Phillips, J. VanCleave. Geology of the West. Vol. I, No. 8, Oct., 1877. (A H).

Mudge, B. F. Fossilization of flesh an impossibility. Vol. I, No. 8, 10, Oct., Dec., 1877. (A H).

Mudge, B. F. Fossil leaves in Kansas. Vol. I, No. 2, Jan., 1878. (A H).

Missouri (Kansas) Mineral Production. Anon. Vol. II, No. 2. April, 1878. Correspondence of the Engineering and Mining Journal. (A H).

Snow, F. H. On the dermal covering of a Mosasauroid Reptile. Vol. II, No. 8, Nov., 1878. (A H).

Great Springs, Cawker City. Vol. III, No. 2, June, 1879. Correspondence Kansas City Times. (A H).

Mudge, B. F. The new Sink-hole in Meade county. Vol. III, No. 3. June, 1879. (A H).

Mudge, B. F. Are birds derived from Dinosaurs? Vol. III, No. 4, August, 1879. (A H).

Thorne, J. The Rosedale Gas and Coal Wells. Vol. III, No. 7, Nov., 1879. (A H).

Broadhead, G. C. Notes on the surface geology of southwest Missouri and Southeast Kansas. Vol. III, No. 8, Dec., 1879. (A H).

Guild, Edgar W. Western Kansas—Its Geology, Climate, Natural History, etc. Vol. III, No. 8, December, 1879. (A H).

Parker, J. D. Kansas Scientific Survey. Vol. IV, No. 10, Feb., 1881. (A H).

Haworth, Erasmus. Chemical and Dynamical Geology. Vol. V, No. 2, June, 1881. (A H).

Broadhead, G. C. Geological notes on the Central Branch Union Pacific Railroad. Vol. V, No. 3, July, 1881. (A H).

Sternberg, C. H. The Fossil Flora of the Cretaceous Dakota group of Kansas. Vol. V, No. 4, August, 1881. (A H).

Broadhead, G. C. Carboniferous Rocks of Southeast Kansas. Vol. V, No. 5, Sept., 1881. (A H).

Parker, J. D. The Burlington Gravel Beds. Vol. V, No. 6, Oct., 1881. (A H).

Haworth, E. Joplin City White Lead Works. Vol. V, No. 7, November, 1881. (A H).

Haworth, E. Chert Rocks of Sub-carboniferous Kansas. Vol. V, No. 2, March, 1882. (A H).

Broadhead, G. C. The chalk beds of Wa-Keeney, Kansas. Vol. V, No. 10, February, 1882. (A H).

Broadhead, G. C. Geological Notes on a part of Southeast Kansas. Vol. VI, No. 3, July, 1882. (A H).

Sternberg, C. H. Loup Fork Group of Kansas. Vol. VI, No. 4, Aug., 1882. A H).

Chase, Geo. S. Kansas Academy of Science. Text of bill providing for a geological survey of Illinois. Vol. VI, No. 9-10. Jan.-Feb., 1883. (A H).

Clerk, F. L. The Lead and Zinc Region of Missouri and Kansas. Vol. VII, No. 6, Oct., 1883. (A H).

Haworth, E. Notes on Kansas Minerals. Vol. VII, No. 6. Oct., 1883. (A H).

Knaus, Warren. Note on a new Mineral (Celestite) in Central Kansas. Vol. VII, No. 10, February, 1884. (A H).

Lantz, D. E. The Supply of Coal. Vol. VII, No. 12, April, 1884. (A H).

Kansas Coal. Vol. VII, No. 12, April, 1884. Reprinted from the Kansas City Journal. (A H).

Sternberg, C. H. The Flora of the Dakota Group. Vol. VIII, No. 1, May, 1884. (A H).

Parker, J. D. The Russell Artesian Well. Vol. VIII, No. 2-3. June-July, 1884. (A H).

Jerome, F. E. Russell Artesian Well. Vol. VIII, No. 2-3. June-July, 1884. (A H).

Lykins, W. H. R. List of Fossils in Kansas City and vicinity. Vol. VIII, No. 2-3, June-July, 1884. (A H).

Scammon, E. A. Coal in Kansas for 1883. Vol. VIII, No. 2-3. June-July, 1884. (A H).

Haworth, Erasmus. Geology and Mineralogy of Cherokee county, Kansas, Notice of. Vol. VIII, No. 2-3, June-July, 1884. (A H).

Sternberg, C. H., and W. W. Russ. Note on Saurian, Ottawa Co. Vol. VIII, No. 2-3. June-July, 1884. (A H).

Sternberg, C. H. Directions for Collecting Vertebrate Fossils. Vol. VIII, No. 4, Aug., 1884. (A H).

Parker, J. D. The Burlington Gravel Beds. Vol. VIII, No. 7, Nov., 1884. (A H).

Brown, Dr. R. J. Is a Geological Survey of the State a Necessity? Vol. VIII, No. 8, Dec., 1884. Read before the Kansas Academy of Science, Nov., 1884. (A H).

West, E. P. The last Submersion and Emergence of Southeastern Kansas from the Carboniferous Seas, or those affecting the Carboniferous formation in Kansas. Vol. VIII, Nos. 9 and 10, Jan. and Feb., 1885, (A H).

Bailey, E. H. S., and E. W. Walter. The new Artesian Well at Fort Scott. Vol. VIII, No. 9. Jan., 1885. (A H).

The Geological Survey of Kansas (editorial). Vol. VIII, No. 10, Feb., 1885. (A H).

Parker, J. D. Kansas Scientific Survey. Vol. VIII, No. 10, Feb., 1885. (A H).

Cragin, F. W. Tertiary in Harper County. Vol. VIII, No. 2, March, 1885. (A H).

Cragin, F. W. Some Geological and Topographical Features of Southern Kansas. Vol. VIII, No. 12, April, 1885. (A H).

Holder, Chas. F. Monster Sea-turtle found in Kansas. Vol. IX, p. 333. (A H).

Bulletin of the Geological Society of America. Vol. I, New York, 1890. Contains (p. 26) remarks of R. Hay on the absence of lignite under Kansas prairie in certain localities as illustrating pressure. (A).

Vol. II, Rochester, 1891. On p. 19, H. S. Williams refers to Kansas Carboniferous formations, and on p. 518, R. T. Hill refers to Cragin on the Kansas Cretaceous. (A).

Vol. III, Rochester, 1892. Contains, on page 80, remarks of G. C. Broadhead on black soils in Kansas, and on p. 519 a contribution to the geology of the great plains, by Robert Hay, which describes the Tertiary deposits of western Kansas and their relation to subjacent Cretaceous. (A).

Vol. VI, Rochester, 1894. Contains (p. 29) Kansas river section of the Permo-carboniferous and Permian rocks of Kansas, by Chas. S. Prosser. (A).

Manual of Geology, by J. D. Dana. 2d Ed., New York, 1876.

Treats of Kansas Carboniferous, pp. 291-320; Permian, 356; Triassic, 423; Chalk and Cretaceous, 455-6. (A).

Elements of Geology, by Joseph LeConte. New York, 1879.

Treats of Kansas coal measures, p. 339; Permian, 402; Jura-trias, 440; Cretaceous, 551.

Text Book of Geology, by Sir Archibald Geikie, illustrated. London, 1885.

Refers (p. 818) to Odontornithes, or toothed birds from the Cretaceous beds of Kansas, and gives Marsh's figures of Hesperornis regalis and Ichthyornis victor.

An American Geological Railway Guide. 2d Ed., by James McFarlane, Ph. D. New York, 1890. The geology on the Kansas railways is supplied by Prof. Orestes St. John.

Johnson's Universal Cyclopedia, New York, 1886. Vol. IV, p. 552, article "Kansas" has half a column on "Geology and Mineralogy", which credits the state with Coal Measures, Permian Triassic, Cretaceous, and Drift formations, but blunders on the thickness of the coal seams. (A H S).

Encyclopedia Britannica, R. S. Peale reprint, Chicago, 1892. Vol. XIII, p. 842, article "Kansas", has half a column under "Geology and Minerals," which is inaccurate and not up to date. (S).

Vol. X, p. 352, article "Geology," refers to Permian in Kansas.

Appleton's New American Cyclopedia, New York, 1871, Vol. X, article "Kansas," relates entirely to territorial times when Pike's Peak was "the highest mountain in Kansas." The only definite geological allusion that is correct for the state now is that the Missouri coal fields extend into Kansas. (S).

Appleton's Annual Cyclopedia. Vol. II, 1877, p. 416, records discovery of lead. (S).

Vol. VI, 1881, p. 468, gives product of coal from census of 1880. (S).

Vol. XV, 1890, p. 68, article "New finds of Salt," mentions those in Reno Co., Kansas. (S).

Chambers's Encyclopedia, Chicago and New York, 1886. Vol. IV, p. 57, article "Kansas," says "Coal, lignite, lead, marble, kaolin, gypsum and salt are among the minerals" of the state. (S).

Article "Kansas River," says Republican fork rises in the Rocky mountains.

Chambers's Encyclopedia, Lippincott's Edition, Phila., 1890. Vol. VI, p. 392, article "Kansas" enumerates the following Kansas minerals: "Lead, zinc, coal, lignite, rock salt, mineral paint, gypsum, building stone, brick, clay, hydraulic cement." Gives output of coal, lead, and zinc for 1888-89. Article "Kansas River" says the river is formed by the "junction of the Smoky Hill fork and the Solomon river." (S).

Alden's Manifold Cyclopedia, New York, 1890. Vol. XXI, pp. 113, 114, article "Kansas," gives geology as including Coal Measures, Permian Triassic and Cretaceous. Records discovery of rock salt in 1887, and gives coal, lead, zinc and building stones as the worked minerals.

Geological Maps of Kansas.

Outlined reduction of the maps of Kansas, Nebraska and Dakota geology, by F. V. Hayden. Trans. Amer. Phil. Soc., Vol. XII, Phila., 1862. (V).

Sectional map of Miami county, Kansas, by E. W. Robinson. Scale, 240 chains 1 inch. In Report of Geology of Miami Co., by G. C. Swallow, 1865. (H V).

Map showing the superficial strata of Kansas, by B. F. Mudge. Geology of Kansas, Topeka, 1878. (A H S V).

Map of mineral regions of Jasper and Newton counties, Mo., and Cherokee county, Kansas. Hutchinson and Co., Joplin, 1889. (A).

Map showing Tertiary formations of Smoky Hill-Republican region, by R. Hay. Final report of Artesian and Underflow Investigations, Washington, 1892. (H).

Miscellaneous.

Notes on the geology of the survey for the extension of the U. P. Road, Eastern Division, from the Smoky Hill to the Rio Grande, by John L. Leconte, M. D. Phila., 1868. (H).

Notes the occurrence of vertebrate fossils on the Smoky Hill river.

Wilder's Annals of Kansas, Topeka, 1875. (New edition, later.) Refers to the State Geological Survey and Academy of Science, pp. 382, 388, 407, 417, 1013, et al. (H S U).

On p. 487 (1st edition) refers to the visit of Agassiz to Leavenworth in 1868, and refers to Leavenworth "Conservative" of that time for larger account. (A H S U).

Centennial History of the state of Kansas, by Prof. Chas. R. Tuttle. Madison, Wis., and Lawrence, Kans., 1876. (A H).

Gives localities of sandstones, limestones, and brick clays, and refers to opening of Leavenworth coal mine, pp. 51-62.

History of the state of Kansas, A. T. Andrews, Chicago, 1883. Has chapter on Geological Structure, illustrated, pp. 35-43. Mainly compiled from Prof. Mudge's reports and cites (p. 43) R. Hay on the igneous rocks of Woodson Co. (H).

On p. 275 gives organization and legislative recognition and brief history of Kansas Academy of Science, with names of the prominent geologists.

Kansas. Information concerning its Agriculture, etc. Special pamphlet by Wm. Sims, Secretary State Board of Agriculture, Topeka, 1884. (H).

Contains, pp. 2-8, Mineral Resources of Kansas, by O, St. John.

Congres Geologique International. Compte Rendu de la 5me session at Washington, 1891. Washington, 1893. (A).

Gives geology of the western plains, particularly northwestern Kansas, by S. F. Emmons, Robert Hay, and R. T. Hill, pp. 443-448.

Geologie. Asie et Amerique, par Emm. de Margerie. Extrait de l' Annuaire Geologique Universel. Tome VI, p. 575. Le Mans (France), 1890.

Gives Trinity beds in southern Kansas, and ascribes their discovery to "M. Cragin," pp. 32, 33.

REPORT OF THE BOARD OF CURATORS.

Your board of curators have the honor to report: That the office room of the Academy of Science at the state house has finally been cleared of the Labor Bureau, the State Historical Society, and all their paraphernalia, leaving the Academy in full possession of the rooms.

During January and February, 1894, Prof. Robert Hay was employed several days in overhauling, cleaning, and relabeling the specimens. The paleontological cases were moved from the vestibule into the west room and the specimens rearranged in them.

There have been added to the museum during the past year 28 specimens of reptiles and fishes of the state, from various counties (all are labeled); 500 specimens of coleoptera from Reno county, labeled; a number of specimens of rocks and geodes from Barber, Butler, Cherokee, Jackson, Norton, Shawnee and Sumner counties; rock salt from Rice county; silica from McPherson, Ellsworth, Lincoln and Jewell counties; two large specimens of petrified wood from the Dakota sandstone in northwest Kansas; and a large fossil, 35 feet in length, from the Niobrara, in Mitchell county. This last, which was supposed to be a petrified reptile, proves to be vegetable.

A. H. THOMPSON,
B. B. SMYTH,
ROBERT HAY,
Curators.

REPORT OF LIBRARIAN.

The number of books and pamphlets received during the past two years is 2,150, slightly greater than during the corresponding previous period. But they are of considerably more value, as the Kansas Academy is gradually becoming recognized by the best societies and scientific institutions of the world.

There have been sent out to institutions and individuals within the past year 1,644 copies of Vol. XIII, and about 300 copies of the other back volumes. The cost of sending these has been $169, of which $120 has been provided for by the Secretary of the State Board of Agriculture, $33 has been received from all other outside sources, leaving a deficiency of $16.

The reprinting of the early proceedings is not yet completed; but work is in progress.

The correspondence of the library has materially increased of late years. Your librarian has kept a record of all letters and cards sent out, and a copy of all letters of any importance. These are both submitted. An average of about four hours a day has been given to this and the cataloguing of books received, and an average of about six letters per day written.

No binding has been done during the past year. Four hundred and fifty volumes have been prepared and are ready for binding whenever it can be done.

Your librarian herewith submits a list of the Academy's correspondents, and recommends its publication.

A list of accessions to the library during the past two years is also submitted.

B. B. SMYTH, Librarian.

LIST OF CORRESPONDENTS

OF THE KANSAS ACADEMY OF SCIENCE.

INSTITUTIONS AND LIBRARIES TO WHICH THE TRANSACTIONS ARE SENT.

BY B. B. SMYTH, LIBRARIAN.

ALABAMA.

University: Geological Survey of Alabama.

ARKANSAS.

Little Rock: Arkansas Geological Survey.

CALIFORNIA.

Berkeley: The University of California.
Carpinteria: Carpinteria Science Club.
Mt. Hamilton: The Lick Observatory Library.
Sacramento: California State Library.
Sacramento Free Library.
San Diego: San Diego Society of Natural History.
West American Scientist, C. R. Orcutt, publisher.
Stanford University: Leland Stanford Junior University.
San Francisco: Astronomical Society of the Pacific.
California Academy of Sciences.
California State Mining Bureau.
San Francisco Free Public Library.
State Board of Forestry.
State Board of Horticulture.
The Lick Observatory Library.
The Technical Society of the Pacific Coast.
Santa Barbara: Santa Barbara Free Public Library.
Santa Barbara Society of Natural History.

CANADA.

Belleville, Ont.: Murchison Scientific Society.
Chicoutimi, Que.: Le Naturaliste Canadien, M. L'Abbe Huard, publisher.
Fort Garry, Man.: Institute of Prince Rupert's Land.
Hamilton, Ont.: Hamilton Association.
Halifax, N. S.: Botanical Society of Canada.
Nova Scotia Institute of Natural Science.
Kingston, Ont.: Queen's Society of Canada.
London, Ont.: Canadian Entomologist.
Entomological Society.
Montreal, Que.: British Association for the Advancement of Science.
Canadian Record of Science.
McGill University.
Natural History Society of Montreal.
Numismatic and Antiquarian Society.
Royal Society of Canada.
Ottawa, Ont.: Department of Agriculture.
Geological and Natural History Survey.
Ottawa Field Naturalists' Club.
Quebec, Q.: Literary and Philosophical Society.
St. John, N. B.: Natural History Society.
St. John's, N. F.: Geological Survey of Newfoundland.

Toronto, Ont.: Canadian Institute.
Canadian Journal of Science.
Natural History Society of Toronto.
University of Toronto.
Winnipeg, Man.: Manitoba Historical and Scientific Society.

COLORADO.

Boulder: University of Colorado.
Colorado Springs: Colorado College Scientific Society.
Denver: Colorado Scientific Society.
Colorado State Library.
University of Denver.
Pueblo: Free Public Library.

CONNECTICUT.

Bridgeport: Bridgeport Scientific Society.
Hartford: State Library of Connecticut.
Meriden: Meriden Scientific Association.
New Haven: Connecticut Academy of Arts and Sciences.
Yale College Library.

DELAWARE.

Dover: Delaware State Library.

DISTRICT OF COLUMBIA.

Washington, D. C.: American Monthly Microscopical Journal.
Anthropological Society.
Biological Society of Washington.
National Academy of Sciences.
Philosophical Society of Washington.
Department of Agriculture, Library of Division of Botany.
Library of Division of Entomology.
Library of Division of Forestry.
Library of Division of Ornithology and Mammalogy.
Library of Division of Microscopy.
Library of Division of Mycology.
Library of Division of Pathology.
Library of U. S. Geog. and Geol. Survey of Rocky Mountains.
Library of U. S. Geological Survey.
Library of U. S. Weather Bureau.
Bureau of International Exchanges.
Library of Smithsonian Institution.
Library of U. S. National Museum.
The Director, Bureau of Ethnology.
Library of Bureau of Ethnology.
U. S. Coast and Geodetic Survey.
U. S. Fish Commission Library.
U. S. Naval Observatory.
U. S. Navy Department Library.
Bureau of Education.
Congressional Library.
Patent Office Scientific Library.
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Library of Secretary of Agriculture.
Library of Secretary of the Interior.
Library of Smithsonian Institution.

ILLINOIS.

Astoria: Fulton County Scientific Association.
Champaign: University of Illinois.
Chicago: Chicago Academy of Sciences.
Chicago Public Library.
Field Columbian Museum.
Geological Department, University of Chicago.
Newberry Library.
Ridgway Ornithological Club.
University of Chicago Library.

Elgin: Elgin Scientific Society.
Evanston: Northwestern University.
Jacksonville: Illinois College.
Peoria: Peoria Public Library.
Peoria Scientific Association.
Princeton: Princeton Academy of Sciences.
Rockford: Rockford Scientific Society.
Rock Island: Augustana College Library.
Springfield: Geological Survey of Illinois.
Illinois State Library.
Illinois State Board of Agriculture.
Illinois State Museum of Natural History.
Urbana: Illinois State Laboratory of Natural History.

INDIANA.

Bloomington: Botanical Gazette.
Indiana State University.
Brookville: Brookville Society of Natural History.
Indiana Academy of Science.
Greencastle: De Pauw University.
Indianapolis: Department of Geology and Natural History.
Indiana Geological Survey.
Indiana State Library.
Indianapolis Public Library.
Indianapolis Lyceum of Natural History.
Terre Haute: Rose Polytechnic Institute.
Terre Haute Science Association.

IOWA.

Ames: Agricultural College Library.
Iowa Experiment Station.
Council Bluffs: Free Public Library.
Davenport: Davenport Academy of Natural Sciences.
Des Moines: Iowa State Library.
Iowa City: Iowa Academy of Science.
Iowa Geological Survey.
State Historical Society.
State University of Iowa.

KANSAS.

Anthony: High School Library.
Atchison: Midland College Library.
Baldwin: Baker University Library.
Burlington: Burlington Library Association.
Burrton: Burrton Library.
Clay Center: High School Library.
Concordia: High School Library.
Effingham: Atchison County High School.
Emporia: College of Emporia.
Emporia High School Library.
State Normal School Library.
Fort Scott: S. E. Kansas Normal College.
Girard: Literary and Library Society.
Goodland: Public School Library.
Great Bend: Central Kansas College.
Highland: Highland University Library.
Holton: Campbell Normal University Library.
Hutchinson: Public School Library.
Kansas City, Kan.: The Naturalist.
Lansing: State Penitentiary Library.
Larned: Public School Library.
Lawrence: Kansas State University Library.
Chemical Department, State University.
Haskell Indian School.
Kansas University Quarterly.
Lawrence City Library.

Leavenworth: Leavenworth Public Library.
 Leavenworth High School Library.
 National Military Home.
Lecompton: Lane University Library.
Lindsborg: Bethany College Library.
McPherson: McPherson College Library.
Manhattan: Kansas State Agricultural College.
 Kansas Experiment Station.
Norton: Public School Library.
Olathe: Deaf and Dumb Institution.
Osborne: High School Library.
Oswego: Oswego College for Young Ladies.
Ottawa: Ottawa University Library.
 Ottawa Science Club.
Paola: Paola Free Public Library.
Phillipsburg: Phillipsburg High School Library.
Pittsburg: Pittsburg High School Library.
Salina: Kansas Wesleyan University.
 Salina Normal University.
Stockton: Stockton Academy Library.
 Stockton High School Library.
Topeka: College of the Sisters of Bethany.
 State Historical Society.
 State Horticultural Society.
 Harrison School Library.
 Kansas State Library.
 Lincoln School Library.
 Polk School Library.
 State Board of Agriculture.
 State Insane Asylum.
 State Reform School.
 Topeka City Library.
 Topeka High School Library.
 Topeka Philosophical Society.
 Washburn College Library.
Washington: Friends' Academy Library.
Wellington: Wellington Library Association.
Wichita: Garfield University Library.
 Lewis Academy Library.
Winfield: Public School Library.
 Southwestern Kansas College.

KENTUCKY.

Louisville: Louisville Library Association.
 Polytechnic Society of Kentucky.

LOUISIANA.

New Orleans: New Orleans Academy of Science.

MAINE.

Augusta: State Library.
Portland: Library Association of Portland.
 Portland Society of Natural History.

MARYLAND.

Baltimore: Johns Hopkins University.
 Maryland Academy of Sciences.

MASSACHUSETTS.

Boston: American Academy of Arts and Sciences.
 Boston Athenæum.
 Boston Public Library.
 Boston Scientific Society.
 Boston Society of Natural History.
 Boston Zoological Society.
 Estes & Lauriat, publishers.

Boston: Marine Biological Laboratory, Back Bay.
Massachusetts Horticultural Society.
Science Observer.
State Library of Massachusetts.
Summer School of Technology.
Cambridge: Cambridge Entomological Club.
Harvard College Library.
Harvard Natural History Society.
Lawrence Scientific School, Harvard College.
Museum of Comparative Zoology.
Nuttall Ornithological Club.
Peabody Museum.
Hyde Park: Ornithologist and Oologist.
Lawrence: Lawrence Public Library.
Salem: American Association for Advancement of Science.
Essex Institute.
Peabody Academy of Science.
Tufts College: Tufts College Library.
Williamstown: Williams College Library.

MICHIGAN.

Adrian: Adrian Scientific Society.
Agricultural College: Agricultural College Library.
Ann Arbor: American Meteorological Journal.
University of Michigan Library.
Detroit: Detroit Public Library.
Detroit Scientific Association.
Lansing: Michigan State Library.

MINNESOTA.

Minneapolis: American Geologist.
Geological and Natural History Survey.
Minnesota Academy of Natural Sciences.
Minneapolis City Library.
University of Minnesota Library.
St. Anthony Park: U. of M. Experiment Station.
St. Paul: St. Paul Academy of Natural Sciences.
St. Paul Public Library.
State Library of Minnesota.

MISSOURI.

Columbia: Agricultural Experiment Station.
University of Missouri Library.
Jefferson City: Geological Survey of Missouri.
Missouri State Library.
Kansas City: Kansas City Academy of Medicine.
Kansas City Academy of Science.
Kansas City Public Library.
Sedalia: Sedalia Natural History Society.
St. Louis: Missouri Botanic Garden.
St. Louis Academy of Science.
Washington University Library.
St. Louis Public Library.

NEBRASKA.

Crete: Doane College Library.
Lincoln: Nebraska Experiment Station.
Nebraska State Library.
University of Nebraska Library.

NEW JERSEY.

Bloomfield: North Jersey Botanical Club.
Newark: Newark Entomological Society.
New Brunswick: Geological Survey of New Jersey.
Trenton: Trenton Natural History Society.

MONTANA.

Helena: Montana State Library.

NEW MEXICO.

Las Cruces: New Mexico Agricultural College.

NEW HAMPSHIRE.

Exeter: Exeter Natural History Society.

NEW YORK.

Albany: New York State Museum of Natural History.
Albion: The Museum, Walter F. Webb, publisher.
The Oologist, Frank H. Lattin, publisher.
Buffalo: Buffalo Society of Natural Sciences.
Elmira: Elmira Academy of Sciences.
Geneva: N. Y. Agr. Experiment Station.
Hamilton: Colgate University Library.
Ithaca: Cornell University Library.
The Insectary, Cornell University.
New Brighton: Natural Science Association of Staten Island.
New York: American Museum of Natural History.
Astor Library.
Columbia College Library.
Cooper Union for Advancement of Science and Art.
Electric Age.
Electrical Review.
Electrical World.
Linnæan Society of New York.
Mineral Collector, Arthur Chamberlain, editor.
New York Academy of Sciences.
New York Microscopical Journal.
Science.
Scientific American.
Torrey Botanical Club, Columbia College.
Veterinary Infirmary.
Zoological Gardens, Central Park.
Poughkeepsie: Vassar Brothers Institute.
Vassar College Library.
Rochester: Rochester Academy of Science.
University of Rochester.
Schenectady: Union College Library.
Syracuse: Central Library.

NORTH CAROLINA.

Chapel Hill: Elisha Mitchell Scientific Society.
University of North Carolina.

NORTH DAKOTA.

Bismarck: North Dakota State Library.

OHIO.

Cincinnati: Cincinnati Society of Natural History.
Cincinnati University Library.
Cleveland: Cleveland Public Library.
Western Reserve Historical Society.
Columbus: Ohio Academy of Science.
Ohio State University.
Ohio State Library.
Granville: Denison Scientific Association, Denison University.
Denison University Library.
Oberlin: Library of Oberlin College.
Wooster: Ohio Experiment Station.

OKLAHOMA.

Oklahoma City: Agricultural Experiment Station.

OREGON.

Eugene City: University of Oregon.
Portland: Library Association of Portland.
Salem: Oregon State Library.

PENNSYLVANIA.

Easton: Lafayette College Library.
Harrisburg: State Library.
Lancaster: Linnæan Scientific and Historial Society.
Philadelphia: Academy of Natural Sciences.
American Entomological Society.
American Philosophical Society.
Franklin Institute.
Naturalists' Journal.
Naturalists' Leisure Hour, Monthly Bulletin.
Numismatic and Antiquarian Society.
P. Blakiston, Son & Co., publishers.
Pennsylvania Geological Survey.
University of Pennsylvania Library.
Pittsburg: Pittsburg Library Association.
South Bethlehem: Lehigh University Library.

SOUTH CAROLINA.

Charleston: Elliot Society of Science and Art.

SOUTH DAKOTA.

Huron: South Dakota State Library.
Sauk Rapids: Dakota School of Mines.
Sioux Falls: South Dakota Geological Survey.
Vermillion: University of Dakota Library.

TEXAS.

Austin: Geological Survey of Texas.
Texas Academy of Science.
Texas State Library.
University of Texas Library.
Houston: State Geological and Scientific Association.

TENNESSEE.

Nashville: State Board of Health.
Tennessee State Library.

UTAH.

Salt Lake City: Museum of Natural History.

VERMONT.

Burlington: University of Vermont Library.
Vermont Agricultural Experiment Station.
Newport: Orleans County Society of Natural History.

WASHINGTON.

Olympia: Washington State Library.
Seattle: University of Washington.
Spokane: Northwest Mining Review.
Spokane Academy of Sciences.
Tacoma: Tacoma Academy of Science.

WEST VIRGINIA.

Morgantown: W. V. University Experiment Station.

WISCONSIN.

Madison: Wisconsin Academy of Sciences.
University of Wisconsin Library.
State Historical Society.
Milwaukee: Milwaukee Public Museum.
Waupun: Waupun Library Association.

WYOMING.

Cheyenne: Wyoming State Library.

MEXICO.

Mexico: Sociedad Mexicana de Historia Natural.
Observatorio Meteorologico Magnetico Central.
Sociedad Cientifica "Antonio Alzate."
University of Mexico.

CUBA.

Havana: Academia de Ciencias, Fisicas y Naturales.

JAMAICA.

Kingston: Curator Botanic Gardens.

TRINIDAD.

Port of Spain: Scientific Society of Trinidad.

GUATEMALA.

Guatemala: Instituto Nacional de Guatemala.
Sociedad Guatemalteca de Ciencias.

ARGENTINA.

Buenos Aires: Revista Argentina de Historia Natural.
Sociedad Cientifica Argentina.
Sociedad Entomologica Argentina.
Cordoba: Academia Nacional de Ciencias en Cordoba.
Observatorio Nacional Argentina.
La Plata: Florentino Ameghino, Dir. Revista Argentina.
Revista de la Musee de la Plata.
Revista Argentina de Historia Natural.

