TRANSACTIONS

OF THE

TEXAS ACADEMY OF SCIENCE

FOR 1905.

TOGETHER WITH THE PROCEEDINGS FOR THE SAME YEAR

VOLUME VIII.

AUSTIN, TEXAS, U. S. A.
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CONTENTS.

[ANNUAL ADDRESS BY THE PRESIDENT.]

THE AESTHETIC ELEMENT IN SCIENTIFIC THOUGHT.

DR. THOS. H. MONTGOMERY, JR.*

It has been our custom in the presidential addresses to present more general subjects, and to try to keep out of the ruts of our accustomed paths. This is a matter of some difficulty, at least to some of us, because we fear to climb lest we should fall. But braving this danger, and offering my vulnerability to several points of attack, I would bring to your consideration an element in scientific thought that seems to have generally escaped appreciation; at least I know of no writing where it has been mentioned.

And I would ask you to consider it particularly in the case of naturalists, because that is the type of mind with which I happen to be most conversant. We may include under the good old name naturalist all such as deal with the living in Nature, all those who have been variously termed natural scientists, natural philosophers, psychologists, biologists. Many new names are often a burden and the minute subdivisions of the paths of learning are of significance but to those whose minds are too narrow to embrace more than a single road.

We should define Science as learning, in which men seek for interpretations of phenomena without any ulterior motive except the pleasure of the work itself and the hope of discovery. Hopes of pecuniary emolument can not, accordingly, be the directives towards a scientific calling, the influences must be of quite a different kind. The world naturally judges like the small boy who with open-mouthed curiosity watches the naturalist afield in his work of collecting, then examining the specimens, asks, "Are they good to eat? How much are you paid for them?" But what the naturalist seeks, interpretations, he can use directly neither to still his bodily hunger nor for monetary gain.

Then it may be supposed that scientists carry out their labors primarily with a view to recognition, to fame, that this and not the

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work itself is their impelling motive. Clearly the scientist must have recognition, if only from a few colleagues, he will have the "well done." For should one become shipwrecked like our philosophical friend Defoe upon an oceanic isle, without expectation of rescue and beyond the reach of the mails, is it not likely that his ardor for research would diminish? Yet though this is so, scientists do not try short cuts towards fame. For one may work most intensely for a year or a number of years, and the result be a little memoir published in a journal; the world knows nothing of it, the author's wife of his bosom and his intimate friends seem to think it has the value of an ancient Greek coin, that they can not decipher; perhaps less than a score of savants gleaned from the world over will be all to carefully persue it. He would obtain a far greater reading circle by writing for a popular magazine, or by issuing a textbook; but men of rich ideas have seldom time for such misuse of the pen, and God grant that they overcome the temptation! The greater part of scientific thought is monographic and above the common mind, and the thousands of small and laborious memoirs published each year do not spell fame in the common opinion. Accordingly, though the ambition for praise is probably always present, it is not desire for the praise of the multitude, and further there is much work done without any thought of praise whatsoever.

Thus neither financial advancement nor fame is the impulse towards the study, it must be something else.

In the case of most men who have attained considerable prominence in their scientific callings, their inclination towards their subject has appeared in the tender years of life, and was not the result of a deliberate choice in later years. We then say of them in somewhat loose expression, yet certainly with more accuracy than is generally supposed, that they were born to the profession; that they possessed tendencies powerful enough to counterbalance environmental influences. For this reason it becomes most instructive to compare those influences that are strongest during childhood.

The child does not at once proceed to the analysis of phenomena; he is rather immediately arrested by something else appealing in them. We say he has curiosity, and that some children have this to greater extent than others; those who have it to the greatest degree make the best incipient material for scientists. Now what we at present call the scientific mind used to be called the curious mind, and the curious minds of centuries ago founded our academies and museums, and laid the basis for modern speculation. They rooted themselves in the still older alchemical and astrological ideas, also in a combination of legendary folk-lore and religious superstition. Often these pioneer curious minds were really braver that we moderns, for they sedulously collected all objects that they could not understand, while we are too frequently accustomed to circumvent the inexplicable.

Curiosity in the child is an inclination towards what he deems beautiful, as well as towards what he considers mysterious. With this discrimination of the beautiful comes the desire to possess it; therefrom the wish to collect, and finally out of that the habit of comparison. Perhaps a child is born without fear, but he soon learns to associate a sense of fear with the mysterious, as with the darkness and the thunder. He is drawn towards this mysterious that he can not understand, and peoples it with imaginary terrors. He has a distinct attraction, however subdued and hard to understand though it be, in the mysterious that he fears, just as early races came first to supplicate then to praise what terrified them. According as the open expression of delight in the beautiful that he does not fear predominates or does not predominate over the sense of the mysterious that he does fear, the child may be open to external impressions and vivacious, or be more dreamy and subject to musings. But in either case his liking for a thing is an expression of his attraction for the beautiful or mysterious.

Now what is it that keeps the mature scientific mind interestedly occupied in complex studies? The work itself is trying, it brings out the gray hairs and developes the scholar's stoop. Yet scientific men who are usually occupied in arduous teaching through three-quarters of the year fill up all possible intervals of time in their summer vacations with their own studies, and are apt to consider the duties of the teacher an infringment upon their proper work. Indeed one who maintains that teaching is sufficient application, should not be called scientific because he is not aiding in the increase of knowledge but only in its transmission.

One attribute noticeable among scientists is a feeling of affection as well as of veneration for the objects of their examination. This has been particularly the case with the greater naturalists, the masters of interpretation. It is the note of childhood that keeps them from growing old. Here and there is one who is more cold-blooded towards the object of his studies, more impersonal to it, working as we say without feeling of heart. But among the truly great of all generations, if not among those of smaller gauge and weaker intellect, there is found a chord of harmony with the object, a real love for the thing investigated, and this quite apart from the rational interpretation. Caressingly the anatomist guards and hoards his collections, as the bibliophile his Elzevirs, and developes or rather maintains a real love for the organisms that he has with so much care learned to appreciate. "My library," he says, "are these animals, living, breathing creatures like myself. Their characters are the letters of an alphabet whereby I am to read them. In all of them great beauty is to be found." Thus it is that the naturalist comes to recognize his oneness with the rest of Nature, his harmony with the whole, and realizes that he himself is but a small step in a very great progress. This is the idea of comradeship, and it embodies respect. But this feeling of oneness is an outgrowth of the naturalist's learning, it is associated with but not the cause of that enthusiasm that keeps him at his work.

His enthusiasm, his motive force, seems to me to be due in very great part to one of the influences of curiosity in the child, namely to a delight in the beautiful. He maintains his enthusiasm and keeps at his work through all odds because he continues to regard as beautiful the objects of his investigation. He perceives beauty and is held by it quite as much in the phenomenon as in the interpretation of the phenomenon. All intellectual men find a beauty in the rational interpretation, for that is an operation of the higher mental powers. But the point on which I would insist is that at the same time the naturalist, if he be truly one, continues his love for the beauty of the phenomenon or object on which he bases his conclusions, and does not regard it simply as a stepping stone to the latter. Indeed this appreciation of the formal beauty is the stimulus in the great part of his work. The important incentive in scientific work is not cold logic, not any statistical summation, but delight in the beauty of the phenomena; it is so potent because it constitutes a major part of the desire to investigate.

Scientific explanations are creations of the scientist, consequently he has in some degree the same fondness for them as he has for his children. But we can not explain unless we have something to explain, and for the same reason there can be no desire for interpretation unless there first be a love of the phenomena. Before a generalization is possible, in any synthetic study, there must be an examination of phenomena through sensations. A man studies those phenomena that he finds most beautiful, and continues at his work just so long as he feels their charm.

In the pastime of the anatomist there is much that would seem repulsive, which may be suggested rather than described. But he carries out this part of it to lay bare the wonderful harmony of line and the perfect symmetries to be discovered in such studies. No more beautiful lines have been chiselled upon marble or painted upon canvas than those laid by Nature upon living organs. The anatomist appreciates these as beauties, set though they be in blood and not in a gilded frame; in his hunt for homology and likeness he never overlooks this formal beauty.

There is a high mental desire for the explanation, but at the same time the sensuous love of the object. It is the appreciation of this formal beauty that keeps him at his table, and his ideas of the beautiful are very much one with those of the artist. How much charm in the flower, in the living Medusa with its changing hues, in the iridescence of a shell, in the transparent but vivid colors of the surface organisms of the sea! All these a naturalist relishes to the full; a great part of his pursuit is aesthetic. He who does not see and cherish this beauty is not a true naturalist, a Nature-lover, and because he has not his heart in his work need expect no great results.

This sense of the beautiful is closely bound up with another element in the scientific mind, that which Ribot has characterized as the creative imagination. Ribot argues that logic and reason alone can not give new interpretations, but can simply assort and arrange what is known. New working hypotheses, he explains, are products of the imagination, which is a mental process capable of taking greater steps than can the reason. Now its connection with the sense of the beautiful appears to me to be just this. The appreciation of the beautiful is not a conscious rational process, but rather a subconscious mental condition. So long as such appreciation is maintained, so long is the mind kept receptive, not entirely overrun by reasoning, and therefore so much more open to processes of the imagination. It may well be that my characterization of these mental states is far from exact, but it suffices if my general meaning is clear; it is, that the appreciation of the beautiful in the phenomena keeps the mind in its pristine receptivity, and so allows for those creative musings and dreamings that are collectively known as imagination and that are so necessary for any progress in Science.

Now this relation is not at all generally comprehended. For in an article published about a year ago in "Harper's Magazine," by President Hadley of Yale University, three groups of minds are distinguished as the literary, the scientific and the administrative. The last named is well characterized, and includes all those whom we speak of as men of affairs, those who have the handling of other men. But the distinction of the other groups is highly artificial, and shows an entire misunderstanding of the scientific spirit. Hadley includes in his scientific group all those interested in facts, and classes together with those pursuing pure Science, engineers, physicians, and technologists of every description; Hadley's idea of Science seems to be that of an especially skilled form of manual labor. His so-called literary group includes all men of ideas, artists, poets, and general writers so far as they are not administrative.

A little reflection shows that his scientific group is quite untenable because disharmonious. For in the first place a scientist is very cautious in saying that he is dealing with facts: he has to do with phenomena but he does no longer call them facts; scientists have a clear conception of the difficulties involved in the idea of facts. In the second place, and this is the cardinal point, the scientist does not simply handle these phenomena and describe or utilize them for some practical purpose, but he explains them and shows their correlations. To carry out interpretations he must be a man of ideas to quite the same extent as a poet or an essayist, and possess quite as high gifts of the imagination.

Then there is an enormous mental difference between the pure technologist and the pure scientist. We do not wish to imply, for instance, that the mind of the pure mathematician is higher than the mind of the engineer, for they are rather complemental. But the former is a scientist and the latter not, in that the former seeks interpretations and the latter applications. A physicist is scientific so long as he keeps in mind explanations, but not when he simply constructs apparatus. In the same way there are two very different kinds of men interested in the microscope: the one constructs it, but he is not a scientist no matter how excellent a technician he may be; the scientist is he who patiently reasons and imagines with his eye at the ocular. There is an enormous difference between the technical expert and the scientific interpreter, for the first builds apparatus, makes use of phenomena, while the second tries to relate the phenomena and bring them together into certain broad generalizations. If there is a particular mental group that may be sharply defined, it is the group of minds interested in mechanical constructions, and it might be called a technological group. But it is an egregious error to rank these and scientists together, they are rather to be considered as entirely divergent both in work and aims. Scientists need to use apparatus, they are obliged sometimes to invent it, but this apparatus is not a primary interest to them but simply a tool; they look ahead far beyond the means employed.

Then on the other hand there is really a very close consanguinity of the artistic temperament and the scientific. Scientists properly belong close to the artists and far from the technologists. Artists and scientists are in equal measure men of ideas, and both are seeking interpretations, both are necessarily highly imaginative. We may say there is only this difference between them, that the scientist places some cogs upon the wheel of his imagination and the artist prefers not to. The artist gives free rein to his fancy, and has no criterion of its value save the opinions of fellow critics. The scientist has constantly to check his working hypotheses when they fall out of harmony with the phenomena investigated. It is incorrect to say that Science is a matter of reason and Art of taste, for both are founded upon the fertility of the imagination. The artist's enthusiasm is maintained by his appreciation of the formally and chromatically beautiful, and we have tried to show that the enthusiasm of the naturalist is due to just the same influence.

There have been many examples of the combination of the scientist and the artist. The greatest of them was Goethe, who, had he only understood human nature as did Shakespeare, would have embodied the greatest perfection of the human mind. All know his "Faust," and his wonderfully rich word-painting; fewer are familiar with his important treatise on optics, and his studies on the transmutation of species and on comparative anatomy. The poet and dramatist Maeterlinck is at the same time a naturalist. Ruskin, Chaucer, Francis Bacon, Saint-Pierre, and a host of others have combined the poet and the naturalist. Again, how well Charles Kingsley and Oliver Wendel Holmes united the two paths of mind. Then how many painters and sculptors have been true naturalists at heart, particularly the greatest of them, Michael Angelo. The great theme of painter and poet, indeed, next to the personification of religious faith, has been the sea; and every naturalist knows the same delight is the resistless, heaving waters whose creatures he studies with such care. Many of our laboratories have been placed upon the sea-coast, and we give as the reason because the sea contains the greatest number of animal groups; but the aesthetic element has had its influences in the choice of such locations, and we can say that naturalists have been attracted quite as much by the beauty of the sea. Scientists are not mechanical thinkers, they are lovers of the natural.

In the same way many scientists of note have engaged in literary and artistic labors. Newton had his flute, and Audubon his violin. Cuvier the anatomist is famed as the author of masterpieces of eulogy delivered in the French Academy, and so is the chemist Berthelot. And though Darwin had no ear for music, he had great judgment in landscape painting.

There is no need to enlarge the list of such examples. They all show the essential kinship of the artistic and scientific spirit, an agreement dependent upon the appreciation of the beautiful. How often one hears it said of a scientist, he has the artistic temperament! It even goes to the extent that both usually remain poor and shabby, and have little so-called practical knowledge; they aret equally so absorbed in their ideas as to have no time to make money.

There is a very immediate application to be made from the recognition of the community of the artistic and scientific spirit. This depends, as we have seen, upon the love of the beautiful and the high development of the imagination without any direct thought of application to human use. With both it is work for the work's sake and usually in the face of obstacles. The application is this. In the training of a scientist as well as of an artist the mind is not to be loaded with so-called facts, but the imagination is to be appealed to, and the sense of the beautiful to be enlarged. There come many to the schools and universities who are both scientists and artists at heart; but they do not get the manna they seek. The general modern method of teaching them what we consider most useful instead of what is most attractive to them, kills their sense of the beautiful, thereby their nascent enthusiasm, and drives them with abhorrence to other fields. There is so much beauty that can be offered the student, so much that will awaken delight and hold it, that it is indeed a pity not to select just such objects. Should we not give the beginner some view of the grand generalizations while we are putting him through the mill of the rudiments? Must the dry rudiments come first? Is one to labor for several years at learning minute points of grammar and syntax before he is introduced to the riches of Aeschylus? The poor, thirsty student sketches painfully the structure of a jelly-fish but learns little enough of its wonderful life history. Or must one learn the structures of many animals and many parts before he is given the key of the idea of descent with modification? No, that is surely wrong, the teacher should rather translate some of the major harmonies as an incentive to the student to learn to read them for himself. When the boy expects bread do not give him a stone. The test of the good teacher is not any thorough preparation in minutiae, nugacious memorizing, but the holding of attention by appeal to the aesthetic sense. This is the proper weapon of the teacher, as wit is of the politician. The present dearth of the scientific spirit in America, and I think that is the present condition, is largely due to bad teaching or to too much teaching. We have more laboratories than there is need for, why is it so hard to keep them filled?

It was pointed out that the childish mind always contains some attraction to the mysterious, coupling an idea of the attractive with the dimly understood. Sometimes this condition continues into riper years, as notably in the case of Nathaniel Hawthorne, and we loosely say that the child has become a poet. We should say: the child has remained a poet. For it may very well be that the growth of the mind from infancy, like that of the body certainly, is a process of increasing specialization with the progressive loss of certain early potentialities; and that our teaching developes one side to the suppression of the others, but does not really create any new tendency. It is very much the same kind of facination that forms the investigator in Science. He feels himself irresistibly drawn to the unknown, as to a magnet of desire, as to something accordingly that is to be pursued for its promise of revealed beauty. Just this is the bond of union between the poet and the naturalist. And through all ages the truly great poets and truly great naturalists have recognized this brotherhood.

This leads us to another general conclusion. No thoroughly scientific interpreter, one with a longing to explain the mysterious and with a real love for the objects of his study, can be without a religion. Linnaeus stated this: "O Jehova, quam ampla sunt tua opera, quam ea omnia sapienter fecisti quam plena est terra possessione tua." For the study itself creates an object of worship and thereby engenders a belief. The broader this field of knowledge, the more comprehensive the religion. The earlier naturalists recognized this more fully than we are apt to do to-day, men like Leon Dufour, Von Baer, De Candolle and Louis Agassiz; they all felt they were exponents of a religion of Nature, priests before her altar. Did not Lesser write on the religion of entomology? The scientist who succinctly appreciates Nature embodies a feeling of reverence and awe to her, and realizes to the full how vast is the length and depth of the unknown. What is religion but praise and worship? Formulation of a creed is theology, churches have been impositions upon religion and not outgrowths from it. Andrew J. White has put it rightly, that there has been much warfare between science and theology but none between science and religion. The naturalist's idea of movement and of life, his appreciation, which may amount to worship, of the beautiful and lucid, and his longing to penetrate the unknown, all these make for a religion. There are times when he can not help considering the inception of things, for he has no right to stop short of beginnings. And whether he accepts the conception of one or of many Gods, or prefers to speak of an initial Unknown, or to regard Nature coterminous with God, he is bound to perceive the essential unity and order in all phenomena, and to stand in awe, reverently, before the great plan of perfection. Only the little, cramped thinker judges there is no mystery and that all will sometime be explained.

Let us recall what old Dr. Thomas Burnet wrote more than two hundred years ago in his "Sacred History of the Earth": "The greatest Objects of Nature are, methinks, the most pleasing to behold; and next to the great Concave of the Heavens, and those boundless Regions where the Stars inhabit, there is nothing that I look upon with more Pleasure than the wide Sea and the Mountains of the Earth. There is something august and stately in the Air of these Things, that inspires the Mind with great Thoughts and Passions; we do naturally upon such Occasions, think of God and his Greatness. And whatsoever hath but the Shadow and Appearance of *Infinite,* as all Things have that are too big for our Comprehension, they fill and over-bear the Mind with their Excess, and cast it into pleasing kind of Stupor and Admiration."

There is needed to-day more of this old-time spirit. Dr. Brooks has said that the microtome is responsible for the small number of naturalists. And indeed to many biologists the vital phenomena appear in the form of transparent, thin slices. Mutely in our museums stand thousands of stuffed skins of birds, and hundreds of thousands of dried bodies of insects. We go so far to eliminate the living from these collections, that we constantly fumigate to destroy the poor Dermestes that would make its home there. Such specimens are very necessary in their way, but they should be regarded as simply parts of animals. Pity the man who has only a museum training, who knows only motionless carcasses, who goes into the field armed only with a cyanide bottle or a gun, and who writes at his desk only descriptions! That kind of education presents a miserable inadequate comprehension of animals and plants, and can not lead to a reverential appreciation of them. To understand organisms one must know how they work and change. It makes little difference what particular objects one is trying to interpret, provided one maintains a broad point of view. When one does that, and does not limit himself to too narrow a path of inquiry, then he can not but feel the uprising within himself of love and awe of the natural. He learns how pitifully weak he is in explanation, how great the unknown, and realizes that he is not a high priest but a supplicant. Then for the first time he has won the true spirit, and enters the lists armed properly with patience and humility. He alone deserves the name of naturalist, all the others fall short of it. He has become a worshipper of Nature.

SOME TESTS OF PAVING BRICK.

BY THOS. U. TAYLOR, M. C. E.*

Constituents: Paving bricks are made from some form of clay which is generally found impure. Kaolin or pure clay has about the following constituents:

Silicon	46 per cent
Alumina	40 per cent
Water	14 per cent
Total	100 per cent

Pure clay is a very rare product and as for forming the constituent for paving brick it can be eliminated as a factor inasmuch as practically all paving brick clay is of impure varieties. These impurities consist of Soda, Ferric Oxide, Magnesia, Potash, Lime, etc. It is well known that pure Alumina is capable of resisting high temperatures and that it is easily moulded but that it shrinks and cracks on drying. The presence of Silica prevents the shrinking and cracking but renders it less responsive to moulding processes. The presence of lime and magnesia, while infusible in themselves or with alumina, readily fuse in an excess of silica and form vitrified brick.

The commercial paving brick is manufactured from some form of clay which is often impregnated with other impurities. Great caution has to be observed not only in mining the clay but also in the complete process throughout from the mining to the completing of the brick. The clay is generally reduced to a powder and then thoroughly mixed so as to form a uniform product. They are burnt in an up-draft or down-draft kiln and statistics show that the down-draft run will turn out from 80 to 90 per cent of the charge as good pavers.

It is not the object of this paper to deal with the full details of the manufacture of paving brick but to give some results of tests made at the University of Texas of the different paving bricks used west of the Mississippi, and before giving the result of these tests I call attention to the following Specifications for Paving Brick as given by the National Brickmakers Association as published in 1901.

"1. *Dimensions of the Machine:* The standard machine shall be 28 inches in diameter and 20 inches in length, measured inside the

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rattling chamber. Other machines may be used, varying in diameter from 26 to 30 inches, and in length from 18 to 24 inches; but if this is done, a record of it must be attached to the official report. Long rattlers must be cut up into sections of suitable length by the insertion of an iron diaphragm at the proper point.

"2. *Construction of the Machine:* The barrel may be driven by trunnions at one or both ends, or by rollers underneath, but in no case shall a shaft pass through the rattler chamber. The cross section of the barrel shall be a regular polygon having fourteen sides. The heads shall be composed of gray cast-iron, not chilled or case-hardened. The staves shall preferably be composed of steel plates, as cast iron peans and ultimately breaks under the wearing action on the inside. There shall be a space of one-fourth of an inch between the staves for the escape of the dust and small pieces of waste. Other machines may be used having from 12 to 16 staves, with openings from one-eighth to three-eighths of an inch between staves, but if this is done a record of it must be attached to the official report of the test.

"3. *Composition of the Charge:* All tests must be executed on charges containing but one make of paving material at a time. The charge shall be composed of bricks to be tested and iron abrasive material. The brick charge shall consist of that number of whole bricks or blocks whose combined volume most nearly amounts to 1000 cubic inches, or eigth per cent of the cubical contents of the rattling chamber. (Nine, ten or eleven are the number required for the ordinary sizes on the market.) The abrasive charge shall consist of 300 pounds of shot made of ordinary machinery cast iron. This shot shall be of two sizes, as described below, and the shot charge shall be composed of one fourth (75 pounds) of the larger size and three-fourth (225 pounds) of the smaller size.