BRAZIL.

Rio Janeiro: Sociedade de Geographia do Rio de Janeiro.

CHILE.

Santiago: Instituto de Hijiene de Santiago.
La Societe Scientifique du Chili.

COLOMBIA.

Bogota: Sociedad de Naturalistas Colombianos.

GUIANA.

Georgetown: Geological Survey of British Guiana.

PERU.

Arequipa: Harvard Observatory.
Lima: Academia de Ciencias Naturales.

VENEZUELA.

Caracas: Sociedad de Ciencias, Fisicas y Naturales.

ALGERIA.

Algiers: Societe Algerienne de Climatologie et Sciences Physiques.

AUSTRALIA.

Adelaide, S. A.: Royal Society of South Australia.
Brisbane, Q. L.: Royal Society of Queensland.
Hobartton, Tas.: Royal Society of Tasmania.
Melbourne, Victoria: Geological Survey of Victoria.
Sidney, N. S. W.: Royal Society of New South Wales.
Townsville, Q. L.: Geological Survey of Queensland.
Wellington, N. Z.: New Zealand Geological Survey.

AUSTRO-HUNGARY.

Brunn, Moravia: Naturforschender Verein.
Budapest, Hungary: Geologische Gesellschaft fur Ungarn.
Royal Hungarian Society of Natural Sciences.
Ungarische Naturwissenschaftliche Gesellschaft.

Prag, Bohemia: K. bohmische Gesellschaft der Wissenschaft.
Wien, Austria: K. Akademie der Wissenschaften.
Emil Soeding, Antiquariat.
Naturwissenschaftlicher Verein.

BELGIUM.

Brüssels: Academie Royale des Sciences, etc., de Belgique.
Societe Belge de Geologie, de Paleontologie, et de Hydrologie.
Societe Entomologique de Belgique.
Societe Royale de Botanique de Belgique.
Societe Royale Linneenne de Bruxelles.
P. Wytsman, Antiquariat.
Liege: Societe Geologique de Belgique.
Societe Royale des Sciences.

DENMARK.

Kjobenhaven (Copenhagen): Kongelige Danske Videnskabernes Selskab.

FRANCE.

Beauvais: Chas. Janet.
Bordeaux: Societe Linneenne de Bordeaux.
Caen: Academie Nationale des Sciences, Arts et B. L.
Societe Linneenne de Normandie.
Cherbourg: Societe Nationale des Sciences Naturelles de Cherbourg.
Dijon: Academie des Sciences, Arts & Belles Lettres de Dijon.
Gap: Societe d' Etudes des Hautes Alpes.
Le Havre: Societe Havraise d' Etudes Diversees.
Societe des Sciences, Arts, et Belles Lettres.
La Rochelle: Academie des Belles Lettres, Sciences et Arts de la Rochelle.
L' Academie de la Rochelle — Societe des Sciences Naturelles.
Lyons: Academie des Sciences, B. L. et Arts de Lyon.
Societe Linneenne de Lyon.
Societe d' Etudes Scientifiques de Lyon.
Marseilles: Academie des Sciences, Lettres et Arts.
Faculte des Sciences de Marseille.
Societe de Horticulture et de Botanique.
Orleans: Societe d'Agriculture, Sciences, B.-L. et Arts.
Paris: Academie des Sciences, Institute de France.
Societe Americaine de France.
Societe Botanique de France.
Societe Entomologique de France.
Societe Geologique de France.
Societe Meteorologique de France.
J. B. Bailliere & Fils.
C. Reinwald & Cie.
Librarie Ch. Chadenat.
Pau: Societe des Sciences, Lettres et Arts de Pau.
Rouen: Academi de Sciences, B. L. et Arts de Rouen.
Toulouse: Academie des Sciences, Inscriptions et Belles-Lettres.
Societe des Sciences, Physiques et Naturelles.
Versailles: Societe des Sciences, Nat. & Med. de Seine et Oise.

ALSACE AND LORRAINE.

Metz, Lorraine: Academie de Metz.
Strassburg, Alsace: Societe des Sciences, Agriculture & Arts, de la Basse Alsace.

LUXEMBOURG.

Luxembourg: Institut Grand Ducal de Luxembourg, Sec. des Sci. Nat. & Mathematiques.
Societe de Botanique du Grand Duche de Luxembourg.

GERMANY.

Berlin, Prussia: Berliner Entomologischer Verein.
Bernhard Hache, Berlin, W., Charlottenstr. 37 u. 38.
Botanischer Verein der Provinz Brandenburg.
Deutsche Botanische Gesellschaft.
Deutsche Geologische Gesellschaft.
Konigliche Akademie der Wissenschaften.

Bonn, Prussia: Naturhistorischer Verein der Prussischen Rheinland und Westfalens.
Brandenburg, Prussia: (See Berlin—Botanischer Verein.)
Bremen, Ger.: Naturwissenschaftlicher Verein.
Chemnitz, Saxony: Naturwissenschaftliche Gesellschaft
Dresden, Sax.: Naturwissenschaftliche Gessellschaft "Isis."
Frankfurt-am-Main: Gartenbau Gesellschaft "Flora."
Frankfurt-am-Oder: Naturwissenchaftlicher Verein des Regierungs-Bezirks.
Giessen, Hesse: Oberhessischer Gesellschaft fur Natur und Heilkunde.
Gorlitz, Sax.: Naturforschende Gesellschaft.
Halle-an-der-Saale.: Kaiserlichen Leopoldinisch-Carolinischen Deutchen Akademie der Naturforscher.
Naturwissenschaftlicher Verein fur Sachsen u. Thuringen.
Hamburg, Germ.: Naturwissenschaftlicher Verein Hamburg-Altona.
Hanover, Pruss.: Naturhistorische Gesellschaft.
Naturwissenschaftliche Gesellschaft.
Kiel, Pruss.: Naturwissenschaftlicher Verein fur Schleswig-Holstein.
Leipzig, Sax.: Dr. Felix Flugel.
Koniglich-Sachsische Gesellschaft der Wissenschaften.
Magdeburg, Sax.: Naturwissenschaftlicher Verein.
Munchen (Munich), Bav.: K. Baierische Akademie der Wissenschaften.
Munster, Pruss.: Westfalischer Provinzial-Verein fur Wissenschaft und Kunst.
Nurnberg, Bav.: Naturhistorische Gesellschaft.
Offenbach, Baden: Verein fur Naturkunde.
Osnabruck, Pruss.: Naturwissenschaftlicher Verein.
Regensburg, Bav.: K. Baierische Gesellschaft der Wissenschaften.
Naturwissenschaftlicher Verein zu Regensburg.
Wiesbaden, Pruss.: Nassauischer Verein fur Naturkunde.
Wurzburg, Bav.: Unterfrankischer Kreis-Fischerei-Verein.

GREAT BRITAIN.

Bath, Eng.: Journal of Microscopy and Natural Sciences.
Birmingham, Eng.: Mason Science College.
Belfast, Irel.: Natural History and Philosophical Society.
Aberdeen, Scot.: Natural History Society.
Bristol, Eng.: Bristol Naturalists' Society.
Cambridge, Eng.: Cambridge Philosophical Society.
Dublin, Irel.: Dublin Society of Natural History.
Royal Dublin Society.
Royal Geological Society of Ireland.
Royal Irish Academy.
Edinburgh, Scot.: Botanical Society.
Edinburgh Geological Society.
Royal Society of Edinburgh.
Glasgow, Scot.: Geological Society.
Philosophical Society.
Hull, Eng.: Hull Literary and Philosophical Society.
Kew, Eng.: Royal Botanic Gardens.
Liverpool, Eng.: Liverpool Geological Association.
Literary and Philosophical Society.
London, Eng.: Geological Society of London.
Geologists' Association, University College.
Linnæan Society, Burlington House, W.
Royal Botanic Society.
Dulau & Co., 37 Soho Square, W.
Wm. Wesley & Son, 28 Essex street, Strand, W. C.
Williams & Norgate, Covent Garden, W. C.
Bernard Quaritch, 15 Picadilly.
Edward Stanford, Charing Cross, S. W.
Manchester, Eng.: Literary and Philosophical Society.
Penzance, Eng.: Royal Geological Society of Cornwall.
Wigan, Eng.: Free Library.
York, Eng.: Yorkshire Philosophical Society.

HOLLAND.

Leiden: Nederlandsche Entomologische Vereeniging.

ITALY.

Bologna: Accademia delle Scienze dell 'Istituto di Bologna.
Catania: Accademia Gioenia di Scienze Naturali.
Firenze (Florence): Societa Entomologica Italiana.
Genova (Genoa): Accademia delle Scienze, Lettere ed Arti.
Milano: Societa Italiana di Scienze Naturali.
Napoli: Societa Americana d'Italia.
Padova (Padua): R. Accademia di Scienze, Lettere ed Arti.
Pisa: Societa Toscana di Scienze Naturali.
Roma: Accademia Pontificia di Nuovi Lincei.
Societa Italiana delle Scienze.
R. Comitato Geologico d' Italia.
Rassegna delle Scienze, Geologiche in Italia.
Siena: Rivista Italiana di Scienze Naturali.
Torino: Accademia Reale delle Scienze.
Venezia (Venice): R. Istituto Veneto di Scienze, Lettere ed Arti.

NORWAY.

Christiania: Den Geologiske Undersogelse.
Det Kongelige Norske Frederiks Universitet.
Videnskabs Selskabet.
Norwegischen Meteorologischen Institut.
Stavanger: Stavanger Museum.
Throndhjem: The Royal Norwegian Society of Sciences.

SWEDEN.

Stockholm: Entomologiske Forening.
Kongliga Svenska Vetenskaps Akademien.
Upsala: Kongliga Universetet Library.
Kongliga Vetenskaps Societaten.

PORTUGAL.

Lisboa (Lisbon): Academia Real des Sciencias.

RUSSIA.

Helsingfors, Finland: Finnische Akademie der Wissenchaften.
Finska Vetenskaps Societet.
Societas pro Fauna et Flora Fennica.
L' Institut Meterologique Central.
Kasan: Societe Physico-Mathematique de Kasan.
Moscow: La Societe Imperiale des Naturalistes de Moscow.
St. Petersburg: La Comite Geologique a l'Institut des Mines.
L'Academie Imperiale des Sciences de St. Petersbourg.
Societe Imperiale Mineralogique, a l'Institut des Mines.

SPAIN.

Barcelona: Academia de Ciencias, Artes y Oficios.
Cordova: Academia Nacional de Ciencias Exactas.
Madrid: Real Academia de Ciencias de Madrid.

SWITZERLAND.

Basel: Naturforschende Gesellschaft in Basel.
Bern: Naturforschende Gesellschaft.
Geneva: Archives des Sciences Physiques et Naturelles.
Societe de Physique et d'Histoire Naturelle.
Rene de Saussure.
H. Georg, 10 Corraterie.
Neuchatel: Societe des Sciences Naturelles.
Societe Neuchateloise de Geographie.
Saint Gall: Saint Gallischen Naturwissenschaftliche Gesellschaft.
Schaffhausen: Schweizerische Entomologischer Gesellschaft.
Societe des Sciences Naturelles.
Zurich: Naturforschende Gesellschaft.
Societe des Sciences Physiques et Naturelles.

ACCESSIONS TO THE LIBRARY,

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BY B. B. SMYTH, LIBRARIAN.

Dimensions of books when given are in centimetres, breadth and length; when not given are usually octavo, or about 14–15x20–23 centimetres.

AMERICA (UNITED STATES).

ALABAMA.

UNIVERSITY.—Geological Survey of Alabama, Eugene Allen Smith, Ph. D., State Geologist:

Report on the Cahaba coal field, by Joseph Squire, with Appendix on the Geology of the Valley Regions adjacent to the Cahaba field, by Eugene A. Smith. 180 pp.; 7 pll.; 31 figs. in the text, and a map, 108x112 cm.; bound in black cloth.

Report on the geological structure of Murphree's Valley, and its minerals and other materials of economic value, by A. M. Gibson, Asst. Geologist; 132 pp.

Report on the Coal Regions of Blount Mountain, with map and sections, by A. M. Gibson, Asst. Geologist.

Geological map of Alabama, 72x100 cm., with explanatory chart, same size by Eugene A. Smith, State Geologist.

ARKANSAS.

LITTLE ROCK.—Arkansas Geological Survey.

CALIFORNIA.

BERKELEY.—University of California:

Annual Report of the Secretary of the Board of Regents, for the year ending June 30, 1893, 153 pp.

Annual Report for the year ending June 30, 1894, 121 pp.

Bulletin of the Department of Geology, Andrew C. Lawson, Editor. Vol I, not completed. The geology of Carmelo bay, by Andrew C. Lawson, pp. 1-59; pll. 1-4. The Soda-Rhyolite north of Berkeley, by Charles Palache, pp. 61-70; pl. 5. Eruptive rocks of Point Bonita, by F. Leslie Ransome, pp. 71-113; pll. 6, 7; 10 figs. The Post-Pliocene diastrophism of the coast of Southern California, by Andrew C. Lawson, pp. 116-160; pll. 8, 9. Lherzolite-Serpentine and associated rocks of the Potrero, San Francisco, by Charles Palache, pp. 161-179. On a rock from the vicinity of Berkeley containing a new Soda Amphibole, by Chas. Palache, pp. 181-191; pll. 10, 11. Geology of Angel Island, by F. Leslie Ransome, pp. 193-240; pll. 12-14. Geomorphogeny of the coast of northern California, by Andrew C. Lawson, pp. 241-271. On Analcite Diabase from San Luis Obispo Co., Cal., by Harold W. Fairbanks, pp. 273-300; pll. 15, 16.

Library Bulletin, No. 12. Classification of Books, by Joseph C. Rowell, 50 pp.

University of California Studies: Notes on the Development of a Child, by Milicent Washburn Shinn, 178 pp.; 11 figs.

University of California—Agricultural Experiment Station:

Report of Work of the Agricultural Experiment Stations of the University of California, for the year 1891-92, by E. W. Hilgard. 312 pp.

LOS ANGELES.—(See Orcutt.)

ORCUTT.—C. R. Orcutt, Editor:

West American Scientist, Vol. VII, June, 1890, to October, 1891, 276 pp.; 6 pll. Contains, among other articles, Charles Christopher Parry, with portrait, by C. R. Orcutt, pp. 1-5. Fauna and Flora of Colorado—IV, by T. D. A. Cockerell, pp. 7, 8. Butterflies of San Diego, by P. C. Truman, pp. 19,20. Climate of the Pacific beach and its effects, by P. C. Redmondino, M. D., pp. 29-35. Land mammals of San Diego, by F. Stevens, pp. 36-40. Geology of Vancouver Island, by M. Lopatecki, pp. 47-49. The Colorado Desert, by C. R. Orcutt, pp. 55-58.

Parry's lotus tree, illustrated, by the late Dr. Albert Kellogg, pp. 63-66. Notes on Echinocactus, by C. R. Orcutt, pp. 67-70; 2 figs. Easter Island, with 8 illustrations, pp. 76-83. Forest trees of Oregon, by Prof. Thomas Condon, pp. 87, 88; 115-117; 142, 143. California Trees and Flowers, by C. R. Orcutt, pp. 93-100; 123-133; 144-152. The Tuna, by C. R. Orcutt, pp. 153-158; 3 figs. David Starr Jordan, by F. W. Goding, p. 174. The Douglas Fir, pp. 177-181. The Golondrina plant, by C. R. Orcutt, pp. 190-195. The rainbow cactus, illustrated, by C. R. Orcutt, pp. 136-139. Revision of the bombylid genus Aphoebantus, by D. W. Coquillett, pp. 254-264.

Vol. VIII, March, 1892, to November, 1894, 120 pp.; 3 pll. Contains: Flowers in California, California shrubbery, with plate of Romneya; Notes on planting, by Miss K. O. Sessions; Culture of California bulbs, by Carl Purdy; Fruits all the year round, by C. R. Orcutt; New Mexico, Baja California and Southern California; The Cantillas of northern Lower California; Water on the Colorado Desert; Yucca baccata; The physical conditions of life in the depths of the sea, by Frank C. Baker, Curator Field Columbian Museum, Chicago; Lepidopterous larvae on mesquite, by C. H. Tyler-Townsend; Cacti at home, by C. R. Orcutt, 3 figs.; etc., all short articles.

Also the following: The Semi-Tropical Planter, San Diego, Vol. I, 1887, Nos. 1-8; Vol. II, No. 1; Nos. 24, 37, and 38.

The Great Southwest, San Diego, Vol. I, 1889, Nos. 1-7; Vol. II, 1890, Nos. 1-12; Vol. III, 1891, Nos. 1-12; Vol. IV, 1892, Nos. 1-5; Vol. V, 1893, Nos. 3, 42-48, 50, 51, 53, and 55, October, 1894.

Science and Horticulture, San Diego, Los Angeles, and Pasadena, 1891, Vol. I, Nos. 2-5; Vol. II, Nos. 8, 11; Vol. III, 1894, Nos. 3-6.

Out-of-Doors for Women, by Mrs. Olive L. Orcutt, Publisher, San Diego, Los Angeles, and Orcutt, Vol. I, 1893-'4, Nos. 2, 3, 5, 7, 8, 9, 11, 12.

PASADENA.—(See Orcutt.)

SACREMENTO.—California State Board of Horticulture, B. M. Lelong, Secretary:

Annual Report for 1891, 15x23 cm., bound in black cloth, 463 pp., with map of the state, showing counties, railroads, mountains, valleys, lakes, etc.

California State Mining Bureau, J. J. Crawford, State Mineralogist:

Bulletin No. 1. A Description of the desiccated human remains in the California State Mining Bureau, by Winslow Anderson, M. D., 1-31 pp.; 4 figs.; also Historical sketch of the Pacific coast aborigines, pp. 32-41.

No. 2. Methods of mine timbering, by W. H. Storms. 51 pp.; 40 figs.

No. 3. The gas and petroleum yielding formations of the central valley of California, by W. L. Watts, M. E. 95 pp.; 10 colored plates; 4 maps; 5 figs.

No. 4. Catalogue of California Fossils, by J. G. Cooper. 59 pp.; 6 colored plates.

Eleventh Report of the State Mineralogist (first biennial), two years ending September 15, 1892. 572 pp; 13 large maps; 14 lithographic plates; 15 photoplates; 19 figs.; 20 sketch maps and sections.

Twelfth Report of the State Mineralogist (second biennial), two years ending September 15, 1894. 542 pp.; 2 large maps; 2 lithographic plates; 25 photoplates; 35 figs.; 25 sketch maps and sections.

SAN DIEGO.—(See Orcutt.)

SAN FRANCISCO.—California Academy of Sciences:

Proceedings, Second Series, Volume III, Part 2, 1890-1892, 383 pp.; 14 pll. On the Prothallium and Embryo of Marsilia vestita, by Douglas H. Campbell, pp. 183-206. A new Notodonta, by H. H. Behr, pp. 206. Land and fresh-water mollusca of Lower California, by J. G. Cooper, pp. 207-218; 338-345. Additions to the flora of the Cape region of Baja California, by T. S. Brandegee, pp. 218-228. Anatomical studies of new species of Ocnerodrilus, by Gustav Eisen, pp. 228-290. Anatomical structures of two species of Kerria, by Gustav Eisen, pp. 291-318. An Illustration of the flexure of rock, by George H. Ashley, pp. 319-324. Geological surveys in the state of California, by Anthony W. Vogdes, pp. 325-337. Description of a new kangaroo rat from Lower California (Dipodomys merriami melanurus subsp. nov.), collected by Walter E. Bryant, by C. Hart Merriam, pp. 345-347.

Vol. IV, Part 1, 1893-1894, 457 pp.; 14 pll. Report on some Mexican Hymenoptera, by William J. Fox, pp. 1-25; 92-121. Collection of Formicidae from Lower California and Sonora, Mex., by Theo. Pergande, pp. 26-35. Tunicata of the Pacific Coast of N. A. 1.—Perophora annectens n. sp., by William E. Ritter, pp. 37-85. Studies in Portulacaceae, by Katharine Brandegee, pp. 86-91. Some parasitic hymenoptera from Lower California, by William H. Ashmead, pp. 122-129. Land and fresh-water mollusca of Lower California, by J. G. Cooper, pp. 130-143. Description of a new species of ribbon fish (Trachypterus rexsalmonorum) from San Francisco, by David S. Jordan and Charles H. Gilbert, pp. 144-146. Description of a little known agonoid fish (Hippocephalus japonicus), by Frank Cramer, pp. 147-153. Description of a new wood-rat from the Coast range of Central California, by W. W. Price, pp. 154-156. Description of a new species of wood-rat from Arizona, by Flora Hartley, pp. 157-160. Formicidae of Lower California, Mexico, by Theo. Pergande, pp. 161-165. On some Pliocene fresh-water fossils of California, by J. G. Cooper, pp. 166-172. Studies in Ceanothus, by Katharine Brandegee, pp. 173-222. Observations upon the heteropterous Hemiptera of Lower California, by P. R. Uhler, pp. 223-295. Descriptions of three new lizards from California and Lower California, with a note on Phrynosoma blainvillii, by John Van Denburgh, pp. 296-301. The Coleoptera of Baja California, by George H. Horn, pp. 302-449. Notes on Crotalus Michellii and "Crotalus pyrrhus," by John Van Denburgh, pp. 450-455. Phrynosoma solaris, with a Note on its Distribution, by John Van Denburgh, pp. 456-457. Pocket mice from Lower California, collected by Walter E. Bryant, by Dr. C. Hart Merriam, pp. 457-462.

Occasional Papers, IV: Part I. A Classified and Annotated Bibliography of the Palaeozoic Crustacea, 1698-1892, by Anthony W. Vogdes, pp. 1-252. Part II. Catalogue of the Trilobites, pp. 253-360. Part III. Catalogue of Nontrilobites, pp. 361-412.

San Francisco Free Public Library:

Report of the Board of Trustees, 1894, 40 pp.

Technical Society of the Pacific Coast:

Transactions, Vol. IX, No. 12. Railway Entrances to San Francisco, by R. E. Bush, pp. 287-294. A topographical map of the State of California, pp. 295-303.

Vol. X. 314 pp.; 3 maps; 11 figs. An experience with a 24-inch gas main, by J. B. Crockett, pp. 15-26. Some Problems of Municipal engineering, by Charles D. Marx, pp. 27-48. Electric transmission of power long distances, by W. C. F. Hasson, pp. 49-72. Phonographic Topography, by Ernest McCullough, pp. 73-82. Some problems in pumping fluids, by J. Richards, pp. 92-118. Inter-oceanic ship-canal communication by the American isthmus, by N. J. Mason, pp. 119-148. Notes on the artesian well and the effect of irrigation on subsurface water in the San Joaquin valley, by C. E. Grunsky, pp. 157-182. The existing state of the fluid fuel question, by Admiral Selwyn, pp. 187-198. Country road construction, by Julius H. Striedinger and Otto von Geldern, pp. 201-237. The Red Point drift gravel mine, with discussion, by Charles F. Hoffmann, pp. 291-308.

SANTA ANA.—(See Orcutt.)

COLORADO.

COLORADO SPRINGS.—Prof. F. W. Cragin, Colorado College:

On a new Cave Fauna in Utah, by A. S. Packard, jr., M. D. From Bulletin of the U. S. Geol. and Geog. Survey of the Terr., pp. 157-179; figs. 1-5.

New and Little-known Invertebrata from the Neocomian of Kansas, by F. W. Cragin, 12 pp. 1 pl.

Colorado College Studies: Fifth Annual Publication, 73 pp.; 2 pll. Origin and use of the natural gas at Manitou, Colorado, by William Strieby; pp. 14-36. Herpetological notes from Kansas and Texas, by F. W. Cragin, pp. 37-39. The Choctaw and Grayson terranes of the Arietina, by F. W. Cragin, pp. 40-48. Descriptions of invertebrate fossils from the Comanche series of Texas, Kansas, and Indian Territory, by F. W. Cragin, pp. 49-72; pl. i-ii.

DENVER.—Colorado Scientific Society:

Proceedings, Vol. III, part III, 1890. Pp. xxvii-xxxvi; 243-485; one sketch map; 1 pl. Production of carbonate of soda from the alkaline waters of Owen's lake, by Ernest LeNeve Foster; pp. 245-252. Identification of Dinosaurs from the Denver group, by Geo. L. Cannon, jr.; pp. 253, 254. Iron-ore beds at the Province of Santiago, Cuba, by F. F. Chisholm; pp. 259-263. Gold Deposits in the Quartzite Formation of Battle Mountain, by Franklin Guiterman; pp. 264-268. Geology of the Rosita Hills, Custer county, Colorado, by Whitman Cross; pp. 269-279. Fulgurite from the Spanish Peaks, by R. C. Hills; pp. 280-286. The Nature of the Chemical Elements, by Charles Skeele Palmer; pp. 287-307. Notes on the Geology of Perry Park, Colo., by Prof.

George L. Cannon, jr.; pp. 308-315. A Boulder county mine, by John F. Farish; pp. 316-322. Columbite and Tantalite from the Black Hills of South Dakota, by Dr. W. P. Headden; pp. 323-350. The Quartz Porphyry of Flagstaff Hill, Boulder county, Colorado, by Chas. S. Palmer and Henry Fulton, pp. 351-359. Orographic and structural features of Rocky Mountain geology, by R. C. Hills (Address of the retiring President), pp. 359-458.

Vol. IV ,1891, 1892, 1893, 486 pp. Artesian wells of Denver, by P. H. van Diest, pp. 1-6. Classification of the Huerfano Eocene, by R. C. Hills, pp. 7-9. Separation of manganese in the volumetric determination of zinc, by J. Dawson Hawkins, pp. 10-13. Types of past eruptions in the Rocky Mountains, by R. C. Hills, pp. 14-32. Nature of the Chemical Elements, by Charles Skeele Palmer, pp. 33-74; 165-173; 355-364. Formation of alloys of tin and iron, by Wm. P. Headden, pp. 81-122. Present limitations of electric power in mining, by Irving Hale, pp. 123-150. Ore-deposits of Newman Hill, Colo., pp. 151-164; map. Technical determination of zinc, pp. 176-191. Post-Laramie beds of Middle Park, Colo., by Whitman Cross, pp. 192-214. Volumetric method for the determination of lead, by F. C. Knight, pp. 215-223. Geology of Palmer lake, Denver, etc., by Geo. L. Cannon. jr., pp. 224-270; map. Production of columbous and tungstous oxides in forming compounds of iron and tin, by Wm. P. Headden, pp. 271-293. Latest method of electric car control, by Irving Hale, pp. 294-303; map. Review of the Russell process, by L. D. Godshall, pp. 306-322. Certain dissimilar occurrences of gold-bearing quartz, by T. A. Rickard, pp. 323-339; map. Evidence bearing on the formation of ore deposits by lateral-secretion, by P. H. van Diest, pp. 340-354. Solution of the equations, $x^2 + y = 7$, $x + y^2 = 11$, by Francis T. Freeland, pp. 367-372, with diagram. Nickel: Historical sketch, by W. L. Austin, Ph. D., pp. 373-394. Nickel: Occurrence, geological distribution, and genesis of its ore deposits, by Philip Argall, pp. 395-421; 8 figs. Question of a standard of value, by O. J. Frost, pp. 423-447.

Mode of occurrence of gold in the ores of the Cripple Creek district, by Dr. Richard Pearce, 16 pp.; 1 pl.

Sanitary chemical character of some of the wells of Denver, by Prof. C. Strong, 9 pp.

Geology of the Cripple Creek gold mining district, Colorado, by Whitman Cross, and Ore Deposits of Cripple Creek, by R. H. F. Penrose, jr., 37 pp.

Ore Deposits of Camp Floyd district, Tooele county, Utah, by R. C. Hills, 12 pp.; 2 figs.

A suspected new mineral from Cripple Creek, by F. C. Knight, 6 pp.

Notes on the geology of the western slope of the Sangre de Cristo Range in Costillo county, Colorado, by E. C. and P. H. van Diest, 5 pp.; 2 sketch maps.

DISTRICT OF COLUMBIA.

WASHINGTON.—Biological Society of Washington:

Proceedings, Vol. VIII, 1893; 151 pp.; 13 pll. A jumping mouse (Zapus insignis Miller) new to the United States, by Gerrit S. Miller, jr., April 22, 1893; 8 pp. Paleontology of the Cretaceous formations of Texas: The invertebrate paleontology of the Trinity division, by Robert T. Hill, June 3, 1893; 9-40; pll. I-VIII. Description of a new white-footed mouse from the Eastern United States, by Gerrit S. Miller, jr., June 30, 1893; pp. 55-70. Development of the brachial supports in Dielasma and Zygospira, by Charles E. Beecher and Charles Schuchert; and On the development of the shell of Zygospira recurvirostra, by Charles Schuchert, July 13, 1893; pp. 71-82; pll. X, XI. Rediscovery of The Mexican Kangaroo rat (Dipodomys phillipsi Gray), by Hart Merriam, with field-notes by E. W. Nelson, July 18, 1893; pp. 83-96. Paleontology of the Cretaceous formations of Texas and the invertebrate fossils of the Caprina limestone beds, by Robert T. Hill, July 20, 1893; pp. 97-108; pll. XII, XIII. Two new wood rats from the Plateau region of Arizona (Neotoma pinetorum and N. arizonae), with remarks on the validity of the genus Teonoma of Gray, by C. Hart Merriam, M. D., July 31, 1893; pp. 109-112. Notes on Thomomys Bulbivorus, by Gerrit S. Miller, Jr., August 16, 1893; pp. 113-116. Description of a new species of Lagomys from Alaska, by E. W. Nelson, December 21, 1893; pp. 117-120. Juncus marginatus and its varieties, by Frederick Vernon Coville, December 21, 1893; pp. 121-128. Descriptions of eight new ground squirrels of the genera Spermophilus and Tamias from California, Texas, and Mexico, by C. Hart Merriam, M. D., December 28, 1893; pp. 129-138. Description of a new species of Arvicola, of the Mynomes group, from

Alaska, by E. W. Nelson; pp. 139-142. Preliminary descriptions of four new mammals from southern Mexico, collected by E. W. Nelson, by C. Hart Merriam, December 29, 1893; pp. 143-146. The yellow bear of Louisiana (Ursus luteolus Griffith), by C. Hart Merriam, pp. 147-152.