"4. *Size of Shot.* The larger size shall weigh 7 1-2 pounds about and be about 2 1-2 inches square and 4 1-2 inches long, having edges rounded to a radius of about 1-4 inch. The smaller size shall be 1 1-2 inch cubes, weighing about seven-eighths of a pound each, with square corners and edges. The individual shot shall be replaced by new ones when they have lost one-tenth of their original weight.*

"5. *Revolutions of the Charge:* The number of revolutions of the standard test shall be 1800, and the speed of rotation shall not fall below 28 nor exceed 30 per minute. The belt power shall be sufficient to rotate the rattler at the same speed whether charged or empty.

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*It has been proposed to use chilled steel shot, which have practically no wear, and thereby save the expense of replacing and frequently re-weighing the cast-iron shot.

"6. *Condition of the Charge:* The bricks composing the charge shall be thoroughly dried before making the test.*

"7. *Calculating the Results:* The loss shall be calculated in percentages of the weight of the dry brick composing the charge, and no result shall be considered as official unless it is the average of two distinct tests, made on separate charges of brick."**

For the basis of comparison, it can be stated that one city in Ohio a few years ago had fourteen samples of paving brick tested and the average loss was 18.97 per cent, their range being from 15.60 to 24.35 per cent. These brick were about 3x4x9 inches. It must be stated that brick 2x4x8 inches will lose as much as 6 per cent more than blocks.

From tests made at the University of Texas it is clear that a comparison of blocks from one company and brick from another is not a fair test, because testimony is conclusive that the larger the specimen, the less the per cent of wear they indicate under rattler tests. A perfectly fair test of say six varieties of brick would be given by requiring all of them to be of the same size and by using one or two specimens in each run of the rattler.

*"Soft brick saturated in water to 8 per cent. lost only 67 per cent. as much as brick from the same lot tested dry." It has been clearly proved that dry brick lose more than wet ones, but the reason for this difference has not been established. It is reasonable to suppose that different kinds of brick having different percentages of absorption should have different losses for different degrees of moisture.

**There is considerable difference in practice as to the methods of considering broken brick, some experimenters counting all pieces weighing 1 less than 1 pound as abraded material; while others put the limit at half a pound. The latter is apparently the more common.

RATTLER TESTS.

Dimensions of University of Texas Rattler (Inside measurements).

Diameter, 28 inches.
Length, 20 inches.
Staves, 14.

Volume of Rattler—12,322 cu. in.
Volume of Shot—1,173 cu. in.

No. of Exp.	Nature of Charge	Weight		Per cent Lost	Per cent of Rattler Filled
		Before	After		
1	6 Thurber . . . . 4x3x7 3-4 in. (558 cu. in.)	690	491	26.09	
Jan. 27, 1906	6 Coffeeville V. B. & T. Co. . . . . 4x2 1-4x8 1-2 in. (359 cu. in.)	625	509	21.44	17.93
	Volume of brick charge—1017 cu. in.				
2	12 Coffeeville V. B. & T. Co. . . . . 4x2 1-4x8 1-2 in. (918 cu. in)	1277	1040	17.93	16.97
Jan. 28, 1906	Volume brick charge—918 cu. in.				
3	10 Coffeeville V. B. & T. Co. . . . . 4x 3 1-4xx8 1-2 in.	1489	1288	13.49	18.57
Jan. 28, 1906	Volume of brick charge—1105 cu. in.				
4	12 Thurbers . . . . 4x3x7 3-4 in	1363	1013	25.88	18.58
Jan. 29, 1906	Volume of brick charge—1116 cu. in.				
5	4 Thurbers . . . . 4x3x7 3-4 in. (372 cu. in)	447	327	26.84	
	4 Pittsburg V. B. & T. Co. . . . . 3 1-2x3 7-8x8 in. (403 cu. in.)	397	285	28.21	18.30
Jan. 29, 1906	4 Coffeeville V. B. T. Co. . . . . 4x2 1-4x8 1-2 in. (306 cu. in.)	424	345	18.63	
	Volume of brick in charge—1081 cu. in.				
6	2 Purrington Block. . . . . . . 3 1-4x3 3-4x8 1-4 in. (201 cu. in.)	288	256	10.4	
	2 Thurber Brick . . . . . . 4x3x7 3-4 in. (186 cu. in.)	241	187	22.8	14.46
Apr. 23, 1906	2 Coffeeville V. B. & T. Co. . . . . 3 1-4x4x8 1-2 in. (221 cu. in.)	297	267	10.1	
	Volume of brick charge—608 cu. in.				
7	3 Coffeeville V. B. & T. Co. . . . . 4x2 1-4x8 1-2 in. (229.5 cu. in.)	322	280	12.5	
	2 Thurber Brick . . . . . . 4x3x7 14 in. (174 cu. in.)	235	180	23.4	14.43
Apr. 24, 1906	2 Purrington Block . . . . . . 3 1-4x3 3-4x8 1-4 in. (201 cu. in.)	287	257	10.5	
	Volume of brick charge—604.5 cu. in.				
8	2 Thurber Brick . . . . . . 4x3x7 1-4 in. (174 cu. in.)	242	186	23.1	
	2 Purrington Block . . . . . . 3 1-4x3 3-4x8 1-4 in. (201 cu. in.)	289	251	9.65	14.36
Apr. 24, 1906	2 Coffeeville V. B. & T. Co. . . . . 3 1-4x4x8 1-2 in. (221 cu. in.)	298	264	11.8	
	Volume of brick charge—596 cu. in.				

THE SPATIAL CONCEPTION OF THE BLIND.

BY F. J. DOHMEN, PH. D.*

In this paper it is not my intention to give an exhaustive psychological investigation, but rather a rough summary of facts noted by various writers, which I shall supplement with observations drawn from my own experience.

At the outset it is necessary to define somewhat minutely the class of individuals to which the discussion applies. The term blind is not so simple as might be thought without reflection. In the first place there are many gradations of blindness, from that which merely takes away the power of reading by sight to that which is total. Obviously those blind persons who are able still to distinguish spatial relations by sight will not be proper subjects for investigation here, as they will always rely chiefly on this remnant of sight for their space perceptions and conceptions. On the other hand, blind persons not hereby excluded must be distinguished according as they were born blind, or at least lost their sight in early years, or at an age, when the visual conception of space was so well developed as to be retained in a considerable measure. Some writers place this lower limit at four years, others at about six to seven. In my own case it is six, and I am pretty well convinced that I retain no visual ideas of space relations. To be sure, the most satisfactory study is to be made with those born blind, or who lost sight within perhaps the first year of life.

After this introduction we must turn to the perceptions which give spatial ideas. The most elementary of these is touch. Indeed, many older writers maintained that all spatial perception was built upon it. The present view seems to be that sight is able to develop space ideas alone, indeed that it is preeminent. This view is taken by James Muensterberg, and Wundt, also by Theodor Heller in a set of three articles published in 1895 in Vol. XI of the Philosophische Studien, entitled Studien zur Blinden-Psychologie, which is an extensive treatise on the psychology of the blind. Some have extended the same view to the sense of hearing.

Be this as it may, it is obvious that a considerable difference exists between the space-perception of the normal individual and that of the blind person. The faculty of sight, once developed, has a wide

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range. It acts at a considerable distance. The blind person must rely almost wholly on touch, whose field is very limited.

The term touch is here used in its broadest sense, not applying merely to the perceptions due to contact of a certain limited portion of the skin of the hand with an object, but including both those due to such contact with any part of the skin, the outer sense of touch, and such arising from motion of the parts of the body in the muscular strain and in the joints, inner sense of touch. The latter plays an important part in the spatial perceptions.

Those who see seem generally to rely on sight alone for the space perceptions and conceptions, so that some writers deduce them entirely from this source, sometimes going so far as to deny the blind space-conception altogether (Platner at the end of the 18th century, cited by Heller).

The sense of hearing, even if it should not have the power of giving original space-perception, clearly does so after a sufficient development and practice. On this matter there is a considerable literature. Many blind persons have given their testimony, which, however, is quite conflicting. This conflict is due to the fact that most of the writers made no experimental investigation. They often ascribed their perception to a peculiar sensitivitity in the skin of the face, and called the phenomenon facial perception. Psychologists, such as James and Wundt, have discussed this matter, and have reached the conclusion that it is chiefly due to the sense of hearing. Wundt admits the possibility of sensations being aroused in the skin of the forehead by the pressure of the air resulting from the approach to an object, and Heller insists on this point rather strongly. John Vars, a blind student, in one of his articles in the Mentor, speaks of this matter, and remarks, that this perception takes place only when one is very near to an object, within a few inches, which agrees with Heller, and that therefore the blind can not derive much benefit from it.

Drs. Mezes and Hilgartner conducted a series of experiments in this field ten years ago, and presented their results to this Academy in a paper read June 15, 1896. Their experiments brought out the paramount importance of the sense of hearing. When the face of the subject was covered with a pad made of two pieces of cotton cloth with absorbent cotton between them, while the ears were left free, the perception was undisturbed. When, on the other hand, the ears were stopped with bags of fish-skin filled with flour, or with putty and cotton, few cases of perception were noted, and these were always accompanied by other circumstances, such as walking from sun-shine into shade for instance, which rendered the results doubtful.

Now it must not be supposed that the blind gain through this aural perception very definite information as to space relations. They can to some extent judge the distance of an object away from them and its heighth, if this is not greater than their own; distinguish a continuous wall from a broken one, best illustrated by different kinds of fences, whether solid or made of slats. They gain a comparative idea of the thickness of trees or similar objects which they pass. Recesses in a continuous wall, such as are afforded by doors and windows can be detected, and sometimes a change of material in such a surface can be perceived, thus when a wooden door occurs in a plastered wall, while the plane of the door is not appreciably back of that of the wall.

The result then is, that the only accurate space-perception of the blind is had through touch, and primarily through touch involved in clasping an object in the hand, or holding it in both hands. This is a most important distinction from sight, which, as already mentioned, is not bound to such close range. The act of seeing, furthermore, is almost automatic, while an act of touch nearly always requires a distinct volition. It follows, therefore, that a seeing person is continually led to have spatial images in the mind, while this is not the case with the blind person. The latter, in his association with the seeing, who think and speak in terms of sight, is continually confronted with ideas from this source. He can however only in few instances investigate matters by touch, indeed this would require a great expenditure of time and physical exertion, not to mention the fact that many objects are inaccessible to him, either on account of their position, or on acocunt of their delicacy or minuteness.

The field of his experience being thus limited, the blind person must resort to other means, if he is to gain space ideas beyond the most crude. In the first place, when an object presents itself to the touch, and is of dimensions sufficiently small to permit its being very nearly covered by the clasp of both hands, a rough idea of its form is had, which must be perfected by an analysis of its various parts, expressed in the words, *feeling of it.* In this way a pretty clear conception of its spatial character is formed. This process is employed also, when the object permits of being touched at its extremes by both hands simultaneosuly with extended arms.

It seems that few blind persons get beyond this, and hence their conceptions are always of objects in their natural size. One person who was given sight by the removal of congenital cataract expressed surprise at being shown the picture of a human face in a locket, that this could be put into so small a space.

Turning now to that small class of individuals whose power of spatial conception is greater, we find that this greater power is due to a synthetic process, as James and Heller both point out. An object too large to be handled in the ways above mentioned must be investigated piece by piece successively by the analyzing touch. These separate and successive images are combined, synthesized into one tactile conception. This assumes the nature of a model of such size that it might be dealt with in the simpler analytic way. When this stage of development has been reached, a conception may be formed also from description. Here the elements of the description, if they are objects already known, are used in the same way as the successive impressions when the synthetic touch is used. In this manner the scope of spatial ideas can be greatly enlarged.

Heller, following F. Hitschmann, who published an article entitled Ueber Begruendung einer Blindenpsychologie von einen Blinden, in Vol. III of the Zeitschrift fur Psychologie und Physiologie der Sinnesorgane, expresses the opinion that only very few blind persons have spatial conceptions which are at all comparable in adequacy with those of the seeing. Only those whose work or inclination leads them to exercise the touch habitually and with attention acquire a marked development of space conception. Others have almost no space ideas beyond those of their own bodies. They attach to things which it would seem ought to be spatial, other marks. Thus, particular persons are represented by the sound of the voice, the touch and shape of the hand, or by the sound of the walk. This substitution of other marks for spatial ones in the ideas of things, which may take place with all persons, must predominate with the blind, as one understands from their difficulty in adequate space perception.

THE ANATOMY OF THE INTERNAL UROGENITAL ORGANS OF CERTAIN NORTH AMERICAN LIZARDS.*

BARNEY BROOKS, B. S.**

With Plates I-IV.

It was suggested to me by Prof. Thos. H. Montgomery, Jr., under whose direction this work was done, to undertake the anatomical examination of the internal urogenital organs of lizards, because those of the American species are practically a *terra incognita*.

The organs were dissected in both sexes in the following Texan species:

Iguanidae.
- Sceloporus floridanus (Baird).
- Holbrookia texana (Girard).
- Phrynosoma cornutum (Harlan).
- Phrynosoma sp.
- Crotaphytus collaris (Say).
- C. wizlizenii (Baird and Girard).

Scincidae.
- Eumeces guttulatus (Hallowell).

Anguidae.
- Gerrhonotus infernalis (Weigmann).

Teiidae.
- Cnemidophorus gularis (Baird and Girard).

In none of the species here described have these organs been previously examined, and of observations on distinctly American forms I know of only the papers of Cope (1900), which treats the internal organs quite summarily, and of Coe and Kunkle (1904) concerning the genus *Anniella*. The two common European species *Lacerta viridis* and *L. vivipara* have been well investigated, notably by Lereboullet, Leydig and Braun. But otherwise the literature on these structures seems to be monographic rather than comparative, and is widely scattered in the journals so that much of it was inaccessible to me; a list of it is given at the end of the present communication.

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*Contributions from the Zoological Laboratory of The University of Texas, No. 69.

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I. OBSERVATIONS.

1. Holbrookia texana. (Pl. IV., Fig. 16.)

(a) male.

The specimen dissected was in fresh condition and was of average size; measuring from the tip of the snout to the vent 5.5cm.

The testes (T) are two large bodies lying close to the dorsal wall of the body cavity. They are supported by two folds of peritoneum (M). The right one is invariably placed more anterior than the left. They are approximately equal in size, each measuring about 5mm. by 3mm. and their long axes are nearly parallel with the long axis of the body. Through the creamy white sheath, which forms the exterior portion of the testicle, the windings of the seminiferous tubules can be plainly seen.

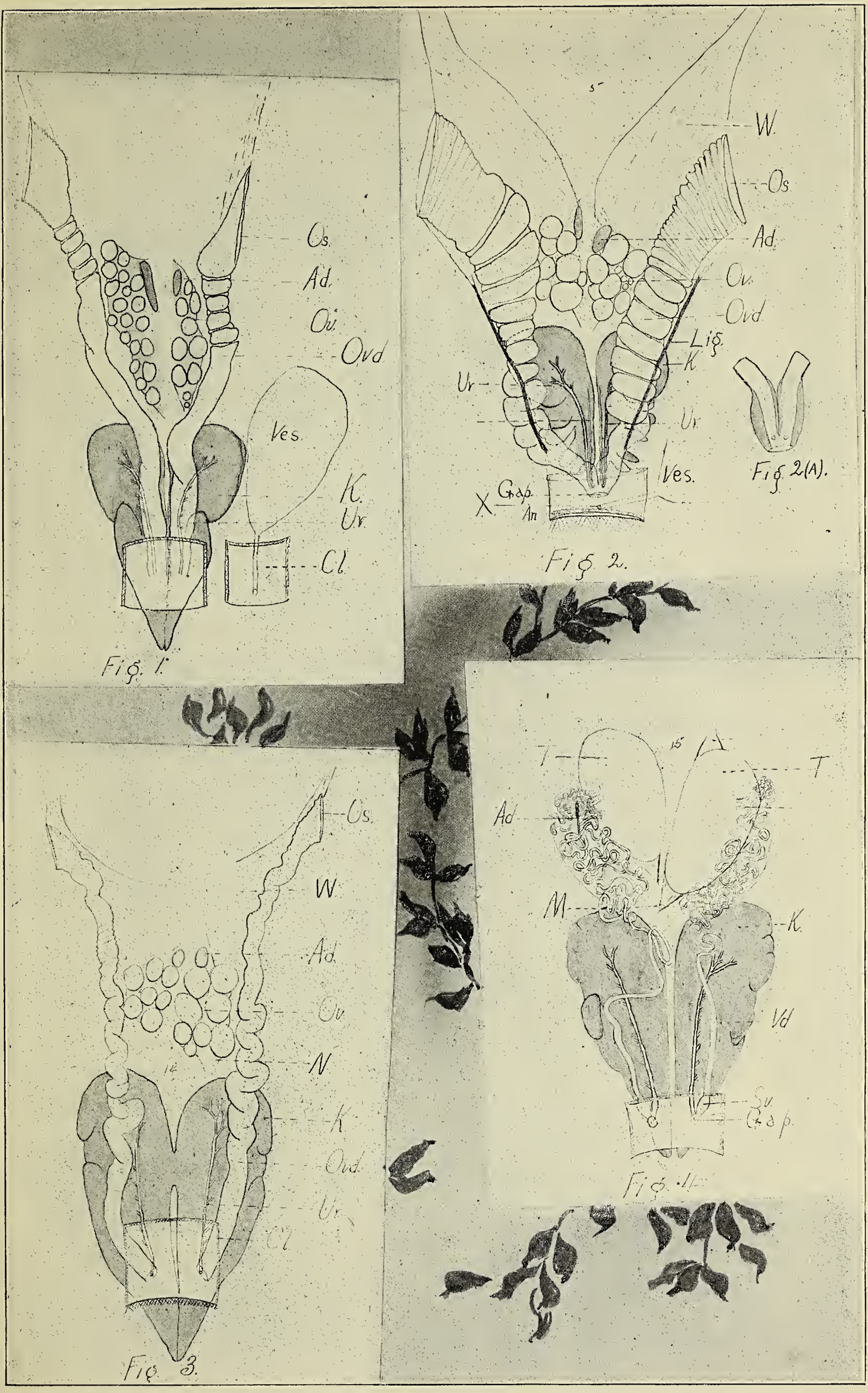
The spermaducts (Vd) are rather thick walled tubes which are very much convoluted in the region of the testes. Each arises from a fan-like formation of collecting tubules (vasa efferentia) which depart from the anterior ends of the testes. The number of these tubules could not be accurately determined, but was approximated as being six or eight. The straight enlarged portion of each spermaduct runs along the ventral surface of the kidneys and then enlarges into a small bladder-like formation which may well be called the seminal vesticle (Sv.). The ureter joins the spermaduct just posterior to the seminal vesicle, and the two have a common opening into the cloaca on a small papilla (G. ap.) just behind the sphinter muscle.

The kidneys (K.) are, in fresh condition, pink colored bodies lying side by side close to the dorsal wall. Their anterior ends are entirely separated, and, although not divided into separate lobes, there can be seen slight demarcations on their surface which shows that there is a tendency toward a separation into lobes. The posterior ends are closely applied to each other. Each of them tapers to a point a short distance behind the anus. The entire length of the kidney is about 10mm. and the greatest width about 2mm. Approximately one-fifth of the kidney lies behind the anus.

The ureters (Ur.) are small tubes extending along the ventral surface of the kidneys just median to the spermaducts. They join the spermaducts just before the latter open into the cloaca, as has already been mentioned. The ureters give off branches at fairly regular intervals as they pass over the surface of the kidneys, and the extreme anterior ends branch out dendritically.

In this species there is no urinary bladder.

The adrenals were found to be present in all the specimens examined. They are small irregular bodies which lie imbedded in the


Os.
Ad.
Ov.
Ovd.
Ves.
K.
Ur.
Cl.
Fig. 1.
W.
Os
Ad.
Ov.
Ovd.
Lig.
K.
Ur.
Ur.
Ves.
Gap.
X
An
Fig. 2.
Fig. 2(A).
Os.
W.
Ad.
Ov.
N.
K.
Ovd.
Ur.
Cl.
Fig. 3.
T
T
Ad.
M.
K.
Vd.
Sv.
Gap.
Fig. 4.

windings of the spermaduct near the extreme anterior ends of the testes.

(b) female. (Pl. I, Fig. 3.)

The female examined was evidently not the same species as the male just described.

In this form the ovaries (Ov.) lie close to the dorsal wall of the abdominal cavity. They are supported by two folds of peritoneum (N); the right one is somewhat anterior to the left.

The oviducts (Ovd.) are tubes which begin some distance in front of the ovaries with a large slit like ostium (Os.). The ducts are very thin walled in this region and collapsible. Posteriorly they gradually become thicker walled and, after a few convolutions in the region of the anterior ends of the kidneys, they pass across these bodies and open into the cloaca by two distinctly separate openings.

The kidneys of the female were slightly different from those of the male, but this was no doubt due to the fact that the two specimens were of slightly different species. The kidneys showed no signs of being divided into lobes, but each had a large notch in the side through which blood vessels passed. The two kidneys were also closely applied to one another behind the anus, and there was a bridge of kidney substance which joined the two kidneys at about their middle point. But this bridge formation did not seem to be present in all of the specimens, and would therefore best be considered as an individual variation rather than a fixed structure.

The ureters (Ur.) are practically the same as in the male, as far as branching out over the kidney is concerned. The ureters open into the cloaca just at the point where the oviducts terminate so that it is difficult to say whether they open into the cloaca or into the oviducts.

The adrenals (Ad.) are present as small yellow bodies lying in the fold of the peritoneum which support the ovaries.

2. Sceloporus floridanus.

(a) male (Pl. IV., Fig. 15.)

In *Sceloporus floridanus* the male genital organs are very similar in appearance to those of *Holbrookia,* as are the kidneys. The testes in *Sceloporus* are relatively larger and not so symmetrically placed in the abdominal cavity, and the windings of the spermaduct are simpler. The animal dissected measured (snout to vent) 7cm.

The testes (T.) are relatively large, each measuring about 7mm. by 5mm. The left one lies considerably more posterior than the right (about two-thirds of the left being entirely behind the right). The left testicle was invariably pigmented at the anterior pole over a zone covering about one-third of the surface of the entire testicle. The liver sends a branch posteriorly which extends a little distance past the anterior end of the right testicle.

The kidneys (K.) measured each 12mm. by 2.5mm. They are not divided up into any distinct lobes, but blood vessels cause a large notch to be formed near the middle of each. Each kidney (especially on dorsal view) shows itself to be made up of lobules which could not be accurately counted, but were estimated to be about seventy-five. The kidneys are distinctly separated in front, but connected by a bridge about midway of their length and closely applied to each other at their posterior ends. The ureters branch out over the kidneys. From the study of sections it was determined that about twelve branches are given off from each ureter. These twelve primary branches by repeated division send branches to every portion of the kidney. The ureter joined the spermaduct just before the latter opened into the cloaca and, as far as could be determined, had a common opening. But it is certain that the two tubes do not join until they have almost reached the end of the papilla on which they open into the cloaca.

The spermaducts (Vd.) arise from several collecting tubules which can be plainly seen coming out of the dorsal side of the testes. The windings of the spermaduct together with the collecting tubules form a very narrow cord in the region of the testes. Posterior to the testes the spermaduct runs almost straight across the kidneys to its opening into the cloaca. The length of the spermaduct would not exceed 3cm. if it were straightened out. It gradually increases in diameter as it approaches the cloacal opening. There is a distinct enlargement (Sv.) on each spermaduct which could very properly be called a seminal vessicle.

The adrenal (Ad.) was very distinct on the left side, but was not found on the right.

Another form, geographical race, of this same species, but from a quite different locality, was compared in order to determine whether subspecific anotomical differences would be found. But examination showed the two specimens to be practically alike. There were slight differences in the shape of the kidneys and the form of the windings of the spermaducts, but no more differences than one would expect from an examination of two individuals of the same locality. The organs of this form are figured in Fig. 10, Pl. III.

(b) female. (Pl. II., Fig. 6.)

In the female also the urogenital system is very similar to that of the genus *Holbrookia*. The specimen examined measured about 8cm. from the tip of the snout to the vent.

The ovaries (Ov.) are small bodies situated close to the dorsal wall of the body cavity. The right one is placed just a little anterior to the left. Each is supported by a fold of peritoneum, which is attached firmly to the dorsal wall of the abdominal cavity.

The oviducts (Ovd.) are not very complexly convoluted. They begin anteriorly with a broad slit like ostium (Os.), which opens into the body cavity. The anterior portions of the oviducts are large very thin walled tubes which are flattened out and wrinkled. They gradually get smaller and thicker posteriorly. Around their extreme posterior ends there is a muscular band. They open into the cloaca through two distinct apertures.

The kidneys are practically like those of the male. The same may be said of the ureters, which open into the cloaca at the same points as the oviducts do.

The adrenals (Ad.) were present as two golden yellow bodies imbedded in the folds of the peritoneum which support the ovaries.

3. Crotaphytus collaris.

(a) male. (Pl. IV., Fig. 13.)

The specimen examined was an old museum specimen which had evidently been in formalin for a long time, and measured from the tip of the snout to the vent about 10cm.

The testes (T.) were badly shrunken, but it was estimated that in a fully distended condition they would measure about 8mm. by 6mm. A noticeable peculiarity concerning their arrangement was that, contrary to the general rule in lizards, the left testicle was placed somewhat anterior to the right one.

The spermaducts (Vd.) are tubes which arise from the collecting tubules coming off from the anterior ends of the testes. They are complexly coiled into ribbon-like masses, held together by connective tissue and pass, dorsal to the testes, back to the anterior ends of the kidneys. The spermaducts enlarge considerably at this point and run across the ventral surfaces of the kidneys, each expanding into a bladder-like seminal vesicle just before opening out with the corresponding ureters on two small papillae in the cloaca.

The kidneys (K.) are rather long and narrow, and measure about 35mm. in length and about 3.5mm. in width at this greatest diameter. The anterior ends are distinctly separate, while the posterior are closely applied to each other. There is also a bridge of kidney substance connecting the two kidneys at about their middle point. There is no tendency to division into lobes, and there is no noticeable demarcation of lobules on their surface. There is, however, a considerable notch in the lateral edge of each.

The ureters (Ur.) are tubes which run across the ventral faces of the kidneys, giving off branches at regular intervals which pass into the kidneys. The ureters join the corresponding spermaducts and open with the latter on two small papillae in the cloaca.

Only one adrenal (Ad.) was found, and was a golden yellow body imbedded in the windings of the spermaduct near the anterior end of the left kidney.

(b) female. (Pl. III., fig. 12.)

The ovaries (Ov.) are small bodies almost exactly symmetrically placed on each side of the vertebral column close to the dorsal wall of the abdominal cavity. They are supported as usual by two mesenteries.

The oviducts (Ovd.) are large tubes which begin anteriorly with a large slit like ostium (Os.) and continue posteriorly until they open into the cloaca through two distinct openings. The right oviduct is without any convolutions and is almost straight. The left one though not looped on itself, is thrown into wave like folds, the lines of whose crests run perpendicular to its long axis: that is, the winding is dorsal-ventral rather than from side to side.

The kidneys (K) and ureters (Ur.) are practically like those of the male.

The adrenals (Ad.) were present as golden yellow bodies embedded in the folds of the peritoneum which support the ovaries.

Another species of this same genus was also dissected, namely *Crotaphytus wizlizenii,* and showed approximately identical structural relations.

4. Phrynosoma sp.

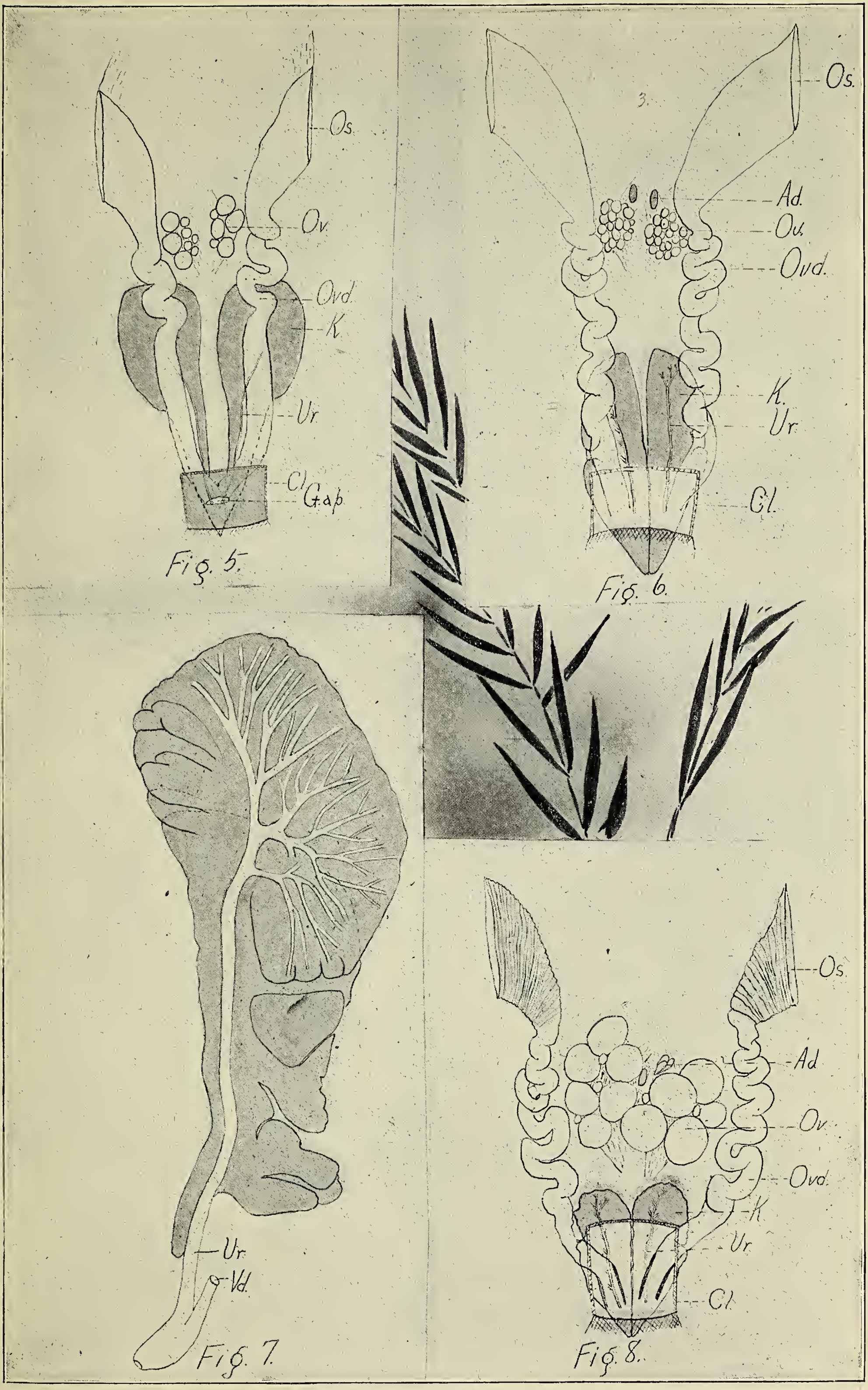
(a) male. (Pl. III., fig. 11.)

The exact species was not determined, a small, light colored form from Brewster County, Texas. The specimen dissected measured 4cm. from the tip of the snout to the vent.

The urogenital system is relatively bulky, and fills almost the whole of the posterior portion of the abdominal cavity.

The testes (T.) are relatively large bodies placed on each side of the vertebral column about midway between the mouth and anal opening. Each measured about 5mm. through the greatest diameter. The left one was placed slightly posterior to the right.

The spermaducts (Vd.) were complexly convoluted in the region of the testes. They arise from about a half dozen collecting tubules, which come out from the dorsal sides of the testes. They widen considerably near the anterior ends of the kidneys, and then run with a few curves across the latter, each swelling into a small seminal


Os.
Ov.
Ovd.
K.
Ur.
Cl
Gap
Fig. 5.
Os.
Ad.
Ov.
Ovd.
K.
Ur.
Cl.
Fig. 6.
Ur.
Vd.
Fig. 7.
Os.
Ad
Ov.
Ovd.
K
Ur.
Cl.
Fig. 8.

versical (Sv.) just before opening with the corresponding ureter into the cloaca.

The ureters (Ur.) are small tubules which run across the ventral faces of the kidneys, each giving off branches at rather regular intervals until it has reached a point near the anterior end of the kidney where it breaks up immediately into several branches which drain this end of the kidney.

The kidneys (K.) are rather long and narrow. They measure about 10mm in length and 3mm. in width at the point of greatest diameter. Their anterior ends are divided into imperfect lobes, but the notches marking the lobes do not extend very far into the kidney substance. The posterior ends of the kidneys extend a short distance behind the anal aperture.

A small adrenal (Ad.) was found on the right side imbedded in the convolutions of the spermaduct.

Another species of *Phrynosoma* (*Phrynosoma cornutum*) was examined but the essential differences consisted merely in the testes being relatively smaller and the windings of the spermaduct slightly different. In this form two adrenals were found. Pl. I., fig. 4, shows the organs of *P. cornutum.*

(b) female. (Pl. II., fig. 8.)

The ovaries (Ov.) are close to the dorsal wall on each side of the vertebral column. The left is placed slightly posterior to the right one.

The oviducts (Ov.) begin anteriorly with large ostia (Os.) and have several convolutions. They open into the cloaca through two distinct openings. There is a slight muscular thickening around the posterior end of each oviduct just before it opens into the cloaca.

The kidneys (K.) and ureters (Ur.) are practically the same as those of the male.

The adrenals (Ad.) were present on each side as golden yellow bodies lying imbedded in the folds of the peritoneum which support the ovaries. The left adrenal was divided into lobes.

5. Eumeces guttulatus.

(a) male. (Pl. III., fig. 9.)

The urogenital system of this form is relatively large and bulky, and fills almost the entire posterior third of the body cavity. The specimen examined was an old alcoholic museum specimen that measured 5cm. from the tip of the snout to the anus.

The testes (T.) are large and lie close to the dorsal wall of the body cavity just anterior to the kidneys. In fact, the posterior ends of the testes and the anterior ends of the kidneys overlap for a short distance. The testes are as usual a little asymmetrically placed, the left one being slightly anterior to the right one. They are practically the same size, each measuring about 5mm. by 3mm.

The spermaducts (Vd.) are small delicate tubules, very complexly convoluted in the region of the testes. About the middle of the right kidney and near the anterior end of the left kidney they enlarge suddenly and then run straight to their openings in the cloaca.

The ureters (Ur.) join the spermaducts and open into the cloaca through the same openings. Their anterior ends branch out into numerous branches which spread out over the kidneys.

The kidneys (K.) are relatively large and bulky. They measure 10mm. in length and 3mm. in greatest width. Their posterior one-thirds are closely apposed. They are not divided up into distinct lobes. There is a slight irregularity at about their middle points which may indicate a tendency toward lobulation. The kidneys are mostly anterior to the anal opening, but there is a small tip of their posterior ends which extends behind it.

The adrenals (Ad.) were present on each side as relatively large elongated bodies imbedded in the windings of the spermaduct.

There was in this form a peculiarity which was not present in any of the species already described. This was the presence of a large urinary bladder. The bladder (Ves.) is a large flask-shaped body which lies just ventral to the cloaca. The larger anterior end is supported by two strong ligaments which are joined to the sides of the abdominal cavity. The posterior end narrows down to a tube like neck which opens into the cloaca on the ventral side at a point (x) slightly posterior to the openings of the spermaducts and ureters.

(b) female. (Pl. I., fig. 1.)

The ovaries (Ov.) are somewhat elongated, placed symmetrically in the body cavity, and are supported by two folds of peritoneum which are joined to the walls of the body cavity on each side of the vertebral column.

The oviducts (Ov.) are two large flat tubes, each beginning anteriorly with a wide ostium (Os.). They are thrown into waves in the region of the ovaries. Posterior to the ovaries, however, they continue with but slight undulations to their openings into the cloaca.

The ureters (Ur.) are like those of the male, and open with the corresponding oviducts into the cloaca.

The kidneys (K.) are similar to those described in the male. They are distinctly divided into anterior and posterior lobes, thus realizing the tendency shown in the male.

The adrenals (Ad.) were present on each side in the folds of the peritoneum which support the ovaries.

The large urinary bladder (Ves.) was also present in the same relative position as in the male.

6. Gerrhonotus infernalis.

(a) male. (Pl. IV., fig. 17.)

The specimen studied was one which had been in alcohol for a considerable length of time, and measured from the tip of the snout to the anus about 15cm.

The testes (T.) were small elongated bodies lying close together on each side of the vertebral column. Each is supported by a fold of peritoneum. The right testicle is placed slightly in front of the left. The left testicle measured 10mm. by 2mm. while the right one measured only 8mm. by 2mm.

The spermaducts (Vd.) were relatively simple, not being complexly wound, and are convoluted only in the immediate region of the testes. Along the remainder of their course they undulate from side to side. These bends together with the connective tissue which holds them together form narrow ribbons which extend from the testes back to the urogenital openings in the cloaca. There was no distinct seminal vesicle present, but observations on other species leads me to believe that this may be present during only certain times of the year. There was however a gradual enlarging of the spermaducts as they approach their posterior openings. Each spermaduct joined with the corresponding ureter and the two had a common opening out into the cloaca on one of the papilla-like projections of the dorsal wall of the cloaca.

But the most peculiar character of the urogenital system of *Gerrhonotus* is the general appearance of the kidneys. They are large conspicuous bodies lying in the posterior portion of the abdominal cavity, almost filling the posterior third of it. Each kidney (K.) is made up of a large anterior lobe and several small posterior lobes. The anterior lobe is flat, bean-shaped, and its anterior median edge is divided so as to form secondary lobes, but these are not marked off as plainly as the larger divisions. The branchings of the ureter (Ur.) upon this larger anterior lobe gives it a peculiar fan-like appearance. The remainder of the kidney is composed of eight smaller lobes, which gradually grow smaller toward the posterior end of the kidney. The entire kidney is placed in front of the anus, none of it being posterior to the opening of the ureter into the cloaca.

The ureters (Ur.) are very much branched. The main branches of the ureter break up into smaller ones and these in turn into still smaller ones until the entire kidney is supplied. The main branch of the ureter joins with its corresponding spermaduct, and they open into the cloaca through a common opening (G. ap.) situated on the end of one of the papillae on the dorsal wall of the cloaca.

The general appearance of the kidney and ureter is shown in Pl. II, Fig. 7.

In *Gerrhonotus infernalis* there is a very large urinary bladder (Ves.), which opens into the posterior portion of the cloaca on the ventral side, and its anterior end is held in place by two strong ligaments attached to the dorsal wall of the abdominal cavity.

The adrenals (Ad.) are present on both sides as golden yellow bodies lying imbedded in the windings of the spermaducts just anterior to the testes.

(b) female. (Pl. I, Fig. 2.)

In the female we find the most complicated urogenital system of any of the forms described in this paper. The specimen examined was an adult and measured from the tip of the snout to the anus about 15cm.

The ovaries (Ov.) lie close to the dorsal wall of the abdominal cavity. They are not exactly, but almost, symmetrically placed, the right one being slightly in front of the left. The specimen was taken in the late fall, and each ovary contained a half dozen large eggs and numerous smaller ones. Each ovary was supported by a strong fold of peritoneum which is firmly attached to the dorsal wall of the body cavity.

The oviducts (Ovd.) are large flat tubes which are thrown into many wave-like folds. There is a strong ligament (Lig.) to which these folds are attached. Each oviduct is also supported by a large thick fold of peritoneum (W.) inserted on the dorsal wall of the body cavity. Just before emptying into the cloaca, there is a large thickening of muscles around the oviducts. This is not shown in the main figure (Fig. 2), but in figure 2a. These thickened muscular tubes open into a common tube which in turn opens into the cloaca.

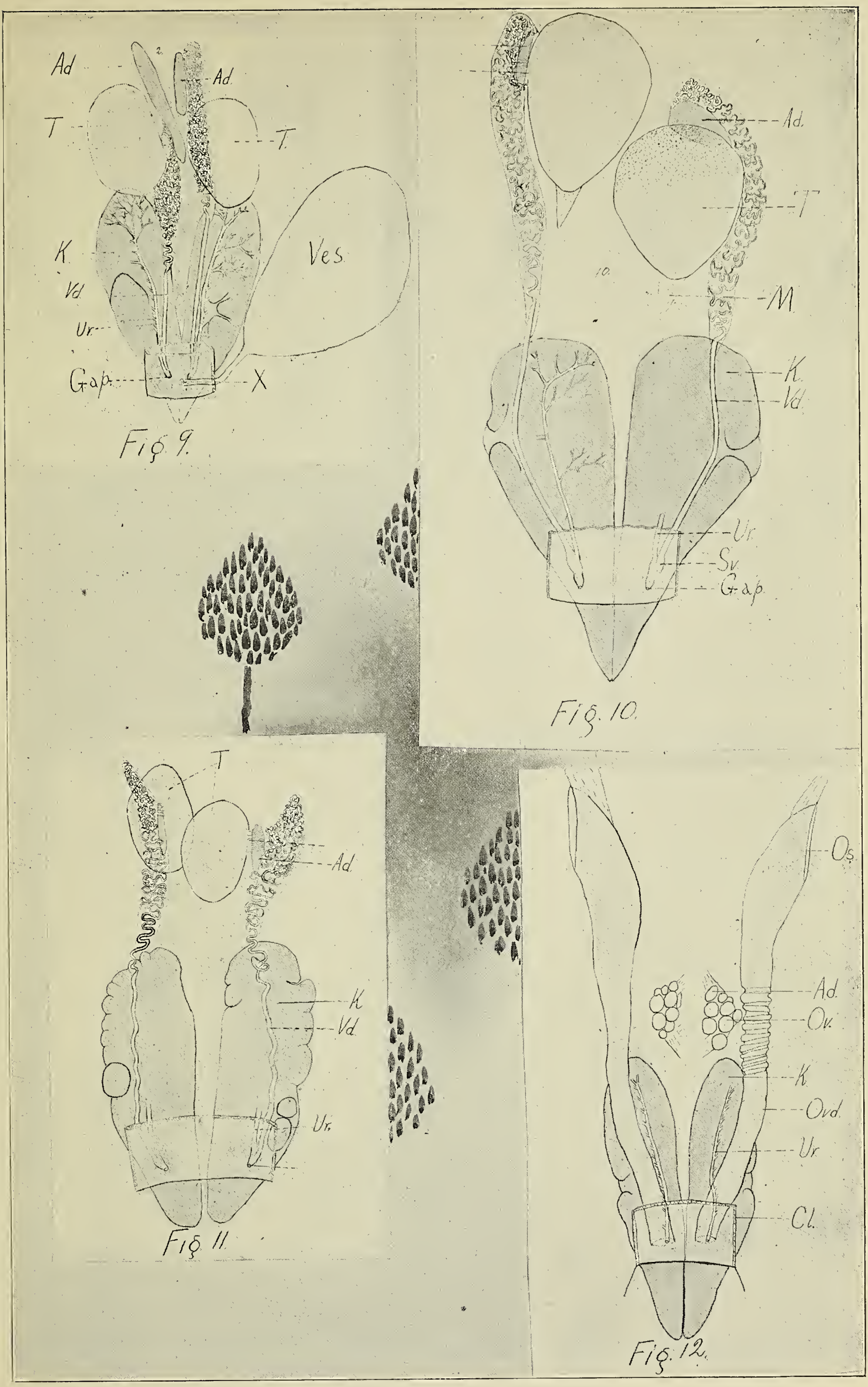
The ureters (Ur.) which are similar to those of the male open into the dorsal wall of the short vagina-like formation through two small apertures.

The kidneys (K.) are practically the same as those found in the male.

The adrenals (Ad.) were also present in their usual position.

A large urinary bladder (Ves.) was found just as in the male.

In the specimen dissected, there were found two small tubules


Ad
Ad.
T
T.
Ves.
K
Vd
Ur.
Gap.
X
Fig. 9.
Ad.
T
M
K.
Vd.
Ur.
Sv.
G.a.p.
Fig. 10.
T
Ad.
K
Vd.
Ur.
Fig. 11.
Os.
Ad.
Ov.
K
Ovd.
Ur.
Cl.
Fig. 12.

arising close by the sides of the ureters and extending forward median to the ureters, and ending blindly at a point about the middle of the kidneys. Owing to the fact that I had only one specimen, I could not say whether this character was constant or just an individual variation. These would seem to be the remains of the old embryonic Wolffian duct.

7. Cnemidophorus gularis.

(a) male. (Pl. IV., Fig. 14.)

The testes (T.) are small round bodies lying close to the wall of the body cavity. They are almost, but not exactly, symmetrically placed, the right one being slightly anterior to the left, and are held in place by two folds of peritoneum which are attached to the dorsal wall of the abdominal cavity.

The spermaducts (Vd.) arise from collecting tubules which come out from the middle of the dorsal side of the testes. The spermaducts then wind from side to side in short waves back to their posterior openings into the cloaca. These bends are held in place by a strip of connective tissue, which together with the waves of the spermaduct forms a narrow ribbon which extends from the testicles back to the urogenital openings, which are found on two small papillae on the dorsal wall of the claoca. Just before the spermaducts open out into the cloaca, they expand into two small seminal vesicles.

The ureters (Ur.) are small tubes which run over the ventral portion of the narrow ends of the kidneys, giving off occasional branches, and finally enter a notch in the anterior portion of each kidney and immediately branch out into numerous forks. They join with the corresponding spermaducts and open with the latter through the same openings (G. ap.) into the cloaca.