Vol. IX, 1894; 138 pp.; 2 pll. Social insects from psychical and evolutional points of view, by C. V. Riley, Ph. D., April, 1894; pp. 1-74. Fossil Cycadean trunks of North America, with a revision of the genus Cycadeoidea Buckland, by Lester F. Ward, April 9, 1894; pp. 75-88. Notes on some appendages of the Trilobites, by Chas. D. Walcott, March 30, 1894; pp. 89-97; pl. I. Synaptomys cooperii Baird in Eastern Massachusetts; with notes on Synaptomys stonei Rhoads, especially as to the validity of this species, by Outram Bangs, Boston, April 14, 1894; pp. 99-104. A new rabbit from western Florida, by Gerrit S. Miller, Jr., and Outram Bangs, June 9, 1894; pp. 105-108. Preliminary descriptions of eleven new kangaroo rats of the genera Dipodomys and Perodipus, by Dr. C. Hart Merriam, June, 1894; pp. 109-116. Abstract of a study of the American wood rats, with descriptions of fourteen new species and subspecies of the genus Neotoma, by Dr. C. Hart Merriam, July 2, 1894; pp. 117-128. Description of a new field mouse (Arvicola terraenovae sp. nov.) from Codroy, Newfoundland, by Outram Bangs, July 27, 1894; pp. 129-132; pl. II. Description of a new musk rat from Codroy, Newfoundland, by Outram Bangs, September 15, 1894; pp. 133-138.

Dr. George H. Boehmer, Smithsonian Institution, Hon. Memb. K. A. S.:

Prehistoric Naval Architecture of the North of Europe, by George H. Boehmer. From the report of the U. S. National Museum, 1891, pp. 525-648; pll. lxviii-lxxxiv; figs. 25-151.

F. W. Clark, Ph. D., Chief Chemist U. S. Geological Survey:

Report of Committee on Atomic Weights, published during 1893. Reprinted from Journal of the American Chemical Society, Vol. XVI, No. 3, March, 1894, 15 pp.

Barton W. Evermann, Ph. D., Ichthyologist U. S. Fish Commission:

Description of a new sucker, Pantosteus Jordani, from the Upper Missouri basin, by B. W. Evermann, 19x28 cm. From Bulletin of the U. S. Fish Commission for 1892, pp. 152-156.

Report of the Commissioner of Fish and Fisheries on investigations in the Columbia river basin in regard to the salmon fisheries, same size, 57 pp.; 13 pll. The salmon fisheries of the Columbia river basin, by Marshall McDonald, U. S. Fish Commissioner, pp. 3-18; map of Montana, Idaho, Washington, and Oregon, showing waters inhabited by salmon. Report upon investigations in the Columbia river basin, with descriptions of four new species of fishes, by Prof. Chas. H. Gilbert, Leland Stanford Junior University, and Barton W. Evermann, Ichthyologist of the U. S. Fish Commission, pp. 19-57; pll. ii-xiii, including chart of the Columbia river from the Pacific ocean up past The Dalles to Celilo, 160 cm. in length.

Edward Lee Greene, Catholic University:

Manual of the Botany of the Region of San Francisco Bay, being a systematic arrangement of the higher plants growing spontaneously in the counties of Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, Santa Clara, and San Francisco, in the State of California, by Edward Lee Greene, Professor of Botany in the University of California. 328 pp.

Pittonia, a Series of Papers relating to Botany and Botanists, Vol. I, 1887-1889, 331 pp. Echinocystis sec. Megarrhiza, pp. 1-4; 143-145. West American Asperifoliae, pp. 8-23, 55-60. New Genera and Species, mostly Californian, pp. 28-40; 60-74; 139-143; 153-176; 215-225, 260; 280-292; 300-303. Botany of San Miguel, pp. 74-93. American Polemoniaceae, pp. 120-143. Botany of Cedros Island, pp. 194-208. Vegetation of San Benito islands, pp. 261-269.

Vol. II, 1889-1892, 314 pp.; one plate. Vegetative Character of the Species Cicuta, pp. 1-11. New or Noteworthy Species, pp. 11-24; 67-81; 100-106; 158; 161-171; 216-233; 282; 293-298. The North American Neilliae, pp. 25-31. Contributions to North American Euphorbiaceae, by C. F. Millspaugh, M. D., pp. 82-89; pl. I. Reprint of Fraser's Catalogue, pp. 114-119. Genera of Rafinesque, pp. 120-133. North American Loti, pp. 133-150. Priorities in Generic Nomenclature, pp. 173-184. Studies in the Compositae, pp. 242-251; 287-290. American Polemoniaceae, pp. 251-260.

Chas. W. Smiley, Publisher:

The American Monthly Microscopical Journal, containing contributions to biology. Vol. XIII, 1892, Nos. 10-12, pp. 225-292; 3 pll. Index of refraction, by A. B. Aubert, M. S. The Protozoa—a phylum of the animal kingdom considered biologically, by H. L. Osborn. A Bacteriological potato-section cutter, by Charles F. Dawson, M. D. Bacteriology: What has been done in relation to Hygiene. Diatomology, by K. M. Cunningham. Diatoms of the Connecticut shore.—III, by W. A. Terry. Radiolaria: Life-history and classification, by Rev. Fred'k B. Carter. The analyzing eye-piece, by William Lighton. The practical use of the microscope in Pharmacy, by Alfred H. Dohme, Ph. D. Bacterioidal forms in tissues and eggs of insects, by Prof. F. Blochmann. Notes on new rotifers, by Charles Rousselet. Callidina magnacalcarata, by F. A. Parsons. The grasshopper, Oedipoda carolina: An introductory study in Zoology, by H. L. Osborn. The Brine Shrimp of the Great Salt Lake, by J. E. Talmage.

Vol. XIV, Nos. 1-12, 1893, 358 pp; 12 pll. Contains: Experiments with Yeast—a biological study, by J. W. Smith. A parasitic fungus (Heterosporium asperatum), by George Massee. Influence of the study of bacteriology in the development of aseptic surgery in the hospitals of Paris in 1892, by Robert Reyburn. Diatoms of the Connecticut shore.—IV, by Wm. A. Terry. Has the fresh-water sponge a nervous system? by J. M. Stedman. Biological descriptions of certain common hydroid animals, by H. L. Osborn. Radiolaria, by Rev. Fred'k B. Carter. On some minute magnetic and hyaline spherules found in terrace dust, from Bulletin of the Microscopical Society of Calcutta. Seeds of Mullein (Verbascum thapsus L.), by R. H. Ward, M. D. Flexible sandstone, by R. D. Oldham. A study of a new fungus, by Geo. F. Atkinson. A pneumatic bubble remover, by A. P. Weaver. On some recent advances in water analysis and the use of the microscope for the detection of sewage contamination, by Geo. W. Rafter. On the microscope in medicine, by Ephriam Cutter, M. D., LL. D. Trichinae spiralis, by W. N. Sherman; 4 colored figures. The American potato rot or blight, by Joseph F. James, 2 figs. Crenation of red blood-corpuscles, by M. L. Holbrook. Microscopical study of Ohio limestone, by G. Perry Grimsley. Spiral vessels of castor-oil plant, by R. H. Ward. The contractile vesicle, by Dr. Alfred C. Stokes. Fungous diseases of the sugar-beet, by L. H. Pammel; 4 plates. Magnetic and glassy particles on house-tops, by K. M. Cunningham. Microscopy at the Columbian Exposition, by Henry L. Tolman. Classification of the Radiolaria, by Rev. Fred'k B. Carter. The use of ruthenium red in plant histology, by A. B. Aubert. Penicillium and some other fungi, by Henry Leslie Osborn. Aberrant forms in cultivated diatoms, by Dr. Samuel Lockwood. Observations on Amoeba and Stentor, by James H. Logan; 11 figures. Preliminary list of the microscopical animals found in the Ridgewood water-supply, by Smith Ely Jelliffe. The Chicago water-supply in the World's Fair Ground, by Smith Ely Jelliffe. Karyokinesis in embroyos of the domestic cat, by Frank S. Aby. Stereoscopic photomicrography, by Dr. W. C. Borden. The action of leucocytes toward foreign material, by Edith J. Claypole.

Vol. XV, Nos. 1-11, 1894, 360 pp.; 11 pll. On the Study of Yeasts, with descriptions of the Hansen culture box and of a new infection needle for the study of lower organisms, by J. Christian Bay. Sarcina ventriculi in blood stains, by W. N. Sherman. The Bacillariaceae or Diatomaceae, by Arthur M. Edwards. Aeration of tissues and organs in Mikania and other phanerogams, by W. W. Rowlee. Radiolarian shale from Manitoba, by Fred'k B. Carter. Studies of the histology of various mammalian tissues, by Henry L. Osborn. Red snow as seen by means of a microscope, by Arthur M. Edwards. Formalin in Bacteriology, with more especial reference to its action on the bacillus of diphtheria, by Dr. W. W. Alleger. Studies in the biology of the Diatoms, by K. M. Cunningham. Some new or little-known Diatoms, by M. P. T. Cleve. The Diatom, considered as a protozoan, with method of demonstration, by K. M. Cunningham. Synura, with plate, by George C. Whipple. On the limitation of Tuberculosis, by Dr. W. W. Alleger. Study of the microscopic phenomena of commencing inflammation, with special reference to the diapedesis of the white blood corpuscles, by Charles F. Craig, M. D. The geranium leaf as a cell aggregate, by Henry L. Osborn. The fruits of the order Ranunculaceae, by Karl M. Wiegand. Histological structure of the enteron of Necturus maculatus, by B. F. Kingsbury. Keys to the genera of Pediculidae and Mallophagidae, by Herbert Osborn.

WASHINGTON.—Congres Geologique International:

Compte Rendu de la Cinquieme Session, Washington, 1891, 530 pp.; 21 pll.; 39 figs. Troisieme Partie: A. La correlation par plantes fossiles, par L. F. Ward; pp. 97-109. B. The Pre-Cambrian rocks of North America, by C. R. Van Hise; pp. 110-150. Quatrieme Partie: A. Geology of Washington and vicinity, by W. J. McGee; pp. 219-251. B. Geological Guide Book of the Rocky Mountain excursion, edited by Samuel Franklin Emmons; pp. 253-487; pll. i-xiii; figs. 1-32; map. C. Excursion to Lake Superior: Pre-Cambrian geology of the Lake Superior region, by C. R. Van Hise; pp. 489-512; pll. xiv-xxi; figs. 33-39.

Smithsonian Institution, S. P. Langley, Secretary:

Annual Report of the Board of Regents, for the year ending June 30, 1891, 750 pp.; 15 fig., bound in black cloth. Celestial Spectroscopy, by Wm. Huggins, pp. 69-102. Stellar Numbers and Distances, the Sun's Motion in Space, and the Southern Observatory, by Agnes M. Clerke, pp. 103-126. Applications of Physics and Mathematics to Geology, by C. Chree, pp. 127-153. Origin of Rock Pressure of natural gas in Ohio and Indiana, by Edwin Orton, pp. 155-162. Geysers, by Walter H. Weed, pp. 163-178. The Gulf Stream, by Alexander Agassiz, pp. 189-206; 6 figs. On the Absolute Measurement of Hardness, by F. Auerbach, translated by Carl Barus, pp. 207-236. The Flow of Solids, by Wm. Hallock, pp. 237-246; 4 figs. Divergent evolution through cumulative segregation, by Rev. J. T. Gulick, pp. 269-336. The Struggle for Life in the Forest, by James Rodway, pp. 337-347. Geographic distribution of life in North America, by C. Hart Merriam, M. D., pp. 365-415. The Corbin Game Park, by John R. Spears, pp. 417-423; 1 fig. Summary of progress in anthropology in 1891, by Otis T. Mason, pp. 433-502. The Mounds of the Mississippi Valley, historically considered, by Lucien Carr, pp. 503-599. Some of the possibilities of Economic Botany, by G. L. Goodale, pp. 617-646. On the Relation of Natural Science to Art, by Dr. E. du Bois-Reymond, F.R.S., pp. 661-682.

Annual Report for the year ending June 30, 1892, 860 pp.; 178 figs. The History of the Telescope, by Prof. C. S. Hastings, pp. 95-109. Geological Change, and Time, by Sir Archibald Geikie, pp. 111-131. Geological History of the Yellowstone National Park, and Soaping Geysers, by Arnold Hague, pp. 133-161; map. Continental Problems of Geology, by G. K. Gilbert, pp. 163-173; 5 figs. Pre-Columbian Copper Mining, by R. L. Packard, pp. 175-198. Discharge of Electricity through exhaustive tubes without electrodes, by J. J. Thomson, F.R.S., pp. 229-254; 15 figs. The Molecular Process in Magnetic Induction, by Prof. J. A. Ewing, F.R.S., pp. 255-268; 15 figs. Crystallization, by G. D. Liveing, F.R.S., pp. 269-280; 7 figs. The Rejuvenescence of Crystals, by Prof. John W. Judd, F.R.S.,; pp. 281-288. Deduction from the Gaseous Theory of Solution, by Prof. Orme Masson; pp. 287-298; 3 figs. Liquids and Gases, by Prof. Wm. Ramsey, F.R.S.; pp. 303-312; 2 figs. Present Problems in Evolution and Heredity, by Henry Fairfield Osborn; pp. 313-374; 12 figs. Report on the Migration of Birds, by Prof. J. A. Palmen; pp. 375-386; 1 pl. The Empire of the Air: an ornithological essay on the flight of birds, by L. P. Mouillard; pp. 397-463; 14 figs. Progress of Anthropology in 1892, by Prof. Otis T. Mason; pp. 465-512. The Advent of Man in America, by Armand de Quatrefages; pp. 513-520. Prehistoric New Mexican Pottery, by Henry Hales; pp. 535-554; 17 figs. Relics of an Indian Hunting Ground in York county, Pa., by Atreus Wanner; pp. 555-570; 68 figs. Aboriginal Burial Mounds in Seneca county, Ohio, by Russell J. Thompson; pp. 571-575; 4 figs. Indian Remains on the Upper Yellowstone, by Col. Wm. S. Brackett; pp. 577-581; 3 figs. The Inventors of the Telegraph and Telephone, by Prof. Thomas Gray, F. R. S. E., pp. 639-657. Explorations in Mongolia and Tibet, by W. Woodville Rockhill; pp. 659-679; 12 figs. Progress of Astronomy for 1891, 1892, by Wm. C. Winlock, pp. 681-774.

Annual Report for the year ending June 30, 1893, 808 pp.; 94 pll. The Wanderings of the North Pole, by Sir Robert Ball, F. R. S.; pp. 75-87. The Great Lunar Crater Tycho, by A. C. Ranyard; pp. 89-94. The Early Temple and Pyramid Builders, by J. Norman Lockyer; pp. 95-105. Variable Stars, by Prof. C. A. Young; pp. 107-111. The Luminiferous Ether, by Sir G. Stokes; pp. 113-119. Atoms and Sunbeams, by Sir Robert Ball, F. R. S.; pp. 121-133. Fundamental Units of Measure, by T. C. Mendenhall; pp. 135-149. Photography in the Colors of Nature, by F. E. Ives; pp. 151-162. Electric Spark Photographs of Flying Bullets, by C. V. Boys, F. R. S.; pp. 165-182; pll. II-XII. Magnetic Properties of Liquid Oxygen, by Prof. James Dewar; pp. 183-187; 1 fig. The

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U. S. Government Collections, by R. W. Shufeldt, M. D., pp. 369-436; pll. XV-XCVI. 4. The Shofar—its use and origin, by Cyrus Adler, Assistant Curator of Oriental Antiquities, pp. 437-450; pll. XCVII-C. 5. The Crump Burial Cave, Blount county, Ala., by Frank Burns, U. S. Geological Survey, pp. 451-454; pl. CI. 6. Minute stone implements from India, by Thomas Wilson, Curator of Prehistoric Anthropology, pp. 455-460; pll. CII, CIII. 7. Comparative Oology of North American Birds, by R. W. Shufeldt, M. D., pp. 461-493.

United States Commission of Fish and Fisheries, Marshall McDonald, Commissioner:

Bulletin, Vol. VI, 1886, 15x23 cm., bound in black cloth, 495 pp.; 7 pll.; 19 figs. Contains 136 short articles giving general accounts of the fisheries of the Atlantic Coast, Pacific Coast, Gulf of Mexico, the Great Lakes, New England, Canadian, Newfoundland and Labrador, Scotch, Maltese, Australian, Norwegian, and Japanese fisheries; with accounts of cod, mackerel, halibut, herring, sardine, salmon, lobster, oyster, and other fisheries; natural history of fishes; enemies of fish and oysters; deep-sea research and tools; and fish culture in general, including the culture and distribution of shad, whitefish, catfish, salmon, trout, carp, striped bass, goldfish, and other fishes, with instructions for fish culture and distribution of fish.

Vol. VII, 1887, same size, 475 pp.; 23 pll.; 55 figs. Contains the following, among other titles: The Canadian and American fisheries of the Great Lakes, by John H. Russell, pp. 7-11. Loch Leven trout introduced in the United States, by Charles W. Smiley; pp. 28-32. Notes upon Fish and the Fisheries, pp. 33-48. Hatching cod in Norway, by Carl Rognerud, pp. 113-119. Report of the fishes observed in Great Egg Harbor bay, New Jersey, during the summer of 1887, by Tarleton H. Bean, pp. 129-152; pll. I-III. American sardine industry in 1886, by R. Edward Earll and Hugh M. Smith, pp. 161-192. Results of investigations of the schooner Grampus on the Southern mackerel grounds in the spring of 1887, by D. E. Collins, T. H. Bean, and Richard Rathbun, pp. 217-267. The Aquarium: A brief exposition of its principles and management, by William P. Seal, pp. 274-282. The Beam-trawl fishery of Great Britain, with notes on beam-trawling in other European countries, etc., by J. W. Collins, pp. 289-407; pll. IV-XXIII; 34 figs. Results of salmon planting in the Hudson river, by Fred Mather, pp. 409-424. Review of the Mackerels (Scombrinae) of America and Europe, by Fletcher B. Dresslar and Bert Fesler, pp. 429-446; pll. I-XI.

Vol. VIII, 1888, 18x27 cm., bound in black cloth, 494 pp.; 74 plates and maps; 76 figs. Albatross Explorations: Alaska, Washington and Oregon, by Z. L. Tanner, U. S. N., commanding, pp. 1-96; pll. I-XII; map of Alaska peninsula, 80x160 cm., also map of the western coast of the United States from Umpqua river to Vancouver Island, 30x60 cm. Explorations of the Allegheny region and Western Indiana, by David Starr Jordan, pp. 97-173; pll. XIII-XV; figs. 1-13. Suggestions for improving fishing vessels, by J. W. Collins, pp. 175-192; pll. XVI-XXVII. Fishes of Yucatan, by Tarleton H. Bean, pp. 193-206; pll. XXVIII-XXIX. Recent methods of hatching fish eggs, by Wm. F. Page, pp. 207-218; pll. XXX-XXXIV; figs. 1-4. Report on Michigan fishes, by C. H. Bollman, pp. 219-225. Sturgeon industries of the eastern coast, by John A. Ryder, pp. 231-328; pll. XXXVII-LIX. Review of Serranidae in the waters of America and Europe, by David Starr Jordan and Carl H. Eigenmann, pp. 329-441; pll. LX-LXIX. Transplanting of lobsters to the Pacific coast, by Richard Rathbun, pp. 443-472; pll. LXX, LXXI. Invertebrates of lakes Geneva and Mendota, Wis., by S. A. Forbes, pp. 473-494; pll. LXXII-LXXIV.

Vol. IX, 1889, 516 pp.; 166 pll. Explorations in Colorado and Utah during the summer of 1889, by David Starr Jordan, pp. 1-40; pll. I-V. Streams and lakes of the Yellowstone National Park, by David Starr Jordan, pp. 41-63; pl. VI-XXII; map of the park 36x50 cm. Two species of larval Dibothria from the Yellowstone National Park, by Dr. Edwin Linton, pp. 65-79, 337-361; pll. XXIII-XXVII, CXVII-CXIX. Fishes of Missouri and Arkansas, by S. E. Meek, pp. 113-141; pl. XLII. Fishes of Alabama and Tennessee, by Charles H. Gilbert, pp. 143-159; pl. XLIII. Salmon and salmon rivers of Alaska, by Tarleton H. Bean, pp. 165-208; pll. XLV-LXXIX, including several maps folded in. Embryology of the sea bass (Serranus atratus), by Henry V. Wilson, pp. 209-277; pll. LXXXVIII-CVII; 12 figs. in text. Fishing grounds off west coast of Florida, by A. C. Adams and W. C. Kimball, pp. 289-312, pl. CXI; 1 figure in text. Giant scallop fishery of Maine, by Hugh M. Smith, pp. 313-335; pll. CXII-

CXVI, with map. Physical investigations off New England coast, made 1889, by U. S. F. C. Grampus, by Wm. Libby, Jr., pp. 391-459; pll. CXXIV-CLVIII. Oyster fishery of Connecticut, by J. W. Collins, pp. 461-497; pll. CLIX-CLXVI.

Vol. X, 1890, 460 pp.; 94 pll.; 11 figures in text. Observations on Aquaria at Central station, pp. 1-12; pll. I-IV. Fishing vessels and boats of the Pacific coast, by J. W. Collins, pp. 13-48; pll. V-XVII. Notes on a collection of fishes from the lower Potomac river, by Hugh M. Smith, M. D.; pp. 63-72; pll. XVIII-XX. Fisheries of New England States, by J. W. Collins and Hugh M. Smith, pp. 73-176. Fisheries of Lake Ontario, by Hugh M. Smith, M. D.; pp. 177-125; pll. XXI-L. Fishes of Iowa, by S. E. Meek, pp. 217-248. Fishes of Kentucky, by Albert J. Woolman, pp. 249-292; pl. LI. Oyster culture in South Carolina, by John D. Battle, pp. 303-330; 7 maps of the coast of South Carolina, averaging 40-70x60-75 cm., folded in. Biology of the oyster grounds of South Carolina, by Bashford Dean, pp. 335-362; pll. LXII-LXVII. Oyster culture in France, by Bashford Dean, pp. 363-388; pll. LXVIII-LXXVIII; 2 figures in text. Morphology of lamellibranchiate mollusks, by James L. Kellogg, pp. 389-436; pll. LXXIX-XCIV.

Vol. XI, 1891, 436 pp.; 88 pll. Fish-cultural investigations in Montana and Wyoming, by Barton W. Evermann, pp. 3-60; pll. I-XXVII. Investigations in Texas in 1891, by Barton W. Evermann, pp. 61-90; pll. XXVIII-XXXVI. Fisheries of the Gulf States, by J. W. Collins and Hugh M. Smith, pp. 93-200. Invertebrate fauna of Wyoming and Montana, by S. A. Forbes, pp. 207-258; pll. XXXVII-XLII. Fisheries of the South Atlantic states, by Hugh M. Smith, pp. 271-356; pll. XLIII-LXXXIV. European methods of oyster culture, by Bashford Dean, pp. 357-406; pll. LXXXV-LXXXVIII.

Commissioner's Report, Part XVI, for 1888, 15x23 cm., bound in black cloth, 1006 pp.; 90 plates and charts; 133 figures. Fisheries of the Pacific coast of the United States, by J. W. Collins, pp. 3-269; pll. I-XLIX. Investigations of the steamer Albatross, for the year ending June 30, 1889, by Z. L. Tanner, pp. 395-512; pll. L-LII. Notes on entozoa of marine fishes, with descriptions of new species, by Edwin Linton, pp. 523-542; pll. LIII-LX; 90 figs. Anatomy of Thysanocephalum crispum Linton, by Edwin Linton, pp. 543-566; pll. LXI-LXVII; 43 figs. Review of the Centrarchidae of North America, by Charles H. Bollman, pp. 557-579; pll. LXVIII-LXXII. Review of the apodal fishes of America and Europe, by D. S. Jordan and B. M. Davis, pp. 581-677; pll. LXXIII-LXXX. Chemical composition of food-fishes, by W. O. Atwater, pp. 679-868; pll. LXXXI-LXXXIX. U. S. Fish Commission in the Centennial Exposition at Cincinnati, 1888, by J. W. Collins, pp. 869-885; pl. XC.

Commissioner's Report, Part XVII, 1889-1891, 848 pp.; 67 pll. Investigations of the Albatross from July 1, 1889, to June 30, 1890, by Z. L. Tanner, pp. 207-342; pl. I. Oyster resources and fisheries of the Pacific Coast, by Chas. H. Townsend, pp. 343-372; pll. 2-11. Coast fisheries of Texas, by Charles H. Stevenson, pp. 373-420; pll. 12-27. Sparoid fishes of America and Europe, by David Starr Jordan, pp. 421-544; pll. 28-62. Entozoa from Yellowstone park, by Edwin Linton, pp. 545-564; pll. 63-67; figs. 51, 52. Plankton Studies, by Ernst Haeckel, translated by George Wilton Field, pp. 565-641.

The Fisheries and Fishery Industries of the United States, by George Brown Goode, Assistant Director of the U. S. National Museum, and staff of associates, 23x29 cm., bound in black cloth. Section I. Natural History of Useful Aquatic Animals, with an atlas of 277 pll. Vol. I, text, 930 pp. Vol. II, 277 plates, separately bound. Part I. Mammals. A.—The whales and porpoises, by G. Brown Goode; pp. 7-32, pll. 1-11. B.—The seals and walruses, by Joel A. Allen; pp. 33-74; pll. 12-25. C.—The habits of the fur-seal, by Henry W. Elliott; pp. 75-113; pll. 26-32. D.—The manatees and the Arctic Sea-cow, by Frederick W. True; pp. 114-140; pll. 33, 34. Part II. Reptiles and batrachians, by Frederick W. True; pp. 141-167. Part III. Fishes, by G. Brown Goode; pp. 169-682; pll. 35-252. Part IV. Mollusks, by Ernest Ingersoll and John R. Ryder; pp. 687-750; pll. 252-260. Part V. Crustaceans, worms, radiates, and sponges, by Richard Rathbun; pp. 763-850; pll. 261-277.

Section II. Geographical Review for the year 1880, 788 pp. Part I. The Coast of Maine and its Fisheries, by R. Edward Earll; pp. 1-102. Part II. The Fisheries of New Hampshire, by W. A. Wilcox; pp. 105-112. Part III. The Fisheries of Massachusetts, by A. Howard Clark; pp. 115-280. Part IV. The Fisheries of Rhode Island, by A. Howard Clark; pp. 283-310. Part V. The Coast of Connecticut and its Fisheries, by A. Howard Clark; pp. 313-340. Part

VI. New York and its Fisheries, by Fred Mather; pp. 343-378. Part VII. New Jersey and its Fisheries, by R. Edward Earll; pp. 381-400. Part VIII. Pennsylvania and its Fisheries, by R. Edward Earll; pp. 403-406. Part IX. Delaware and its Fisheries, by Joseph W. Collins; pp. 409-420. Part X. Maryland and its Fisheries, by R. Edward Earll; pp. 423-448. Part XI. Virginia and its Fisheries, by Marshall McDonald; pp. 451-474. Part XII. North Carolina and its Fisheries, by R. Edward Earll; pp. 477-498. Part XIII. The Fisheries of South Carolina and Georgia, by R. Edward Earll; pp. 501-518. Part XIV. Eastern Florida and its Fisheries, by R. Edward Earll; pp. 521-532. Part XV. Fisheries of the Gulf of Mexico, by Silas Stearns; pp. 535-588. Part XVI. The Fisheries of the Pacific Coast, by David Starr Jordan; pp. 591-630. Part XVII. The Fisheries of the Great Lakes, by Frederick W. True; pp. 633-674. Appendix. Historical Reference to the Fisheries of New England, by A. Howard Clark; pp. 677-738.

Section III. The Fishing Grounds of North America with forty-nine charts, edited by Richard Rathbun, 238 pp.; 4 pll. A.—The Fishing Grounds of the Eastern Coast of North America from Greenland to Mexico, by Joseph W. Collins and Richard Rathbun; pp. 5-75; 11 charts. B.—From the Straits of Fuca to Lower California, by David Starr Jordan; pp. 79-81. C.—Fishery Resources of Alaska, by Tarleton H. Bean; pp. 82-116. D.—Fishery resources of the Great Lakes, by Ludwig Kumlien and Frederick W. True; pp. 117-130. E.—Geographical Distribution of Fresh-water Food-fishes in the several hydrographic basins of the U. S., by David Starr Jordan; pp. 133-144. Ocean Temperatures of the Eastern Coast of the United States, with 32 charts, by Richard Rathbun; pp. 155-238.