The kidneys (K.) of *Cnemidophorus* are especially interesting. They are club-shaped organs lying close to the dorsal wall of the body cavity. Their anterior ends are large and thick. They rapidly attenuate at a point about halfway between their anterior and posterior ends, and continue back to a point about even with the openings of the ureters and spermaducts into the cloaca. Thus the kidneys lie entirely in front of the anus. The anterior large ends are not divided into lobes, but small lobules can be seen scattered over the surface. The narrow posterior ends are very thin and in some places consist in the main simply of connective tissue. Along the median edges of the kidney these splotches of connective tissue make it assume a peculiar segmented appearance. In each bar of kidney substance there seems to be a single collecting tubule wound into a knot. The kidneys terminate posteriorly in a strip of connective tissue.

The adrenals (Ad.) are present on each side as golden yellow bodies imbedded in the windings of the spermaducts near the point where the collecting tubules come out from the testes.

(b) female. (Pl. II., fig. 5.)

The female urogenital system is far simpler than had been anticipated. The specimen dissected was a fresh alcoholic one, measuring about 6.5cm. from the tip of the snout to the vent.

The ovaries (Ov.) are small and placed exactly symmetrically in the body cavity, and are supported as usual by two folds of peritoneum.

The oviducts were extremely simple. Each begins anteriorly with a slit like ostium (Os.) and continues posteriorly with a few convolutions in the region of the ovaries. The two posterior ends join before opening into the cloaca.

The ureters (Ur.) are practically the same as those of the male. They open into the vagina-like pouch formed by the joining of the two oviducts.

The kidneys (K.) are also practically the same as those found in the male, excepting that instead of entirely ceasing in front of the anal aperture, they are continued posterior to the anus as narrow strips of connective tissue, which are applied to each other just as the posterior ends of the kidneys are in *Holbrookia, Sceloporus,* etc. Thus in this form we can still say the kidneys lie entirely in front of the anus, as that part which does extend posterior to the anus contains almost no kidney substance proper.

II. CONCLUSIONS.

A main object of this study was to make a contribution to the question of how much value the comparison of the differences in the internal urogenital organs would have in determining genetic relationship. *Apriori* one might consider these organs to show considerable value of this kind. For, in the first place, this is one of the oldest organ systems in Vertebrates, in that all members of this group possess ovaries and testes and kidneys. And in the second place these internal organs would not so readily become modified by external conditions as do certain other structures given more prominence in classification. Cope has drawn attention to the copulatory organs of the male, and has laid considerable stress upon them as guides of descent, particularly in the case of the Ophidia. But as yet no one appears to have compared the internal organs of lizards with this object in view.

We may say that the germ cells are really the earliest cells of the organism, in that some of them, by loss of characters, become somatic cells. The gonads or germ glands, accordingly, their seats of growth and multiplication, should promise to be conservative structures. In fact they are, and only unimportant microscopical differences were found between the ovaries of the different genera, or between the testes.

The vasa deferentia vary in complexity of convolution, but this, like the convolution of the oviducts, may well vary temporarily according to the state of the sexual activity. In all the genera studied their posterior apertures are disconnected, and each opens conjointly with the ureter of its side upon a cloacal papilla. Seminal vesicles, a dilation of the posterior part of each vas deferens, were found in all but *Eumeces* and *Gerrhonotus*.

The oviducts also always open conjointly with the ureters. But while in *Sceloporus, Holbrookia, Phrynosoma, Crotaphytus* and *Eumeces* the opening of the right oviduct is always separated from that of the left, in *Gerrhonotus* and *Cnemidophorus* they are united; the latter is clearly a secondary modification. In the last two genera also, as well as in *Eumeces,* another specialization appears, namely, a muscular sphincter around the posterior ends of the oviducts.

A urinary bladder is present in both *Eumeces* and *Gerrhonotus,* but completely absent in the other genera studied. This is in disagreement with the statement of Cope (1900), "urinary bladder generally present."

Adrenal glands are present in all, though sometimes unpaired. Histological study shows them to be composed of sympathetic nerve cells as well as of glandular tissue. Whether they represent interrenals or suprarenals, or both, appears to have been not yet satisfactorily determined by embryologists; on this question one may compare the papers of Braun (1879), Howes (1887), Leydig (1853) and Petit (1896).

It may be found that the lobulation and degree of posterior extension of the kidneys will furnish characters of phylogenetic import. In *Holbrookia, Sceloporus* and *Crotaphytus* these organs are nearly smooth, without lobes, and extend for a considerable distance posterior to the anus. *Phrynosoma* differs only in having the kidneys slightly notched along their lateral edges. In *Eumeces* each kidney consists of two large lobes, an anterior larger one, and a posterior one that extends behind the anus. In *Gerrhonotus* each is composed of a large anterior lobe and several smaller posterior ones, none of which extend behind the anus. Finally in *Cnemidophorus* each kidney is essentially unilobar, with simply a connective tissue extension beyond the anus. The differences in kidney configuration agree with other family differences. The extension of the kidneys behind the anus is probably a primitive condition, as the relations in *Cnemidophorus* would indicate, where the connective tissue continuation would represent the capsule from which the tubules had withdrawn. Whether smoothness of outline or lobulation in the more primitive condition in lizards, remains to be determined.

All the examined species are oviparous, so that there are no secondary modifications such as uteri. Yet there are on the whole greater differences between the female organs than between the male, showing that in this regard the male is more conservative. The Iguanidae from the standpoint of the female reproductive organs would appear less specialized than the other families, in that the former have neither a union of the oviducts nor a well developed sphincter muscle of the oviducts; the Iguanidae also lack the urinary bladder.

Too few genera have been examined to permit further generalizations. But a wider comparison of numerous forms would undoubtedly serve to correct a classification that is too largely based upon skeletal characters. For as Lereboullet, the author of the admirable monograph upon the Lizard, sagaciously concluded, no one single organ system should be the whole basis of a scheme of classification.

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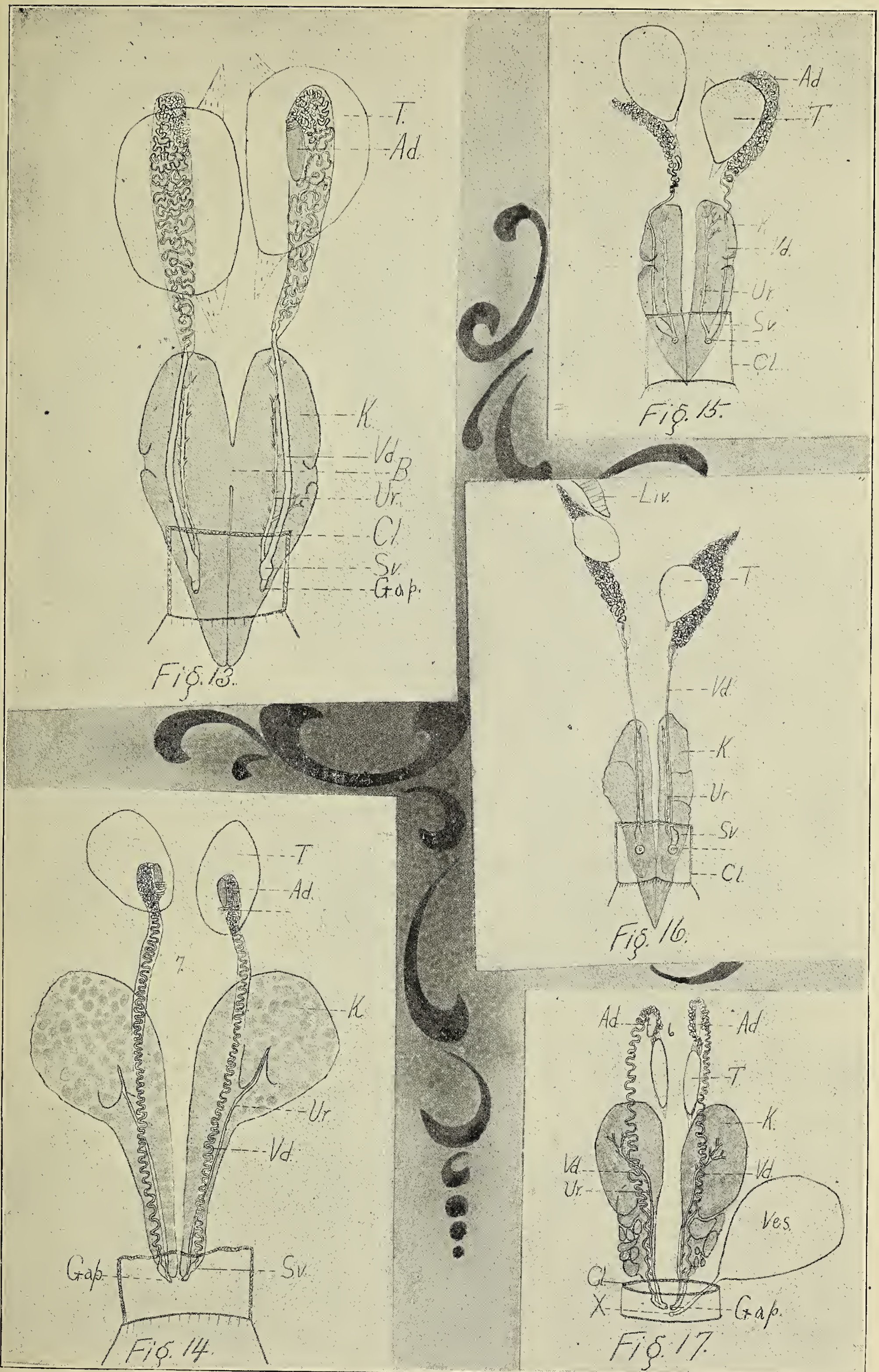
PLATE IV.



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EXPLANATION OF THE PLATES.

Abreviations used:

An.—Anus.
Ad.—Adrenal.
B.—Bridge joining the kidneys.
Cl.—Cloaca.
G. ap.—Genital aperture.
K.—Kidney.
Lig.—Ligament holding the folds of the oviduct.
Liv.—Liver.
M.—Peritoneal fold supporting the testes.
N.—Peritoneal fold supporting the ovaries.
Ov.—Ovary.

Ovd.—Oviduct.
Os.—Ostium.
Sv.—Seminal vesicle.
T.—Testes.
Ur.—Ureter.
Ves.—Urinary bladder.
Vd.—Vas deferens.
W.—Fold of peritoneum supporting the oviduct.
X.—Openings of the urinary bladder.
All the figures are ventral views.

Plate I.

Fig. 1. Female Eumeces guttulatus enlarged 3 1-2 times.
Fig. 2. Female Gerrhonotus infernalis, natural size.
Fig. 2 (a). Showing the joined ends of the oviducts of Gerrhonotus infernalis.
Fig. 3. Female Holbrookia texana, enlarged 3 1-2 times.
Fig. 4. Male Phrynosoma cornutum, enlarged 3 1-2 times.

Plate II.

Fig 5. Male Cnemidophoros gularis.
Fig. 6. Female Sceloporos floridanus, enlarged 2 1-2 times.
Fig. 7. Right kidney of Gerrhonotus infernalis (camera drawing), showing the branches of the ureter in the anterior lobe.
Fig. 8. Female Phrynosoma sp., enlarged 2 1-2 times.

Plate III.

Fig. 9. Male Eumeces guttulatus, enlarged 3 1-2 times.
Fig. 10. Male Sceloporus floridanus, enlarged 3 1-2 times.
Fig. 11. Male Phrynosoma, sp.
Fig. 12. Female Crotaphytus collaris, enlarged 3 1-2 times.

Plate IV.

Fig. 13. Male Crotaphytus collaris, enlarged 2 1-2 times.
Fig. 14. Male Cnemidophoros gularis.
Fig. 15. Male Sceloporos floridanus.
Fig. 16. Male Holbrookia texana, enlarged 2 1-2 times.
Fig. 17. Female Gerrhonotus infernalis, natural size.

THE INDEBTEDNESS OF THE GERMAN LANGUAGE TO THE LATIN.

BY SYLVESTER PRIMER.*

The debt which modern civilization owes to the two elder civilizations of Greece and Rome will best be repaid by a frank acknowledgment of their beneficial influence upon the formative period of the language and life of modern times. For all modern nations show this influence in the very origin and growth of their language and political government. It would be an interesting and pleasant task to trace out this influence and show its bearing on all modern thought and life. But that would exced the scope of this article; hence we shall confine ourselves here to a few points bearing directly upon the German language.

The Gothic is the noblest of all the German dialects and deserves especial mention. As early as the third century of the Christian era the Goths accepted christianity and in the fourth century Bishop Ulfila undertook the translation of the bible into his native tongue. The Goths already possessed a spoken and written language of their own, as seen in their heroic ballads, preserved oral tradition (see Jordanis), and written laws, or better, proverbs of ethic and political content. The translator was also well prepared for his work, for he spoke and wrote both Greek and Latin, had been educated at the Greek court, and had been at the Roman (?) court on an embassy. It would be a difficult task to show positive proof of the influence of the classics upon this translation as the translator has used native words and constructions as far as possible and the grammar is purely Germanic, or but slightly influenced by the Greek and Latin. The few fragments we possess from other sources are insufficient to form any comparison of the earlier language with that of Ulfila. Yet the careful observer will realize that the highly cultivated languages of Greece and Rome backed by an old and well-developed civilization, must have exerted that subtle influence, not only upon the language of the Goths, but also upon their civilization itself, which culture always exerts upon the uncultured. The indebtedness of the Gothic to Greece and Rome will therefore be one of refinement. For the intellectual development of the Germans in these early times was under foreign influence which has left its trace in all their writings. The language itself, especially the Gothic and Old High German dialects,

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was such that the melodious Latin and Greek words were easily assimilated. Yet Bishop Ulfila created numberless genuine expressions for foreign ideas that the older dialects did not possess, both for things of ordinary and social life, and for state and church, which foreign influence later suppressed and for which loan words were substituted. For instance Ulfila used *waddjus* (wall), *augo-dauro* (window), etc., for the modern *mauer, fenster,* both of Latin origin. Numberless examples might be added, but these must suffice.

When the Germans first fell under the influence of the superior Roman culture and felt the need of enlarging their vocabulary, they adopted two different methods for enriching their language. For material things of life they accepted loan words, but for the intellectual life they formed words from their own language to express the new idea in thought and feeling. The effect of this proceedure may be seen in the Middle High German which is symmetrical and has a rich development in a series of immortal works. Compared with the earlier language of the Hildebrandslied the Muspili, the Gothic translation of the bible and the Old High German monuments, the Middle High German shows a flexibility and expressiveness that make it superior to any stage of German except the present.

After their conversion and assimilation into the church the priests destroyed the old German songs and music and wrote church songs like the Latin church songs and adopted the church music. Thus we have Olfried's Evangelienbuch, the Heiland and other church poems. We have also laws and profane writings where the older thoughts and feelings are giving way to the new.

During the Middle Ages the native German was under the ban. Latin reigned supreme in church and science, in cloister, school and university. It was not until the renaissance that the Latin became a dead language. Thus no chance was given in this early period for the further development of the native dialect. For Latin was spoken by all but the lowest caste. All documents were in Latin. Church and state suppressed the so-called vulgar speech. Not till 1238 do we find public documents in the German language and from this time on the German gains ground slowly but surely. In 1274 German becomes the official language for public documents, but Latin still remained in the church and at court. The church insisted on Latin as the universal language of intercommunication. Germany felt the need of using its own language and succeeded in introducing it into a part of the church service. But the Latin had dominated the mother tongue so long that a new language had to be formed. Morover the upper classes had used the universal language (Latin) as an elegant and noble language and had considered it the only language proper for them so long that they despised their own tongue. Therefore, when patriotic men endeavored to reform and enoble the German, they found so many Latin technical expressions embedded in the language that their learned German looked like a rough cast of the universal language rather than native German. Though the German of the sixteenth century is thoroughly German, yet its rudeness and lack of form clearly shows that without the aid of the educated language no real refinement of taste is possible. Had not the thirty years' war nipped this effort at reform in the bud, the history of the German language would have been different. But the popular element of the language disappeared in the distress of that devastating war. The intellectual life was impoverished, even selfconsciousness died out, and the Germans, perhaps pardonably, turned to their neighbors for inspiration in language and poetry, preferably to France, a daughter of the Latin, whence came foreign words for all phases of life. The court, the nobility, in fact all of the upper classes vied with each other in speaking French. Poetry, which had been consecrated to the German tongue, now followed the new mode and adopted loan words in masses. Patriotic people again took up the battle for the purification of their language and have accomplished much in this way and are still doing an excellent work.

The real formation of the modern German is, however, to be found in the efforts of Maximilian and his chancel to improve their language. Ecks' Catholic bible (Ingolstadt, 1537), which formed the basis of Luther's translation, shows clearly the significance of this movement as it is the result (in language at least) of Maximilian's efforts. Luther wisely used the results that had been achieved before his time in his efforts to form a universal German, and we know the result of his life's work.

It will be seen from the above slight sketch that the dominance of the Latin in church and state has been a constant menace to the German, and has given it a new character by the introduction of foreign elements both in the vocabulary and grammar. The examination of Simon Rote's Freundwoerterbuch (1571) will convince any one that the German had been mutilated. If we compare Rote's Dictionary with the unfinished dictionary of Luther, it will be found that the former contains five hundred Latin words to one hundred in the latter, and a comparison of Eck's translation of the bible will show that Luther has substituted a large number of good German words for the loan words of Eck.

The following table will show the indebtedness of the various periods to the Latin:

I. Roman Period (6-9 A. D.):

(a) The words here are mostly proper names and often only Latinized German words.

Armenius (Ger. Hermann).
Augsburg (Augusta, burg is German).
Regensburg (Reginum, burg).
Strassburg (Strataburgium).
Mainz (Mogontiacum, Magontiacum, Moguntia).
Worms (Barbelomagus).
Koeln (Cologne, Colonia).
Bonn (Bonna).

II. (About the second century.) The vegitable kingdom furnishes a greater variety in this early period, especially from the garden and field:

Kirsche (cerasus), *Pfirsiche* (persicum), *Pflaume* (prunum), *Pfebe,* (pepo), *Maulbeere* (morum), *Feige* (ficus), *Birne* (pirum), *Linse* (lens), *Wicke* (vicia), *Zwiebel* (cepula), *Minze* (mentha), *Retticke* (radix), *Kohl* (caulis), *Lattich* (lactuca), *Fenchel* (feniculum), *Eppich* (apium), *Kerbel* (caerefolium), *Larche* (lariz), *Lorbeer* (laurus), *Buchsbaum* (buxus), *Rose* (rosa), *Lilie* (lilium), *Vielchen* (viola), *Wein* (vinum), *Most* (mustum), *Kelter* (caleitrare), *Presse* (pressa), *Kelch* (calix), *Becher* (bicarium), *Ohm* (ama), *Kufe* (cupa), *Winzer* (vinitor), *Pech* (pix).

III. From the animal kingdom the German took the names of several animals, as: *Esel* (asinus), *Maultier* (mula), *Saumtier* (sagnia), *Katze* (cattus), *Fasan* (phasianus), *Pfau* (pavo), *Strauss* (struthio).

IV. Household words: *Mauer* (murus), *Turm* (turvis), *Kammer* (cameru), *Soeller* (solarium), *Keller* (cellarium), *Pfeiler* (pilarium), *Pforte* (porta), *Fenster* (fenestra), *Speicher* (spicavium), *Kerker* (carcer), *Ziegel* (tegula), *Estrich* (astricus), *Schindel* (scindula), *Strasse* (strata), *Platz* (platea), *Weiler* (villarium), *Schleusen* (exclusa), *Tisch* (discus), *Tafel* (tabula), *Spiegel* (speculum), *Schuessel* (scutula), *Pfanne* (patina), *Trichter* (tractarius), *Socke* (soccus), *Sohle* (solea), *Schurze* (excurtus).

V. Commerce introduced numberless new words as: *kaufen* (cauponari), *Meile* (milia), *Markt* (mercatus), *Muenze* (moneta), *Pfund* (pondo), *kosten* (constare), *Zoll* (telonium), *Zins* (census), *Brief* (breve), *Siegel* (sigillum), *Sack* (saccus), *Korb* (corbis), *Kiste* (cista), *Schrein* (scrinium), *Arche* (arca), *Flaum* (pluma), *Kissen* (culcitinum), *Pfuehl* (pulvinus), *Pfeffer* (piper), *Kuemmel* (cuminum), *Senf* (sinapi), *Kochen* (coguere), *Speise* (expensa).

VI. Medicine, statecraft, writing: *Fieber* (febris), *Artz* (archiater), *Pflaster* (emplastrum), *schreiben* (scribere), *sicher* (securus), *Kaeser* (Cæsar), *Pacht* (pactum).

VII. Christianity: *Pein* (poena), *Plage* (plaga), *Marter* (martyrium), *verdammen* (damnare), *opfern* (operari or offerre), *predigen* (praedicare), *Priester* (presbyter from Gr.), *Propst* (praepositus), *Abt* (abbas), *Moench* (monachus), *Dechant* (decanus), *messe* (missa), *mette* (matutina), *Feier* (feriae), *Vesper* (vesper), *Segen* (signum), *Muenster* (monasterium), *Kloster* (claustrum), *Klause* (clausa), *Tempel* (temlum), *Orgel* (organum), *Altar* (Altare), *Kanzel* (cancelli), *Kreuz* (crux), *Pfosten* (postis), *Kessel* (catillus), *Insel* (insula), *Butter,* (butyrum), *Kaese* (caseus), *Anker* (ancora), *Pfeil* (pilum), and the days of the week.

This list will give an idea of the enlargement of the German vocabulary in the earlier period of the Christian era and the first years of German contact with the Latin races. We need not cite the later loan words introduced through the French and Italian, for they are readily recognized and are such words as are constantly being introduced into every living language. They are mostly school terms, law terms, medicine, etc.

The grammatical indebtedness of the German to the Latin is such as any primitive language in its formative period owes to a cultured language when brought directly under its influence.

The modern period of German, however, dates back to Maximilian and Luther, though it was moulded into its present shape by excellent Latin scholars even after the latter had ceased to be a living language; grammatical forms and syntax show this best. Compare the constructions especially. The direct influence is best seen in the long sentences and artificially built periods. Read Lessing's works and he was a rare classic scholar and compare Milton in English. The Germans now claim that this influence has been pernicious to the deelopment of a graceful and easy style.

In word-formation the Latin influence has been all-powerful. In the Old High German many expressions for abstract, especially christian ideas were wanting, therefore, eager moncks like Notker, Labeo, Williram, etc., set about correcting this fault, not by simply borrowing from the Latin, but by forming independent words from the German roots and giving them the desired meaning. Thus we have *ge-wissen* (conscientia), *gevatter* (com-pater), *Mittler* (mediator), *Beichte* (Old High German *bi-jiht* (con-fessio), *anferstehen* (resurgere), *barmherzig* (Old High German *armherzi,,* misericors), *aus-druck* (ex-pressio), *ab-art* (de-generatio), *weider-stehen* (resistere), *ab- bitten* (de-precare), *emp-fang* (re-ceptio), *ent-sprechen* (correspondere, *wieder-glanz* (re-splendere), *wieder-hallen* (re-sonare).