Section IV (bound with Section III). The Fishermen of the United States, by G. Brown Goode and J. W. Collins; pp. 1-178; pll. 1-19.

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Vol. II, text, 904 pp. Part XV, The Whale Fishery, by A. Howard Clark and James T. Brown; pp. 3-293. Part XVI. The Blackfish and Porpoise Fisheries, by A. Howard Clark; pp. 295-310. Part XVII. The Pacific Walrus Fishery, by A. Howard Clark; pp. 311-318. Part XVIII. The Seal and Sea-Otter Industries, by Henry W. Elliott and others; pp. 320-491. Part XIX. The Turtle and Terrapin Fisheries, by Frederick W. True; pp. 493-504. Part XX. The Oyster, Scallop, Clam, Mussel, and Abalone Industries, by Ernest Ingersoll, pp. 507-626. Part XXI. The Crab, Lobster, Crayfish, Rock-Lobster, Shrimp, and Prawn Fisheries, by Richard Rathbun; pp. 629-810. Part XXII. The Leech Industry and Terpang Fishery, by Richard Rathbun; pp. 811-816. Part XXIII. The Sponge Fishery and Trade, by Richard Rathbun; pp. 817-841.

United States Department of Agriculture, Sterling J. Morton, Secretary:

Annual Report of the Secretary for 1886, 720 pp.; 37 figs.; 45 pll., bound in black cloth. Reports of the Botanist, Geo. Vasey, pp. 69-94; figs. 1-21. Mycological Section, F. Lamson-Scribner, pp. 95-139; pll. I-VIII; 3 maps. Microscopist, Thos. Taylor, pp. 139-148; pll. I-VII. Ornithologist, C. Hart Merriam, pp. 227-258; figs. 1, 2; map. Pomologist, H. E. Van Deman, pp. 259-276; pll. I-X. Entomologist, C. V. Riley, pp. 459-592; pll. I-XI. Bureau of Animal Industry, D. E. Salmon, Chief, pp. 593-686; pll. I-IX.

Report for 1887, 724 pp.; 5 figs.; 61 pll. Reports of the Entomologist, C. V. Riley, pp. 48-180; pll. I-VIII. Botanist, Geo. Vasey, pp. 301-322; pll. I-XVII. Vegetable Pathologist, F. Lamson-Scribner, pp. 323-398; pll. I-XVIII. Ornithologist and Mammalogist, C. Hart Merriam, pp. 299-456; 1 pl. Bureau of Animal Industry, D. E. Salmon, Chief, pp. 457-522; pll. I-IV. Forestry Division, B. E. Fernow, Chief, pp. 605-616; map of Rocky mountain region, 48x77 cm., showing timber areas. Microscopist, Thos. Taylor, pp. 617-626; pll. I-VII. Pomologist, H. E. Van Deman, pp. 627-652; pll. I-IX.

Report for 1888, 708 pp.; 63 plates, some of them colored lithographs; 1 map. Reports of the Entomologist, C. V. Riley, pp. 53-144; pll. I-XII. Bureau of Animal Industry, D. E. Salmon, Chief, pp. 145-220. Chemist, H. W. Wiley, pp. 221-304. Botanist, Geo. Vasey, pp. 305-324; pll. I-XIII. Section of Vegetable Pathology, B. T. Galloway, Chief, pp. 325-404; pll. I-XIX; map of the United States, 42x77 cm., showing distribution of potato rot. Ornithologist, C. Hart Merriam, M. D., pp. 477-536; 3 figs. Microscopist, Thomas Taylor, pp. 559-564; pll. I-IX. Pomologist, H. E. Van Deman, pp. 565-596; pll. I-X. Chief of Forestry Division, B. E. Fernow, pp. 597-641; figs. 1-3. Ostrich Farming in America, by T. C. Duncan, Ph. D.; pp. 685-702; 2 pll.

Report for 1889, 560 pp.; 44 litho. and other plates. Reports of the Microscopist, Thos. Taylor, pp. 191-200; 13 litho. plates (colored). Entomologist, C. V. Riley, pp. 331-362; pll. I-VI. Ornithologist and Mammalogist, C. Hart Merriam, Chfef of Division, pp. 363-376; pll. I, II, colored. Botanist, Dr. Geo. Vasey, pp. 377-396; pll. I-XI. Section of Vegetable Pathology, B. T. Galloway, Chief, pp. 397-432; pll. I, II. Pomologist, H. E. Van Deman, pp. 433-452; pll. I-X.

Report for 1890, 612 pp.; 50 plates, some of them colored. Reports of the Chief of the Bureau of Animal Industry, D. S. Salmon, pp. 75-132. Chemist, H. W. Wiley, pp. 133-192. Division of Forestry, B. E. Fernow, Chief, pp. 193-236. Entomologist, C. V. Riley, pp. 237-264; pll. I-VII. Ornithologist, C. H. Merriam, pp. 277-285. Microscopist, Thomas Taylor, pp. 361-374; pll. I-XI. Botanist, Geo. Vasey, pp. 375-392; pl. I-VIII. Chief of the Division of Vegtable Pathology, B. T. Galloway, pp. 393-408; pll. I-V. Pomologist, H. E. Van Deman, pp. 409-424; pll. I-IX. Artesian and Underflow Investigations, Richard J. Hinton, Special Agent, pp. 471-488; map of the Great Plain region, 20x40 cm., showing artesian wells. Division of Garden and Grounds, Wm. Saunders, Supt., pp. 557-596, contains a descriptive catalogue of 431 economic plants.

Report for 1891, 654 pp.; 59 colored litho. and other plates. Reports of the Chief of the Division of Forestry, B. E. Fernow, pp. 191-229; pll. I-VIII, including 3 maps showing distribution of pines in the United States. Entomologist, C. V. Riley, pp. 231-266. Ornithologist and Mammalogist, C. Hart Merriam, Chief, pp. 267-271. Botanist, Geo. Vasey, pp. 341-358; pll. I-X. Division of Vegetable Pathology, B. T. Galloway, Chief, pp. 359-378; pll. I-III. Pomologist, H. E. Van Deman, pp. 379-404; pll. I-XI. Microscopist, Thomas Taylor, Chief, pp. 405-417; pll. I-IX. Fiber Investigations, Chas. R. Dodge, Special Agent, pp. 417-438; pll. I, II. Artesian and Underflow Investigations and Irrigation Inquiry, Richard J. Hinton, Special Agent, pp. 439-450; map of Western United States, 50x66 cm. Weather Bureau, Mark W. Harrington, Chief, pp. 539-631; pl. I-VIII, including 6 weather maps of the United States.

Report for 1892, 656 pp.; 71 plates, some colored. Reports of the Bureau of Animal Industry, D. E. Salmon, Chief, pp. 85-122. Division of Chemistry, H. W. Wiley, Chemist, pp. 123-152. Division of Entomology, C. V. Riley, Entomologist, pp. 153-180; pll. I-XII. Ornithologist and Mammalogist, C. Hart Merriam, pp. 181-200; pll. I-V, gophers in colors. Botanist, Geo. Vasey, pp. 201-214; pll. I-IX. Division of Vegetable Pathology, B. T. Galloway, Chief, pp. 215-246; pll. I-IV. Pomologist, H. E. Van Deman, pp. 247-280; pll. I-XIII. Microscopist, Thos. Taylor, pp. 281-292; pll. I-IX. Division of Forestry, B. E. Fernow, Chief, pp. 293-358; pll. I-VI. Fiber Investigations, Charles Richard Dodge, Special Agent, pp. 359-376; pll. I-VI. Weather Bureau, Mark W. Harrington, Chief, pp. 551-626; pll. I-IV, including 2 weather maps of the United States. Special Report on tea raising in South Carolina, by Chas. U. Shepard, pp. 627-640; pl. I-III.

Bulletins: Artesian Wells upon the Great Plains; being the report of the Geological Commission appointed to examine a portion of the Great Plains east of the Rocky Mountains, and report upon the localities deemed most favorable for making experimental borings, 1892, 38 pp.; 1 large map.

Report of the Special Agent in charge of the Artesian and Underflow Investigations and of the Irrigation Inquiry, for 1891, by Richard J. Hinton. From report of the Secretary of Agriculture, 1891, pp. 439-450; map of western half of United States 50x66 cm., showing artesian wells and irrigation canals.

United States Department of Agriculture—Division of Botany, Frederick V. Coville, Botanist:

Annual Report of the Botanist, for 1891, by Geo. Vasey. From the Report of the Secretary of Agriculture for 1891, pp. 341-358; pll. I-X.

Annual Report for 1893, by Frederick V. Coville. From the Report of the Secretary of Agriculture for 1893, pp. 235-244.

Bulletins, No. 12, 19x29 cm. Grasses of the Southwest; Plates and Descriptions of the grasses of the desert region of Western Texas, New Mexico, Arizona, and Southern California, by Dr. Geo. Vasey, Botanist Department of Agriculture. Part I, issued October 13, 1890, 50 plates and descriptions. Part II, issued December, 1891, 50 plates and descriptions.

No. 13, same size. Grasses of the Pacific Slope. Plates and descriptions of the grasses of California, Oregon, Washington, and the Northwestern Coast, including Alaska and the adjacent islands, by Dr. Geo. Vasey, Botanist of the U. S. Department of Agriculture. Part I, issued October 20, 1892, plates and descriptions, I-L. Part II, issued June 1, 1893, plates and descriptions, LI-C.

No. 14, 15x23 cm. Ilex Cassine, the aboriginal North American tea, its history, distribution, and use among the native North American Indians, by E. M. Hale, M. D., 22 pp.; 1 pl.

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Farmers' Bulletin, No. 10. The Russian Thistle and other troublesome weeds in the wheat region of Minnesota and North and South Dakota, by L. H. Dewey, 16 pp.; 2 pll.

Circular 1-B. Hungarian Brome Grass, by F. Lamson-Scribner, Special Agent, 4 pp.

Contributions for the United States National Herbarium, Vol. I, No. 3, issued November 1, 1890. List of Plants collected by Dr. Edward Palmer in 1890 in Lower California and Western Mexico, by Geo. Vasey and J. N. Rose, pp. i-vi, 63-90; pl. I.

No. 4, issued June 30, 1891. List of plants collected by Dr. Edward Palmer in 1890 in Western Mexico and Arizona, by J. N. Rose, pp. i-vii, 91-127; pll. II-XI.

No. 5, issued September 20, 1892. List of plants collected by Dr. Edward Palmer in 1890 on Carmen Island, by J. N. Rose, pp. 129-134; pll. XII-XIV. List of plants collected by the U. S. S. Albatross in 1887-91 along the western coast of America. 1 and 2. Lists of plants from Cocos and Galapagos islands, by J. N. Rose, pp. 135-138. 3 and 4. Lists of ferns and mosses from Patagonia and Fuegia, by Daniel C. Eaton, pp. 138, 139. 5. List of liverworts from Southern Patagonia, by A. W. Evans, pp. 140-142; pl. XV, XVI. List of lichens from Southern Patagonia, by J. W. Eckfeldt, p. 142. Revision of the North American species of Hoffmanseggia, by E. M. Fisher, pp. 143-150. Index of new species of North American Phanerograms and Pteridophytes, compiled by Josephine A. Clark, pp. 151-176.

No. 6, issued December 6, 1892. List of plants collected by C. S. Sheldon and M. A. Carleton in the Indian Territory in 1891, by J. M. Holsinger, pp. 189-219; pll. XVII, XVIII. Observations on the native plants of Oklahoma Territory and adjacent districts, by M. A. Carleton, pp. 220-232.

No. 7, issued July 15, 1893. Systematic and Alphabetic Index of new species of North American Phanerogams and Pteridophytes, published in 1892, by Josephine A. Clark, pp. i-iii, i-iii, 233-264.

No. 8, issued October 31, 1893. Notes on some Pacific coast grasses, by George Vasey, pp. 265-266. Descriptions on new or noteworthy grasses from the United States and Mexico, by George Vasey, pp. 267-285; pl. XIX. Four new plants from Texas and Colorado, and list of plants new to Florida, by J. M. Holsinger, pp. 286-288; pll. XX, XXI. Three new plants from Alaska and California, by J. N. Rose, pp. 289-290; pll. XXII, XXIII. Lichens from California and Mexico, collected by Dr. Edward Palmer from 1888 to 1892, by J. W. Eckfeldt, pp. 291, 292.

Vol. II, No. 3, issued May 10, 1894. Manual of the Phanerogams and Pteridophytes of Western Texas, by John M. Coulter, pp. 347-556.

Vol. 3, No. 1, issued February 25, 1892. Monograph of the Grasses of the United States and British America, by Geo. Vasey, pp. 1-89.

No. 2, issued June 10, 1894. Preliminary revision of the North American species of Cactus, Anhalonium, and Lophophora, by John M. Coulter, p. 95-132.

Vol. IV, No. 1, issued November 29, 1893. Botany of the Death Valley Expedition: A report on the botany of the expedition sent out in 1891 by the U. S. Department of Agriculture to make a biological survey of the region of Death Valley, Cal., by Frederick Vernon Coville, pp. 1-300; pll. I-XXI.

United States Department of Agriculture—Division of Chemistry, Harvey W. Wiley, Chemist:

Buletins: No. 4. An Investigation of the Composition of American Wheat and Corn, by Clifford Richardson, Assistant Chemist; 98 pp.

No. 13. Foods and Food Adulterants; 1180 pp. Part I, Dairy Products; pp. 1-128; pll. I-XII. Part II. Spices and Condiments, by Clifford Richardson; pp. 127-260; pll. XIII-XXVIII. Part III. Fermented Alcoholic Beverages, malt liquors, wine, and cider, by C. A. Crampton, Assistant Chemist; pp. 261-400. Part IV. Lard and Lard Adulterations, by H. W. Wiley; pp. 401-554; pll. XXIX-XXXVIII. Part 5. Baking Powders, by C. A. Crampton; pp. 555-624. Part VI. Sugar, Molasses and Sirup, Confections, Honey and Beeswax; pp. 633-874. Part VII. Tea, Coffee and Cocoa Preparations, by Guilford L. Spencer, Assistant Chemist; pp. 875-1012; pll. XXXIX-XLVII. Part VIII. Canned Vegetables, by K. P. McElroy, Second Assistant Chemist; pp. 1015-1168.

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No. 18. Sugar-producing Plants: Record of Analyses of the Commissioner of Agriculture, under the direction of the chemist, 1887-'88. Sorghum, Ft. Scott, Kansas; Rio Grande, N. J.; Sugar Cane, Lawrence, La.; with study of data on sorghum and sugar cane, 132 pp.

No. 20. Record of experiments conducted by the Commissioner of Agriculture in the manufacture of sugar from sorghum at Rio Grande, N. J.; Kenner, La.; Conway Springs, Douglass, and Sterling, Kans., 1888, by H. W. Wiley, Chemist; 162 pp.

No. 21. Report of experiments in the manufacture of sugar by diffusion, at Magnolia Station, Lawrence, La., 1888-'89, by Guilford L. Spencer; 68 pp.

No. 22. Record of experiments at Des Lignes sugar experiment station, Baldwin, La., 1888, by C. A. Crampton, Assistant Chemist; 34 pp.

No. 24. Proceedings of the Sixth Annual Conventon of the Association of Official Agricultural Chemists held at the U. S. Department of Agriculture, September 10-12, 1889. Methods of analysis of commercial fertilizers, cattle foods, dairy products, and fermented liquors. Edited by Harvey W. Wiley, Secretary of the Association; 236 pp.

No. 25. A Popular Treatise on the extent and character of food adulterations, by Alex. J. Wedderburn, Special Agent; 61 pp.

No. 26. Record of Experiments of the production of Sugar from Sorghum in 1889 at Cedar Falls, Iowa; Rio Grande, N. J.; Morrisville, Va.; Kenner, La.; College Station, Md.; and Conway Springs, Attica, Medicine Lodge, Ness City, Liberal, Arkalon, Meade, Minneola, and Sterling, Kans.; by H. W. Wiley, Chemist; 112 pp.

No. 28. Proceedings of the Seventh Annual Convention of the Association of Official Agricultural Chemists, held at the U. S. National Museum, August 28-30, 1890. Methods of analysis of commercial fertilizers, foods and feeding stuffs, dairy products, fermented liquors, and sugars. Edited by Harvey W. Wiley, Secretary of the Association; 232 pp.

No. 29. Record of Experiments with Sorghum in 1890, by Harvey W. Wiley; 126 pp.

No. 30. Experiments with Sugar Beets in 1890, by H. W. Wiley; 94 pp.

No. 33. Experiments with Sugar Beets in 1891, by H. W. Wiley; 158 pp.

No. 34. Record of Experiments with Sorghum in 1891, by Harvey W. Wiley; 132 pp.

No. 38. Proceedings of the Tenth Annual Convention of the Association of Official Agricultural Chemists held at Chicago, Illinois, August 24-26, 1893. Edited by H. W. Wiley, Secretary of the Association; 232 pp.

No. 40. Record of Experiments with Sorghum in 1893, by Harvey W. Wiley; 38 pp.

United States Department of Agriculture—Division of Entomology, C. V. Riley, Entomologist.

Bulletins: No. 27. Reports on the damage by destructive locuts 1891; 64 pp.

No. 28. The more destructive locusts of North America and Mexico, by Lawrence Bruner, 1892; 40 pp.

No. 29. Report on the boll worm of cotton (Heliothis armiger Hubn.), by F. W. Mally; 74 pp.; 2 pll.

No. 30. Reports of Observations and experiments in the practical work of the division; 68 pp.

No. 31. Catalogue of the exhibit of economic entomology at the World's Fair Columbian Exposition, Chicago, 1893; 122 pp.

No. 32. Reports of observations and experiments in the practical work of the division; 60 pp.

Circular No. 2. June, 1891. The Hop Plant-louse and the Remedies to be used against it; 8 pp.; 1 photographic plate; 5 figs. No. 3. An important enemy to fruit trees; 10 pp.; 5 figs.

Insect Life: A periodical bulletin, devoted to the economy and habits of insects, especially in their relations to agriculture. Edited by C. V. Riley, Entomologist, and L. O. Howard, First Assistant, with the assistance of other members of the divisional force. Vol. V, September, 1892, to July, 1893, 410 pp. Contains, among other articles, the following: The possible and actual influence of irrigation on insect injury in New Mexico, by C. H. Tyler-Townsend, pp. 78-81. Notes on the Aegeriidae of central Ohio, II, by D. S. Kellicott, pp. 81-86. The Pear-tree Psylla (Psylla pyricola), by M. V. Slingerland, pp. 100-104, 226-230. Kansas Notes, by V. L. Kellogg, pp. 114-117. Notes on plant faunae, by T. D. A. Cockerell, pp. 117-121. The glassy-winged sharp-shooter, (Homalodisca coagulata Say), illustrated, pp. 150-154. The Osage orange pyralid (Loxostege maclurae Riley), illustrated, by Mary E. Murtfeldt, pp. 155-158. Food plants of some Jamaican Coccidae, by T. D. A. Cockerell, pp. 158-160, 245-247. "Maxillary Tentacles" of Pronuba, illustrated, by John B. Smith, pp. 161-163. The potato-tuber moth (Lita solanella Boisd.), by R. Allan Wight, pp. 163, 164. The strawberry weevil (Anthonomus signatus Say), illustrated, by F. H. Chittenden, pp. 167-186; figs. 13-17. Belvosia—a study, illustrated, by S. W. Williston, M. D., pp. 238-240. Observations on some hymenopterous parasites of Coleoptera, by F. H. Chittenden, pp. 247-251. The present year's appearances of the Periodical Cicada, pp. 298-300. Further notes on yucca insects and yucca pollination, illustrated, by C. V. Riley, pp. 300-310. On the pollination of Yucca whipplei in California, by D. W. Coquillett, pp. 311-314. Further notes on the cottontail bot, with the breeding and identification of the fly, by C. H. Tyler-Townsend, pp. 317-320. The sugar-beet web-worm (Loxostege sticticalis L.), pp. 320-322. Report on a trip to northwest Missouri to investigate grasshopper injuries, by Herbert Osborn, pp. 323-325. The angoumois grain moth or "fly weevil" (Gelechia cerealella), by L. O. Howard, pp. 325-328. Descriptions of Noctuidae from the Death Valley, illustrated, by J. B. Smith, pp. 328-334.

Vol. VI, November, 1893, to September, 1894. 410 pp. Contains, among other articles, the following: Experiments with the hop-louse in Oregon and Washington, by Albert Koebele, pp. 12-17. Reports on outbreaks of the western cricket and of certain locusts in Idaho, by Robert Milliken, pp. 17-24. The present status of the recent Australian importations, by D. W. Coquillett and A. Koebele, pp. 24-29. Injurious and other locusts of New Mexico and Arizona, by C. H. Tyler-Townsend, pp. 29-32. Fifth annual meeting of the Association of Economic Entomologists—presidential address, by S. A. Forbes, pp. 61-71. The distribution of Coccidae, by T. D. A. Cockerell, pp. 99-103. The economic value of parasites and predacious insects, by J. B. Smith, pp. 142-146. The cheese or meat skipper, by Mary E. Murtfeldt, pp. 170-176. Dipterous parasites in their relation to economic entomology, by C. H. Tyler-Townsend, pp. 201-206. Hymenopterous parasites of the California red scale, illustrated, by L. O. Howard, pp. 227-236. Entomological memoranda for 1893, by Mary E. Murtfeldt, pp. 257-259. A new and destructive peach-tree scale, (Diaspis lanatus Morg. and Ckll.), illustrated, pp. 287-296. Acorn insects, primary and secondary, by Mary E. Murtfeldt, pp. 318-324. Bees, illustrated, by C. V. Riley, pp. 350-360. The San Jose or pernicious scale (Aspidiotus perniciosus Comst.), illustrated, pp. 360-369. Completed life-history of the sugar-beet web-worm (Loxostege sticticalis L.), illustrated, by L. O. Howard, pp. 369-373.

Vol. VII, Nos. 1-3, September to December, 1894. 280 pp. Contains, among other articles, the following: The cranberry girdler (Crambus topiarius Zell.), illustrated by Samuel H. Scudder, pp. 1-5. Two parasites of important scale insects, illustrated, by L. O. Howard, pp. 5-8. The buffalo tree-hopper (Ceresa bubalus Fab.), illustrated, by C. L. Marlatt, pp. 8-14. Supplementary notes on the strawberry weevil, its habits and remedies, by F. H. Chittenden, pp. 14-23. Insects injuring drugs at the University of Kansas, by Vernon L. Kellog, pp. 31,32. Senses of insects, illustrated, by C. V. Riley, pp. 33-41. A maritime species of Coccidae, by T. D. A. Cockerell, pp. 42-44. An abnormal tiger swallow-tail, illustrated, by L. O. Howard, pp. 44-47. Sixth annual meeting of the Association of Economic Entomologists: A brief account of the rise and condition of official economic entomology, by L. O. Howard, pp. 55-108. Notes on insecticides, by C. L. Marlatt, pp. 115-126. Observations on new and old insecticides and their combination with fungicides, by B. T. Galloway, pp. 126-132. Economic entomological work, and the wood leopard moth in the parks of New York city, by E. B. Southwick, pp. 135-138. Work in economic entomology at the University of Kansas for the season of 1894, illustrated, by Francis H. Snow, pp. 140-145. Notes on some discoveries and observations of the year in West Virginia, by A. D. Hopkins, pp. 145-153. The eastern occurrences of the San Jose scale, by L. O. Howard, pp. 153-163. San Jose scale in New Jersey, by John B. Smith, pp. 163-168. The pear-tree psylla in Maryland, by C. L. Marlatt, pp. 175-185. Notes from New Mexico, by T. D. A. Cockerell, pp. 207-212. Damage by the American locust, illustrated, by L. O. Howard, pp. 220-230. The hibernation of the chinch bug, by C. L. Marlatt, pp. 232-235. The maple pseudococcus (Pseudococcus aceris Geoff.), illustrated, by L. O. Howard, pp. 235-240. A new sawfly injurious to hollyhocks, by T. D. A. Cockerell, pp. 251-254. Scorpions, centipedes, and tarantulas, pp. 260-263.

United States Department of Agriculture—Fiber Investigations, Charles Richard Dodge, Special Agent in Charge:

Report No. 6. On the uncultivated bast fibers of the United States, including the history of previous experiments, etc., by Charles Richard Dodge; 54 pp.

United States Department of Agriculture—Forestry Division, B. E. Fernow, Chief:

Bulletins: No. 3. Preliminary Report on the Use of Metal Track on Railways as a Substitute for Wooden Ties, by E. E. Russell Tratman, 1889. 80 pp.; 6 drawings.

No. 4. Report on the Substitute of Metal for Wood in Railroad Ties, by E. E. Russel Tratman, with a discussion on Practical Economies in the use of Wood for Railway Purposes, by B. E. Fernow, Chief of Forestry Division; 364 pp.; pll. No. 1-30.

No. 7. Forest Influences; 198 pp.; 63 figs.

United States Department of Agriculture—Division of Microscopy, Thomas Taylor, M. D., Microscopist:

Report of the Microscopist for the year 1892, by Thomas Taylor, M. D. From Report of Secretary of Agriculture for 1892, pp. 281-292; 9 pll. Contains 4 colored and 2 uncolored plates of three edible and one poisonous mushrooms; also a colored plate showing eight oils acted upon by silver nitrate.

Food Products.—I. Twelve Edible Mushrooms of the United States, with directions for their identification and their preparation as food, by Thomas Taylor, M. D. 20 pp.; 1 pl., 12 figs.

II. Eight Edible and Twelve Poisonous Mushrooms of the United States, with directions for the culture and culinary preparation of the edible species, by Thomas Taylor, M. D. 24 pp.; 5 pll.

III. Improved Methods of Distinguishing between Pure and Fictitious Lard. Four Edible Mushrooms of the United States, by Thomas Taylor, M. D. 22 pp.; 6 pll., 5 colored lithographs.

United States Department of Agriculture—Division of Ornithology and Mammalogy, Dr. C. Hart Merriam, Chief:

Bulletin No. 2. Report on Bird Migration in the Mississippi Valley in the years 1884-85, by W. W. Cooke; 314 pp.; map.

No. 4. The Prairie Ground Squirrels or Spermophiles of the Mississippi Valley, under the direction of Dr. C. Hart Merriam, Chief of Division, by Vernon Bailey, Field Agent. 1893. 68 pp.; 3 pll.; 4 maps.

North American Fauna. A serial. No. 5, July 30, 1891. Results of a Bibliogical Reconnoisance of South-central Idaho, by Dr. C. Hart Merriam; 187 pp.; 1 pll. Descriptions of a New Genus of two New Species of North-American Mammals, by Dr. C. Hart Merriam; pp. 87-112; pl. II.

No. 7. May, 1894. The Death Valley Expedition. A Biological Survey of parts of California, Nevada, Arizona, and Utah. 394 pp.; 14 pll.; 5 maps. Reports on Birds, by A. K. Fisher, M. D.; pp. 7-158. Reptiles and Batrachians, by Leonard Stejneger; pp. 159-228. Fishes, by C. V. Riley, S. W. Williston, P. R. Uhler and Lawrence Bruner; pp. 235-268. Mollusks, by R. E. C. Stearns; pp. 269-283. Desert Trees and Shrubs, by C. Hart Merriam, M. D.; pp. 295-343. Desert Cactuses and Yuccas, by C. Hart Merriam, M. D.; pp. 345-359.

Reports for 1887, by C. Hart Merriam, M. D.; pp. 399-456; 1 pll. For 1888; pp. 257-536; 3 figs. For 1889; pp. 237-276; 2 photographic pll. For 1890; pp. 278-285. For 1891; pp. 267-271. For 1892; pp. 181-200; 5 colored pll.

United States Department of Agriculture—Division of Pomology, H. E. Van Deman, Chief of Division:

Bulletins: No. 2. Report on the Adaptation of Russian and other fruits to the extreme northern portions of the United States; 64 pp.

No. 4. Report on the relative merit of various stocks for the Orange, with notes on Mal di goma and the Mutual Influence of Stock and Scion; 22 pp.

Report of the Pomologist for 1892, by H. E. Van Deman; pp. 247-280; 14 litho. and photo. pll.; 2 figs.

Report of the Assistant Pomologist for 1893, by Wm. A. Taylor; 296 pp.; 9 colored lithograph plates.

United States Department of Agriculture—Division of Vegetable Pathology, B. T. Galloway, Chief of Division:

Botanical Division, Section of Vegetable Pathology. Bulletins: No. 2. Report on the Fungous Diseases of the Grape Vine, by Lamson Scribner, B. Sc.; 136 pp.; 7 lithograph plates, 3 colored; 4 figs.

No. 7. Black Rot (Laestadia bidwellii), by F. Lamson-Scribner and Pierre Viala; 68 pp.; 1 litho. pl.

No. 9. Peach Yellows: A preliminary report, by Erwin F. Smith; 254 pp.; 37 litho. pll., 6 colored; 7 maps folded in.

No. 10. Report on the Experiments made in 1888 in the treatment of the downy mildew and black rot of the grape vine; 56 pp.; 2 pll.

Division of Vegetable Pathology, Bulletins: No. 2. The California Vine Disease. A preliminary report of investigations, by Newton B. Pierce, special agent; 216 pp.; 25 pll.; 7 colored lithographs; 1 chart.

No. 3. Report of the Experiments made in 1891 in the treatment of plant diseases, by B. T. Galloway; 76 pp.; 8 pll., 5 diagrams.

No. 4. Experiments with Fertilizers for the prevention and cure of peach yellows, 1889-'92, by Erwin F. Smith, Special Agent; 198 pp.; 23 pll., 26 half tones.

No. 5. The Pollination of Pear Flowers, by Merton B. Waite, Special Agent; 12 pll., including 5 outlines, 7 half tones; 4 figs.

No. 7. The Effect of Spraying with fungicides on the growth of nursery stock, by B. T. Galloway; 42 pp.; 17 figs.

Farmers' Bulletin No. 4. Fungous Diseases of the grape and their treatment, by B. T. Galloway; 12 pp.

No. 5. Treatment of smuts of oats and wheat; 8 pp.

No. 7. Spraying Fruits for insect pests and fungous diseases, with its relation to public health; 20 pp.

Circulars: No. 6. Treatment of Black Rot of the Grape; 4 p. No. 7. Grape vine diseases; 4 p. No. 8. Experiments in the treatment of pear leaf-blight and the apple powdery mildew; 10 p. No. 10. Treatment of nursery stock for leaf-blight and powdery mildew, by B. T. Galloway; 8 p.; 3 fig.

Journal of Mycology, a quarterly bulletin, by B. T. Galloway, Chief of the Division. Vol. V. No. 4, December, 1889; pp. 179-250.

Vol. VI. No. 2, September, 1890; pp. 43-88. No. 3. January, 1891; pp. 89-136; pll. IV-VI.

United States Department of Agriculture—Weather Bureau, Mark W. Harrington, Chief of Bureau:

Bulletin No. 13. Temperatures Injurious to Food Products in storage and during transportation, with methods of protection, by H. E. Williams; 20 pp.

Circular of Information. Protection from Lightning, by Alexander McAdie: 22 pp.; 11 figs., 7 colored.

Monthly Weather Review, 24x29 cm., by Prof. Cleveland Abbe, Editor. January, 1894; 46 pp.; 6 maps. February, 1894; 47-98 pp.; 7 maps. March, 1894; pp. 99-148; 7 pll. May, 1894; pp. 193-234; 4 maps. June, 1894; pp. 235-272; 4 maps. July, 1894; pp. 273-310; 4 maps. August, 1894; pp. 311-340; 5 maps. September, 1894; pp. 351-382; 4 maps; 2 charts folded in. October, 1894; pp. 292-429; 4 maps; 2 charts with corrections and additions.

Report of the Chief of the Weather Bureau, 1891-'92, 24x29 cm., bound in black cloth; 528 pp.; 4 pll., 24 figures.

For 1893, by Mark W. Harrington; 122 pp., 4 plates of drawings.

United States Department of the Interior—Census Office:

Atlas of sixteen maps, 50x82 cm., accompanying Report on Forest Trees of North America, by Prof. C. S. Sargent, special agent, showing distribution of trees throughout North America.

United States Department of the Interior—U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell in charge:

Contributions to North American Ethnology, 24x29 cm., bound in brown cloth, vignette. Vol. IX. Dakota Grammar, Texts, and Ethnography, by Stephen Return Riggs. Edited by James Owen Dorsey. 271 pp. Part I, Grammar, pp. 1-79; Part II, Texts, pp. 81-152; Part III, pp. 153-232.

United States Department of the Interior—U. S. Geological Survey, Chas. D. Walcott, Director:

Eleventh Annual Report, 1889-90. Part I—Geology. Report of the Directors and Administrative Reports, pp. 1-577, pll. I-LXI. The Natural Gas Field of Indiana, by Arthur John Phinney, pp. 617-741, 1 map; pll. LXI-LXVI; 6 maps in pockets.

Part II—Irrigation. Hydrography, pp. 1-110, pll. LXVII-LXXIV. Engineering, pp. 111-200, pll. LXXV-XCVI. The Arid Lands, pp. 203-289. Topography, pp. 293-345.

Twelfth Annual Report, 1890-1. Part I—Geology. Report of the Director and Administrative Reports, pp. 1-345, pll. I-XXXI. The Lafayette Formation, by W. J. McGee, pp. 353-521, pll. XXXII-XXXVII. The North American Continent During Cambrian Time, by Charles D. Walcott, pp. 529-567, pll. XXXVIII-XLV. The Eruptive Rocks of Electric Park and Sepulcher Mountain, Yellowstone and National Park, by Joseph Paxson Iddings, pp. 577-663, pll. XXXIX-LIII, fig. 1-80; 6 maps in pockets.

Part II—Irrigation. Report upon the location and survey of reservoir sites during the fiscal year ending June 30, 1891, by A. H. Thompson, pp. 1-569, pll. LIV-CXLVI, figs. 81-270.

Thirteenth Annual Report, 1891-2. Part I—Report of Director, pp. 1-65. Administrative Reports, pp. 69-240, 2 large maps in pocket.

Part II—Geology. Second Expedition to Mount St. Elias, by Israel Cook Russell, pp. 7-91, pll. I-XXI. The Geological History of Harbors, by Nathaniel Southgate Shaler, pp. 97-206, pll. XXII-XLVI. The Mechanics of Appalachian Structure, by Bailey Willis, pp. 217-274, pll. XLVII-LXXIII. The Average Elevation of the United States, by Henry Gannett, pp. 284-289, pll. LXXIV-XCVII. The Rensselaer Grit Plateau in New York, by T. Nelson Dale, pp. 297-337, pll. XCVIII-CI. The American Tertiary Aphidae, by Samuel Hubbard Scudder, pp. 347-356, pll. CII-CVII, fig. 1-41, 1 map in pocket.

Part III—Irrigation. Water Supply for Irrigation, by F. H. Newell, pp. 7-92, pll. CVIII-CX. American Irrigation Engineering, by Herbert M. Wilson, pp. 109-346, pll. CXI-CXLVII. Engineering Results of Irrigation Survey, by Herbert M. Wilson, pp. 357-426, pll. CXLVIII-CLXXXIII. Report on Sites of the Arkansas river, Colorado, by A. H. Thompson, pp. 431-435. Report on Location and Survey of Observation of Reservoir Sites during the fiscal year ending June 30, 1892, by A. H. Thompson, pp. 451-477, pll. CLXXXIII-CLXXXIV. Figs. 42-160, 2 maps in pocket.

Bulletins: No. 97. The Mesozoic Echinodermata of the U. S., by William Bullock Clark. 1893. 207 pp.; 50 pl.

98. Flora of the Outlying Carboniferous Basins of Southwestern Missouri, by David White. 1893. 139 pp.; 5 pl.

99. Record of North American Geology for 1891, by Nelson Horatio Darton. 1892. 72 pp.

100. Biography and Index of the Publications of the U. S. Geological Survey, 1879-1892, by Philip Creveling Warman. 1893. 495 pp.

101. Insect Fauna of the Rhode Island Coal Field, by Samuel Hubbard Scudder. 1893. 27 pp.; 2 pll.

102. A Catalogue and Biography of North America Mesozoic Invertebrata, by Cornelius Breckinridge Boyle. 1893. 315 pp.

103. High Temperature Work in Igneous Fusion and Ebullition, chiefly in relation to pressure, by Carl Barus. 1893. 57 pp.; 9 pl., 2 folded in.

104. Glaciation of the Yellowstone Valley north of the Park, by Walter Harvey Weed. 1893. 41 pp.; 4 pl.

105. The Laramie and the overlying Livingston Formation in Montana, by Walter Harvey Weed, with Report of Flora, by Frank Hall Knowlton. 1893. 68 pp.; 6 pl.; one three-page colored map, folded in.

106. The Colorado Formation and its Invertebrate Fauna, by T. W. Stanton. 1893. 288 pp.; 45 pl.

107. The Trap Dikes of the Lake Champlain Region, by James Furman Kemp and Vernon Freeman Marsters. 1893. 62 pp.; 4 pl.

108. A Geological Reconnoisance in Central Washington, by Israel Cook Russell. 1893. 108 pp.; 12 pll.

109. The Eruptive and Sedimentary Rocks on Pigeon Point, Minnesota, and their contact phenomena, by William Shirley Bayley. 1893. 121 pp.; 16 pl.; 1 large map.

110. The Paleozoic Section in the vicinity of Three Forks, Montana, by Albert Charles Peale. 1893. 56 pp.; 6 pl.; two two-paged colored maps.

111. Geology of the Big Stone Gap coal field of Virginia and Kentucky, by Marius R. Campbell. 1893. 106 pp.; 6 pl.; two large maps folded in.

112. Earthquakes in California in 1892, by Charles D. Perrine. 1893. 57 pp.

113. A Report of the Work done in the Division of Chemistry during the fiscal years 1891-'92 and 1892-'93. F. W. Clarke, chief chemist. 1893. 115 pp.

114. Earthquakes in California in 1893, by Charles D. Perrine. 1894. 23 pp.

115. A Geographic Dictionary of Rhode Island, by Henry Gannett. 1894. 31 pp.

116. A Geographic Dictionary of Massachusetts, by Henry Gannett. 1894. 126 pp.

117. A Geographic Dictionary of Connecticut, by Henry Gannett. 1894. 67 pp.

Mineral Resources of the United States, bound in black cloth. For 1886, by David T. Day; 790 pp.

For 1891, by David T. Day; 609 pp.

For 1892, by David T. Day; 833 pp.

For 1893, by David T. Day; 794 pp.

Monographs. 24x29 cm., bound in black cloth. Vol. XXI. Tertiary Rhynchophorous Coleoptera of the United States, by Samuel Hubbard Scudder. 1893; 176 pp.; 13 pll.

Vol. XXII. A Manual of the Topographic Methods, by Henry Gannett, chief topographer. 1893; 300 pp.; 18 pll.; large map folded in pocket.

Topographical maps of portions of Kansas, 40x50 cm., covering one-half degree each in latitude and longitude, with contour lines 20 to 50 feet apart in elevation. Six sets, embracing the following sheets, topographically arranged: Hiawatha, Seneca, Marysville, Oskaloosa, Topeka, Wamego, Junction City, Clay Center, Lawrence, Burlingame, Eskridge, Parkerville, Abilene, Garnett, Burlington, Emporia, Cottonwood Falls, Newton, Hutchinson, Lyons, Great Bend, Larned, Ness City, Iola, Fredonia, Eureka, Eldorado, Wichita, Cheney, Kingman, Pratt, Kinsley, Speareville, Parsons, Independence, Sedan, Burden, Wellington, Caldwell, Anthony, and Medicine Lodge.

Same sheets alphabetically arranged: Abilene, Anthony, Burden, Burlingame, Burlington, Caldwell, Cheney, Clay Center, Cottonwood Falls, Eldorado, Emporia, Eskridge, Eureka, Fredonia, Garnett, Great Bend, Hiawatha, Hutchinson, Independence, Iola, Junction City, Kingman, Kinsley, Larned, Lawrence, Lyons, Marysville, Medicine Lodge, Ness City, Newton, Oskaloosa, Parkerville, Parsons, Pratt, Sedan, Speareville, Topeka, Wamego, Wellington, and Wichita.

Also one each of the following sheets of the survey of Kansas: Atchison, Coldwater, Columbus, Concordia, Dodge, Fort Scott, Kansas City (mounted on linen), Meade, Minneapolis, Mound City, Olathe, and Salina.

Also one each of the following sheets of the topographical survey in Colorado: Vilas, Albany, Two Butte, Higbee, Timpas, Apishapa, Granada, Lamar, Las Animas, Nepiesta, Pueblo, Cheyenne Wells, Kit Carson, Arroyo, Sanborn, Big Springs, and Limon.

United States Navy Department—U. S. Naval Observatory:

Report of the Superintendent of the U. S. N. Observatory for the year ending June 30, 1893, Captain F. V. McNair, Superintendent. 13 pp.

The American Ephemeris and Nautical Almanac for 1890, 18x27 cm., bound in blue cloth. Simon Newcomb, Professor U. S. Navy, Superintendent. 538 pp.; 2 eclipse maps.

For 1891, 515 pp.; 2 eclipse maps.
For 1892, 521 pp.; 2 eclipse maps.
For 1893, 528 pp.; 2 eclipse maps.
For 1894, 532 pp.; 2 eclipse maps.
For 1895, 532 pp.; 2 eclipse maps.
For 1896, 534 pp.; 2 eclipse maps.

Washington Observations. 25x30 cm., bound in green cloth. Observations made during the year 1885 at the United States Naval Observatory, with three appendices. Commodore George E. Belknap, U. S. N., Superintendent. 1891. Astronomical Observations in 1885; pp. xxiii-cv. Observations and Results; pp. 3-298. Appendix I. The International Astrophotographic Congress and a visit to certain European Observatories and other Institutions, by Albert G. Winterhalter; pp. 1-354; 29 half-tone and other full-page engravings; numerous wood cuts. Appendix II. Saturn and its Ring,1875-1889, by Asaph Hall; pp. 1-22; 3 litho plates. Appendix III. The Solar Parallax and its related constants, including the figure and density of the Earth, by William Harkness; pp. 1-169. Volume contains a total of 968 pp.

Observations made during the year 1886 at the United States Naval Observatory, with one appendix. Commander Allan D. Brown, U. S. N., Superintendent. 1891. Astronomical Observations in 1886; pp. xxvii-xcix. Observations and Results; pp. 3-221. Appendix I. Magnetic observations at the United States Naval Observatory, 1888 and 1889, by J. A. Hoogewerff; pp. 1-100; plates I to XIV. Volume contains a total of 428 pp.

Observations made during the year 1889 at the United States Naval Observatory, with one appendix, Captain Robert L. Phythian, U. S. N., Superintendent. 1893. Report of the Superintendent; pp. v-xix. Transit Circle; pp. xxiii-liii. Meridian Transit and Equatorials; pp. lv-lix. Astronomical Observations and Reductions; pp. 1-61. Results of Astronomical Observations; pp. 63-111. Meteorological Observations and Results; pp. 1-57. Appendix I. Magnetic Observations for 1892, by S. J. Brown; pp. 1-73. Volume contains a total of 313 pages.

United States Treasury Department—U. S. Coast and Geodetic Survey, T. C. Mendenhall, Superintendent:

Report of the Superintendent for the year ending June, 1878. 1881. 23x29 cm., bound in black cloth. Pp. 330; 26 maps and charts folded in. Contains besides the report of the superintendent, Appendix No. 6. Observations made at Summit Station, Calif., of the transit of Mercury, May, 1878; pp. 81-87; pll. 27, 28. No. 7. Observations of the transit of Mercury, May 6, made at Washington, D. C.; pp. 88-91. No. 8. Adjustment of the primary triangulation between the Kent Island and the Atlantic base-lines; pp. 92-120. No. 9. On the Physical Survey of the Delaware river in front of Philadelphia; pp. 174-267; pl. 29-32. No. 10. Meteorological Researches, by William Ferrel, Part II, Theory of cyclones, tornadoes and waterspouts; pp. 174-267; pll. 33-38. No. 11. Discussion of Tides in Penobscot bay, Me., by William Ferrel; pp. 268-304; pl. 39.

Report for the year ending June, 1879. 1881. Pp. 240; 16 pll.; 32 maps folded in. Contains besides the report of the superintendent, Appendix No. 6. Dredging Operations in the Caribbean Sea. A letter from Professor Alexander Agassiz to the Superintendent; pp. 95-102, with two maps. No. 8. Comparison of Local Deflections of the Plumb-line, by C. A. Schott, assistant Coast and Geodetic Survey; pp. 110-123; pl. 36. No. 9. On the secular change of Magnetic Declination in the United States and foreign stations, by Charles A. Schott; pp. 124-174; pll. 37-39. No. 10. Physical Hydrography of the Gulf of Maine, by Henry Mitchell; pp. 175-190; pll. 40, 41. No. 11. Report on the preparation of Standard Topographical Drawings, by Edwin Hergesheimer; p. 191; pll. 42-49.

Report for the year ending June, 1880. 1882. Pp. 444; 84 pll.; 32 maps folded in. Contains besides the report of the superintendent, Appendix No. 12. Report on the Blue Clay of the Mississippi river, by George Little, Ph. D.; pp. 145-171; pl. 48. No. 14. On the Determination of time, longitude, latitude, and azimuth, by Charles A. Schott, Assistant; pp. 201-286; pll. 62-72. No. 16. Report on the Currents and temperatures of Bering Sea and the adjacent waters, by Wm. H. Dall, Assistant; pp. 297-340; pll. 80, 81. No. 18. An attempt to solve the problem of the first landing place of Columbus in the New World, by Capt. G. V. Fox, assistant secretary of the navy; pp. 347-411; pl. 83. No. 19. An inquiry into the variation of the compass off the Bahama Islands at the time of the Landfall of Columbus in 1492, by Charles A. Schott, Assistant; pp. 412-417; pl. 84.

Report for the year ending June, 1881. 1883. Pp. 496; pll. 33-63; 32 maps folded in. Contains besides the report of the superintendent, Appendix Nos. 8, 9. Terrestrial Magnetism.—Directions for magnetic observations with portable instruments, and collection of results for declination, dip, and intensity, by C. A. Schott, Assistant; pp. 126-224; pll. 34-37. No. 10. Meteorologic Researches. Part III—Theory of barometric hypsometry and reduction of the barometer at sea-level, by William Ferrel; pp. 225-268; pl. 38. No. 11. The Report on the Oyster Beds of the James River, Virginia, and of Tangier and Pocomoke Sounds, Maryland and Virginia, by Lieut. Francis Winslow, U. S. N. Association, C. and G. S.; pp. 269-353; pll. 39-63. No. 15. On the Deduction of the Ellipticity of the Earth from Pendulum Experiments, by C. S. Peirce, Assistant; pp. 442-456.

Report for the year ending June, 1882. 1883. Pp. 590; pll. 26-52; 25 maps. Contains besides the report of the superintendent, Appendix No. 11. Results of the Transcontinental Line of geodesic spirit leveling near the parallel of 39 degrees, executed by Andrew Braid, Assistant. Part I—From Sandy Hook, N. J., to St. Louis, Mo., C. A. Schott, Assistant; pp. 209 and 517-556; pll. 33-36. No. 12. Secular Variation of the Magnetic Declination in the United States and foreign stations, by C. A. Schott, Assistant; pp. 277-328; pll. 37-40. No. 14. Records and Results of magnetic observations made at the charge of the "Bache Fund" of the National Academy of Sciences, 1871-1876, by J. E. Hilgard, Superintendent; pp. 329-426. No. 17. Discussion of the Tides of the Pacific Coast of the United States, by William Ferrel; pp. 437-450; pll. 45-47. No. 21. A new reduction of La Caille's observations of fundamental stars in the southern heavens, 1749-1757, by C. R. Powalky, Ph. D.; pp. 469-502. No. 22. Report of a conference on gravity determinations; pp. 503-516.

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Report for the year ending June, 1886. 1887. Pp. 476; pll. 18-39; 17 maps folded in. Contains besides the report of the superintendent, Appendix No. 7. An examination of some of the early voyages of discovery and exploration on the northwest coast of America from 1539-1603, by Prof. George Davidson; pp. 155-253; pl. 18. No. 9. Report of changes in the shore-line and beaches of Martha's Vineyard, as derived from comparison of recent with former surveys, by Henry L. Whiting, Assistant; pp. 263-266; pl. 21. No. 10. A report on the Delta of the Delaware, by Henry Mitchell, Assistant; pp. 267-279; pl. 22. No. 11. A report of Gulf Stream explorations: Observations of currents, 1886, by Lieut. J. E. Pillsbury, U. S. N., Assistant; pp. 281-290; pll. 23-28. No. 12. The secular variation of the magnetic declination in the United States and foreign stations (sixth edition—greatly enlarged), by Charles A. Schott; pp. 291-407; pll. 29-33. No. 13. On the circulation of the sea through New York Harbor, by Henry Mitchell, Assistant; pp. 409-433; pll. 35-39.

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Report for the year ending June, 1888. 1889. Pp. 584; pll. 19-60; 18 maps folded in. Contains beside the report of the superintendent, Appendix No. 6. Part I.—The value of the "Arcano del Mare" with reference to our knowledge of the magnetic declination in the earlier part of the 17th century, by Charles A. Schott, Assistant; pp. 167-170. Part II.—Historical review of the work of the Coast and Geodetic Survey in connection with terrestrial magnetism; pp. 171-176; pll. 19, 20. No. 7. The secular variation of the magnetic declination in the United States and foreign stations (seventh edition), by Charles A. Schott; pp. 177-312; pll. 21-25. Nos. 10-12. Heights from spirit-leveling of precision between points in the south; pp. 409-464. No. 13. Differential method of computing the apparent places of stars for determinations of latitude, by E. D. Preston, Assistant; pp. 465-470. No. 14. Determinations of latitude and gravity for the Hawaiian Government, by E. D. Preston; pp. 471-563; pll. 39-60.

Report for the year ending June, 1889. 1890. Pp. 536; pll. 19-50; 18 maps folded in. Contains besides the report of the superintendent, Appendix No. 6. The relation between the metric standards of length of the United States Coast and Geodetic Survey and the United States Lake Survey, by C. A. Schott and O. H. Tittmann; pp. 179-197; pl. 19. No. 7. The need of a remeasurement of the Peruvian arc, by Erasmus D. Preston, Assistant; pp. 199-208. No. 10. Report on the measurement of the Los Angeles base line, Los Angeles and Orange counties, Cal., by George Davidson, Assistant; pp. 217-231; pll. 20-23. No. 11. The Distribution of the magnetic declination in the United States for the epoch 1890, by Charles A. Schott, Assistant; pp. 233-402; pll. 24-27. No. 16. Gulf Stream Explorations: Observations of currents in 1888 and 1889, by Lieut. J. E. Pillsbury, Assistant; pp. 467-477; pll. 31-50.

Report for the year ending June, 1890. 1891. Pp. 810; pll. 21-71; 20 maps folded in. Contains besides the report of the superintendent, Appendix Nos. 8, 9. Results of the observations made at the U. S. Coast and Geodetic Survey Magnetic Observatory between the years 1882 and 1889. Part I.—Results in the absolute measures of the direction and intensity of the earth's magnetic force, by Charles A. Schott, Assistant; pp. 199-241. Part II.—Results of the differential measures of the magnetic declination; pp. 243-457; pll. 21-29. No. 10. The Gulf Stream: Methods of investigation and results of the research, by Lieut. John E. Pillsbury, U. S. N., Assistant; pp. 461-620; pll. 30-54. No. 18. Historical accounts of the United States weights and measures, by O. H. Tittmann, Assistant; pp. 735-758, pl. 68. No. 19. Notes on an original Manuscript Chart of Bering's expedition of 1725-1730, by William Healey Dall; pp. 759-774; pll. 69, 70.

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For the fiscal year ending June 30, 1892. Same size and style. Part II; 552 pp.; 5 half tone pll.; 5 maps; 1 chart; 24 figs. and illustrations. Appendix. No. 1. On the variation of latitude at Rockville, Md., from observations made in 1891 and 1892; pp. 1-51; 2 pll.; 2 figs. No. 2. On the variation of latitude at Waikiki, near Honolulu, Hawaiian Islands, from observations made in 1891 and 1892; pp. 53-159; illustrations 5-17. Nos. 3 and 4. On the results of spirit leveling of precision between Okolona, Miss., and Odin, Ill., and other points in the gulf states; pp. 161-224, with map. No. 6. On the changes in the ocean shore lines of Nantucket Island, Massachusetts; pp. 243-258; 8 pll. and illustrations. Results of observations recorded at the U. S. Coast and Geodetic Survey Magnetic Observatory, Los Angeles, Cal., 1882-1889. Part IV.—Results of the differential measures of the vertical force component, and of the variations of dip and of total force; pp. 253-327. No. 8. On the measurement of the Holton base, Holton, Ind., and the St. Albans base, Kanawha county, W. Va.; pp. 329-503; 2 pll.; 3 maps.

ILLINOIS.

CHAMPAIGN.—Illinois State Laboratory of Natural History; S. A. Forbes, Director:

Biennial Report of the Director, 1891-2; 8 pp.

Bulletins. Index to Vol. 1. 97 pp.

Vol. III. Article XIV.—Bibliographical and Synonymical Catalogue of the described Membracidae of North America, by F. W. Goding, M. D., pp. 391-482.

Natural History Survey of Illinois, S. A. Forbes, Director:

The Ornithology of Illinois, 18x26 cm., bound in green cloth. Vol. I, part 1, Descriptive Catalogue, by Robert Ridgway, pp. 7-500; 20 plates of drawings; photographic plates XXI-XXXII.

S. A. Forbes, State Entomologist:

Third Annual Report on the Noxious Insects of Illinois, by William LeBaron, M. D., pp. 167-202 and 1-37; 6 dia.

Fifteenth Report, Fourth Report of S. A. Forbes, 1885-6. 103 pp.; 4 figs.

Sixteenth Report, Fifth Report of S. A. Forbes, 1887-8, pp. 1-101; pll. I-VI; 6 diagrams. Appendix. Contribution of an Economic Bibliography of the Chance Bug, 1785-1888. Pp. 5-122.

Seventeenth Report, Sixth Report of S. A. Forbes, 1889-90. Pp. ix-xv and 1-87;

pll. I-IV. Appendix. An Analytical List of the Entomological Writings of William LeBaron. Pp. 7-36.

CHICAGO.—Chicago Academy of Sciences:

Bulletins, Vol. I, No. 1. Glacial markings of unusual forms in the Laurentian Hills, by Edmund Andrews, M. D. 9 pp.

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No. 3. List of Batrachia and Reptilia of Illinois, by N. S. Davis, Jr., and F. L. Rice. Pp. 22-32.

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A Naturalist in Mexico, by Frank Collins Baker, 1895, 14x20 cm., 145 pp.; 15 pll., numerous figures.

Field Columbian Museum:

Guide to the Field Columbian Museum (second edition) 1894. 263 pp., with 87 diagrams and descriptions.

Historical and Descriptive account of the Field Columbian Museum, Dec., 1894. 90 pp.; map; 7 photo. pll.; 6 plans.

Wm. R. Head, Hyde Park:

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The Monist, a quarterly magazine. Vol. IV, Part I. Oct., 1893. 160 pp.

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Journal of Geology, semi-quarterly, about 112 pages each. Vol. I, 1893, 882 pp. On the Pre-Cambrian Rocks of the British Isles, by Sir Archibald Geikie, pp. 1-14. Are there Traces of Glacial Man in the Trenton Gravels? by W. H. Holmes, pp. 15-37. Geology as a Part of a College Curriculum, by H. S. Williams, pp. 38-46. The Nature of the Englacial Drift of the Mississippi Basin ,by T. C. Chamberlin, pp. 47-60. Studies for Students: Distinct Glacial Epochs and the criteria for their recognition, by Rollin D. Salisbury, pp. 61-85. An Historical Sketch of the Lake Superior Region to Cambrian Time, by C. R. Van Hise, pp. 113-128; two-page map (pl. I). The Glacial Succession in Ohio, by Frank Leverett, pp. 129-146. Traces of Glacial Man in Ohio, by W. H. Holmes, pp. 147-163; pl. II. The Volcanic Rocks of the Andes, by Joseph P. Iddings, pp. 164-175. On the Use of the Terms Poikilitic and Micropoikilitic in Petrography, by George H. Williams, pp. 176-179. Studies for Students: The making of a geological time-scale, by H. S. Williams, pp. 180-197, 283-295. Malaspina Glacier, by Israel C. Russell, pp. 219-245; 1 sketch map. The Osar Gravels of the Coast of Maine, by George H. Stone, pp. 246-254. The Horizon of Drumlin, Osar, and Kame Formation, by T. C. Chamberlin, pp. 255-267. A Contact Between the Lower Huronian and the underlying granite in the Republic trough, near Republic, Michigan, by Henry Lloyd Smyth, pp. 268-274. A Pleistocene Manganese Deposit, near Golconda, Nevada, by R. A. F. Penrose, jr., pp. 275-282. On the typical Laurentian area of Canada, by Frank D. Adams, pp. 325-340. Melilite-Nepheline-Basalt and Nepheline-Basanite from southern Texas, by A. Osann, pp. 341-346. Some Dynamic Phenomena shown by the Baraboo Quartzite Ranges of central Wisconsin, by C. R. Van Hise, pp. 347-355. The Chemical Relation of Iron and Manganese in Sedimentary

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Vol. II, 1894, pp. 884. The distribution of ancient volcanic rocks along the eastern border of North America, by George H. Williams, pp. 1-31; pl. I. Revolution in the topography of the Pacific Coast since the auriferous gravel period, by J. S. Diller, pp. 32-54. The Name "Newark" in American stratigraphy: A joint discussion, by G. K. Gilbert, B. S. Lyman, pp. 55-61. An abandoned Pleistocene river channel in eastern Indiana, by Charles S. Beachler, pp. 62-65. Studies for Students: Physical geography in the University, by Wm. M. Davis, pp. 66-100. The Glacial Succession in Norway, by Andr. M. Hansen, pp. 123-144. Dual nomenclature in geological classification, by Henry Shaler Williams, pp. 145-160. Origin and Classification of the Greensands of New Jersey, by William Bullock Clark, pp. 161-177. The Nature of Coal Horizons, by Charles Rollin Keyes, pp. 178-186. The Arkansas Coal Measures in their Relation to the Pacific Carboniferous Province, by James Perrin Smith, pp. 187-204. Pseudo-cols, by T. C. Chamberlin, pp. 205-206. Geological Surveys in Missouri, by Arthur Winslow, pp. 207-221. The Oil Shales of the Scottish Carboniferous System, by Henry M. Cadell, pp. 243-249. The Cretaceous Rim of the Black Hills, by Lester F. Ward, pp. 250-266. On Diplograptidae, Lapworth, by Carl Wiman, pp. 267-274; pl. II. Geological Surveys in Alabama, by Eugene Allen Smith, pp. 275-287. The Superficial Alteration of Ore Deposits, by R. A. F. Penrose, jr., pp. 288-317. The Norwegian Coast Plain, by Hans Reusch, pp. 347-349. Glacial Canons, by W J McGee, pp. 350-364. Fossil plants as an aid to geology, by F. H. Knowlton, pp. 365-382. Wave-like progress of an epeirogenic uplift, by Warren Upham, pp. 383-395. The Occurrence of Algonkian rocks in Vermont and the evidence for their subdivision, by Charles Livy Whittle, pp. 396-429. The origin of the oldest fossils and the discovery of the bottom of the ocean, by W. K. Brooks, pp. 455-479. The Amazonian Upper Carboniferous fauna, by Orville A. Derby, pp. 480-501. Geological Surveys of Ohio, by Edwin Orton, pp. 502-516. Proposed genetic classification of Pleistocene glacial formations, by T. C. Chamberlin, pp. 517-538. The Cenozoic deposits of Texas, by E. T. Dumble, pp. 549-567. Outline of Cenozoic history of a portion of the middle Atlantic slope, by N. H. Darton, pp. 568-587. The Metamorphic Series of Shasta County, California, by James Perrin Smith, pp. 588-612. Superglacial Drift, by Rollin D. Salisbury, pp. 613-632, 708-724, 837-851, Glacial Studies in Greenland, by T. C. Chamberlin, pp. 649-666; 768-788. On a basic rock derived from granite, by C. H. Smyth, jr., pp. 667-679. The Quartzite tongue at Republic, Michigan, by H. L. Smyth, pp. 680-691. Sketch of geological investigations in Minnesota, by N. H. Winchell, pp. 692-707. Petrographical sketch of Aegina and Methana, by Henry S. Washington, pp. 789-813. The basic massive rocks of the Lake Superior region, by W. S. Bayley, pp. 814-825. The Geological Surveys of Arkansas, by J. C. Branner, pp. 826-836.