Tacitus tells us that the Germans had heroic ballads and social songs, also epic songs of Arminius and others. But these are all lost and we can only guess what they may have been. Not till the Roman culture invaded Germany do we find a literature worthy of our hearty approval. The Latin models are the works of Notker (Labeo), Ekkehard I., the nun Roswitha who wrote comedies like those of Terence, and others. The knightly period of the Middle Ages produced the first real German poetry which we have to enjoy from that early time and shows the manifest influence of Rome through the medium of the romance languages. But we need not dwell on this phase of Rome's influence as it has left its mark upon all modern literature. The same is true of philosophy and art. Enough has been said to show the indebtedness of the German to the Latin.

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PAPERS PRESENTED AT REGULAR MEETINGS.

FEBRUARY 24, 1905.

"The Metaphysics of Empirical Science," Dr. Warner Fite, Instructor in Philosophy in the University of Texas.

APRIL 14, 1905.

"Underground Water of Texas," Thomas U. Taylor, M. C. E., Professor of Civil Engineering in the University of Texas.

"The Vegetation of the Sotol Country," Dr. William L. Bray, Professor of Botany in the University of Texas.

"Entropy," Dr. Eugene P. Schoch, Instructor in Chemistry in the University of Texas.

FORMAL MEETING, JUNE 14, 1905.

"A Demonstration of the Use of the Electric Furnace in Metallurgy," Dr. Eugene P. Schoch, Instructor in Chemistry in the University of Texas.

"Some Notes on the Chemical Process of Photography," Dr. Henry Winston Harper, Professer of Chemistry in the University of Texas.

(1) "Concerning Green's Theorem and the Cauchey-Riemann Differential Equations, (By title).

(2) "Concerning Series of Analytic Functions," (By title).

(3) "On Sequences of Limited Analytic Functions, (By title).

DR. M. B. PORTER,
Professor of Mathematics in the University of Texas.

OCTOBER 27, 1905.

"The Aesthetic Element in Scientific Thought"—The Annual Address of the President—Dr. Thomas H. Montgomery, Jr., Professor of Zoology in the University of Texas.

NOVEMBER 24, 1905.

"The Science of Economics," Dr. Lindley M. Keasbey, Professor of Political Science in the University of Texas.

DECEMBER 28 AND 29, 1905, JOINT MEETING OF THE TEXAS ACADEMY OF SCIENCE AND THE SCIENTIFIC SOCIETY OF SAN ANTONIO AT SAN ANTONIO.

"Iron Smelting and Steel Making" (Illustrated), Edward C. H. Bantel, C. E., Assoc. Mem. Am. Soc. C. E., Instructor in Engineering in the University of Texas.

"Fighting Asiatic Cholera and First Ascent of Mount Isarog" (Illustrated), Capt. T. J. Dickson, U. S. A., Chaplain 26th Infantry, San Antonio.

"Facts Furnished by the Study of Radium and Deductions Leading to the Present Electron Theory," Eugene P. Schoch, C. E., M. A., Ph. D., Instructor in Chemistry in the University of Texas.

"Some Recent Experiments in Biology," W. L. Bringhurst, Ph. D., San Antonio.

"The Growth of Texas Railroads" (By title), R. A. Thompson, M. A., C. E., Assoc. Mem. Amer. Soc. C. E., Chief Engineer of the Railroad Commission of Texas.

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TRANSACTIONS

OF THE

TEXAS ACADEMY OF SCIENCE

FOR 1906

TOGETHER WITH THE PROCEEDINGS FOR THE SAME YEAR

VOLUME IX.

AUSTIN, TEXAS, U. S. A.
PUBLISHED BY THE ACADEMY
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CONTENTS.

TRANSACTIONS:

PROCEEDINGS:

THE TEXAS ACADEMY OF SCIENCE.

[Annual Address by the President.]

WHAT IS MATTER?

DR. SIDNEY E. MEZES.*

An address of this character is required by custom to set forth large themes. As the representative of a learned society for the occasion, the speaker must assume the virtue of corporated wisdom and scholarship. He speaks, as it were, ex cathedra, and must simulate the manner and matter of such weighty utterances to the best of his poor ability. He must painfully gather wise saws and modern instances, and present them as his own, with a ponderous and unsmiling gravity. The robes are on his shoulders and the insignia in his hands, and no other choice is open.

With this duty laid upon me, I will ask the Academy to consider tonight nothing less than the earliest and the latest problem to excite scientific curiosity. Thales and Anaxemander, the smiling Democritus and the dark Heracleitus asked, at the dawn of science, What is Matter? What is the stuff of which the world is made? And Kelvin, Thompson, Lodge and Rutherford, twenty-five centuries later, with all the resources of modern science at their disposal, are still asking, What is Matter? The great difference is that at last the solution seems to be dawning upon our view, a solution so simple that we can but marvel at the denseness of the human wit which failed, and in large measure still fails, to accept it, though it was proclaimed, in dark words to be sure, by Heracleitus in the early fifth century B. C.

Of course, there is no question as to the reality of matter. No sane man doubts, or ever has doubted that. With the problem properly stated, even Bishop Berkeley would not have done so, though unquestionably he thought he did, and many since his day have been misled by his self-deception. Berkeley merely disagreed, rightly, as we shall see, with the common view of what matter is. He said, in effect, Matter is as different as is at all possible from what you, the man in the street, think it to be. And to Berkeley's real doctrine the doughty Dr. Johnson had no answer. By kicking the stone he

*Professor of Philosophy, University of Texas.

reassured himself that matter is real, as if that needed proof, but failed to cast even the faintest glow of light on what matter is, which is the real question.

Before reflection, all men think they know matter perfectly. Why, they say, matter is the commonest thing in the world; it is everywhere, which is of course true. And, they are likely to add at that stage, everything is matter, which is false, as matter is ordinarily conceived. But, if you are still unsatisfied and press to be told definitely what matter is, the man in the street is likely to resort to the *when* definition, so dear to childhood, as did Dr. Johnson, that colossal wayfarer. Matter is *when* you kick a stone, or *when* you see a tree, or eat its fruit, or hear the thunder roll. Now, it goes without saying that matter is in fact there *when* you do each of these things. But so is much else besides, including yourself, the soreness of your toe if you kick hard enough, the color you see, savor you taste, and sound you hear. But matter, of course, is not pain, color, taste or sound, any more than it is yourself or any other self. All these experiences of ours are there with matter, but matter they simply are not, either singly or all together. Color is with its beauty, in the eye, or rather the mind, of the beholder, and there too is sound with its melody, and all other experiences. They are the effects wrought upon us, through the intermediation of our sense organs, by matter. Given an adequate outer cause, an eye in its organism to be affected, and a mind to perceive, and color is the result. Given cause, ear and mind, and we have sound; or cause, touch organ and mind, and we have the feeling of hardness. But matter, without sense organs or mind, can not have such experiences. And the substance of matter they are not. The truth is that we know so much about the total situation when matter is present that we easily delude ourselves into thinking that we know the matter too, but, as Dr. Higgins once said, in dealing with such experiences we are merely playing with the pebbles on the beach; the sea of reality, matter itself, is still beyond our ken. What matter is not, its effects on our senses, is plain. But what it is, all such talk leaves as dark as before it was uttered.

And, until recently, science has been as dumb and helpless when confronted by this question, as has commonsense. Much is told about the behavior of matter: how fast and far, and when it moves, and what is the result of its impact, etc.; all very interesting and highly useful information. But how anything behaves, what it does, is one thing; what it is, is something entirely different. One is reminded of Dr. Johnson's definition of oats, as a grain eaten by men in Scotland and horses in England, except that he does class it as a grain.

Another familiar device of science is to divide and conquer: though in fact dividing does not itself succeed, but merely leads indirectly towards success. "No wonder," says science, "we have not found out what matter is, for matter is very deceptive, and is not at all what it seems. In fact and in truth matter is made up, not of the large bulks we see, but of minute particles called molecules, in the neighborhood, for the simplest element, hydrogen, of one fifty millionth of an inch in diameter; and these minute molecules are in turn made up of very much smaller particles, atoms, two to a molecule in some elements, many more than two in others. And observe we can point out how the atoms are placed in the different elemental molecules, and see, how beautifully they shift their places in mystic dance, when a chemical reaction occurs. *All* that happens in the intercourse of matter is at bottom but the interplay of atoms and molecules. How wonderful is Nature, and how searching the discoveries of science."

All of which I firmly believe to be true, and know to be profoundly useful truth. For has not science transformed the face of the earth in an incredibly short time, a little over fifty years? And yet how much nearer are we to knowing what matter is when we discover how it is put together? If we ask what wood is, and are told that it is made up of tiny pieces of wood put together thus and so, information, important information, it may well be, is given. But plainly our question is not answered, it is merely pushed a step further back. No, in the equations of science, matter is represented by an x, whose value is seldom sought, though when everything is made of matter it would certainly seem worth while to discover that out of which everything is made. Possibly then, since common sense and science appear to be equally unable to say what matter is, the problem is beyond the scope of human powers. Maybe, as Lord Dundreery says, it is one of those things no fellow can tell. It may be so. But it is well to remember that the discoveries of science have nearly all been things that the fainthearted said no fellow could tell. Besides, as regards the problem of matter, no philisophic generation has ever been wholly agnostic, and the foremost members of the present and latest scientific generation are not agnostic. And moreover—a point of special significance—it is well to remind ourselves that philosophers and scientists, in spite of the difference of their points of view, and of their methods, seem rapidly to be approaching agreement as to the nature of matter. It should then repay us to hear what they have to say.

Insisting, as we have seen, that sensations—colors, sounds, tastes, and the rest, are not matter, or any part of matter, philosophers—at least those unconfused by Hume's over-sophisticated attack on causes, taken so seriously by Kant—these philosophers, I say, maintain that sensations rightly studied tell us what matter is. Known directly and indirectly as effects of matter working on our senses, sensations show matter to be a vastly complicated system of active causes, occupying space—that, and nothing more. Each material object is thus known to be a group of forces, more or less complicated in their interplay, and varied as to their constituent elements. The forces constituting a living cell are very varied in kind, and complicated in interplay, as compared with those composing an equal volume of hydrogen gas; but complicated and varied forces are forces none the less. Moreover, all kinds of matter have one quality in common, the forceful defence of the space they occupy. This is called their resistance or impenetrability. Everything material opposes force to attempted encroachment on its space, and, unless given room elsewhere, absolutely prevents its entire appropriation; though all the forces of the universe pressed upon a single drop of water, it could not be annihilated. Thus impenetrability is the active defense of space. The fundamental constituent of matter is force. And other constituents are the chemical, electrical and physical activities whose effects are familiar. Nor need philosophers deny that matter is made up of molecules and atoms, or of electrons even, provided always these smaller and smaller particles are admitted to be bundles of forces, occupying less and less extended allotments of space.

Where this view departs from that of common sense it is simpler, that is all. Common sense says matter is blue, sweet, soft, etc. No, say the philosophers, these are effects, not properties. Again, common sense says, and here with a shrill insistence, force is not matter, but in it. No, say the philosophers, there is no need of complicating with an unmeaning distinction. Force, activity, achievement, that is all that there is to matter. As Heracleitus said 2,500 years ago, Panta rei, flowing, change, doing is *all*.

Beyond question the blind forces of our nature strongly incline us to ask for more. But in obeying this prompting we are but worshiping an idol of the tribe, a fallacy patent enough as soon as the nature of the mind is understood. The insistence on something more than force in outer objects registers the triumph of the imagination, a blind faculty, as Kant rightly called it, unaware of its own contents and of their significance, over clear-sighted and self-critical reason. Everything we talk of and think about, including matter, is identified, when necessary, and mentally dealt with, by means of its picture stored away in the imagination, which appears automatically when its aid is required. Without such counterfeit presentments, the mind could not make a beginning of dealing with the objects about it, for their names are not pasted upon their backs, and besides, the mind is often concerned with them during their absence, and must then have a representative with which to treat. Now most men picture matter chiefly in visual terms, though partly in terms of touch and muscular feelings, which last are so constantly aroused by the resistence of things. The fallacy consists in clinging to the picture of matter, naively, uncritically, inaccurately constructed before reflection out of our most familiar sensations, and in insisting that it correctly represents matter, although reason clearly demonstrates that sensations are no parts of matter, but only its effects. And the fallacy continues to impose on us because the picture works in subconsciousness, automatically registering dissatisfaction with force, as failing to fill out its notion of what matter is. As soon as we know that the picture of our imagination is formed during the early unthinking days of our ignorance, we know that it has no proper standing as against the critically tested conclusions of reason. But that does not check the dissatisfaction automatically suggested by the imagination, which philosophers feel in common with other men. The difference is that they disregard the feeling.

The same conclusion as to the nature of matter is reached by another avenue of approach, as is pointed out by students of the evolution of mind. Probably the contribution of evolutionary theory to our knowledge of mind that bulks larger than any other, is the discovery, growing clearer with each year of study, that the human mind also is fundamentally just a group of activities, greatly complicated, mysteriously unified, wonderfully resourceful, marvelously progressive, self-conscious moreover, and free, and yet at bottom a system of activities, no more. Activity, doing, will, that is the core of us: the rest, sensation, feeling, idea, they are but the effects of our own or other activities. A spirit, in etomology, is just the active principle of a liquid, and activity is what distinguishes the quick from the dead. Even superman, in his ascending excellence, we must believe to be but vaster and more skillfully and perfectly ordered activity. And man is distinguished from his humbler brethren, and higher animals from lower, by what they can do. Man hesitates, chooses, plans, contrives, and fits things together in fulfillment of his purposes. As we descend the animal scale these activities first diminish, and then disappear, dull routine taking their place. But this implies, not a substitute for activity, but merely its simplification. And the same decrease of complexity obtains as the transition is made from animals to plants, and from plants to inorganic matter. This no doubt seems a hard saying to those who have not followed discoveries and discussions in this field, but to those who have, it is little more than a commonplace. We do not yet know how inorganic activities become systematized into organic, or what determines their form as vegetable or animal. The cell still keeps its secret. But that inorganic is transformed into organic is plainly shown by every breath taken, every meal eaten, and every development of an embryo to maturity, as the reverse transition is shown by all waste processes, including death itself. As men organize themselves into states, and lesser associations, which have organs and modes of activity which no man has, so, it would seem, molecules organize themselves into cells, and cells into living beings, which differ even more vastly in structure and function from the units composing them.

In substance, then, comparative psychology teaches that a man is a complicated system of activities, sensitive and conscious; an animal a less complicated system, sensitive and conscious; a plant a still less complicated system, sensitive, but only dimly conscious, if at all so; and inorganic matter, the simplest system of activities we know, whether either sensitive or conscious we are not yet prepared to say. So much is quite plain. But all is not said. It is also plain that inorganic, or so-called dead matter has, in the way of evolution, developed into organic or living matter, and that matter is being daily transformed into living, yes, into conscious beings, and living and even conscious beings are being daily transformed back into mere matter. These plain facts of themselves throw not a little light on the nature of matter. For they show that the constitution and nature of matter must be such as to allow of the development and interchange discovered. Matter cannot be very dead, it cannot be blankly non-conscious, it would seem, if everywhere and at all times it is, in the ordinary routine of the world, nourishing and stimulating life and consciousness, which in their turn dissolve into mere matter in the same normal way.

Such, too briefly and imperfectly stated, are the contributions of philosophy, and its component and ancillary sciences, to our knowledge of matter. Next we turn to the physical sciences themselves, physics, chemistry, and newborn chemico-physics, and find, as will presently appear, a singularly impressive confirmation of the results set forth. This should not surprise us. It merely adds one more to the many instances where philosophy's reasoned conclusions have proved prophetic of the more concretely reached results of experimental science. The former, glancing over the promised land throughout its rich extent, spies out its prominent landmarks, and sets them up as goals to guide the slow and laborious but sure occupation which it falls to the lot of the latter to undertake. Each task yields its own delights, and each performs its peculiar service.

Where both are indispensable, only the cramped mind will seek to belittle either.

Nearly two and a half centuries ago, in 1658, to be accurate, Boscovich, the great Italian administrator, diplomat and physicist, set forth and ably defended the view that atoms are but forces, each concentrated in a mathematical point, and held apart by their mutual repulsions. The view did not fail of its adherents, numbering among them names as great as that of Faraday. But, even if the prejudices of an imaginative race had allowed it a fair hearing, which they did not, the state of science was not ripe for the general acceptance of the theory. Electricity did not exist for science, and countless hours of research had still to be labored through before a sufficient weight of experimental facts could be accumulated to outbalance our tribal idol, so stiff-necked is an inborn bent of human nature. Besides, Boscovich delayed the triumph of his theory, in its essential principle, in my judgment, by confining his force-atoms to mathematical points, and denying them spacial occupancy, the fundamental attribute of matter; a course the more to be regretted, as the denial is unnecessary, indeed contrary to plain experience.

The status of Boscovich's theory, and its more or less modified successors, remained practically unchanged until the end of the nineteenth and the marvelous beginning years of the present century, a few of the best minds of each generation upholding it, but the large majority of physical scientists, including men of unsurpassed eminence, according it a neglect more or less contemptuous. But these recent years have been bringing about a change. A number of physicists of the first rank are aggressively championing the dynamic theory of matter, and as each unexpected discovery, hurrying upon the heels of its predecessor, brings support to the theory, its opponents seem conscious of engaging in a losing fight.

Before passing to the chief evidence, I will just mention some experiments of the Hindu physicist, Dr. Bose, a professor in Calcutta University, which indicate the trend of much research that is now being prosecuted, and indirectly support the dynamic theory, by tending to show that metals at least are not dead, but alive, bundles of activities like living animals. Dr. Bose's book, "The Response of Matter," I have not been able to secure; the quotation that follows is from a notice of it in the London Review of Reviews. Dr. Bose's discovery is, that stimulated metals give back, under proper conditions of observation, the electric response that has been thought peculiar to, and characteristic of, organic or living matter, and, with variation of conditions, vary their response just as organic matter does.

"When the metals were stimulated by a pinch, they also made their autoghaphic records by electric twitches, and thus, being responsive, showed that they could in no sense be called 'dead'! Nay, more, it was found that given the records for living muscle, nerves, and metals, it was impossible to distinguish one record from the other. For the metals also, when continuously excited, showed gradual fatigue; as with ourselves, so with them, a period of repose revived their power of response—even a tepid bath was found helpful in renewing vigor; freezing brought on cold torpidity, and too great a rise of temperature brought heat rigor. * * *

"Death can be hastened by poison. Then can the metals be poisoned? In answer to this was shown the most astonishing part of Professor Bose's experiments. A piece of metal which was exhibiting electric twitches was poisoned; it seemed to pass through an electric spasm, and at once the signs of its activity grew feebler, till it became rigid. A dose of some antidote was next applied; the substance began slowly to revive, and after a while gave its normal response once more!"

But it is not upon such experimental curiosities that the dynamic theory of matter is based, significant as they may be of the future discoveries of science. It is more substantially founded upon the evidences of the spectroscope, the fast growing knowledge of electricity, and the marvelous results of the experiments on radio-active substances. Many of you are familiar with these facts, and it will only be necessary to recall them briefly, grouping them in such wise as to suggest their significance as clearly as possible.

There has been a disposition among scientists for the last half century, growing constantly stronger, and finally becoming irresistible, to look upon Dalton's atoms as divisible, therefore misnamed, and not the ultimate constituents of matter. Suspicion was first cast upon their simplicity and ultimateness when the spectroscope disclosed several distinct lines in the spectrum of each element, and was reinforced when it appeared that some elements have two or even three distinct spectra. Nor was the case bettered when it was found that many of the lines in the spectra of hydrogen, calcium, iron, and other elements, are missing when the light from very hot stars is broken up. For the inference is right at hand, as Professor Bigelow says, "that at extreme, at stellar, temperatures our elements themselves are dissociated into simpler substances."[1]

Further evidence against the atom resulted from Professor J. J.

[1]Pop. Sci. Mo., July, 1906.

Thomson's studies of cathode rays, strict reasoning from his careful experiments demonstrating them to be swarms of minute particles, or corpuscles, as he called them, moving with velocities approaching that of light, and each weighing about one eight-hundredth as much as a hydrogen atom. These corpuscles are not merely ordinary atoms of smaller bulk, for they do not obey chemical laws, it having been ascertained, among other things, that the absorption of them by different substances is simply proportional to the latters' specific gravity, and quite independent of their chemical properties.

And recently the case against the atom, together with Thomson's ingenious demonstration of his corpuscles, have secured an ample experimental foundation, thanks chiefly to the labors of Bacquerel, the Curries, and Rutherford and Soddy on radio-active substances. These wonderful experiments, at once rapid and reliable, have shown that radio-activity consists in the throwing off of two orders of substances: first, atoms; second, rays or corpuscles of various kinds. But the remarkable fact in the situation is, that while the atomic weight of the original substances, radium, thorium, or uranium, is two hundred or more, the weight of the atoms thrown off is nearer one or two. That is, radium breaks up into hydrogen or helium, thrown off, and the residuum after the emission, which has a different atomic weight from either, and is otherwise shown to be a distinct element. The dream of the alchemist has come true, and elements are transmuted before our eyes. Science has achieved an unsurpassed triumph! But, as far as helping us to fortunes goes, the dream might as well have remained a dream.

As a result of these discoveries, and many others similar, in general, in significance, it has come to be admitted that Dalton's atoms are very complex bodies, each made up of a large number of corpuscles, which are related to one another very much as are the members of a planetary system, though in size corpuscles are unimaginably minute, and the number of them constituting any atom is very much larger than the number of members in any planetary system with which we are acquainted.

With atoms broken up into corpuscles, the problem of the nature of matter shifts one step further back, and becomes the problem of the nature of these tiny bodies. Of this problem two rival solutions are now in the field, offered respectively by the conservatives and by the liberals. The former, while admitting that a corpuscle is in the main an electric charge, or field of electric force, maintain that the charge has a nucleus, or carrier, at its core, which alone is entitled to be called matter, in distinction from the electricity of the charge. Lenard, who has given to corpuscles the significant name of dynamides, has calculated the diameter of this center of actual matter, so-called, and found it to be smaller than 0.3 of 10^{-10}, i. e., smaller than three hundred thousand millionths of a millimeter. This means that the actual matter, so-called, of a cubic meter of so heavy an element as platinum, occupies at most one cubic millimeter of space, the rest of the cubic meter being empty of Lenard's matter and in fact entirely empty of ponderable matter but for the electric charges.

With so much of matter acknowledged to be electric force, which to that extent successfully performs all the functions which used to be attributed to matter, it is natural, say the liberals, to inquire whether the whole of matter cannot be reduced to force—whether matter is not just force and nothing more. Many facts, they say, make this altogether the more probable, indeed the only comprehensible hypothesis.