MOUNT CARMEL.—Jacob Schneck, M. D.:

Notes on Phoradendron flavescens, by J. Schneck; 2 pp.

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NORMAL.—(See Champaign.)

SPRINGFIELD.—Geological Survey of Illinois, Josua Lindahl, State Geologist:

Vol. VIII, Geology and Paleontology, edited by Josua Lindahl, State Geologist. Part I, 892 pp.; 1 pl.; geological map. Part II, 78 litho. pll. Drift Deposits of Illinois, and Economical Geology, by A. H. Worthen, pp. 1-67. Description of Fossil Invertebrates, by A. H. Worthen, pp. 69-154. New Species of Crinoids and Blastoids from the Lower Carboniferous Rocks of Iowa, by Charles Wachsmuth and Frank Springer, pp. 155-208. American Palaeozoic Sponges, by E. O. Ulrich, pp. 209-281. Palaeozoic Bryozoa, by E. O. Ulrich, pp. 283-288.

Illinois State Museum of Natural History, Wm. F. E. Gurley, State Geologist:

Bulletin No. 3. Description of some new species of Invertebrates from the Palaeozoic Rocks of Illinois and adjacent States, by S. A. Miller and Wm. F. E. Gurley, pp. 6-81; pll. I-VIII.

Bulletin No. 4. Upper Devonian and Niagara Crinoids, by S. A. Miller and Wm. F. E. Gurley, pp. 5-37; pll. I-III.

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Bulletin No. 6. Description of some new species of Palaeozoic Echinodermata, by S. A. Miller and Wm. F. E. Gurley, pp. 5-62; pll. I-V.

INDIANA.

BROOKVILLE.—Amos W. Butler:

The Range of the Crossbill in the Ohio valley, with notes on their usual occurrence in summer, by A. W. Butler; pp. 63-72.

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Proceedings, 1892, 176 pp. Contains, among other articles: Analytical and Quaternion treatments of the Problem of Sun and Planet, by A. S. Hathaway, pp. 20-24. The Range of the Crossbill in the Ohio Valley, with notes on their usual occurrence in summer, by A. W. Butler, pp. 63-72. The Ichthyologic Features of the Black Hills region, by B. W. Evermann, pp. 73-78. Modern Geographical Distribution of Insects in Indiana, by F. M. Webster, pp. 81-89.

Proceedings, 1893, 278 pp. Report of the Botanical Division of the Indiana State Biological Survey, by Lucien M. Underwood, director, pp. 13-19; with Appendix A, Bibliography of Indiana Botany, pp. 20-30; Appendix B, List of Cryptogams of Indiana, pp. 30-67. The Fishes of Indiana, by C. H. Eigenmann, director, pp. 67-76. Bibliography of Indiana Fishes, by C. H. Eigenmann and C. H. Beeson, pp. 76-108. Bibliography of Indiana Ornithology, by A. W. Butler, pp. 108-199. Relations of the High Schools of Indiana to the proposed Biological Survey, by W. S. Blatchley, pp. 199-219. On the induration of certain tertiary rocks in northwestern Arkansas, by R. Ellsworth Call, pp. 219-224. The Ash of Trees, by Mason B. Thomas, pp. 239-251. Our Present Knowledge of the Distribution of Pteridophytes in Indiana, by Lucien M. Underwood, pp. 251-258. The Adventitious Plants of Fayette county, Ind., by Robert Hessler, pp. 258-262.

INDIANAPOLIS.—Department of Geology and Natural History:

Fifteenth Annual Report. Maurice Thompson, State Geologist, 1886; 360 pp.; 1 pl. Compendium of Geology and Mineralogy. Indiana building stone, clays of Indiana, Indiana chalk beds, glacial deposits of Indiana, and a terminal moraine in central Indiana, by Maurice Thompson; pp. 10-60. Geology of Tippecanoe county, by S. S. Gorby; pp. 61-96. Henry county and portions of Randolph, Wayne, and Delaware, by A. J. Phinney, M. D.; pp. 97-116. Geology of Washington county, by S. S. Gorby; pp. 117-153. Geological Survey of Clinton county, by W. H. Thompson; pp. 154-159. Geology of Boone county, by S. S. Gorby and S. E. Lee; pp. 160-176. Marshall county, by W. H. Thompson; pp. 177-182. Maxinkuckee, by W. H. Thompson and S. E. Lee; pp. 182-197. Hancock county, by R. T. Brown, A. M., M. D.; pp. 187-197. Geology of Benton county, by S. S. Gorby; pp. 198-220. Geological survey of Starke county, by

W. H. Thompson; pp. 221-227. The Wabash arch, by S. S. Gorby; pp. 228-241. Geographical botany, by Maurice Thompson; pp. 242-252. Origin of the Indiana flora, by John M. Coulter and Harvey Thompson; pp. 253-282. Fossil mammals of the post-pliocene in Indiana, by Maurice Thompson; pp. 283-285. The prehistoric race in Indiana, by S. S. Gorby; pp. 286-313. Natural gas, by Maurice Thompson; pp. 314-334.

Sixteenth Annual Report, 1888, Maurice Thompson, State Geologist; 472 pp.; 10 pll.; map, 50x90 cm. Drift beds of Indiana and the Wabash arch, by Maurice Thompson, pp. 20-53. Fossils and their value, and outline sketch of the minerals of Indiana, by W. H. Thompson, pp. 54-86. Gold, silver and precious stones, and the formation of soils, by Maurice Thompson; pp. 87-97. Report upon the geology of Dekalb and Allen counties, by Charles R. Dryer; pp. 98-130. Pulaski and White counties, by W. H. Thompson; pp. 131-154. Preliminary sketches of the characteristic plants, and of the aquatic and shore birds, of the Kankakee region, by Maurice Thompson; pp. 155-164. Geology of Miami county, and natural gas and petroleum, by S. S. Gorby; pp. 165-301. The structure, classification, and arrangement of American paleozoic crinoids into families, by S. A. Miller; pp. 302-326. Descriptions of echinodermata from the coal measures and subcarboniferous rocks of Indiana, Missouri and Iowa, by S. A. Miller and F. E. Gurley; pp. 327-373; pll. I-X.

Seventeenth Annual Report, 1891, S. S. Gorby, State Geologist; 705 pp.; 20 pll.; 12 figs.; map in colors, 50x90 cm. Report upon the building stones of Indiana, by Maurice Thompson; pp. 18-113. Geology of Steuben county, by Charles R. Dryer; pp. 114-134. Flora of Steuben county, by E. Bradner; pp. 135-159. Geology of Whitley county, by Charles R. Dryer; pp. 160-170 (gives elevations of localities on the third and fourth Erie moraines). Geology of Carroll county, by Maurice Thompson; pp. 171-191. Geology of Wabash county, by Moses N. Elrod and A. C. Benedict; pp. 192-272. Petroleum in Indiana, by A. C. Benedict; pp. 306-325. Natural gas area, by E. T. J. Jordan; pp. 326-364. Butterflies of Indiana ,by W. S. Blatchley; pp. 365-408. Batrachians and reptiles of Indiana, by Dr. O. P. Hay; pp. 409-609; figs. 1-12. Paleontology, by S. A. Miller; pp. 611-705; pll. I-XX.

Indiana Academy of Science.—(See Brookville, Ind.)

TERRE HAUTE.—Barton W. Evermann. (See Washington, D. C.)

Lucien M. Underwood, Ph. D.:

Report of the Botanical Division of the Indiana State Biological Survey, by Lucien M. Underwood, Director; pp. 13-30. List of Cryptogams at present known to inhabit the state of Indiana; pp. 30-67.

IOWA.

AMES.—Iowa Academy of Science (see Des Moines.)

Iowa Agricultural College Experiment Station:

Bulletin No. 22, pp. 819-862.

No. 23, pp. 865-940; 1 plate; 12 figures.

L. H. Pammel, Iowa Agricultural College Experiment Station:

Modification of Plants by Climate, by A. A. Crozier. 36 pp.

On the Pollination of Phlomis Tuberosa L., and the perforation of flowers, by L. H. Pammel. From Trans. St. L. Acad. Sci., V, pp. 241-277; pll. VI, VII.

On the Seed-coats of the Genus Euphorbia, by L. H. Pammel. Trans. St. L. Acad. Sci., V, pp. 543-568; pll. XII-XIV.

On the Influence of Fungicides upon the germination of seeds. Agr. Sci., VIII, pp. 215-231.

Fungous Diseases of the Sugar Beet, by L. H. Pammel, 16 pp.; 7 pll.

Bulletin No. 20, Iowa Agr. Coll. Exp. Sta., pp. 679-730. Grass and leaf-hoppers, by Herbert Osborn; pp. 713-715. Treatment of spot diseases of the cherry and currant, and potato blight, by L. H. Pammel; pp. 716-720. Prevention of corn and oat smut, by L. H. Pammel and F. C. Stewart; pp. 721-723.

No. 21, pp. 735-804; 2 pll. An aromatic bacillus of cheese, by L. H. Pammel; pp. 794-796. Some bacteriological work in the dairy, by L. H. Pammel; pp. 797-804.

No. 22, pp. 819-861.

No. 23, pp. 865-890; 1 pl.; 12 figs. Results of crossing cucurbits, by L. H. Pammel; pp. 906-917. Notes on a few common fungous diseases, by L. H. Pammel; pp. 918-924.

No. 24, pp. 943-1006; 13 figs. Experiments with fungicides, by L. H. Pammel; pp. 985-990.

No. 25, pp. 3-48. Specific gravity and weight of wheat seed, by L. H. Pammel and F. C. Stewart; pp. 26-31.

No. 26. The Russian Thistle, by L. H. Pammel, James Wilson, and J. L. Budd; 32 pp.; 9 plates.

No. 27, pp. 85-154; 4 pll., figs., etc. Potato scab and its prevention, by L. H. Pammel; pp. 120-129. Rutabaga rot, by L. H. Pammel; pp. 130-135.

DAVENPORT.—Academy of Natural Sciences:

Proceedings, Vol. V, Part II. January, 1885—January, 1889. 1893. Pp. i-viii, 185-370; pll. I, II. Ceanothus L.—Recent field notes, with a partial revision of species, by C. C. Parry; pp. 185-194. Synopsis of proceedings; pp. 195-280.

DES MOINES.—Iowa Academy of Sciences:

Proceedings, Vol. I, Part IV, 1893, 142 pp., contains the following papers, or abstracts of them: On the assumption of a special "Nascent Sate," and Some peculiarities of solutions of ferric sulphocyanate, by Launcelot Andrews; pp. 9-15. Experimental engineering at the Iowa Agricultural College, by G. W. Bissell; pp. 16-18. On the geological position of Bennettites dacotensis Macbride, with remarks on the stratigraphy of the region in which the species was discovered, by Samuel Calvin; pp. 18-22. Notes on the lower strata of the Devonian series in Iowa, by Wm. Harmon Norton; pp. 22-24. Derivation of the Unione fauna of the Northwest, and Process of formation of certain quartzites, by Charles R. Keyes; pp. 25-31. Origin of the present drainage system of Warren county, by J. L. Tilton; pp. 31-33. Structure of the Mystic coal basin, and Sigourney deep well, by H. Foster Bain; pp. 33-38. Southern extension of the Cretaceous in Iowa, and Topography of the granite and porphyry region of Missouri, by E. H. Lonsdale; pp. 39-48. Occurrence of zinc in Northeastern Iowa, and Satin spar from Dubuque, by A. G. Leonard; pp. 48-55. North American cycads, by Thomas H. McBride; pp. 62-65. Bacteria: Their relation to modern medicine, the arts and industries, by L. H. Pammel; pp. 66-91. The Johns Hopkins biological laboratory, by W. S. Windle; pp. 112-115. Laboratory notes in zoology, by Herbert Osborn; pp. 124-127.

Iowa Geological Survey:

Iowa Geological Survey, Vol. I; 19x27 cm. First Annual Report of the State Geologist for 1892, with accompanying papers; 472 pp.; 10 pll.; 26 figs. Geological Formations of Iowa, by Charles Rollin Keyes; pp. 11-144; geological map of Iowa (pl. I) and pll. II-IX; figs. 1-15. Cretaceous Deposits of Woodbury and Plymouth Counties, with observations on their economic uses, by Samuel Calvin; pp. 145-161; figs. 16, 17. Ancient Lava Flows in the Strata of Northwestern Iowa, by Samuel W. Beyer; pp. 163-169; fig. 18. Distribution and Relations of the St. Louis Limestone in Mahaska county, Iowa, by Harry Foster Bain; pp. 171-179; figs. 19, 20. Annotated Catalogue of Minerals, by Charles Rollin Keyes; pp. 181-196; pl. X; figs. 21-26. Some Lime-burning Dolomites and Dolomitic Building-stones from the Niagara of Iowa, by Gilbert L. Houser; pp. 197-207. Bibliography of Iowa Geology, by Charles Rollin Keyes; pp. 209-464.

Vol. II, 1894. Coal Deposits of Iowa, by Charles Rollin Keyes; 536 pp.; 18 pll.; 222 figs.

Vol. III. Second Annual Report, 1893, with accompanying papers, 19x27 cm., bound in green cloth; 501 pp.; 37 pll. and maps; 34 figs. Reports of State Geologist, Assistant Geologist, and Chemist; pp. 19-44. Work and Scope of the Geological Survey, by Charles Rollin Keyes; pp. 45-98; geological map of Iowa (pl. I); pll. II-VI. Cretaceous Deposits of the Sioux Valley, by Harry Foster Bain; pp. 98-114; pll. VII, VIII. Certain Devonian and Carboniferous outliers in Eastern Iowa, by William Harmon Norton; pp. 115-133. Geological Section along Middle river in Central Iowa, by J. L. Tilton; pp. 135-146; fig. 2. Glacial Scorings in Iowa, by Charles Rollin Keyes; pp. 147-165; pll. IX-XV; fig. 3. Thickness of the Paleozoic Strata of Northeastern Iowa, by William Harmon Norton; pp. 167-210; fig. 4 and pll. XVII, XVIII, showing sections and records of twelve deep wells in northeastern Iowa. Composition and Origin of Iowa Chalk, by Samuel Calvin; pp. 211-236; pl. XIX. Buried River Channels in Southeastern Iowa, by C. H. Gordon; pp. 237-255; figs. 5-7. Gypsum Deposits of Iowa, by Charles Rollin Keyes; pp. 257-304; map of the Iowa gypsum region (pl. XX); pll. XXI-XXV; figs. 8-12. Geology of Lee County, by Charles Rollin Keyes;

pp. 305-407; geological map of Lee county (pl. XXVI), 30x40 cm.; pll. XXVII-XXXII; figs. 14-25. Geology of Des Moines County, by Charles Rollin Keyes; pp. 409-492; geological map (pl. XXXIII) 25x30 cm.; pll. XXXIV-XXXVII; figs. 26-34.

IOWA CITY.—Iowa Academy of Sciences. (See Des Moines.)

State Historical Society:

Iowa Historical Record, Vol. IX, 1893, pp. 385-576. Contains a complete expose of the "Cardiff Giant" deception, and portraits of Alex. Chambers, L. G. Bell, John A. Parvin, and Charles Mason.

Iowa City—a Contribution to the Early History of Iowa, by Benjamin F. Shambaugh, 116 pp.

The Amish Mennonites—a sketch of their origin, and of their settlement in Iowa, with their creed in an appendix, by Barthimius L. Wick; 60 pp.

Iowa Historical Record, quarterly, Vol. X, Nos. 1-4, 1894, 192 pp.; steel and other engravings of John S. Tilford, Lucinda Humphrey Hay, William G. Hammond, and Samuel Jordan Kirkwood.

Historical Lectures upon early leaders in the professions, 1894, 134 pp.

Constitution and records of the Claim Association of Johnson county, Iowa, with introduction and notes, by Benjamin F. Shambaugh, 192 pp.

State University of Iowa—Laboratories of Natural History:

Bulletin, Vol. II, No. 3, pp. 191-294; 3 pll., containing: I. The Early stages of three North American coleoptera, by H. F. Wickham, pp. 195-201. II. Report on an Entomological reconnoissance to southern Alaska, by H. F. Wickham, pp. 202-233. III. On two species of coleoptera introduced from Europe, by H. F. Wickham, p. 234; 1 pl. IV. Report on zoological explorations on the Lower Saskatchewan river, by C. C. Nutting; pp. 235-293; pll. II, III.

KANSAS.

ATCHISON.—Soldiers' Orphans' Home:

Fourth Biennial Report of the Superintendent, ending June 30, 1894, 14 pp.; 1 pl.

EMPORIA.—The State Normal School:

Catalogue of School, 106 pp.

JUNCTION CITY.—Robert Hay:

Geology and Mineral Resources of Kansas, by Robert Hay, F. G. S. A. From the Eighth Biennial Report of the State Board of Agriculture, 1891-92, 66 pp.; geological map of Kansas; 2 pll.; 12 figs.

Mineral Resources of Kansas (World's Fair edition), 23 pp.

LAWRENCE.—Prof. E. H. S. Bailey, Kansas State University:

A Chemical Examination of the Waters of the Kaw and its Tributaries, by E. H. S. Bailey and E. C. Franklin; 12 pp. From Kan. Univ. Quar., Vol. III, No. 1, July, 1894.

Prof. V. L. Kellogg, now of Leland Stanford Junior University:

Common Injurious Insects of Kansas, by V. L. Kellogg; 126 pp.; 61 figs.

Prof. E. Miller, Kansas State University:

Outline of Mathematical Work, by E. Miller; 12 pp.

L. E. Sayre, Ph. G., Kansas State University:

American Colocynth, by L. E. Sayre, University of Kansas. From American Journal of Pharmacy, June, 1894, 6 pp. 1 pl.

Kansas State University:

Eighth Biennial Report of the Board of Regents and Officers of the University of Kansas, 1891-'92; 30 pp.

Twenty-eighth Annual Catalogue, 1893-4; pp. 3-126; 3 plates.

School of Fine Arts, 1894-5, 34 pp.; 3 half-tone plates.

Catalogue of the School of Law for Collegiate year 1893-4. 16 pp. 1 plate.

Catalogue of the School of Pharmacy for the Collegiate year 1893-4, 32 pp.; 6 plates.

The Kansas University Quarterly, Vol. I, Nos. 3 and 4, pp. i-xvi, 101-196; pll. IX-XIII+I-VII. On the Apioceridae and their Allies, and Diptera Brasiliana, III, by S. W. Williston; pp. 101-123; pl. IX, X. Notes on some diseases of grasses, by W. C. Stevens; pp. 123-132; pll. XI-XIII; 6 figures. Modern higher algebra, by E. Miller; pp. 133-136. Dialect word list, II, by W. H. Carruth; pp. 137-142. Maximum Bending Moments for moving loads in a parabolic arch-rib hinged at the ends, by E. C. Murphy; pp. 143-153. Penology in Kansas, by F. W. Blackmar; pp. 155-177. Bibliography of municipal government in the United States, by Frank H. Hodder; pp. 179-196; pll. I-VII.

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Vol. III, No. 1 and 2, pp. 1–163; pll. I–XIII, pl. VIII being a photograph of Platygonus leptorhinus; 1 map. Vertebrate remains from the lowermost Cretaceous, A new turtle from the Benton Cretaceous, Notes on Uintacrinus socialis Grinnell, Restoration of Platy gonus, On the genus Dolichomyia, with the description of a new species from Colorado, by Dr. S. W. Williston; pp. 1–43; pll. I–VIII. Taxonomic value of the scales of the Lepidoptera, by Vernon L. Kellogg; pp. 45–89; pll. IX, X. Chemical examination of the waters of the Kaw river and its tributaries, by E. H. S. Bailey and E. C. Franklin; pp. 91–102. The Hessian, Jacobian, Steinerian, in geometry of one dimension, by Henry B. Newson; pp. 103–116. Irrigation along the Arkansas in western Kansas, by E. C. Murphy, C. E.; pp. 117–128. List of the birds of Finney county, Kansas, by H. W. Menke; pp. 129–135. A study of the prothorax of Butterflies, by May H. Wellman; pp. 137–142. American Platypezidae, by W. A. Snow; pp. 143–152; pl. XII. Foreign Settlements in Kansas, by W. H. Carruth, with map; pp. 159–163.

University of Kansas Experiment Station:

First Annual Report of the Director for the year 1891. F. H. Snow, Director. Contagious Diseases of the Chinch Bug; 230 pp.; map of Kansas; 3 pll.

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A Key to the Spring Flora of Manhattan, 36 pp. A Key to the Genera of Manhattan Plants, based on fruit characters, 36 pages.

Kansas State Agricultural College:

Thirtieth Annual Catalogue of the officers, students and graduates, 1892–3; pp. 1–68, with 18 half-tones of buildings and departments. Thirty-first Annual Catalogue, 1893–4; 68 pp. with 16 plates.

Kansas State Agricultural College.—Experiment Station:

Sixth Annual Report, 1893, pp. ii–xxii.

Bulletins: No. 35. Actinomycosis bovis or "lump jaw" of cattle. Some observations upon loco, 20 pp.; pll. IX–XV.

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No. 39. Experiments in Feeding Steers, pp. 16-50; pll. IV-VI.
No. 40. Experiments in Wheat, pp. 51-61.
No. 41. The Effect of Fungicides upon the germination of corn, pp. 63-79.
No. 42. Experiments with Oats, pp. 81-92.
No. 43. Experiments with Sorghum and Sugar Beets, pp. 93-114.
No. 44. Further Study of Native Grapes, pp. 115-128.
No. 45. Experiments with Corn, pp. 129-150.
No. 46. Rust of Grains, II, pp. 1-10.
No. 48. Six Years' Experience with Ensilage. Some Forage Plants. Renovating a Prairie Pasture, pp. 33-43.

McPHERSON.—J. A. Udden: See Rock Island, Ill.

On a Natural Formation of Pellets in McPherson County, Kansas, by J. A. Udden Augustana College, Rock Island, Ill., 1893; 4 pp.; 3 figs.

MORGANVILLE.—John H. Schaffner: See Ann Arbor, Mich.

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The Twenty-ninth Annual Catalogue of the Officers and Students, 1893-4, 48 pp.

STERLING.—A. A. Denton:

Field Experiments with Sugar Cane, seasons of 1890, 1891, and 1892, by Hubert Edson, Chemist. 1893. 45 pp.

TOPEKA—Adjutant General of the State of Kansas:

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Tenth Annual Report of the Board of Railroad Commissioners, for the year ending December 1, 1892; 294 pp.; bound in cloth. Official railroad map of Kansas.

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Ninth Annual Report of the Bureau of Labor and Industry, by J. F. Todd, Labor Commissioner. 1893. Bound in cloth. 824 pp.; 4 pll.

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Report of the Commissioner of Forestry for the State of Kansas, for the two years ending June 30, 1894, by E. V. Wheeler, Commissioner; 32 pp.

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State Bank Commissioner:

Second Biennial Report of the Bank Commissioner of the State of Kansas, September 1, 1894, by John W. Breidenthal, Bank Commissioner, 300 pp.

State Board of Agriculture; F. D. Coburn, Secretary:

Ninth Biennial Report of the State Board of Agriculture. 1893-4. Vol. xiv., bound in cloth, by F. D. Coburn, Secretary. 538 pp.; map of foreign settlements in Kansas; 7 pll.; 14 figs. Some discussions of irrigation problems and possibilities, moisture, soils, and related topics, as they pertain to Kansas, by Prof. G. H. Failyer; pp. 324-327. An inquiry into the extent to which irrigation in Kansas is possible, by Prof. Erasmus Haworth; pp. 327-334. Irrigation possibilities upon the higher lands of Western Kansas, by A. B. Montgomery; pp. 334-338. Evaporation and storage of soil moisture, by H. R. Hilton; pp. 341-348. Circulation of water in soils, by Prof. Milton Whitney: pp. 348-363. Water required to produce a pound of dry material, by Prof. F. H. King; pp. 354-367. 367. Fruit and vegetable growing under irrigation, by C. H. Longstreth, Lakin: pp. 367-370. How and when to irrigate a small tract, by G. W. Gregory, Garden City, Kans.; pp. 371-374. The natural distribution of roots in field soils, by Prof. F. H. King, from the tenth annual report of Wisconsin Experiment Station; pp. 374-379; 9 colored figures. Observations on Subsoiling: A six years' experience, by Scott Kelsey, Topeka; pp. 380-387. Alfalfa, or Lucern: Its history, characteristics, cultivation, worth and uses; pp. 388-455. Feeding Wheat to Farm-Animals: Its practice in Kansas, and something of its bearing upon agriculture and stock-raising; pp. 456-531.

State Board of Charities:

Ninth Biennial Report of the Board of Trustees of the State Charitable Institutions of Kansas, for the two years ending June 30, 1894. 170 pp.; 15 pll.

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Columbian History of Education in Kansas. 1893. 231 pp., with 13 plates of school buildings in Kansas and 29 figures, portraits of prominent educators of Kansas.

State Inspector of Coal Mines:

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Kansas at the World's Fair. Report of the Kansas Board of World's Fair Managers, containing report of the "Board of Managers Kansas Exhibit," from April, 1892, to March, 1893, and transactions of the "Kansas Board of World's Fair Managers," for March, 1893, to December, 1893, together with illustrations and descriptions in detail of all Kansas exhibits and awards. 1893. 116 pp.; 46 pll.

F. G. Adams, Secretary State Historical Society:

Fourth Annual Report of the United States Geological Survey, by J. W. Powell, Director, 1884, 505 pp.; 85 pll.; 15 figs.

Report on the United States and Mexican Boundary Survey, by William H. Emory, Major 1st Cavalry, U. S. Commissioner, 23x29 cm., bound in black cloth. Vol. I, 1857, 34th Cong., 1st Sess., Ex. Doc. No. 135; 476 pages; 8 steel engravings; 64 half-page steel outline sketches; steel map of U. S. 50x60 cm.; 12 colored lithographs; 46 wood cuts; 21 steel plates of paleontology, embracing 150 figures of shells. Part I. Emory's Report, 258 pp.; 90 pll.; 20 cuts. Part II. Geological reports of Dr. C. C. Parry and Arthur Schott. Paleontology and Geology of the boundary, by James Hall. Description of Cretaceous tertiary fossils, by T. A. Conrad, 174 pp.; 21 pll.; 30 wood cuts.

F. W. Cragin: See Colorado Springs, Colo.

Chas. S. Prosser, Union College, Schenectady:

Kansas River Section of the Permo-carboniferous and Permian rocks of Kansas, by Charles S. Prosser. From the Bull. Geol. Soc. of America, Vol. VI, pp. 29-54.

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U. S. Geological Survey of Wyoming and contiguous territory, 1870, by F. V. Hayden, United States Geologist; 511 pp.; numerous figures.

United States Geological and Geographical Survey of Colorado and adjacent territory, 1875, by F. V. Hayden, United States Geologist, 836 pp.; 70 pll.; 7 maps, and 67 figs.

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Psyche, a Journal of Entomology. Vol. VI, Nos. 199-212. Pp. 343-585; pll. VIII-XXI. The Orthopteran Genus Hippiscus, by Samuel H. Scudder; pp. 347-350, 359-363. Descriptions of new species and genera of West African Lepidoptera, by W. J. Holland; pp. 373-376, 393-400, 411-418, 431-434, 451-454, 469-476, 487-490, 513-520, 531-538, 549-552, 565-568, pll. X, XI, XVII, XVIII, XX, XXI. An interesting Blood-sucking Gnat of the family Chironomidæ, by C. H. Tyler-Townsend; pp. 369-371; pl. VIII. A preliminary Synopsis of the Harvest-spiders (Phalangiidæ) of Mississippi, by Clarence M. Weed; pp. 425-428; pll. XI-XV. The Primitive Number of Malpighian Vessels in Insects, by W. M. Wheeler, pp. 457-460; 485-487; 497-498; 509-510; 539-541; 545-547; 561-564. A New Species of Stenobothrus from Connecticut, with remarks on other New England species, by A. P. Morse; pp. 477-479. Early Stages of two Jamaica Nymphalidæ, by T. D. A. Cockerell; p. 481. Notes on Gluphisia and other Notodontidæ, by A. S. Packard, pp. 499-503, 521-523.

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Thirteenth Annual Report for the year ending December 31, 1894. 16 pp.

MISSOURI

COLUMBIA.—Missouri Agricultural College Experiment Station:

Bulletin No. 21. Field Experiments with wheat. April, 1893. 16 pp.

No. 24. Comparative Tests of different breeds of beef cattle. January, 1894. 89 pp.; 7 pll.

No. 25. Inquiry into the Composition of the flesh of cattle. April, 1894. 105 pp.
No. 26. Dairy Management. July, 1894. 40 pp.

JEFFERSON CITY.—Geological Survey of Missouri, Arthur Winslow, State Geologist.

Bulletin No. 4. Description of some Lower Carboniferous crinoids from Missouri, by S. A. Miller; 40 pp.; 5 pll.

No. 5. Age and origin of the crystalline rocks of Missouri, by Erasmus Haworth, 42 pp.; 4 pll.; 5 figs.; and notes on the clays and building stones of certain western central counties tributary to Kansas City, by G. E. Ladd, Assistant Geologist; pp. 49-86; pl. V.

Sheet Report No. 1, 44x53 cm. The Higginsville sheet in Lafayette county, April, 1892, 18 pp.; with geologic and topographic map, and cross and columnar sections to illustrate.

No. 2, 44x53 cm. The Bevier sheet, including portions of Macon, Randolph, and Chariton counties, 76 pp., 4 figs., map and sections.

No. 3, 44x53 cm. The Iron Mountain sheet, including portions of St. Francois and Madison counties, 86 pp.; 5 pll.; 14 figs.; with map and sections.

Annual Report, Vol. I, 1891. 17x25 cm., bound in brown cloth. Preliminary report on the coal deposits of Missouri, by Arthur Winslow, State Geologist; 228 pp.: 131 illustrations, and block map of Missouri.

Vol. II, 1892. Report on the iron ores of Missouri, by Frank L. Nason, Assistant Geologist; 366 pp.; 8 pll.; geological map of Missouri, 47x54 cm.; 62 figures.

Vol. III, 1892. Report on the mineral waters of Missouri, by Paul Schweitzer, Assistant Geologist; 256 pp.; map; 45 plates and illustrations.

Vol. IV, 1894. Paleontology of Missouri, Part I, by Charles Rollin Keyes, State Geologist; 272 pp.; map; pll. I-XXXII.

Vol. V, 1894. Paleontology of Missouri, Part II, by Charles Rollin Keyes; 266 pp.; pll. XXXIII-LVI.

KANSAS CITY.—Kansas City Academy of Science:

KIRKWOOD.—Mary E. Murtfeldt:

Outlines of Entomology, by Mary E. Murtfeldt. 15x23 cm. Bound in green cloth. 1891. 132 pp.; 45 figs.

ST. LOUIS.—The Academy of Science of St. Louis:

Constitution and History of the Academy of Science of St. Louis. 1893. 92 pp.

Transactions, Vol. VI, 1892-4. No. 4. Flowers and Insects—Labiatae, by Charles Robertson; pp. 101-131.

No. 5. Opening of the Buds of some Woody Plants, by A. S. Hitchcock; pp. 133-142; 4 pll.

No. 6. Materials for a monograph on Inuline, by J. Christian Bay; pp. 151-159.

No. 7. The Physical Basis of Precocity and Dullness, by W. Townsend Porter; pp. 161-181; 2 pll.

No. 8. Geometrical Constructions for cutting from a cone of revolution plane sections, by Edmund A. Engler; pp. 183-190; 3 figs.

No. 9. Sclerotinia Libertiana Fuckel, with a bibliography of fungus root diseases, by L. H. Pammel; pp. 191-232; 2 pll.

No. 10. The Relation between the Growth of Children and their Deviation from the physical type of their sex and age, by Wm. Townsend Porter; pp. 233-250 ; 1 pl.

No. 11. Catalogue of Reptiles and Batrachians found in the vicinity of St. Louis, Mo., by Julius Hunter; pp. 251-261.

No. 12. The Growth of St. Louis children, by Wm. Townsend Porter; pp. 263-380; pll. I-XLVI.

No. 13. A Study of the Relations of Salix Nigra and Salix Amygdaloides, by N. M. Glatfelter, M. D.; pp. 427-431; 1 pl.

No. 14. Flowers and Insects—Rosaceae and Compositae, by Charles Robertson; pp. 435-480.

No. 15. Determinations of the Latitude, Longitude, and Height above sea level of the Laws Observatory of the University of the State of Missouri, by Milton Updegraff; pp. 481-518; 1 plate.

No. 16. Merycism regarded in the light of Atavic tendency, by Edwin C. Runge; pp. 519-536.

No. 17. Post-mortem Detection and estimation of strychnine, by Allerton S. Cushman; pp. 537-544.

The Missouri Botanical Garden (Shaw's), Prof. Wm. Trelease, Director:

Fourth Annual Report. 17x25 cm., bound in green cloth. 1893. 226 pp.; 23 pll. Plants collected in the Bahamas, Jamaica and Grand Cayman, by Albert S. Hitchcock; pp. 47-179; pll. XI-XIV. Further Studies of Yuccas, and their Pollination, by William Trelease; pp. 181-226; pll. I-X, XV-XXIII.

Fifth Annual Report, 1894. 166 pp.; 32 pl. The Venation of the species of Salix described in Gray's Manual, by N. M. Glatfelter, M. D. ; pp. 44-60; pll. I-III. Material for a Monograph on the Tannoids, by J. Christian Bay; pp. 61-87. The Sugar Maples, with a winter synopsis of all North American maples, by William Trelease; pp. 88-106; pll. IV-XVI. Revision of the North American species of Gayophytum and Boisduvalia, by William Trelease; pp. 107-122; pl. XVII-XXVI. Phenological Notes, by J. C. Whitten; pp. 123-135. The Emergence of Pronuba from Yucca capsules, by J. C. Whitten; pp. 137-138. Notes on a list of plants collected in southeastern Missouri in 1893, by B. F. Bush; pp. 139-153. Notes and observations, by Wm. Trelease; pp. 154-166; pll. XXVII-XXXII.

SEDALIA.—F. A. Sampson:

History and Publications of the Missouri State Horticultural Society, by F. H. Sampson; 15 pp. On some new Sedalia Trilobites, by A. W. Vogdes; 4 pp.; 4 pll. Two new Carboniferous Trilobites, by A. W. Vogdes; 5 pp.

NEBRASKA.

LINCOLN.—Elton Fulmer, University of Nebraska:

On the Occurrence of Phosphates in Nebraska, by Elton Fulmer; 4 pp., from Vol. VII, No. 2, Journal of Analytical and Applied Chemistry.

University of Nebraska:

University Studies, Vol. II, No. 1, July, 1894. 80 pp.; 12 pll. Notes on the New Fossil, Daimonelex, by E. H. Barbour; pp. 1-6; pl. I-XII.

University of Nebraska.—Agricultural Experiment Station:

Sixth Annual Report of the Agricultural Experiment Station, 1892; 84 pp., bound in black cloth. Includes Bulletins Nos. 21-26; 1 pl.; 6 figs.

Seventh Annual Report, 1894. Includes Bulletins 27-36. 206 pp.; 12 pll.; 17 figs.

NEW JERSEY.

TRENTON.—New Jersey Agricultural College Experiment Station:

Report of the Botanical Department, by Byron D. Halsted, Botanist; pp. 273-387; 32 figs.

NEW MEXICO.

LAS CRUCES.—T. D. A. Cockerell, N. M. Agricultural College:

Additions to the Flora of Colorado—Fungi, by T. D. A. Cockerell. From Zoe, Vol. IV, pp. 282-285.

A supplementary note to Mr. Johnson's list of Jamaican Diptera, by T. D. A. Cockerell; 2 pp.

The Injurious Insects of New Mexico, by T. D. A. Cockerell; 4 pp.

On some Insects collected in the state of Chihuahua, Mex., by T. D. A. Cockerell, Entomologist of the N. M. Agr. Expa. Sta. From the Annals and Magazine of Natural History, Vol. XV, pp. 204-210.

Notes on Peripatus jamaicensis, Grabh. and Ckll., by T. D. A. Cockerell; 2 pp.

The Twentieth Neotropical Aspidiotus, by T. D. A. Cockerell; 2 pp.

A new Attid Spider from Jamaica, by T. D. A. Cockerell; 2 pp.

NEW YORK.

ALBION.—Frank H. Lattin, Publisher:

The Oologist, 1893. Vol. X, Nos. 4, 5, 6, 9, and 10. Contains, besides other articles, the Raptores of Michigan, by Scolopax; pp. 101-104.

Vol. XI, 1894, Nos. 1-12. 376 pp. Contains, besides other articles, the Raptores of Michigan, by Scolopax; pp. 1-11. Nesting habits of the Brown Pelican in Florida, by Morris Gibbs; pp. 81-84. Of the Passenger Pigeon, by Eugene Pericles; pp. 237-240.

Walter F. Webb, Publisher:

The Museum: A journal devoted exclusively to research in natural science. Vol. I, Nos. 1, 2. 1894. Contains, among other articles, Atlantic Coast Star

Fishes; pp. 18-22. An Ornithological Paradise, some observations gleaned from a sojourn on the famous Farallone Islands, by C. Barlow, Santa Clara, Calif.; pp. 37-44; 4 figs. Arctic Notes on the habits of certain northern birds in Commander Islands and Kamtschatka, by Leonhard Stejneger; pp. 53-58.

HAMILTON.—Colgate University, Department of Geology:

Circular of Information, Courses of Instruction, etc. 1892-1893, 12 pp. 1893-1894, 23 pp.

Prof. A. P. Brigham, Colgate University:

The Geology of Oneida County, by Albert Perry Brigham. 17 pp. (Transactions Oneida Historical Society, 1887-1888.)

A Chapter in Glacial History, by Albert P. Brigham, 13 pp. (Trans. Oneida Hist. Soc., 1889-1892.)

Rivers and the Evolution of Geographic Forms, by Albert P. Brigham, 21 pp.; 2 half tones. (Bull. Amer. Geog. Soc., March, 1892.)

The Finger Lakes of New York, by Albert P. Brigham, 21 pp. (Bull. Amer. Geog. Soc., Vol. XXV, No. 2, 1893.)

ITHACA.—Cornell University—Agricultural Experiment Station:

Bulletin of the Entomological Division. No. 23. Insects Injurious to Fruits; pp. 101-126.

Bulletin No. 33, Entomological Division. Wireworms; pp. 191-272.

Prof. M. V. Slingerland, Cornell University:

Bulletin No. 44, Entomological Division. The Pear-Tree Psylla, by Mark V. Slingerland, Assistant Entomologist; pp. 161-186.

No. 50. The Bud Moth, by Mark Vernon Slingerland; pp. 1-30.

No. 58. The Four-Lined Leaf-Bug, by M. V. Slingerland; pp. 205-239.

No. 61. All Divisions. Sundry Investigations of the year; pp. 297-350; 21 pll. and figs.

No. 64. Entomological Division. On Certain Grass-Eating Insects, by Ephraim Porter Felt; pp. 45-102; pll. I-XIV.

No. 78. The Cabbage-root Maggot, with notes on the onion maggot and allied insects, by M. V. Slingerland; pp. 479-578; 18 figs.

No. 83. A Plum Scale in western New York, by M. V. Slingerland; pp. 677-700; 5 figs.

NEW BRIGHTON.—Natural Science Association of Staten Island:

Proceedings, Vol. III, November, 1891, to October, 1893, about 100 pp. Vol. IV, Nos. 1-12, 53 pp.

NEW YORK.—Astor Library:

Forty-Fifth Annual Report of the Trustees for the year 1893; 41 pp.

Linnaean Society of New York:

Abstract of the Proceedings for the year ending March 2, 1892. 8 pp.

For the year ending March 1, 1893, with a paper on "Milicete Indian Natural History," by Tappan Adney; 41 pp.

For the year ending March 27, 1894, with recent progress in the study of North American mammals, by J. A. Allen, and a consideration of some ornithological literature, with extracts from current criticism, by L. S. Foster; 104 pp.

New York Academy of Sciences:

Transactions, Vol. XII, 1892-1893. 270 pp.; 8 pll. Additions to the Palaeobotany of the Cretaceous formation on Staten Island, by Arthur Hollick; pp. 28-39. Notes on the clays of New York and their economic value, by Heinrich Ries; pp. 40-47. The North American species of the genus Lespedeza, by N. L. Britton; pp. 57-68. On an occurrence of Gabbro (Norite), near Van Artsdalen's Quarry, Bucks county, Penn., by J. F. Kemp; pp. 71-77. Fact and Fallacy in the boomerang problem, by C. H. Emerson, Whitehall, N. Y.; pp. 77-92. A Geological Reconnoisance in the vicinity of Gouverneur, N. Y., by C. H. Smyth, Jr.; pp. 97-108. On Phosphate Nodules from the Cambrian of southern New Brunswick, by W. D. Matthew; pp. 108-120; 4 pll. The Sunapee Saibling; a fourth New England variety of Salvelinus, by John D. Quackenbos; pp. 139-151. Plant Distribution as a factor in the Interpretation of Geological Phenomena, with special reference to Long Island and vicinty, by Arthur Hollick; pp. 189-202. Petrography of the Gneisses of the town of Gouverneur, N. Y., by C. H. Smyth, Jr.; pp. 203-217. On recently discovered deposits of diatomaceous earth in the Adirondacks, by Charles F. Cox; pp. 219, 220. Preliminary contribution to our knowledge of the Cretaceous formation on Long Island and eastward, by Arthur Hollick; pp. 222-237; pll. V-VII. On antennae and other appendages of Triarthrus Beckii, by W. D. Matthew; pp. 237-245; pl. VIII.

Vol. XIII, 1893-1894. 296 pp.; 7 pll.; 10 figs. "The Ore-deposits at Franklin Furnace and Ogdensburg, New Jersey," by J. F. Kemp; pp. 76-98. On Allanite crystals from Franklin Furnace, N. J., by A. S. Eakle, Cornell University; pp. 102-107. A Pleistocene lake-bed at Elizabethtown, Essex county, N. Y., by Heinrich Ries; pp. 107-115; pl. I; 4 figs. Some further notes on the Geology of the north shore of Long Island, by Arthur Hollick; pp. 122-130. Our Conception of "Species" as Modified by the Doctrine of Evolution, by N. L. Britton; pp. 132-135. An orbicular granite from Quonochontogue Beach, R. I., by L. F. Kemp; pp. 140-144; pl. II. Notes on the Petrography of certain basaltic boulders from Thetford, Vt., by E. O. Hovey, Ph. D.; pp. 161-169. Account of an ancient beaver pond and of cut sticks found therein, by Professor Oliver P. Hubbard; pp. 177-181. On Caswellite, an altered biotite from Franklin Furnace, N. J. Quartz Crystals from Ellenville, N. Y., by Albert H. Chester; pp. 181-185. The Intrusive Rocks near St. John, N. B., by W. D. Matthew; pp. 185-206. A group of diabase dikes among the Thousand Islands, St. Lawrence river, by C. H. Smyth, Jr.; pp. 209-214. Geology of Essex and Willsboro' townships, Essex county, N. Y., by Theodore Greeley White; pp. 214-234.

New York Microscopical Society:

Journal, a quarterly magazine. Vol. IX, 1893, 130 pp. Notes on some Researches among the Diatomaceae, by K. M. Cunningham; pp. 85-115.

Vol. X, 1894, 148 pp.; 7 pll. On Uniformly Stained Cover-preparations of Micro-organisms, free from distortion, by Alexis A. Julien, Ph. D.; pp. 1-14. Notes on the Structure of the Endosperm of Phytelephas Macrocarpa Ruiz & Pavon, and of Smilacina racemosa Desf., by J. L. Zabriskie; pp. 14-16; plate 38. The comparative Anatomy of the Vertebrate Skin, by George William Kosmak; pp. 42-51; pll. 41-43. A Contribution to the History of the Formation of the Lichen Thalus, by Carlton C. Curtis; pp. 63-69. The Cretaceous Foraminifera of New Jersey, Part II, original investigations and remarks, by Anthony Woodward, Ph. D.; pp. 91-132.

Torrey Botanical Club:

Bulletin, Vol. XX, 1893, Nos. 1-12; 516 pp.; 34 pll. Studies upon the Seedlings of Plants and of Order Compositae, by W. W. Rowlee; pp. 1-17; pll. CXXXIV-CXXXVIII. A new Species of Listera, with notes on other Orchids, by Thompson Morong; pp. 31-39. Report on the Flora of Luzerne county, Penn., by A. A. Heller; pp. 55-67. The Development of the Sporocarp of Pilularia Americana, A. Br., by Douglas Houghton Campbell; pp. 141-148. An examination of some of the seeds of Native Orchids, by Carlton C. Curtiss; pp. 183-192; pll. CL-CLII. List of the Grasses of Pennsylvania, by Thos. C. Porter; pp. 193-211. Notes on the Flora of Block Island, by W. W. Bailey; pp. 227-239. Index to recent Literature relating to Botany; pp. 263-276. New and Noteworthy North American Phanerogams, VII, by N. L. Britton; pp. 277-282; pl. CLVIII. Two new American Hepaticae, by Alexander W. Evans; pp. 307-310; pll. CLXII, CLXIII. A Study of the Scale characters of the Northeastern America Species of Cuscuta, by W. D. Matthew; pp. 310-314; pll. CLXIV, CLXV. Lichens of the Black Hills and their Distribution, by Thomas A. Williams; pp. 349-355. Botanical Notes from Bainbridge, Georgia, by Aug. F. Foerste; pp. 284-391. Contributions to American Bryology, III, by Elizabeth G. Britton; Notes on the North American species of Orthotrichum; pp. 393-405. Notes on Carex, XVII, by L. H. Bailey; pp. 417-434. The Altitudinal Distribution of the Ferns of the Appalachian Mountain System, by John K. Small; pp. 455-467. The Solandi Process of Sun Printing; pp. 485-488.

Vol. XXI, 1894, Nos. 1-12. 748 pp.; 44 pll. Contributions to American Bryology, IV. Notes on the North American Species of Orthotrichum, II; pp. 1-20. New or noteworthy North American Phanerogams, VIII, by N. L. Britton; pp. 27-37; pll. 173. Additions to the Palaeobotany of the Cretaceous Formation on Long Island, by Arthur Hollick; pp. 49-65; pll. 174-180. A Study of the Genus Psoralea in America, by Anna Murray Vail; pp. 91-119. Western Species of Orthotrichum, by Elizabeth G. Britton; pp. 137-159. A Revision of the Genus Physcomitrium, with descriptions of five new species, by Elizabeth G. Britton; pp. 189-208. The Genus Cassia in North America, by Charles Louis

Pollard; pp. 208-222. The Comparative Anatomy of Corema alba and Corema Conradii, by Marion C. McEwing; pp. 277-285. Recent Discoveries of Cycadean Trunks in the Potomac Formation in Maryland, by Lester F. Ward; pp. 291-299. A New Fossil Nelumbo from the Laramie Group at Florence, Colo., by Arthur Hollick; pp. 307-310. A Revision of the Genus Bruchi, by Elizabeth G. Britton; pp. 343-372. Notes on some Exoasceae of the United States, by George F. Atkinson; pp. 372-380. Notes on Tubercularia pezizoidae Schwein, by Hermann Schrenk; pp. 385-389; pl. 218. The Smilaceae of North and Central America, by Thomas Morong; pp. 419-443. A new fossil Hepatic from the Lower Yellowstone in Montana, by F. H. Knowlton; pp. 458-460; pl. 219. Wing-like Appendages on the Petioles of Liriophyllum populoides Lesq. and Liriodendron alatum Newb., with description of the latter, by Arthur Hollick; pp. 467-471; pll. 220-221. Two Species of Oxalis; and notes on rare species of Polygonum, by John K. Small; pp. 471-482; pll. 222-224. Notes on Maize, by E. Lewis Sturtevant; pp. 503-523.

W. A. Conklin, Ph. D., and R. S. Huidekoper, M. B.:
The Journal of Comparative Medicine and Veterinary Archives, monthly. Vol. XIII, Nos. 9-12, Pp. 579-724.
Vol. XIV, Nos. 3-6. Pp. 129-442.
Vol. XV, Nos. 1, 2. Pp. 1-160.

POUGHKEEPSIE.—Vassar Brothers Institute:
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ROCHESTER.—Rochester Academy of Science:
Brochure 1 of Vol. II, 1892. Pp. 1-112; pll. I-VIII; map.
Brochure 3 of Vol. II, 1894. Pp. 201-288; 3 pll.

SCHENECTADY.—Prof. Charles S. Prosser, Union College:
Bulletin, Vol. 6, 1894. Kansas River Section of the Permo-Carboniferous and Permia Rocks of Kansas, by Charles S. Prosser; pp. 29-54.

NORTH CAROLINA.

CHAPEL HILL.—Elisha Mitchell Scientific Society:
Journal for the ninth year, 1892, Part 2, pp. 55-108; 1 pl. Tenth year, 1893, 98 pp.; 1 pl. Eleventh year, 1894, Part 1. 32 pp.

OHIO.

AKRON.—Prof. E. W. Claypole, Buchtel College:
The Lake Age in Ohio, or some episodes during the retreat of the North American ice-sheet, by E. W. Claypole; pp. 5-42; 4 colored maps.
Prof. G. F. Wright and his Critics, by E. W. Claypole, from the Popular Science Monthly; 18 pp.
Traces of the Ice Age in the Flora of the Cuyahoga Valley, by E. W. Claypole. Tract No. 84, Western Reserve Historical Society, pp. 368-379.
Report on some Fossils from the Lower California Measures, near Wilkes-Barre, Luzerne county, Pa., by E. W. Claypole, from the Proceedings and collections of the Wyoming Historical and Geological Society; pp. 239-254.
The Eccentricity Theory of Glacial Coal versus the Facts, by E. W. Claypole; pp. 534-548.
Structure of the Bone of Dinichthys, by E. W. Claypole, from the Proceedings of the American Microscopical Society, pp. 189-191.

CINCINNATI.—Historical and Philosophical Society of Ohio:
Annual Report, for the year ending December 3, 1894. 16 pp.

CLEVELAND.—Case School of Applied Science:
Annual Catalogue, 1894-95. 118 pp.

COLUMBUS.—Ohio State Academy of Science:
Constitution and By-Laws, Officers, list of Members, and Historical Sketch, 1892. 12 pp.
First Annual Report, 1892. 16 pp.
Second Annual Report, 1893. 52 pp. Lake Licking—a contribution of the buried drainage of Ohio, by W. G. Tight; pp. 17-20. The Phaenogmatic Flora of Summit County, by Dr. K. O. Foltz; pp. 21-31.

Ohio Agricultural Experiment Station: See Wooster.

Prof. W. A. Kellerman, State University: See Ohio Academy of Science.

GRANVILLE.—Denison University:

Scientific Laboratories of Denison University:

Bulletin, Vol. I, 1885, 176 pp.; 11 pll.; and 18 two-page tables for the determination of rock-forming minerals. I. Osteology of the Evening Grosbeak—Hesperiphona vespertina Bonap., with plate I and Frontispiece, by C. L. Herrick; pp. 5–15. II. Metamorphosis of Phyllopod Crustacea, by C. L. Herrick; pp. 16–24; pll. V–VIII and pl. X. III. Superposed Buds, by Aug. F. Foerste, class of '87; pp. 25–36; pl. XIII. IV. Limicole, or Mud-living Crustacea, by C. L. Herrick; pp. 37–42; pl. IX. V. Rotifers of America, Part I, with descriptions of a new genus and several new species, by C. L. Herrick; pp. 38–43; pll. II–IV and pl. X. VI. The Clinton Group of Ohio, with descriptions of new species, by Aug. F. Foerste; pp. 44–63; pll. XIII–XIV. A Compend of Laboratory manipulation, Chapter I, Lithological manipulation, accompanied by a condensed translation of Eugene Hussak's Tables for the determination of rock-forming minerals; pp. 64–122.

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Bulletin, Vol. III, 1888, 137 pp.; 16 pll. I. The Clinton Group of Ohio, Part IV. Chemical and Stratigraphical Geology and Geographical Palaeontology, by A. F. Foerste; pp. 3–12. III. The Geology of Licking Co., Ohio, Parts III and IV. The Subcarboniferous and Waverly Groups, by C. L. Herrick; pp. 13–110; pll. I–XII. V. Notes on Palaeozoic Fossils, by Aug. F. Foerste; pp. 117–136; pl. XIII.

Bulletin, Vol. IV, 1888, 176 pp.; pll. I–XIV. 1. Scientific Buildings; pp. 2–4; pl. XV. 2. Lithological Notes on Contact Phenomena in South Carolina, by G. F. Richards; pp. 5–10; pl. XII. 3. Geology of Licking Co., Ohio, Part IV. List of Waverly Fossils continued, by C. L. Herrick; pp. 11–60; pll. I–XI. 4. List of the Bryozoa of the Waverly Group in Ohio, by E. O. Ulrich; pp. 61–96; pll. XIII–XIV. 5. Geology of Licking County, Ohio, Part II, continued, by C. L. Herrick; pp. 97–123. 6. Tabulated List of Fossils known to occur in the Waverly of Ohio, by W. F. Cooper; pp. 123–130. 7. Miscellaneous Notes. (a) Peculiar habit of the Freshwater hydra, by W. G. Tight; p. 131. (b) List of Algae collected at Granville, by C. L. Payne; p. 132.

Bulletin, Vol. V, 1890, 96 pp.; 20 pll. 1. The Waverly Group, by W. F. Cooper, pp. 24–32. 2. Tabulated List of Fossils known to occur in the Waverly of Ohio, by W. F. Cooper, pp. 33–34. 3. The Central Nervous System of Rodents, preliminary paper, by C. L. Herrick and W. G. Tight, pp. 35–96; pll. I–XIX.

Bulletin, Vol. VI, 1892, 94 pp.; 8 lithograph plates, and 4 half-tones. Some Observations on the crushing effects of the Glacial Ice Sheet, by W. G. Tight, pp. 12–14; pll. A to D. Biological Notes upon Fiber, Geomys and Erethizon, by C. L. and C. Judson Herrick, pp. 15–25. Studies in the Topography of the Rodent Brain: Erethizon Dorsatus and Geomys Bursarius, by C. Judson Herrick. pp. 26–46. Meteorological Observations at Granville. pp. 47–53. Notes upon the Cladocera, Copepoda, Ostracoda and Rotifera of Cincinnati, with description of new species, by C. H. Turner, pp. 57–74; pll. I–II. The Cerebrum and Olfactories of Opposum Didelphys and Virginica, by C. L. Herrick, pp. 75–94; pll. A, B and C.

Bulletin, Vol. VII, 1892, 102 pp.; one map. Catalogue of the Phanerogams and Ferns of Licking County, Ohio, by Herbert L. Jones. Pp. 1–102.

Bulletin, Vol. VIII, 1893; 124 pp. 10 pll. Additional Notes on the Cladocera and Ostracoda of Cincinnati, Ohio, by C. H. Turner; pp. 1–18; pll. I–II. Lantern Slides without a negative, by W. G. Tight, pp. 49–51. Additions and Corrections to the Flora of Licking county, Ohio, by H. L. Jones. Part II, pp. 3–6. Notes from the Botanical Laboratory, by W. G. Tight; pp. 7–12; pl. I.

Notes on American Ostracoda, by C. H. Turner, pp. 13–26; pll. I–II. Electricity as a Laboratory servant, by A. D. Cole, Henry Chisholm, pp. 27–34. A Contribution to the Knowledge of the Preglacial Drainage of Ohio, Part I, by W. G. Tight. Pp. 36–63; 51 plates.

OBERLIN.—Oberlin College:

Preliminary List of the Flowering and Fern Plants of Loraine county, Ohio, by Albert A. Wright; 30 pp.; map of county. Laboratory Bulletin No. 2. Fishes of Loraine county, O., by Lewis M. McCormick; 34 pp.; 14 pll.

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Study of the Chemical Behavior of Pyrite and Marcasite, by Amos Peaslee Brown; pp. 225-243; pll. XVIII, XIX. On the Osteology of Agriochoerus Leidy (Artionyx O. & W.), by W. B. Scott; pp. 243-251.

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Atlas to accompany the final report of the State Geologist, in cloth cover. 1893. Geological map of Pennsylvania, 92x146 cm., on 4 sheets, scale 6 miles to 1 inch. General map of the bituminous coal fields of Pennsylvania, showing the position of the collieries, 4 sheets, 4 miles to 1 inch. Geological map of Lebanon county, 2 miles to 1 inch. Geological and topographical map of most of Bucks and Montgomery counties, 1 mile to an inch, same uncolored, 2 sheets. Four cross sections of Bucks and Montgomery counties, 1 mile to an inch.

Sheets for the Grand Atlas, 76x84 cm. South Mountain sheets C1, C2, and D2, scale 1600 feet to an inch. Berks county, 2 miles to 1 inch. Huntingdon county, 2 miles to an inch.