In the first place, as Sir Oliver Lodge, who shares with Professor J. J. Thomson, another hardheaded Englishman, the distinction of leading the liberals, points out, "And electric charge possesses the most fundamental and characteristic property of matter, viz., mass or inertia.' "[2] If the charges occupying a given space are sufficient, and their potential is sufficiently high, their combined mass will equal, and exhaustively account for, the observed mass of the matter occupying the space. This conclusion was theoretically established long since, and has recently received experimental confirmation from laboratory studies on radio-activity.

On these points I quote the statement of Professor Bigelow, of the University of Michigan: "Long before experimental evidence of the existence of corpuscles had been obtained, it was demonstrated that an electrically charged body, moving with high velocity, had an apparent mass greater than its true mass, because of the electrical charge. The faster it moved the greater became its apparent mass, or, what comes to the same thing, assuming the electrical charge to remain unaltered, the greater the velocity, the less the mass of the body carrying the charge needed to be to have always the same apparent mass. It was calculated that when the velocity equalled that of light, it was not necessary to assume that the body carrying the charge had any mass at all! In other words, the bit of electric charge moving with the velocity of light would have weight and all the properties of mass.

"This might be looked upon as an interesting mathematical abstraction, but without any practical application, if it were not for the fact that Kaufmann determined the apparent masses of

[2]Pop. Sci. Mo., August, 1903.

corpuscles shot out from a radium preparation at different velocities, and compared them with the masses calculated on the basis that the whole of the mass was due to the electric charge. The agreement between the observed and calculated values is so close that it leads Thomson to say: 'These results support the view that the whole mass of these electrified particles arises from their charge.'

"Then the corpuscles are to be looked upon as nothing but bits of electric charge. * * * It is this view which has led to the introduction of the term electron. * * * We have but to concede the logical sequence of this reasoning, all based on experimental evidence * * * and we have a universe of energy in which matter has no necessary part."[3]

Instead of conceiving matter as explained away, energy taking its place, I prefer to conceive of it as explained as being energy and nothing else. This difference in terminology is unimportant, but might lead to confusion, if not pointed out.

Facts as many and as significant as these, added to the reasoned conclusions of philosophy and psychology, would seem adequate to settle the controversy in favor of the dynamic theory of matter, were it not that we are dealing with an idol of the tribe, far more difficult to shatter than the golden calf. But more remains to be said. The validity of an hypothesis rests not only upon the facts that support it, but also upon the ability it gives us to explain puzzles in fields adjacent to its own. This makes it worth while to mention, though space will not allow explanations in detail, that a number of knots in physical theory that before had to be cut, or else left alone, can be handily untied by the dynamic hypothesis. Professor Bigelow is again my authority in the statements, that the theory explains the highly puzzling property of valence, and that "An electronic structure of the atom furnishing a basis from which a plausible explanation of the refraction, polarization and rotation of the plane of polarized light may be logically derived."[4] These explanations bulk large in the aggregate, and the exclusive ability of the dynamic theory to make them adds significantly to its credibility.

As an alternative to the dynamic theory, thus substantially supported, the conservatives have little to offer; indeed, in the last analysis, nothing but a word. The "matter" they refuse to identify with force shrinks down to John Locke's "something I know not what," by which a portion of the mass of bodies is to be accounted for. But Sir Oliver Lodge remarks, "It would be equally true to say unaccounted for. The mass which is explicable electrically is

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[3]Pop. Sci. Mo., July, 1906.

[4]Loc. cit.

to a considerable extent understood, but the mass which is merely material (whatever that may mean) is not understood at all."[5] "What is this matter which so many insist we must assume?" Bigelow asks, and answers: "No man can define it otherwise than in terms of energy. * * * Starting with any object and removing one by one its properties, indubitably forms of energy, we are finally left with a blank, a sort of hole in creation. * * * The last resort is the time-honored definition, 'matter is the carrier of energy,' but it is impossible to describe it. The assumption that matter exists is made, then, because there must be a carrier of energy. But why must there be a carrier of energy? This is assertion, pure and simple, with no experimental backing."[6] When solidity and mass or inertia are adequately explained as dynamic facts, and many puzzling physical facts are similarly accounted for, it is surely superfluous to seek further explanation in something more to be called matter, especially when no man can tell or ever has told us what he means by the word.

This is not the place, even if it were necessary before this audience, to set forth what we know about electric charges, but some mention should be made of the unification introduced into our knowledge by accepting these minute bodies as the building stones of the grosser structures more immediately experienced.

A word first as to their size. "We are sure," says Lodge, "that their mass is of the order one thousandth of the atomic mass of hydrogen, and we are sure that if they are purely and solely electrical their size must be one hundred-thousandth of the linear dimensions of an atom; a size with which their penetrating power and other behavior is quite consistent. Assuming this estimate to be true, it is noteworthy how very small these electrical particles are, compared to the atom of matter * * * If an electron is represented by a sphere an inch in diameter, the diameter of an atom of matter on the same scale is a mile and a half. Or if an atom of matter is represented by the size of this theater (the Sheldonean), the electron is represented on the same scale by a printers' full stop."

"It is a fascinating guess," he proceeds a little later, "that the electrons constitute the fundamental substratum of which all matter is composed. That a group of say 700 electrons, 350 positive and 350 negative, interleaved or interlocked in a state of violent motion, so as to produce a stable configuration under the influence of their centrifugal inertia and their electric forces, constitute an atom of hydrogen. That sixteen times as many, in another stable grouping,

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[5]Loc. cit.

[6]Loc. cit.

constitute an atom of oxygen. That some 10,000 of them go to form an atom of sodium, about 100,000 an atom of barium, and 100,000 an atom of radium.

"On this view all elements would be regarded as different groupings of one fundamental constituent. Of all the groupings possible, doubtless most are so unstable as never to be formed; but some are stable, and these stabler groupings constitute the chemical elements that we know. The fundamental ingredient of which, on this view, the whole of matter is made up, is nothing more or less than electricity, in the form of an equal number of positive and negative electric charges.

"This, when established, will be a unification of matter such as has through all the ages been sought; it goes further than had been hoped, for the substratum is not an unknown and hypothetical protyle, but the familiar electric charge."[7]

And having gone thus far, we cannot escape going farther. For two or more atoms, properly related, form molecules; these groups of forces form, on the one hand, the masses of inorganic matter presented to sense, and on the other living cells; and the last, in turn, organize themselves into living, and ultimately into conscious and rational beings, who, in the last resort, are vastly complicated activities, aware of, and, in a measure, controlling their own intricate interplay.

To an active imagination the dynamic theory opens up fields fascinating to contemplate. Look first at the practical side. Aside from energy of position and molar motion, we are accustomed to think of heat and other forms of chemical energy as the only ones available for human use. But Wetham tells us that, As a mean value, we may say, that in mechanical units, the energy available for radiation in one ounce of radium is sufficient to raise a weight of something like ten thousand tons one mile high." And later that, "The energy liberated by a given amount of radio-active change * * is at least 500,000 times, and maybe 10,000,000 times, greater than that involved in the most energetic chemical action known."[8] Admitting that our coal measures and iron mines may soon give out, it is evident that the present generation need not feel greatly alarmed. For who will deny to ingenious man the ability to harness these literally stupendous new forces as he has their weaker predecessors?

And on the theoretical side the gain is no less great. A respectable hypothesis, which experimental, and even laboratory methods can test, correct, and enlarge, as growing experience demands, can, even

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[7]Loc. cit.

[8]The Recent Developments of Physical Science.

in its initial form, give unity to our thinking. It not only reduces the independent chemical elements to brotherhood in the one mother substance, but it renders matter, as essentially activity, homogenous with active mind, thus freeing us from the hopelessness of dualism, and giving a monistic view of the whole of things. And nowhere is utter death to be found. The universe, plastic, vital through and through, comes out from under the heavy hand of rigid mechanism. Spontaneity is at its heart and in the marrow of its bones. But lawless and chaotic it is not. There is regularity in the operation of its minutest parts, and organization, harmonious co-working is the law of its being from the co-operative union of electrons into atoms to the organization of men into societies, and probably further still. But the order and harmony are not imposed from without by an alien power; as the laws of children's play they are the natural rules of behavior of spontaneous beings, following, unhampered by others besides themselves, the promptings of their own interacting natures.

STUDIES ON AVIAN ANATOMY.—II.

*Geococcyx, Bubo and Aeronautes.**

MARGARET E. MARSHALL, M. A.

Introduction.

This paper is the second in a series dealing with the question of the homologies of the Caprimulgi. After a previous study of *Phalaenoptilus* (Proc. Amer. Phil. Soc., 1905) the writer has studied those forms most easily obtained, with which the Caprimulgi have been compared. They are: a cuckoo, *Geococcyx californianus* (Less.); an owl *Bubo virginianus palesceus* (Stone), and a swift, *Aeronautes melanoleucus* (Baird). There was not time for the study of the entire anatomy of all the birds, so I have examined the alimentary tract, the central nervous system, the nostrils and pecten of the eye, the urogenital system, the musculature of the fore limb, and in *Geococcyx* the pterylosis.

The material used consisted of the following: two adult female *Aeronautes,* one entire, the other lacking a head; three adult female *Geococcyx,* two entire; and one entire adult female *Bubo.*

In order to obviate any misunderstanding in reading the descriptions which follow, an explanation of the terms there employed may not be amiss. In referring to the carina sterni the border designated ''dorsal'' is the line of junction between the carina and the body of the sternum, the latter being mentioned as the ''lateral surface.'' The term ''ventral,'' then, means the free border of the carina. The names of the crests, projections, and surfaces of the humerus are the same as those given by Furbringer (1888), Plate I, figures 9, 10, 11, 12. Also the name processus sterno-coracoideus is that given by him.

I wish to express my profound appreciation of the valuable assistance and ready sympathy of Professor Thos. H. Montgomery, Jr., under whose direction it has been my great pleasure to study for the past two years.

A. OBSERVATIONS.

1. Alimentary tract.

The tongue in *Geococcyx* (T., Pl. I., fig. 10) is long and slender. Posteriorly it is bifid and supplied with spines. In *Bubo* (T., Pl. IV.,

*Contributions from the Zoological Laboratory of The University of Texas, No. 73.

fig. 34) it is broad and thick. It is also bifid posteriorly and covered thickly with spines. In *Aeronautes* (T., Pl. V., fig. 45) it is broad and thick, but is pointed anteriorly and slightly bifid. Posteriorly it is bifid and covered closely with spines.

The crop is absent in all. The duodenum in *Geococcyx* (Duo., Pl. I., fig. 13; Pl. II., figs. 21, 22) measures 12.3cm.; the small intestine (Pl. II., fig. 22), 28.9cm.; the terminal intestine (Pl. I., fig. 11; Pl. II., fig. 22), 10.4cm.; caeca (Cae., Pl. I., fig. 11; Pl. II., fig. 22), 6.1cm. In *Bubo* the measurement of the duodenum (Duo., Pl. III., figs. 24, 29) is 20.8cm.; the small intestine (Pl. III., fig. 29), 45.5cm.; terminal intestine (Pl. III., fig. 23), 7.5cm.; caeca (Cae., Pl. III., fig. 23), 8.2cm. In *Aeronautes* the measurement of the duodenum (Duo., Pl. V., figs. 47, 48, 49), is 13.1cm.; small intestine (Pl. V., fig. 49), 6.4cm. (this is from duodenum to beginning of the cloaca); terminal intestine (Pl. V., fig. 49), 1.8cm. In both *Geococcyx* and *Bubo* the caeca are enlarged at the tips. The type of the intestine in *Geococcyx* is a modification of the plagiocoel. In *Aeronautes* it is orthocoel.

The pancreas in *Geococcyx* (Pan., Pl. II., fig. 21), and *Aeronautes* (Pan., Pl. V., figs. 47, 48, 49), consists of two branches, one being situated in the duodenal loop and the other dorsal to it. There is one duct from each branch and in all cases they enter the ascending branch of the duodenal loop. In *Geococcyx* the entrance is posterior to the bending of the duodenum to pass under the right liver lobe, and in *Aeronautes* it is at the mid point of the ascending loop. The pancreas was not in a condition to be studied in *Bubo* (Pan., Pl. III., fig. 29).

A spleen is present in all the forms, and is situated on or near the junction of the proventriculus and the gizzard, at the right side. The organ is small in *Aeronautes* (Spl., Pl. V., fig. 48), but very large in *Geococcyx* (Spl., Pl. I., fig. 13), and *Bubo* (Spl., Pl. III., fig. 29). Its length in *Geococcyx* is 13mm., its average width 5mm. The length in *Bubo* is 25mm., the average width 10mm. The length in *Aeronautes* is 5mm., the average width 2mm.

The liver of *Geococcyx* (Liv., Pl. II., fig. 21) consists of two lobes, the right being fully one-third larger than the left. In *Bubo* (Liv., Pl. III., figs. 24, 29) the lobes are of almost equal size. In *Aeronautes* (Liv., Pl. V., figs. 47, 48, 49) the right lobe is a third larger than the left. On the dorsal border of the right lobe is a third lobe one-half the size of the left lobe.

A gall bladder is found under the lower border of the right liver lobe in all the birds. Its length in *Geococcyx* (G. bl., Pl. I., fig. 13) is 11mm., the average width is 4mm.; the length in *Bubo* (G.bl., Pl.III., fig. 24) is 26mm., the width 16mm.; in *Aeronautes* (G. bl., Pl. V., fig. 48) the length is 7mm., the width 4mm. The gall duct comes off from the anterior end of the gall bladder in *Geococcyx* and from the posterior end in both of the other birds. The gall ducts enter the ascending branch of the duodenum near the pancreatic and liver ducts.

The liver duct in *Geococcyx* (Liv. d., Pl. I., fig. 13) comes from the central surface of the right liver lobe, posterior to the bridge connecting the two lobes, and near the gall bladder. In enters the ascending branch of the duodenal loop posterior to the gall duct and between the pancreatic ducts. In *Bubo* (Liv. d., Pl. III., figs. 24, 29) the liver duct comes from the right side of the bridge and enters the duodenum anterior to the gall duct. In *Aeronautes* (Liv. d., Pl. V., fig. 48), about the middle of the right liver lobe comes off a liver duct which soon after leaving its surface receives a branch from the bridge connecting the two lobes. This duct then enters the ascending branch of the duodenal loop near the mid point of its dorsal surface behind the gall duct and anterior to the duct from the main branch of the pancreas.

2. Female Urogenital Organs.

The kidneys of *Geococcyx* (K., Pl. I., fig. 28) are not fused. Each consists of three distinct lobes varying slightly in size, and a small right adrenal. In *Bubo* (K., Pl. IV., fig. 32) the kidneys are not fused, and there is no distinct lobulation. In *Aeronautes* (K., Pl. VI., fig. 58) the two separate kidneys possess each two lobes of almost equal size, and there are two larger adrenals.

The ureters begin near the center of the kidney, between the anterior and middle lobes in *Geococcyx;* in *Bubo* near the anterior end of the kidney, and in *Aeronautes* near the posterior end between the two lobes. All enter the cloaca on its dorsal surface, and median to the entrance of the oviducts.

The left ovary and oviduct are well developed in *Geococcyx* (Ov., and L. Ovi., Pl. I., fig. 9). The ovaries are small in *Bubo* (Ov., Pl. IV., fig. 32) and *Aeronautes* (Ov., Pl. VI., fig. 58). The anterior portion of the oviduct was broken and could not be studied in *Bubo.* The infundibulum was too collapsed to make out in *Aeronautes.* In all the forms the right oviduct was represented by a blind sac. The bursa Fabricii (Bf., Pl. IV., fig. 32) was present only in *Bubo.*

3. Central Nervous System.

The brain of all these birds is compact, not elongated, as in *Phalenoptilus.* Only a small portion is exposed. The greatest length of the cerebrum in *Geococcyx* (Cer., Pl. I., figs. 1, 2, 3, 7) is 18mm., the greatest width 13.25mm. In *Aeronautes* (Cer., Pl. V., figs. 38, 39, 40) the greatest length is 12mm., greatest width, 8.25mm.

The anterior-posterior measurement of the optic lobes in *Geococcyx* (Op. l., Pl. I., figs. 1, 2, 3) is 2mm., and the dorsal-ventral measurement is 4.25mm. In *Aeronautes* (Op. l., Pl. V., figs. 38, 39, 40) the anterior-posterior measurement is 1.125mm., the dorsal-ventral measurement is 2mm.

The length of the cerebellum in *Geococcyx* (Cb., Pl. I., figs. 1, 2, 3, 7) is 18.125mm., width from flocculus to flocculus is 12mm. The corresponding measurements in *Aeronautes* (Cb., Pl. V., figs. 38, 39, 40) are 11:5mm. and 7.75mm.

It was not possible to get the measurements of the brain of *Bubo* because of its torn condition.

All the cranial nerves of *Aeronautes* could not be identified on account of being broken.

The brachial plexus is made up of four nerve roots in *Geococcyx* (Pl. I., fig. 7a), four in Bubo (Pl. IV., fig. 31), and five in *Aeronautes* (Pl. V., fig. 41). The branching and anastomosing is most complex in *Aeronautes* and simplest in *Bubo*.

The sacral plexus consists of seven nerve roots in *Geococcyx* (Pl. I., fig. 4) and of five in *Aeronautes* (Pl. V., fig. 46), most complex in the former. The spinal cord was too broken for it to be studied in *Bubo*.

4. Special Sense Organs.

The nostrils in *Geococcyx* (Nos., Pl. I., fig. 2) are median, inferior and oblong. The internal nares (I. n., Pl. I., fig. 12) is a single median club-shaped opening. These organs were not studied in *Bubo*. The nostrils in *Aeronautes* (Nos., Pl. V., fig. 38) are tubular, and larger near the opening than elsewhere. The internal nares (I. n., Pl. V., fig. 44) is a very long, median, irregular slit.

The pecten of the eye in *Geococcyx* (Pl. I., figs. 5, 6) consists of sixteen folds. It measures in height 4mm., and its basal breadth is 7.25mm. In *Bubo* (Pl. IV., figs. 35, 36) it consists of eight folds. The corresponding measurements are 7.125mm. and 6.125mm. In *Aeronautes* (Pl. V., figs. 42, 43) there are fourteen folds. The corresponding measurements are 3mm. and 5mm. In all cases the pecten is heavily pigmented.

5. Myology.

a. Pectoral Muscles.

1. M. pectoralis.—Pars thoracia. The origin in *Geococcyx* (Pect., Pl. II., figs. 14, 17) is on the clavicle, the ventral third of the anterior half of the carina sterni, all its posterior portion and

the posterior three-fourths of the lateral surface of the sternum. It inserts on the ventral surface of the crista lateralis of the humerus, and sends down a tendinous slip to fuse with the tendon of the biceps, running over the tuberculum mediale. The origin in *Bubo* (Pect., Pl. IV., figs. 30, 37) is on the clavicle, interclavicular membrane, carina sterni, except the dorsal third of its anterior portion, and from the posterior three-fourths of the lateral surface of the sternum. It inserts fleshily on the crista lateralis, and fuses with the biceps tendon above the tuberculum mediale. The origin in *Aeronautes* (Pect., Pl. VI., figs. 50, 53, 55) is on the clavicle, the interclavicular membrane, the ventral half of the carina sterni, and from the posterior lateral third of the sternum. It inserts on the crista lateralis and on the tuberculum mediale.

Pars propatagialis. See M. Propatagialis.

Pars abdominalis. This muscle is absent in *Geococcyx*. In *Bubo* (Ab., Pl. IV., figs. 30, 37) the origin could not be made out on account of the torn condition of the bird. At its insertion it is fused with the pars thoracica on the tendon of the biceps. In *Aeronautes* (Ab., Pl. VI., fig. 50) the origin could not be made out. It is fused at its insertion with the pars thoracica on the crista lateralis of the humerus.

2. M. supracoracoideus. Origin in *Geococcyx* (Sup. cor., Pl. II., fig. 16) is on the interclavicular membrane, dorsal two-thirds of the anterior part of the carina sterni, and from the anterior one-fourth of the sternum. It inserts on the ventral surface of the tuberculum laterale of the humerus. Origin in *Bubo* (Sup. cor., Pl. III., fig. 25; Pl. IV., fig. 30) is on the dorsal border of the interclavicular membrane, anterior dorsal third of the carina sterni, and on the anterior one-fourth of the sternum. It inserts on the humerus anterior to the crista lateralis on the ventral surface of the tuberculum laterale of the humerus. Origin in *Aeronautes* (Sup. cor., Pl. VI., figs. 51, 56) is on the dorsal half of the interclavicular membrane, half the carina sterni, and anterior two-thirds of the lateral surface of the sternum. It inserts on the humerus anterior to the crista lateralis on the dorsal surface of the tuberculum laterale of the humerus.

3. M. coraco-brachialis posterior. Origin in *Geococcyx* (Cor.-b. p., Pl. II., figs. 16, 20) is on the posterior two-thirds of the lateral border and dorsal surface of the coracoid. It inserts on the distal end of the apex tuberculi medialis humeri. Origin in *Bubo* (Cor.-b. p., Pl. III., figs. 25, 28) is on the posterior lateral half of the coracoid and has a broad tendinous extension down to the fourth sternal rib. It inserts on the distal end of the apex tuberculi medialis

humeri. Origin in *Aeronautes* (Cor.-br. p., Pl. VI., figs. 51, 56) is on the posterior lateral half of the coracoid, its dorsal surface, and from neighboring border of the sternum. It inserts on the distal end of the apex tuberculi medialis humeri.

4. M. coraco-brachialis anterior. Origin in *Geococcyx* (Cor.-b. a., Pl. II., figs. 16, 17) is fleshy on the lateral border of the anterior end of the coracoid. It inserts also fleshily on the ventral surface of the humerus, reaching the crista lateralis. Origin in *Bubo* (Cor.-br. a., Pl. IV., fig. 30) is semitendinous on the lateral surface of the anterior end of the coracoid. It inserts fleshily on the lateral border and ventral surface of its humerus, not only reaching the crista lateralis, but sending a slender extension down the humeral shaft beside the M. pars humero-cubitalis for one-fourth the length of the humerus. Origin in *Aeronautes* (Cor.-br. a., Pl. VI., figs. 55, 56) is semitendinous on the lateral surface of the anterior end of the coracoid. It inserts on the lateral border of the humerus and on the ventral surface extending down to the base of the insertion of M. pars thoracica.

b. Other trunk muscles inserting on wing, scapula and coracoid.

1. M. deltoideus major. Origin in *Geococcyx* (Del., Pl. II., figs. 14, 15, 16, 17, 19) is semitendinous on the dorso-median border, and on less than the proximal fourth of the dorsal surface of the scapula, extending even to the anterior end of the same and on the dorsal surface entering the foramen triosseum. It inserts on the os humero-scapulare, entire dorsal surface of the humeral head, and on the crista lateralis, terminating on the lateral surface of the humerus two-thirds of its length from the head. Origin in *Bubo* (Del., Pl. III., figs. 26, 28; Pl. IV., fig. 33) is on the anterior dorsal surface of the scapula not quite reaching the extremity, but extends to the dorso-median border and into the foramen triosseum. It inserts on the os humero-scapulare, dorsal surface of the crista lateralis, and down to the mid point of the lateral surface of the humerus. Origin in *Aeronautes* (Del., Pl. VI., figs. 52, 56), is on the dorso-median border of the anterior end of the scapula, scapular facing border of the coracoid, and dorsal extremity of the clavicle. It inserts fleshily on the processus supra-condyloideus lateralis of the humerus.

2. M. deltoideus minor. Origin in *Geococcyx* (Del. m., Pl. II., fig. 17) is on the coracoid facing surface of the anterior end of the scapula, ligamentum coraco-scapulare dorsale. The fibers on its lower surface are fused to those of the M. deltoideus major lying under it, but the muscle lies mainly in front of the M. deltoideus major.

It crosses over the humeral head in front of the os humero-scapulare, and inserts tendinously on the tuberculum laterale of the humerus. Origin in *Bubo* (Del. m., Pl. III., fig. 26; Pl. IV., fig. 30) is from the clavicle facing surface of the coracoid and from the clavicle. Its fibres fuse with the underlying portion of the M. deltoideus major, coming from the foramen triosseum, but it lies mainly in front of that muscle. It crosses the humeral head in front of the os humero-scapulare and is inserted on the tuberculum laterale of the humerus, continuing down the crista lateralis to the insertion of the M. pars thoracica. Origin in *Aeronautes* (Del. m., Pl. IV., fig. 56) the anterior one of the two bundles is from the coracoid facing surface of the scapula and the ligament coraco-scapulare dorsale. It inserts at the base of the crista lateralis of the humerus, anterior to the tendon of the M. supra coracoideus. The origin of the posterior one is on the dorsal surface of the scapula immediately following the first. It inserts at the base of the crista lateralis of the humerus posterior to the tendon of the M. supra-coracoideus. Both bundles are almost covered by the M. deltoideus major, but with its fibres they do not fuse.

3. M. latissimus dorsi. In all the birds this consists of two portions.

M. latissimus dorsi anterior. Origin in *Geococcyx* (Lat. d. a., Pl. II., figs. 15, 19) is fleshy on the posterior part of the first dorsal vertebra, second, third, and part of the fourth. It inserts by a thin tendon on the dorsal surface of the humerus at the base of the M. deltoideus major near the mid point of its insertion. Origin in *Bubo* (Lat. d. a., Pl. III., figs 26, 28; Pl. IV., fig. 33) is on the second and the third dorsal vertebrae. It is inserted tendinously on the dorsal surface of the humerus at the base of the M. deltoideus major. Origin in *Aeronautes* (Lat. d. a., Pl. VI., figs. 52, 54) is tendinous on the second, third, and part of the fourth dorsal vertebrae. It is inserted fleshily on the dorsal surface of the humerus at the base of the posterior bundle of the M. deltoideus minor.

M. latissimus dorsi posterior. Origin in *Geococyx* (Lat. d. p., Pl. II., figs. 15, 20) is semitendinous from dorsal vertebrae following the fourth and tendinously from the anterior border of the ilium. It is inserted semitendinously on the dorsal surface of the humerus between the short heads of the M. pars humero-cubitalis at the beginning of their union. Origin in *Bubo* (Lat. d. p., Pl. III., figs. 26, 28; Pl. IV., fig. 33) is tendinous on the anterior border of the ilium, and has fascia connection with the M. rhomboideus superficialis. Its fibers are fused with those of the M. latissimus dorsi anterior as it passes under that muscle, but it emerges from under the anterior border separate and tendinous, to be inserted immediately anterior to the M. latissimus dorsi anterior. The two muscles are connected by a heavy fascia which extends from the posterior border of the anterior bundle to the mid point of the posterior one, and continues to their insertion. Origin in *Aeronautes* (Lat. d. p., Pl. VI., figs. 52, 54) is tendinous from part of the fourth and the following dorsal vertebrae, and the anterior border of the ilium. It is inserted immediately anterior to one of the short heads, and between it and the other, which comes from the foramen triosseum. The line of separation is not distinct between the two muscle bundles, and they become clearly separate only near their insertions.

4. M. rhomboideus superficialis. In *Geococcyx* (Rh. s., Pl. II., figs. 15, 19) it consists of two portions connected by fascia. Its origin is semitendinous from the two last cervical vertebrae, and the following dorsal ones. It is inserted fleshily on the anterior four-fifths of the dorso-median border of the scapula. Origin in *Bubo* (Rh. s., Pl. III., fig. 26; Pl. IV., fig. 33) is tendinous from the second and following dorsal vertebrae, and from the anterior edge of the ilium. It is inserted fleshily on the entire dorso-median border of the scapula. Origin in *Aeronautes* (Rh. s., Pl. VI., figs. 52, 56) is fleshy from part of the last cervical and following four dorsal vertebrae. It is inserted fleshily on the anterior half of the dorso-median border of the scapula.

5. M. rhomboideus profundus. Origin in *Geococcyx* (Rh. p., Pl. II., fig. 19) is semitendinous from the last cervical vertebra, the first, second, third and part of the fourth dorsal vertebrae. It inserts fleshily on the posterior dorso-median half of the scapula. Origin in *Bubo* (Rh. p., Pl. III., fig. 26; Pl. IV., fig. 33) is fleshy from second, third, fourth, fifth, and part of the sixth dorsal vertebrae. It inserts fleshily on the dorso-median border of the posterior two-thirds of the scapula. Origin in *Aeronautes* (Rh. p., Pl. VI., fig. 56) is tendinous from the dorsal vertebrae following the fourth. It inserts fleshily on the posterior one-third of the dorso-median border of the scapula.

6. M. scapuli-humeralis anterior. Origin in *Geococcyx* (Sc.-hu. a., Pl. II., figs. 18, 19, 20) is fleshy on the dorsal surface of scapula between the M. rhomboideus superficialis and the M. subscapularis, beginning at the anterior edge of the M. scapuli-humeralis posterior and extending to the M. pars scapuli-cubitalis. It inserts fleshily between the short heads of the M. pars humero-cubitalis anterior to the insertion of the M. latissimus dorsi posterior, and reaching the foramen pneumaticum. In *Bubo* this muscle is absent. Origin in *Aeronautes* (Sc.-hu. a., Pl. VI., figs. 51, 54, 56) is fleshy on dorso-

lateral border of the scapula, extending from the anterior border of the M. subscapularis to the M. pars scapuli-cubitalis. It inserts fleshily on the dorsal surface of the humerus between the short heads of the M. pars humero-cubitalis, anterior to the insertion of the M. latissimus dorsi posterior, extending to the border of the foramen pneumaticum.

7. M. scapuli-humeralis posterior. Origin in *Geococcyx* (Sc-hu. p., Pl. II., figs. 15, 19, 20) is fleshy from the posterior three-fourths of the dorsal and lateral surface of the scapula. It inserts by a strong tendon within the border of the tuberculum mediale of the humerus between the long and short heads of the M. pars humero-cubitalis. Origin in *Bubo* (Sc.-hu. p., Pl. III., figs. 25, 26, 28; Pl. IV., fig. 33) is fleshy from the posterior half of the lateral surface of the scapula. It inserts by a strong tendon within the border of the tuberculum mediale of the humerus between two heads of the M. pars humero-cubitalis. Origin in *Aeronautes* (Sc.-hu. p., Pl. VI., figs. 51, 52, 54, 56) is fleshy from the posterior half of the lateral surface of the scapula. It inserts by a short, round tendon within the border of the tuberculum mediale of the humerus between the heads of the M. pars humero-cubitalis.

8. M. subscapularis. Origin in *Geococcyx* (S. sc., Pl. II., figs. 18, 20) is fleshy, and anterior to the M. scapuli-humeralis posterior on the lateral and median surfaces of the scapula. It inserts tendinously on the apex tuberculi medialis humeri, anterior to the insertion of the M. coraco-brachialis posterior. Origin in *Bubo* (S. sc., Pl. III., figs. 25, 26, 28) is fleshy and anterior to the m. scapuli-humeralis posterior on the lateral and median surfaces of the scapula. It inserts by a strong tendon on the apex tuberculi medialis humeri, anterior to the insertion of the m. coraco-brachialis posterior. Origin in *Aeronautes* (S. sc., Pl. VI., figs. 51, 52, 56) is fleshy, and anterior to the m. scapuli-humeralis posterior from the lateral and median surfaces of the scapula. It inserts tendinously on the apex tuberculi medialis humeri, anterior to the insertion of the m. coraco-brachialis posterior.

9. M. serratus superficialis anterior. Origin in *Geococcyx* (Ser. s. a., Pl. II., fig. 18) is fleshy on the anterior border of the second free rib betwen its processus uncinatus and the tip. It inserts tendinously on the ventral border of the scapula dividing the m. subscapularis into a small M. subscapularis externus and a larger m. subscapularis internus. Origin in *Bubo* (Ser. s. a., Pl. III., fig. 25) is fleshy on the first sternal rib, with a small slip from the second. It inserts tendinously on the ventral border of the scapula dividing m. subscapularis into a small m. subscapularis externus and a large

m. subscapularis internus. Origin in *Aeronautes* (Ser. s. a., Pl. VI., fig. 51) is fleshy on the anterior border of the free rib and its processus uncinatus and from the corresponding portion of the first sternal rib. It inserts tendinously on the ventral border of the scapula dividing the m. subscapularis into a large m. subscapularis externus and a small m. subscapularis internus.

10. M. serratus superficialis posterior. Origin in *Geococcyx* (Ser. s. p., Pl. II., fig. 18) is fleshy, in three scallops, the posterior border of the second free rib, first and second sternal ribs, and their processus uncinati. The insertion on the ventro-median border of the scapula is tendinous except at the tip of that bone. This tendinous sheet is continuous with the posterior border of the anterior part of this muscle. Origin in *Bubo* (Ser. s. p., Pl. III., fig. 25) is fleshy in four teeth from the second, third and fourth sternal ribs and their processus uncinati. The insertion on the ventro-median border of the scapula is tendinous except at the tip of that bone, where it becomes fleshy. This tendinous sheet is continuous with the posterior border of the anterior muscle bundle. Origin in *Aeronautes* (Ser. s. p., Pl. VI., fig. 51) is fleshy in four teeth from the second, third and fourth ribs and their processes uncinati. It inserts fleshily on the ventro-median border of the last fifth of the scapula.

11. M. serratus profundus. In *Geococcyx* (Ser. p., Pl. II., fig. 18) it consists of three portions. The first bundle arises from the transverse process of that cervical vertebra preceding the last, and aponeurotically from the muscles of that region, the second from the process of the last cervical vertebra, the third partly from the process of the last cervical vertebra, but mainly from the first short rib, the upper half. They insert on the posterior two-thirds of the median surface of the scapula. In *Bubo* (Ser. p., Pl. III., fig. 25) it consists of two bundles. The first comes from the transverse process of the first dorsal vertebra and the contiguous portion of the free rib; the second from the first sternal rib near its dorsal articulation, dorsal surfaces of third and fourth ribs, and from the intercostal spaces. Both bundles insert on the posterior median surface of the scapula, less than half. In *Aeronautes* (Ser. p., Pl. VI., fig. 51) it consists of two bundles. The first portion coming from the posterior border of the free rib from its dorsal articulation, down almost to the processus uncinatus; the second from the posterior border of the first sternal rib and its process uncinatus. The two portions insert on the middle third of the median surface of the scapula.

12. M. sterno-coracoideus. Origin in *Geococcyx* (St.-co., Pl. II.,

fig. 18) is on the first and second sternal ribs. It inserts on the posterior border of the processus sterno-coracoideus. Origin in *Bubo* (St.-co., Pl. III., fig. 25) is on the first five sternal ribs. It inserts on the outer surface of the processus sterno-coracoideus, runs anteriorly close to the base of the coraco-brachialis posterior to the posterior third of the median surface of the coracoid. Origin in *Aeronautes* (St.-co., Pl. VI., fig. 51) is on the first, second and third sternal ribs. It inserts on the posterior border of the processus sterno-coracoideus.

13. M. subcoracoideus. In *Geococcyx* (Sub. co., Pl. II., figs. 16, 18, 20) the muscle consists of two parts. A fan-shaped division arises from the dorsal fourth of the median surface of the clavicle and partly from the anterior end of the scapula. The long, narrow portion comes from the middle third of the median surface of the coracoid, contiguous to the anterior border of the m. coraco-brachialis posterior, and from the neighboring surface of the interclavicular membrane. The two portions unite just before their insertion, which is tendinous, on the apex tuberculi medialis humeri, anterior to the insertion of the m. coraco-brachialis posterior, and ventral to that of the m. subscapularis. In *Bubo* (Sub. co., Pl. III., figs. 25, 28) it consists of two portions of almost equal size. One division comes equally from the neighboring median surfaces of the coracoid and scapula, with some fibres from the clavicle. The other part comes from the middle third of the median surface of the coracoid. They unite just before their tendinous insertion on the apex tuberculi medialis humeri, anterior to the insertion of the m. coraco-brachialis posterior and ventral to that of the m. subscapularis. In *Aeronautes* (Sub. co., Pl. VI., figs. 51, 55) it also consists of two portions, of almost equal size. One part arises from less than a fourth of the anterior median surface of the scapula, the other from the middle third of the median surface of the coracoid. The two bundles fuse as they bend under the scapula and are inserted tendinously on the apex tuberculi medialis humeri, anterior to the insertion of the m. coraco-brachialis posterior, and ventral to that of the m. subscapularis.

c. Muscles restricted to the wing.

1. M. propatagialis. This muscle, described by Gadow (1891) on page 253, seems to me almost identical with that of m. pectoralis pars propatagialis, described by him on page 245.

Pars propatagialis musculi deltoidei. In *Geococcyx* the two muscles have a common origin on the dorso-median surface of the clavicle and the neighboring anterior end of the coracoid. They become separated only in the distal third of the fleshy mass.

a. M. propatagialis longus (P. pat. l., Pl. II., figs. 14, 15) runs along in the anterior margin of the patagium and fuses with the inner surface of the skin covering the os magnum. In *Bubo*. (P. pat. l., Pl. IV., figs. 33, 37) the two muscles are quite separated at the origin. The fibres of the longus are proximally not distinguishable from those of the m. pars thoracica. The fleshy portion become tendinous at the crista lateralis of the humerus and is fused with the skin covering the distal end of the radius. In *Aeronautes* (P. pat. l., Pl. VI., figs. 50, 52, 57) the two muscles are entirely separated. The longus consists of two distinct portions, one coming from the second dorsal fifth of the clavicle, the ventral and large one from the middle third of the clavicle. The two fuse in the distal third of their fleshy bundles and continue in a common tendon to the os magnum, where it becomes split, one division being inserted on the ventral proximal border of the pollex digit, and the other near the mid point of the pollex digit on the dorsal surface.

b. M. propatagialis brevis. In *Geococcyx* (P. pat. b., Pl. II., figs. 14, 15, 17) the main part of the tendon is inserted on the m. extensor metacarpi ulnaris (radialis?), one-fourth the length of the fleshy portion of the muscle from its origin. From this point a branch is sent to the patagium and there fades out in a fan-like expansion. The other passes over into the heavy fascia extending from the anterior border of the radius down to the feathers. In *Bubo* (P. pat. b., Pl. IV., figs. 33, 37) the brevis comes semitendinously from the dorso-median surface of the clavicle and from the anterior end of the scapula. At its lower corner it is fused to the m. deltoideus major. From its chest-facing surface comes off a strong fascia which passes over the crista lateralis of the humerus and fades out into the m. pars thoracica at the base of the longus. From its distal end come off two strong tendons. The anterior one bifurcates half way to the fore arm. The anterior fork fuses with the tendon of the m. extensor metacarpi culnaris (radialis?), the other one crosses this muscle and continues distally, losing itself in the heavy fascia extending from the anterior border of the radius down to the feathers. The posterior tendon goes direct to the m. extensor metacarpi uluaris (radialis?), proximal to the fork of the anterior tendon, and fuses with it. At the point where the brevis becomes tendinous there is a short tendinous band coming off from its under surface and inserting on the crista lateralis of the humerus. In *Aeronautes* (P. pat. b., Pl. VI., figs. 52, 57) the brevis comes off from the dorsal end of the coracoid. It continues fleshily to the m. extensor metacarpi ulnaris (radialis?), and except at its lower edge, fuses with this muscle. From this edge comes off a short tendon, which merges into the upper distal corner of the m. deltoideus major.

2. M. metapatagialis. In *Geococcyx* (Met., Pl. II., fig. 15) it consists of two narrow bands. The dorsal one comes from the facing ends of the spines of the two dorsal vertebrae preceding the last. It is inserted on the skin above the m. pars humero-cubitalis somewhat proximal to the mid point of the humerus, the insertion is at the base of the humeral feather tracts. The ventral one comes from the anterior border of the first sternal rib near its articulation with the ventral segment. It meets and fuses with the dorsal band at its insertion. In *Bubo* (Met., Pl. III., fig. 25; Pl. IV., fig. 33) the narrow dorsal band arises from the anterior dorsal border of the ilium, and inserts on the skin a little proximal to the mid point of the humerus. The ventral portion is much broader. It has its origin in two scallops on the fourth and fifth sternal ribs, and fuses with the insertion of the dorsal branch. In *Aeronautes* (Met., Pl. VI., fig. 51) only the ventral band was present. It comes from the third and fourth sternal ribs at the base of their processus uncinati.

3. M. biceps brachii. In *Geococcyx* (Bi., Pl. II., figs. 14, 16) it has a tendinous origin on the antero-lateral surface of the coracoid, and on the tuberculum mediale of the humerus. It inserts by two short tendons on facing surfaces of ulna and radius just beyond the proximal border. In *Bubo* (Bi., Pl. IV., figs. 30, 37) the origin is tendinous on the anterior lateral surface of the coracoid and on the tuberculum mediale of the humerus. It inserts by two tendons on facing surfaces of ulna and radius beyond the proximal border. In *Aeronautes* (Bi., Pl. VI., fig. 53) it arises by one long tendon from the lateral border of the anterior end of the coracoid. It inserts by one delicate tendon on the ulna facing surface of the radius.

Pars propatagialis m. bicipitis was absent in all the birds.

4. Triceps cubiti. In all the birds this consists of two separate parts, one m. pars scapuli-cubitalis, and two m. humero-cubitales.

a. Pars scapuli-cubitalis. Origin in *Geococcyx* (Pars. sc. cub., Pl. II., figs. 15, 19, 20) is semitendinous on the neck of the scapula, and the outer surface of the glenoid fossa. It inserts on the ulna between the olecranon process and the external condyle. In *Bubo* (Pars. sc. cub., Pl. III., figs. 26, 28) the origin is semitendinous on the neck of the scapula. As the muscle passes over the m. latissimus dorsi anterior it gives off a strong flat tendon which passes to the humerus anterior to the m. latissimus dorsi anterior, and fuses with the small tendon of the m. latissimus dorsi posterior. It inserts by a broad tendon beyond the proximal rim of the external condyle of the ulna. From this point there comes off a tendon which bends back around the external condyle of the humerus and inserts on the processus supracondyloideus lateralis of the humerus. Origin in *Aeronautes* (Pars. sc. cub., Pl. VI., figs. 52, 54) is semitendinous on the neck of the scapula, and outer glenoid border. In inserts by a short, strong tendon on the proximal rim of the external condyle of the ulna.

b. Pars humero-cubitalis. In *Geococcyx* (Pars. hu. cub., Pl. II., figs. 14, 20) the short head comes from the distal four-fifths of the median surface of the humerus. The other part, divided at its origin by the insertion of the m. scapuli-humeralis posterior, comes from the crista medialis of the humerus and from the margin of the foramen pneumaticum. The parts soon unite and run down to insert by a tendon and a strong aponeurosis on the olecranon process of the ulna, and on the intervening space between it and the external condyle. In *Bubo* (Pars. hu. cub., Pl. III., fig. 28; Pl. IV., figs. 33, 37) one part comes from the median surface of the humerus, and the other, divided at its origin by the insertion of the m. scapuli-humeralis posterior, comes from the crista medialis of the humerus and from within the foramen pneumaticum. Insertion is by tendon and a strong aponemosis on the olecranon process of the ulna and the intervening space between it and the external condyle. In *Aeronautes* (Pars. hu. cub., Pl. VI., fig. 54) one part comes from the median surface of the humerus, and the other, divided at its origin by the m. scapuli humeralis posterior, from the crista medialis of the humerus, and from the rim of the foramen pneumaticum. Its insertion is by a tendon and an aponeurosis on the olecranon process of the ulna and the external condyle.

During the preparation of the present paper errors in my study on *Phalaenoptilus* were discovered. The corrections are given below.

The muscle named M. deltoideus major anterior is the m. deltoideus minor. M. rhomboideus superficialis inserts on the anterior four-fifths of the dorso-median border of the scapula. M. rhomboideus profundus has a tendinous origin on the last cervical and the following dorsal vertebrae, and also from the anterior edge of the ilium. M.scapuli-humeralis posterior inserts within the border of the tuberculum mediale of the humerus, near, but not within the foramen pneumaticum. M. subscapularis arises from the lateral and median surfaces of the scapula. It inserts by a short tendon on the apex tuberculi medialis humeri anterior to the insertion of the m. coraco-brachialis posterior. M. serratus superficialis posterior arises in four scallops from the four sternal ribs. There is a fleshy insertion of a part of the muscle on the posterior tip of the scapula, and a fascia connection between this and the posterior border of the m. serratus superficialis anterior, which is inserted on the scapula. *M. serratus profundus* consists of three portions. The dorsal bundle comes from the free rib at the end of the transverse process; the second from the same rib lower down and from its posterior border; the third from the posterior border of the following rib. *M subcoracoideus* arises on the middle third of the median surface of the coracoid, aponeurotically from the muscles of that region, partially from the neighboring portion of the clavicle. It inserts on the apex tuberculi medialis humeri, anterior to the insertion of the m. coracobrachialis posterior and ventral to the m. subscapularis. The muscle designated *E* is the m. coracobrachialis anterior. It arises from the lateral anterior end of the coracoid. It inserts on the lateral border and on the ventral surface of the humerus, extending down to the anterior border of the crista lateralis of the humerus.

VI. *Pterylosis of Geococcyx.*

(Plate VII.)