A. E. Foote, M. D., 4116 Elm Avenue:

Naturalists' Leisure Hour and Monthly Bulletin, 32 pp. monthly, mainly lists of scientific books.

P. Blakiston, Son & Co., 1012 Walnut Street:

Catalogues of books, occasionally.

PITTSBURG.—Frank W. Very:

Hail-Storms, from the Transactions of the Academy of Science and Art of Pittsburg, by Frank W. Very; 20 pp.; 1 pl.

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Bulletin, monthly, Vol. VIII, Nos. 4-11, pp. 50-196.

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The principles of Elliptic and Hyberbolic Analysis, by Alexander Macfarlane; 48 pp.

On the definitions of the Trigonometric Functions, by Alexander Macfarlane; 49 pp.

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Fifth Annual Report, 1891, 168 pp.

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Proceedings and Transactions, Second Series, Vol. I, 1890-93, 380 pp.; 7 pll. Surface Geology of southeastern Nova Scotia, by Prof. L. W. Bailey, pp. 1-9. The Magdalene Islands, by Rev. G. Patterson, pp. 31-57. Pictou Island, by Prof. A. H. MacKay, pp. 76-83, map. Flora of Nova Scotia, Part I, by Dr. George Lawson, pp. 84-110. Concretionary Structure in rocks, by T. C. Weston, pp. 137-142. Post-glacial extension of the southern part of Nova Scotia, by W. H. Prest, pp. 143-147. Visibility of Venus to the naked eye, by A. Cameron, pp. 148-159; 341-358. Trap minerals in Nova Scotia, by Rev. Dr. Thomas McCullough, pp. 160-166. Geology of Cape Breton: The Lower Silurian, by Edwin Gilpin, jr., pp. 167-174. The Fletcher stone, by K. G. T. Webster, pp. 208-214. The Miocene Tertiary of the Cypress Hills, N. W. T., pp. 223-227; 1 pl. The Pictou coal field, by Henry S. Poole, pp. 228-343; 7 maps and plates. Flora of Newfoundland, Labrador, etc., by Rev. A. C. Waghorne, pp. 359-373.

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Schriften Band IX, 1892, 316 pp. Erdmagnetische Messungen im physicalischen Institut der Universitaet Kiel, von G. Ludeling. Pp. 1-70. Die Pflanzenwelt der Nordfreisischen Inseln, von P. Knuth. Pp. 71-110. Die Rhodophycaen der Kieler Fohrde, von Th. Reinbold. Pp. 111-144. Pilzflora von Schleswig-Holstein, von P. Hennings. Pp. 229-258. Das Plankton des Suesswassers, von C. Apstein. Pp. 267-274.
Band X, Erstes Heft, 1893, 132 pp. Die Phaeophyceen der Kieler Fohrde, von Th. Reinbold. Pp. 21-59. Tageslichtmessungen in Kiel, 1890-1892, von Dr. Leonhard Weber. Pp. 77-94; 2 taf.

LEIPZIG, SAX.—Koniglich-Sachsische Gesellschaft der Wissenschaften—Mathematisch-Physische Classe:
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Jahr 1893, 850 pp. Differentialgleichungen 3ter Ordnung, etc., von M. Krause. Pp. 35-53; 99-119. Die Polhoehe der Leipziger Sternwarte, von R. Schumann. Pp. 173-281. Fr. Hayn, pp. 281-315. Differentials, von Sophus Lie. Pp. 341-348; 370-378. Transformation der Thetafunctionen, von M. Krause. Pp. 99-119; 349-359; 523-537; 805-827. Der Gruppentheorie und Differentialgleichungen, von F. Engel. Pp. 360-369; 468-476; 659-696.

Dr. Otto Kuntze:
Geogenetische Beitrage, von Dr. Otto Kuntze. 80 pp.; 2 geologic sections and 7 figs. botanical.

MAGDEBURG, PRUSS.—Naturwissenschaftliche Verein (Society of Natural Science):
Jahresbericht und Abhundlungen, 1890, 320 pp.; 1 map. 1892, 308 pp.; 16 figs. 1893-1894, 192 pp.; 3 pll.
Festschrift zur Feier des 25 jahrigen Stiftungstages, 1869-1894, 288 pp. Flora von Magdeburg, pp. 75-216. Erdmagnetischen Declination und Horizontalintensitat fur Magdeburg, pp. 1-24.

MUNSTER, PRUSS.—Westfalische Provinzial-Verein fur Wissenschaft und Kunst (Westphalian Provincial Society of Science and Art):
Jahresbericht, Siebzehnter, fur 1888, 240 pp.; 1 plate. Achtzehnter, fur 1889, 194 pp. Einundzwanzigster, fur 1892-3, 220 pp.

NURNBERG, BAV.—Naturhistorische Gesellschaft:
Abhandlungen fur 1892, 32 pp.; 1 pl. Jahresbericht fur 1892, 47 pp. Abhandlungen fur 1893, pp. 33-54; portrait of Dr. Hagen. Jahresbericht fur 1893, 61 pp.

OFFENBACH, BADEN.—Offenbacher Verein fur Naturkunde (Offenbach Society of Natural Science):

33ter, 34ter, 35ter und 36ter Bericht uber die Thatigkeit, 1891-1895; 156 pp.; 1 litho. plate.

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Zehnter Jahresbericht fur die Jahre 1893 und 1894, 308 pp. Diluvial studien, von Dr. J. Martin. Pp. 1-70; 185-240; map. Foraminiferen Fauna des Ober Oligocaens, von A. Hosius. Pp. 73-124. Die Ostrakodens des Mittel Oligocaens, von E. Lienenklaus. Pp. 125-184.

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BIRMINGHAM, ENG.—The Mason College:

Calendar, 12x19 cm., bound in white cloth, 1893-1894, 544 pp; 1894-1895, 536 pp.

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Scientific Proceedings, Vol. VII, 1062 pp.; pll. xviii-xxv. Revolving Machinery for the Domes of Astronomical Observatories, by Sir Howard Grubb, pp. 484-491. Notes on a small collection of Hydrocorallinae, by Sydney J. Hickson, pp. 496-509. The Variolite of Annalong, Co. Down, by Prof. Greenville A. J. Cole, pp. 511-519; pl. XXI. Echinoderms collected by the SS. "Fingal," by F. Jeffrey Bell, pp. 520-529; pll. XXIII-XXV. Appreciation of Ultra-Visible Quantities, by G. Johnstone Stoney, pp. 530-545. Speculation as to a pre-material condition of the Universe, by J. Joly, pp. 563-573. Note on the walking of some of the Arthropoda, by H. H. Dixon, pp. 574-578.

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Scientific Transactions, Vol. IV (Series II.), 1893, 22x28 cm. Part XIV. Fossil Fish Remains of the Coal Measures of the British Islands, by James W. Davis, F. G. S., pp. 703-748, pll. LXV-LXXVIII.

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EDINGURGH, SCOT.—The Botanical Society of Edinburgh:

Transactions and Proceedings, Vol. XIX, 1892-93, pp. 233-636. Increase in Girth of Young Trees in the Royal Botanic Garden, Edinburgh, for five years ending 1891, by David Christison, pp. 261-336; 341-346; 455-535. Temperature and Vegetation in the Royal Botanic Garden, by Robert Lindsay, pp. 255-258; 337-340; 348-350; 437-440; 444-450; 535-543; 554-5; 558-561; 582-584; 590-592; 595-597; 602-605; 608-613. The Embryo-sac of Myosurus Minimus L.:, by Gustav Mann, pp. 351-428; pll. IIIa, IV. Supplementary Notes on the Marine Algae of the Orkney Islands, by George Wm. Traill, pp. 544-546, with zincograph. Morphology of some British Leguminosae, by James A. Terras, pp. 565-581.

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Transactions, Vol. IX, Part II, 1890-92, pp. 241-472; pll. X-XVI; 4 diagrams. Pectolite and Okenite, by M. Forster Heddle, pp. 241-256. The Geology of Kyle, by James S. M'Lennan, pp. 264-276. The Leaf-Caves of Mull, by John Dougall, M. D., pp. 286-289. Peculiar U-shaped Tubes in Sandstone, by John Smith, pp. 289-292; pl. X. Carboniferous Ostracoda in the strata of Western Scotland, by John Young, pp. 301-312. Carboniferous Foraminifera in lower limestone shales, by John Young, pp. 313-320. Alleged Proofs of Submergence in Scotland during the Glacial Epoch, by Dugald Bell, pp. 321-345; with map. A Glacial Mound in Glen Fruin, Dumbartonshire, by Dugald Bell, pp. 345-354; pll. XII, XIII. Geology of the Carsphairn District, by David Forsyth, pp. 376-390; pll. XIV, XV. Geology of Fife, by Alex. S. Wilson, pp. 392-406. Notes on a visit to the Culbin Sands, Morayshire, by James Barclay Murdock, pp. 406-414; pl. XVI, and map.

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Geological Society of London:

Abstract of Proceedings, Session 1892-3, Nos. 595-611. 126 pp. Session 1893-4, Nos. 612-628. 126 pp.

List of Members of the Society, Nov. 1, 1892. 80 pp.

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Memoires and Proceedings, Fourth Series, Vol. VII, 1892-3. 270 pp.; 2 pll. Marine Mollusca of Bombay, by James Cosmo Melvill. Pp. 17-51. Twenty-five new species of shells from Bombay, by James Cosmo Melvill. Pp. 52-78; litho. pl. i; 25 figs. Method of Integration, by James Bottomley. Pp. 78-89. Fossil plants of the Coal Measures, by Dr. W. C. Williamson. Pp. 91-128. Rate of Explosions in gases, by Harold B. Dixon. Pp. 128-158. Collection of plants from Colorado, by J. C. Melvill. Pp. 214-219.

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Transactions, Vol. XI, Part I, 1887. (Seventy-third Annual Report.) The Pliocene Beds of St. Erth, by Robert William Bell, pp. 46-50. Serpentinous Rock in Whitsand Bay, by R. N. Worth, pp. 51-55.

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Buletino delle Sedute, Nuova Serie, Fascicolo XXXII, XXXVI-XXXVIII. Marzo, 1893, 23 pp., 1 plate; Febbraio, 1894, 23 pp.; Giugno, 1894, 30 pp.; Dicembre, 1894, 15 pp.

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Bullettino, 1893, Trimestre I-IV, 428 pp.; Bullettino, 1894, Trimestre I-II, 312 pp., 6 plates.

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Atti, Vol. XXVIII, 1892-93, 940 pp., 7 pll.; Vol. XXIX, 1893-94, 842 pp., 19 pll.

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LISBOA (LISBON).—Academia Real das Sciencias de Lisboa:

Os Descobrimentos Portugueses e Os de Colombo: Tentativa de Coordinacao Historica, por Manuel Pinheiro Chagas. 1892. 244 pp.

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HELSINGFORS, FINL.—Finska Vetenskaps-Societeten (Scientific Society of Finland):

Bidrag till Kannedom af Finlands Natur och Folk. Vol. LI, 534 pp. Askvädren i Finland, 1888-1890, af A. F. Sundell. Pp. 1-175; 285-332; 4 pll. Kritisk Ofversigt af Finlands Basidsvampar, af P. A. Karsten. Pp. 177-230. Finlands Mogelsvampar (Hyphomycetes fennici), af P. A. Karsten. Pp. 343-524.

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Herbarium Musei Fennici, 2d ed., II, Musci, by J. O. Bomansson & V. F. Brotherus. 84 pp. and map.

Meddelanden, Vol. XVII, 1890-1892, 272 pp.; steel portrait of S. O. Lindberg. Vol. XIX, 1893, 176 pp., with a German review.

KAZAN.—Fisiko-Matematicheskago Obshestva pre Imperatorskome Kazanskome Yniversitete (Physico-Mathematical Society of the Imperial University of Kazan):

Bulletin, Second Series, Tome III, 1893, 372 pp.; 3 pll. Tome IV, Nos. 1, 2, 1894, 24 pp.; 2 pll.

ST PETERSBURG.—Geological Committee of Russia:

Bulletins of the Geological Committee, Vol. XI, 1892, 372 pp.; geological map, and 4 lithograph plates of shells; with a supplement of 234 pp. Vol. XII, 1893, 324 pp.; geological chart, and supplement of 244 pp.

Memoires du Comite Geologique, 25x32 cm. Vol. IV, No. 3, 1893. Fauna of the lower Devonian along the Ural, by Th. Chernisheva; 222 pp.; 14 lithograph plates of shells. (Russian and German.)

Vol. VIII, No. 2, 1893. Die Ammoniten der Unteren Volgastufe, von A. Michalski. Pp. 329-497. (German.) No. 3, 1894. Upper Devonian Plants, by I. Shmalhousen; 36 pp.; 2 photolith. pll.

Vol. IX, No. 2, 1893. The Lower Tertiary of Southern Russia, by N. Sokolova. 328 pp.; map, and 2 halftone illustrations. No. 3, 1894. Fauna of the Lower Oligocene of Ekaterinoslav, by Dr. N. Sokolova. 136 pp.; 4 litho. pll.; geological section, and 24 figs. in text.

Vol. X, No. 2, 1893. Theodolitic Method for the goniometrical and optical study of crystals as applied to mineralogy and petrography, by E. S. Tedorova; 104 pp.; 14 pll. and 45 figs. (Russian and French.)

Vol. XII, No. 2, 1892. Upper Silurian Fauna of Timan, by N. Lebedeva; 48 pp.; 3 litho. pll. of fossil shells.

Imperatorskoie Akademie Nauk (Imperial Academy of Sciences):

Bulletin, 21x30 cm., Nouvelle Serie IV (XXXVI), No. 1. Revisio synoptica Meloidarum generis Ctenopus Fisch., par Andrea a Semenova. Pp. 11-20. Das Genus Sparganium L. Von K. F. Meinshausen. Pp. 21-41. Crustacea Caspia: A contribution to the knowledge of the carcinological fauna of the Caspian Sea, by G. O. Sars. Pp. 51-74, with 8 plates. Uber den saecularen Gang der magnetischen Declination in St. Petersburg-Pawlowsk, von H. Wild. Pp. 89-103, mit 1 tafel. Zur Kenntnis der artesischen Wasser in St. Petersburg, von Theodor Grosset. Pp. 131-161.

No. 2. Le spectre de l'etoile variable B Lyrae, par A. Belopolsky. Pp. 163-195, avec 2 planches. Zur Kenntnis der Tremataspiden, von Dr. J. Victor Rohon. Pp. 201-225, mit 2 tafels. Determination de l'orbite de la comete 1890, VI, par N. Bobrinskoy. Pp. 227-246. Crustacea Caspia, Part II, par G. O. Sars. Pp. 297-338, avec 12 planches.

Bulletin, Fifth Series, Tome I, No. 1, September, 1894; 112 pp.; 2 pll.; 4 figs., and map of European Russia.

Memoires, 25x34 cm. Tome XXXIX, 1893. Faune Ornithologique de la Siberie Orientale, par Dr. L. Taczanowski. Part II. Pp. i-viii et 685-1278, with a phototype portrait of the author.

Tome XL, No. 1, 1892. Scientific Results of the Expedition to the New Siberian Islands in 1885 and 1886. Part IV. Post-tertiary Mammals, by J. D. Cherski, 512 pp.; 4 litho. pll. of 52 figures. No. 2, 1893. Wandlungen der anlautenden dentalen spirans im Ostjakischen, von Nikolai Anderson, 352 pp.

Tome XLI, No. 1, 140 pp. No. 2, mathematical, 36 pp. No. 3. Calculs et Recherches sur la Comete d'Encke, par O. Backlund. II, 1893. Perturbations par les Planetes Venus, la Terre, Mars, Jupiter, et Saturne, de 1871-1891. Pp. i-xx; 1-174. No. 4, German and Greek, 21 pp. No. 5. Upper Silurian Fish, von Dr. J. V. Rohon, 128 pp.; 3 pll.; 22 figs. No. 6. Craniology of Saghalien, by Prof. A. Tarenetsky; 48 pp. No. 7. Calculs et Recherches sur la Comete d'Encke, par O. Backlund. III. Pertubations par les Planetes Venus, la Terre, Mars, Jupiter, et Saturne, pendant la periode 1848-1871. Pp. i-viii; 1-154. No. 8. Geographische Verbreitung der Suesswasser Protozoen, von Dr. V. Sheviakova, 204 pp.; 4 pll. and map 34x50 cm. No. 9. "Weissen Korper," von Victor Faussek, 32 pp.; 3 pll.

Tome XLII, No. 4. Beobachtungen des Neptunestrabanten am 30-zollingen Pulkowaer Refractor, von Hermann Struve. Pp. 1-68. No. 6. Ueber die bestnmmung der Absoluten Magnetischen Declination im Konstantinow'schen Observatorium zu Pawlowsk, von H. Wild. Pp. 1-36; Tafels I, II.

Imperatorskago Mineralogicheskago Obshestva (Imperial Mineralogical Society):

Materials upon Russian Geology. Tome XVI, 1893, 340 pp.; 2 pll.; 20 figs., and chromo-lithograph map, 58x74 cm. Principal article: The Geotectonic of the peninsula of Kerch, by N. Andrewsove. Pp. 63-340, with a geological map.

Zapiski (Annual Report), Second Series, Vol. XXIX, 1892, 276 pp.; litho. portrait of P. A. Chickacheva. Vol. XX, 516 pp.; 4 plates of fossil shells, and 189 figures of crystals in text.

SPAIN.

BARCELONA.—Real Academia de Ciencias y Artes:

Boletin, 23x29 cm. Tercera Epoca. Vol. I, Nos. 9-12, 1894. Pp. 156-186; 1 litho pl.

Memoiras, 23x29 cm. Tomo I. Euler y sus obras, por D. Lauro Clariana Ricart (conclusion). Pp. 245-254. XIV. El Infinito Matematico en la Cadena Cinematica Cilindrica, por Luis Canalda. Pp. 255-266. XV. La Experimentacion Toxicologica ensaya critico, por el Dr. D. Ignacio Valenti Vivo. Pp. 267-278. XVI. Mas Monumentos Megaliticos en Cataluna, por D. Luis Mariano Vidal. Pp. 279-300; figs. 1-20. XVII. Algunas Consideraciones sobre las Diatomaceas. Memoria postuma del Dr. D. Francisco de S. de Delas y de Gayola. Pp. 301-314. XVIII. Absurdos Geometricos que engendran ciertas interpretaciones del Infinito Matematico, por el D. Jose Domenech y Estapa. Pp. 315-329.

Tomo II. I. Flora del Valles, por Dr. D. Juan Cadevall y Diars. Pp. 1-32 plus.

Compensacion de algunas observaciones de Declinacion Magnetica in la peninsula Iberica, por Don Rafael Pardo de Figueroa. Pp. 1-48 plus; figs. 1-7a.

Descripcion de los Depositos Pliocenicos del Llano de Barcelona, por Dr. D. Jaime Almero. Pp. 1-32 plus.

Historia de la Real Academia de Ciencias y Artes, por el Dr. D. Jose Balari y Jovany. 14x22 cm. 208 pp.

MADRID.—Real Academia de Ciencias, Fisicas y Naturales de Madrid:
Memorias, 20x30 cm. Tomo XVI. Estudio Sistematico de las bases organicas de origen animal (Ptomainas, Leucomainas, etc.), por Dr. D. Jose Ubeda y Correal. 290 pp.

SWEDEN AND NORWAY.

CHRISTIANIA, NORW.—Videnskabs Selskabet i Christiania (Academy of Sciences of Christiania):
Forhandlinger for 1891. Norske Oldsager i Kobenhavns Museum, af Dr. Ingvald Undset. 16 pp.
No. 2. Aristoteles, af P. O. Shjott. 16 pp.
No. 3. De Nordiske Klover-blad formede spaender, af Dr. Ingvald Undset. 15 pp.; 3 litho. pll.
No. 4. Vegetationen i Troldheimen, af Ove Dahl. 21 pp.
No. 5. Die Lehre Hegels vom Wesen der Erfahrung, von Dr. George Kent. 80 pp.
No. 6. Das Schmelzen des Binneneises, von O. E. Schiotz. 22 pp.
No. 7. Mytholcgiske Studier, af P. O. Shjott. 19 pp.
No. 8. Bidrag til Kundskab om Biscayervalen. 14 pp.
No. 9. Ascomyceter fra Dovre, af Axel Blytt & E. Rostrup. 14 pp.
No. 10. Norske Myriopoders Udbredelse, af Edv. Ellingsen. 12 pp.
No. 11. Oversigt over de tri-cirrate Arter af Slegten Onus, af R. Collett. 17 pp.
Oversigt over Videnskabs-Selskabets Moder i 1891. 66 pp.
Forhandlinger for 1892. No. 1. Stedbestemmelse paa hoie Bredder, af H. Geelmuyden. 36 pp.; 1 litho. chart.
No. 2. Myxomyceter fra Norge, af Axel Blytt. 13 pp.
No. 3. Karplanternes udbredelse i Norge, af Axel Blytt. 73 pp.
No. 4. Om to Kalktufdannelser i Gudbrandsdalen, af Axel Blytt. 50 pp.
No. 5, 48 pp. No. 6, 27 pp. No. 7, 34 pp. No. 8. Lejeuneae Madagascarienses, af W. H. Pearson. 9 pp.; 2 pll.
No. 9, philological, 8 pp., chart, 35x36 cm. No. 10., chemical, 7 pp. No. 11. Vegetationen i Troldheimen, af Ove Dahl. 33 pp.
No. 12. Om gravitationen, af Hans J. Kiaer. 30 pp.
No. 13. On a Collection of Birds from Tongoa, New Hebrides, by R. Collett. 11 pp.
No. 14. Hepaticae Madagascarienses, by W. H. Pearson. 11 pp., 1 pl.
No. 15, chemical, 14 pp. No. 16, chemical, 11 pp.; 1 pl. No. 17, mathematical, 21 pp. No. 18, mineralogical, 11 pp.
Oversigt over Videnskabs-Selskabets Moder i 1892. 56 pp.
Nordische Lehnworter im Lappischen, von J. K. Quigstad. 380 pp. (Christiania V. S. Forhandlinger, 1893, No. 1.) And more.
Videnskabs-selskabets Skrifter. Historiskfilosofiske Classe. 18x27 cm. No. 1. Heraldry, af Gustaf Storm. 36 pp.; 2 pll.; 22 figs. No. 2, philological, 23 pp. No. 3, historical, 216 pp. No. 4, philological, 176 pp. No. 5, antiquities, 36 pp.

Royal University of Norway—Norwegian Meteorological Institute:
Jahrbuch des Norwegischen Meteorologischen Instituts, 25x32 cm., fur 1891, 107 pp. Herausgegeben von Dr. H. Mohn.

STAVANGER, NORW.—Stavanger Museum:
Aarsberetning for 1893. 87 pp.; 1 litho. pl.

STOCKHOLM, SW.—Entomologiska Foreningen i Stockholm (Entomological Society of Stockholm):
Entomologisk Tidskrift, Arg. XIII, Haft 4, 1892, pp. 209-292; 1 colored lithograph.
Arg. XIV, Hafts 1-4, 1893, 300 pp; 6 litho. pll.
Arg. XV, Hafts 1-2, 1894, 200 pp.; 3 litho. pll.

Kongliga Svenska Vetenskaps-Academien (Royal Swedish Academy of Sciences):
Bihang till K. S. V. A. Handlingar. Division I. Mathematics, Astronomy, Mechanics, Physics. Vols. XII, 1887, 332 pp.; 5 pll. XIII, 1888, 308 pp.; 5 pll. XIV, 1889, 260 pp.; 6 pll. XV, 1890, 430 pp.; 4 pll. XVI, 1891, 300 pp.; 21 pll. XVII, 1892, 312 pp.; 3 pll. XVIII, 1893, 236 pp.; 4 pll.
Division II. Chemistry, Mineralogy, Geognosy, Physical Geography. Vols. XII, 1887, 204 pp.; 5 pll. XIII, 1888, 284 pp.; 14 pll. XIV, 1889, 168 pp.; 3 pll. XV,

1890, 96 pp.; 4 pll. XVI, 1891, 218 pp.; 5 pll. XVII, 1892, 338 pp.; 5 pll.; 2 geological charts, 26x40 cm. XVIII, 1893, 164 pp.

Division III. Botany. Vols. XII, 1887, 372 pp.; 12 pll. XIII, 1888, 544 pp.; 20 pll. XIV, 1889, 106 pp.; 7 pll. XV, 1890, 114 pp.; 3 pll. XVI, 1891, 540 pp.; 13 pll. XVII. 1892, 136 pp.; 4 pll. XVIII, 1893, 488 pp.; 13 pll.

Division IV. Zoology. Vols. XII, 1887, 92 pp.; 4 pll. XIII, 1888, 646 pp.; 22 pll. XIV, 1889, 106 pp.: 7 pll. XV, 1890, 114 pp.; 3 pll. XVI, 1891, 420 pp.; 19 pll. XVII, 1892, 484 pp.; 22 pll. XVIII, 1893, 258 pp.; 32 pll.

Carl von Linne's Brefvexling, by Ewald Ahrling. 112 pp.

Om Sveriges zoologiska Hafsstation Kristineberg, af Hjalmar Theel. 48 pp.; 4 pll.; 1 chart.

Ofversigt, Arg 44, 1887, 755 pp.; several figures. Arg. 45, 1888, 649 pp.; several figures. Arg. 46, 1889, 691 pp.; several figures. Arg. 47, 1890, 568 pp.; several figures. Arg. 48, 1891, 792 pp.; several figures. Arg. 49, 1892, 576 pp.; several figures. Arg. 50, 1893, 707 pp.; several figures.

THRONDHJEM, NORW.—Det Kongelige Norske Videnskabers Selskab (Royal Norwegian Society of Sciences):

Skrifter, 1891. Bishop Gunnerus's Botany of Denmark and Norway, 1718-1766, ved Ove Dahl. Pp. 1-152. Algological notes, by M. Foslie. 263-266. Marine algae of Isle of Wight, by M. Foslie. Pp. 267-282. Diptera brachycera, by V. Storm. Pp. 283-213.

Skrifter, 1892. Bishop Gunnerus's Botany, by Ove Dahl. Pp. 1-62. Explorations bryological in Norway, by N. Bryhn. Pp. 159-224.

Skrifter, 1893. Bishop Gunnerus's Botany, 1768-1772, ved Ove Dahl. Pp. 1-74, with map, 45x75 cm. Botanical Survey, by Ove Dahl. Pp. 73-113. Norwegian algae, by M. Foslie. Pp. 114-144.

UPSALA, SW.—Kongliga Upsala Universitet (Royal University of Upsala):

Upsala Universitets Arsskrift, 1892, 688 pp. Philosophy, jurisprudence, theology, natural history.

Arsskrift, 1893, 672 pp.; 1 plate. Medicine, mathematics, natural science.

Inbjudningsskrift (300-year Jubilee Festival), 362 pp.; 1 pl. Contains theses of candidates for degrees of D. D., LL. D., and Ph. D.; and names among its alumni the following distinguished citizens of Kansas: Olof Olssen, Carl Aaron Swensson; also Gerard DeGeer, August Gustaf Eisen, A. R. Akerman, and other eminent Americans.

SWITZERLAND.

BASEL.—Naturforschenden Gesellschaft:

GENEVA.—Societe de Physique et d'Historie Naturelle de Geneve:

Compte Rendu des Seances, IX, 1892, 132 pp. X, 1893, 104 pp.

Henri de Saussure:

Revision de la Tribu des Heterogamiens (Orthopteres de la Familie des Blattides), par Henri de Saussure. Pp. 287-318. (Revue Suisse de Zoologie, Tome I.)

NEUCHATEL.—Societe Neuchateloise de Geographie:

Bulletin, 16x24 cm. Tome VI, 1891, 460 pp.; 3 plates and charts. Tome VII, 1892-1893, 680 pp.; 24 plates and charts folded in.

SCHAFFHAUSEN.—Schweizerischen Entomologischen Gesellschaft:

Mittheilungen, Vol. VIII, Heft Nr. 10, Jan. 1893, pp. 379-416; pll. I, II.

Vol. IX, Hefts 2-4, 1894, pp. 59-225. Ueber die Systematik der Cetoniden, von G. Schoch. Pp. 164-225.

Coleoptera Helvetiae, von Dr. Gustav Stierlin (cont.). Pp. 289-448.

Fauna insectorum Helvetiae—Diptera, von Dr. Gustav Schoch. Pp. 1-27; 1-73.

ST. GALLEN.—St. Gallische Naturwissenschaftliche Gesellschaft:

Bericht uber die Thatigkeit, 1891-1892, 401 pp. Fur 1892-1893, 377 pp.; 2 pll.; portrait of Dr. B. Wartmann.

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CORRIGENDA.

(Errata are the editor's especial abhorrence.)

The meeting at Manhattan, recorded on page 87, was held December 27, 1894.

The name Lora L. Walters, occurring on pages 88, 89, 200, 366, and 370, should be Lora L. Waters, wherever it occurs.

The name Z. S. Sharp, on page 88, should be S. Z. Sharp.

The name T. D. Hewitt, page 367, should be J. D. Hewitt.

The name T. R. Mead, on page 368, should be J. R. Mead.

The name Henride Sausure, page 369, should be Henri de Saussure.

The name Dr. Jacob Schenck, page 369, should be Dr. Jacob Schneck.

The name Alva T. Smith, page 369, should be Alva J. Smith.

The name T. D. Walters, page 370, should be J. D. Walters.

Other errors are obvious enough, and may be corrected or overlooked by the courteous reader.

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