The dorsal head feathering begins as a single row median to each nostril, then broadens to cover the fore part of the head, becoming a single median row back of the eyes. With the two parallel rows which arise above each eye it forms a narrow band of five rows, which runs back to the base of the head. The tract is fairly dense on the side of the head. Around the ear is a circle of feathers formed partly by the lower one of the two rows arising in front of the eye. Below the ear the rows run obliquely downward and upward to join, respectively, the ventral and dorsal tracts. The feathering of the infra-mandibular region consists of a narrow median band which is divided in its posterior half. The chin and throat are occupied by rows of feathers running obliquely from the median line out to the side of the neck where they terminate. The ventral cervical tract becomes strong toward the base of the neck. The dorsal tract is a broad band at its origin on the nape of the neck, and narrows gradually to end abruptly between the shoulder blades. It is renewed on each side of this break by a single row which soon becomes strong, and then divides to enclose an elliptical apterion. Uniting again it reaches its greatest expansion between the insertion of the femora, then gradually diminishes and terminates near the base of the oil gland. The strong humeral tract is continuous with the ventral one. On the dorsal surface of the wing is a wide tract covering almost the entire surface of the patagium and extending to the posterior border of the ulna. There is a narrow band along the posterior border of the humerus. The alula bears six strong feathers which extend from its distal extremity around its posterior border to the base. Beginning at the base the feathers increase in length successively till the sixth is reached which is the shortest of all, the fifth being the longest. Along the anterior margin occur contour feathers. There are ten primaries which become successively shorter from the wrist to the hand. There are twelve secondaries, and the wing is quin-cubital. The strong femoral tract runs into the dorsal tract, and grows weak as it crosses to the knee. The dorsal surface of the thigh is sparsely covered. The feathering of the leg extends to the heel and is not dense except along the posterior and anterior borders.

The ventral tract merges anteriorly with the lower cervical and the humeral tracts. Near the clavicle two rows median to the main tract separate from it, and continue to the small tract in front of the anus, where it is joined by a single row which comes from the extremity of the main tract. On the ventral surface of the wing the feathers are distributed along the margins, over the alula and between the patagium and the ulna. The crural tract consists of a narrow band along the posterior edge of the leg down to the heel, but not reaching the ventral tract. At the anterior border of the leg it is joined to the ventral tract, and along this border is fairly dense. From this rows extend out to near the middle of the leg.

There are ten rectrices. On the dorsal surface there are five coverts. On the ventral only four were found. At the base of the oil gland is a semicircle of six small feathers. On the ventral surface there is a dense tract on each side of the tail. The anus is almost surrounded by a small tract.

B. *Conclusions.*

The following comparisons are limited to the genera described in this paper and to *Phalaenoptilus* treated in my previous one, partly because much of the literature on this subject was inaccessible, but mainly because I desired to limit the comparisons to genera personally examined.

In the myology there are some exact agreements and many close resemblances. All the birds agree in the presence of an oil gland, a spleen and a gall bladder; in the absence of the biceps slip and powder downs; in the number of pancreatic branches and ducts. Characters which show differences are given in the following table.

	Number of Liver Lobes	Number of Liver Ducts	Number of Calca	Kidneys: Right and Left Kidney Fused	Kidneys: Right and Left Kidney not Fused	Kidneys: Number of Lobes of Right Kidney	Kidneys: Number of Lobes of Left Kidney	Kidneys: Number of Adrenals	Number of Nerves in Brachial Plexus	Number of Nerves in Sacral Plexus	Number of Primaries	Number of Secondaries	Number of Rectrices	Number of Phalanges of Last Toe	Middle Toe Serrated	Syrinx	Sternum	Young: With Down	Young: Without Down
Geocaccyx	2	1	2	---	x	3	3	1	4	7	10	12	10	5	----	Bronchial	Two Notches		x
Bubo	2	1	2	---	x	----	----	----	4		11	15	12	5	----	"	"	x	
Aeronautes	3	2	---	---	x	2	2	2	5	5	10	8-11	10	3	----	Leaches Bronchial	-----		x
Phalaenoptilus	2	1	2	x	----	3	2	----	3		10	12	10	4	x	"	One Notch	x	

It appears from comparison of the structures mentioned that *Phalaenoptilus* and *Aeronautes* go together, and *Bubo* and *Geococcyx.* The relation, however, is less close between the two former than between the two latter. The question of the relationship of the Caprimulgi, however, is not one to be settled by the examination of a few genera, but requires a more careful and thorough investigation of many related forms than has yet been made.

It is interesting to note here that *Phalaenoptilus* is probably the most primitive of these four genera. The elongated brain and its relatively small size compared with the head, the fairly well developed right oviduct, and the downy plumage of the young are facts which indicate it as the most primitive.

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(Exclusive of the Osteology.)

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Description of the Plates.

The following abbreviations have been employed:
Ab., Musculus pectoralis, pars abdominalis.
A. C., Anterior commissure.
Ad., Adrenal.
Ap. tb. m., Apex tuberculi medialis humeri.
Bf., Bursa Fabricii.
Bi., Musculus biceps brachii.
C., Coracoid.
Cae., Caeca.
Cb., Cerebellum.
Cer., Cerebrum.
Cj., Conjunction of Duodenum and Gizzard.
Cl., Clavicle.
Clo., Cloaca.
Con., Processus supracondyloideus lateralis of the humerus.
Cor. br. a., Musculus Coraco-brachialis anterior.
Cor. br. ai., M. coraco-brachialis anterior insertion.

Cor. br. p., M. coraco-brachialis posterior.
Cor. br. pi., M. coraco-brachialis posterior insertion.
Del., M. deltoideus major.
Deli., M. deltoideus major insertion.
Del. m., M. deltoideus minor.
Del. mi., M. deltoideus minor insertion.
Duo., Duodenum.
E., Eye.
Eu., Aperture of Eustachian tube.
Ext. met. ul. r., Musculus extensor metacarpi ulnaris (radialis?).
Ext. met. ul. ri., Musculus extensor metacarpi ulnaris radialis, insertion.
F., Funnel shaped opening of oviduct into coelome.
F. pn., Foramen pneumaticum.
G., Glottis.
G. bl., Gall bladder.
Giz., Gizzard.
Gl. d., Gall duct.
Ht., Heart.
Hu., Humerus.
Hu. sc., os humero-scapulare.
Hy., Hypophysis.
Il., Ilium.
In., Infundibulum.
I. n., Internal nares.
Int., Intestine.
K., Kidney.
Lat. d. a., Musculus latissimus dorsi anterior.
Lat. d. ai., Musculus latissimus dorsi anterior insertion.
Lat. d. p., M. latissimus dorsi posterior.
Lat. d. pi., M. latissimus dorsi posterior insertion.
Lig. hu. sc., Ligamentum humero-scapulare.
Liv., Liver.
Liv. d., Liver duct.
L. ovi., Left oviduct.
L. P., Lumbar pad or Lumbalwulst or sinus rhomboidalis.
Met., Musculus metapatagialis.
Mo., Medulla oblongata.
Nos., Nostril.
O. c., Occipital condyle.
Olf. l., Olfactory lobe.
Op. ch., Optic thalamus.
Pan., Pancreas.

Pan. d., Pancreatic duct.
Pars. hu. cub., Musculus pars humero-cubitalis.
Pars. hu. cubi., M. pars humero-cubitalis insertion.
Pars. sc. cub., M. pars scapuli cubitalis.
Pars. sc. cubo., M. pars scapuli cubitalis origin.
Pars. sc. cubi., M. pars scapuli cubitalis insertion.
P. c., Posterior commissure.
Pect., Musculus pectoralis, pars thoracica.
P. pat. l., M. propatagialis longus.
P. pat. b., M. propatagialis brevis.
Pn., Pineal eye.
Prov., Proventriculus.
R., Radius.
Rh. S., Musculus rhomboideus superficialis.
Rh. Si., M. rhomboideus superficialis insertion.
Rh. p., M. rhomboideus profundus.
Rh. pi., M. rhomboideus profundus insertion.
R. ovi., Right oviduct.
S., Musculus ilio-tibialis internus or sartorius.
Sc. hu. a., M. scapuli-humeralis anterior.
Sc. hu. ao., M. scapuli-humeralis anterior origin.
Sc. hu. ai., M. scapuli-humeralis anterior insertion.
Sc. hu. p., M. scapuli-humeralis posterior.
Sc. hu. po., M. scapuli-humeralis posterior origin.
Sc. hu. pi., M. scapuli-humeralis posterior insertion.
Sc., scapula.
S. c., Semicircular canals.
Ser. p., M. serratus profundus.
Ser. s. a., M. serratus superficialis anterior.
Ser. s. p., M. serratus superficialis posterior.
Sp., Spinal cord.
Sp. I., First spinal nerve.
Spl., Spleen.
S. Sc., Musculus subscapularis.
St., Sternum.
St. Co., Musculus sterno-coracoidus.
Sub. co., M. subcoracoideus.
Sub. coi., M. subcoracoideus insertion.
Sup. cor., M. supracoracoideus.
Sup. cori., M. supracoracoideus insertion.
Sup. cor. t., M. supracoracoideus tendon.
T., Tongue.
Ul., Ulna.

Ur., Ureter.
I., First cranial nerve.
II., Second cranial nerve.
III., Third cranial nerve.
IV., Fourth cranial nerve.
V., Fifth cranial nerve.
VI., Sixth cranial nerve.
VII., Seventh cranial nerve.
VIII., Eighth cranial nerve.
IX., Ninth cranial nerve.
X., Tenth cranial nerve.
XI., Eleventh cranial nerve.
XII., Twelfth cranial nerve.

All the figures are drawn from free hand sketches. Those of *Geococcyx* and *Bubo* are mostly drawn life size, and have been reduced one-half in the reproduction. Those of *Aeronautes* are mostly twice life size, some three times, and have been reduced one-third. In all cases the lateral view of the pecten of the eye is three times life size, and the view from the apex a little more than three times.

PLATE I.

Geococcyx californianus.

Fig. 1. Ventral view of the brain.
Fig. 2. Dorsal view of brain, with outline of head and nostrils.
Fig. 3. Brain viewed from left side.
Fig. 4. Dorsal view of sacral plexus.
Fig. 5. Lateral view of pecten of the eye.
Fig. 6. Pecten seen from its free apex.
Fig. 7. Median longi-section of brain.
Fig. 7a. Dorsal view of brachial plexus.
Fig. 8. Female excretory organs, ventral view.
Fig. 9. Female urogenital organs, ventral view.
Fig. 10. Dorsal view of tongue and glottis.
Fig. 11. Ventral view of the posterior portion of alimentary tract.
Fig. 12. Ventral view of internal nares and aperture of Eustachian tube.
Fig. 13. Dorsal view of duodenal loop and pancreas.

PLATE II.

Geococcyx californianus.

Fig. 14. Superficial muscles of breast and inner arm.

Fig. 15. Superficial muscles of back and outer arm.

Fig. 16. Deeper muscles of breast and inner arm.

Fig. 17. View of shoulder muscles seen from the front to show the musculus deltoideus minor.

Fig. 18. Muscles of shoulder and chest.

Fig. 19. Deeper muscles of back.

Fig. 20. Muscles of upper arm.

Fig. 21. Ventral view of viscera.

Fig. 22. Ventral view of intestine, showing its convolutions. Parts separated for sake of clearness. The dotted lines represent the portion of the intestine covered by superficial folds.

PLATE III.

Bubo virginianus.

Fig. 23. Ventral view of posterior portion of alimentary tract.

Fig. 24. Dorsal view of liver, gall bladder and duodenum.

Fig. 25. Muscles of shoulder and chest.

Fig. 26. Muscles of wing.

Fig. 27. Ventral view of portion of the brain.

Fig. 28. Muscles of upper arm and other muscles inserting on it.

Fig. 29. Ventral view of viscera.

PLATE IV.

Bubo virginianus.

Fig. 30. Muscles of upper wing.

Fig. 31. Dorsal view of brachial plexus, anterior end turned towards left.

Fig. 32. Female urogenital organs, ventral view.

Fig. 33. Superficial muscles of back and outer wing.

Fig. 34. Dorsal view of floor of mouth.

Fig. 35. Pecten of the eye seen from its free apex.

Fig. 36. Lateral view of pecten.

Fig. 37. Superficial muscles of chest and inner wing.

PLATE V.

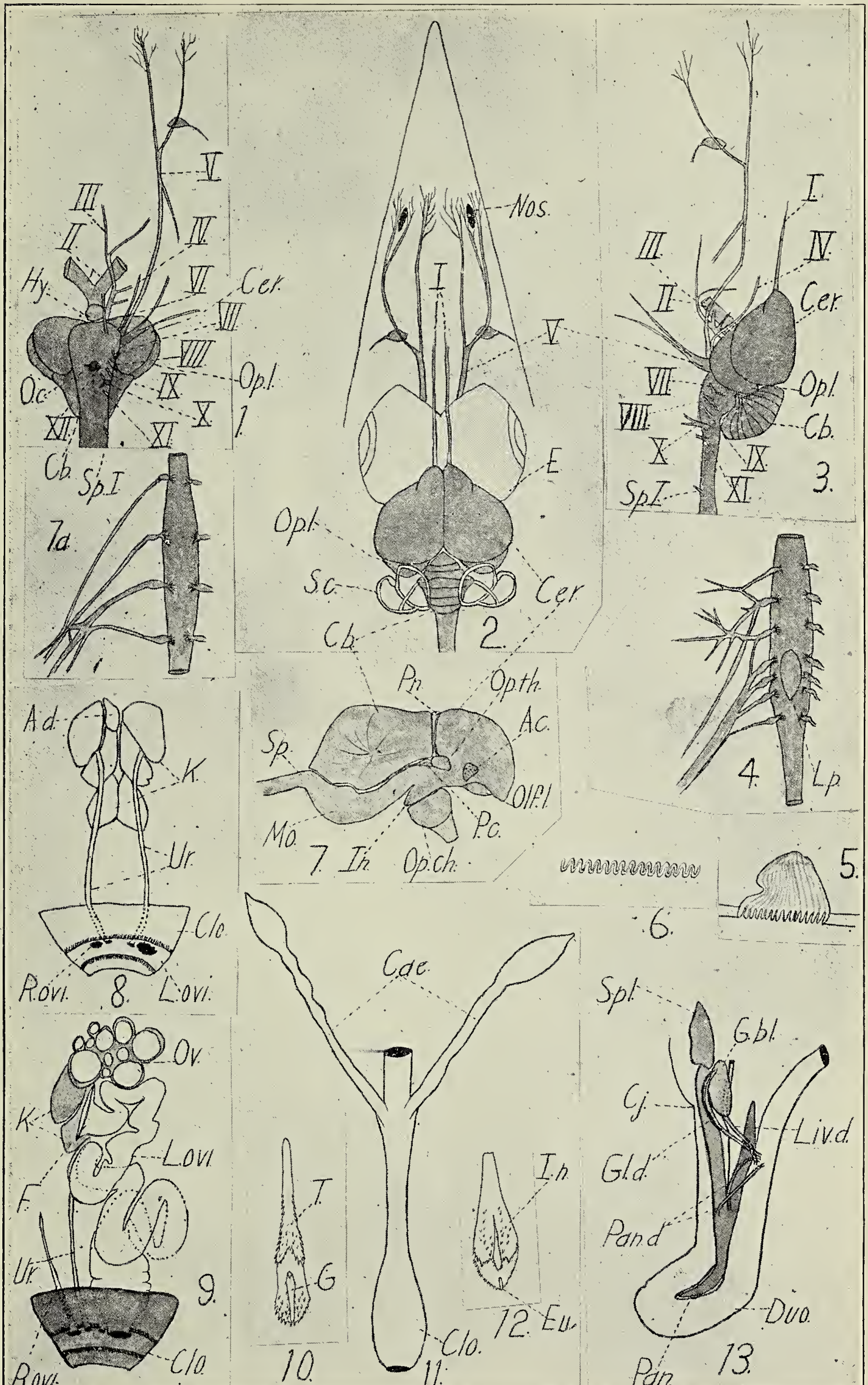
Aeronautes melanoleucus.

Fig. 38. Dorsal view of brain, with outline of head and nostrils.

Fig. 39. Brain viewed from left side.

Fig. 40. Ventral view of brain.

Fig. 41. Dorsal view of brachial plexus.



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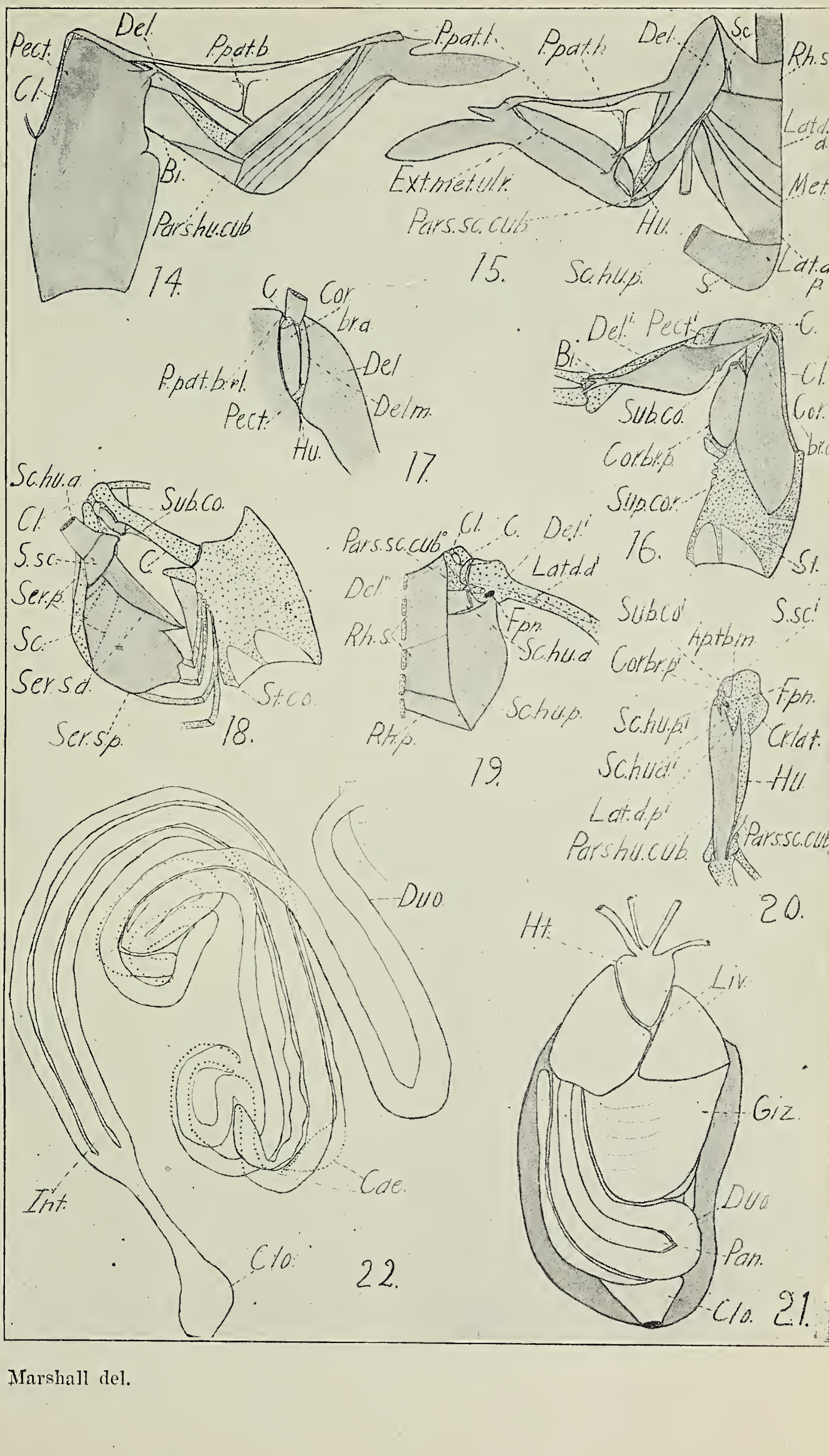

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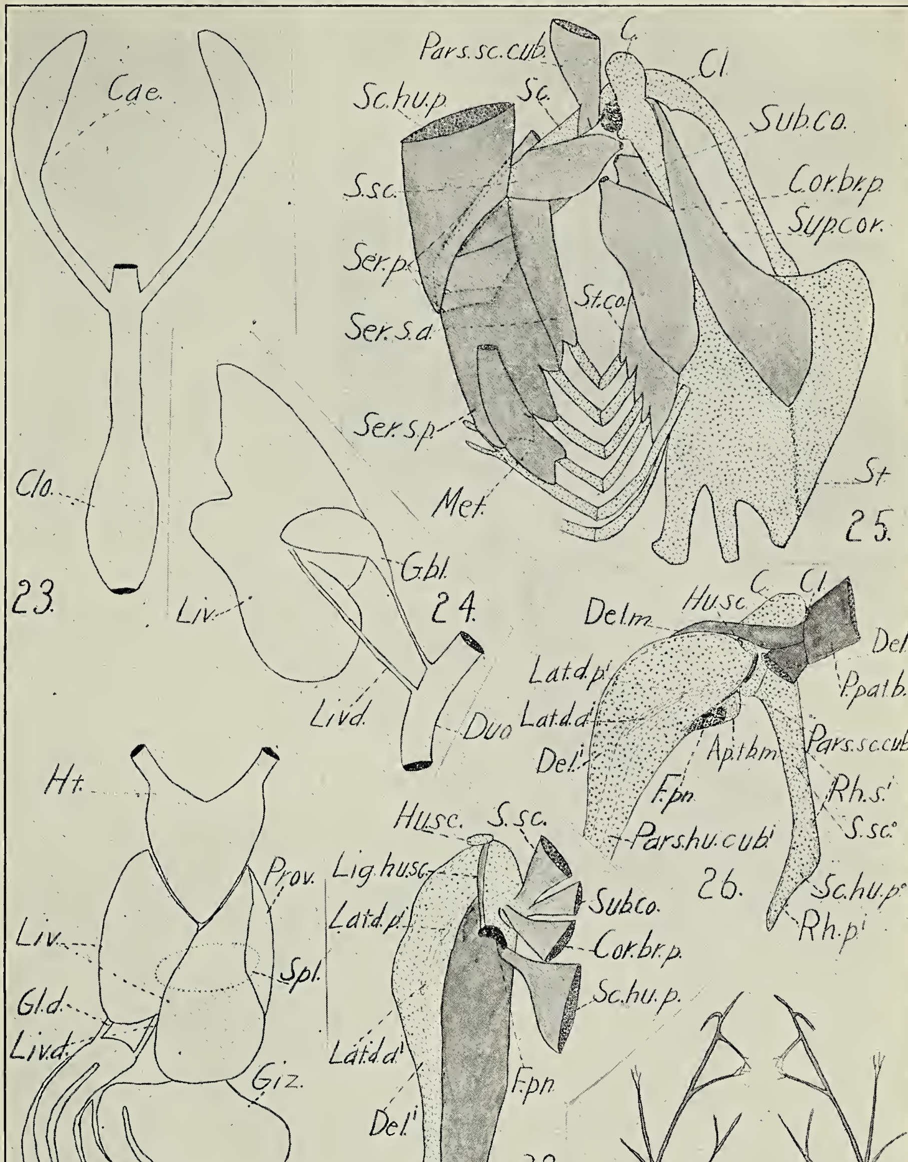

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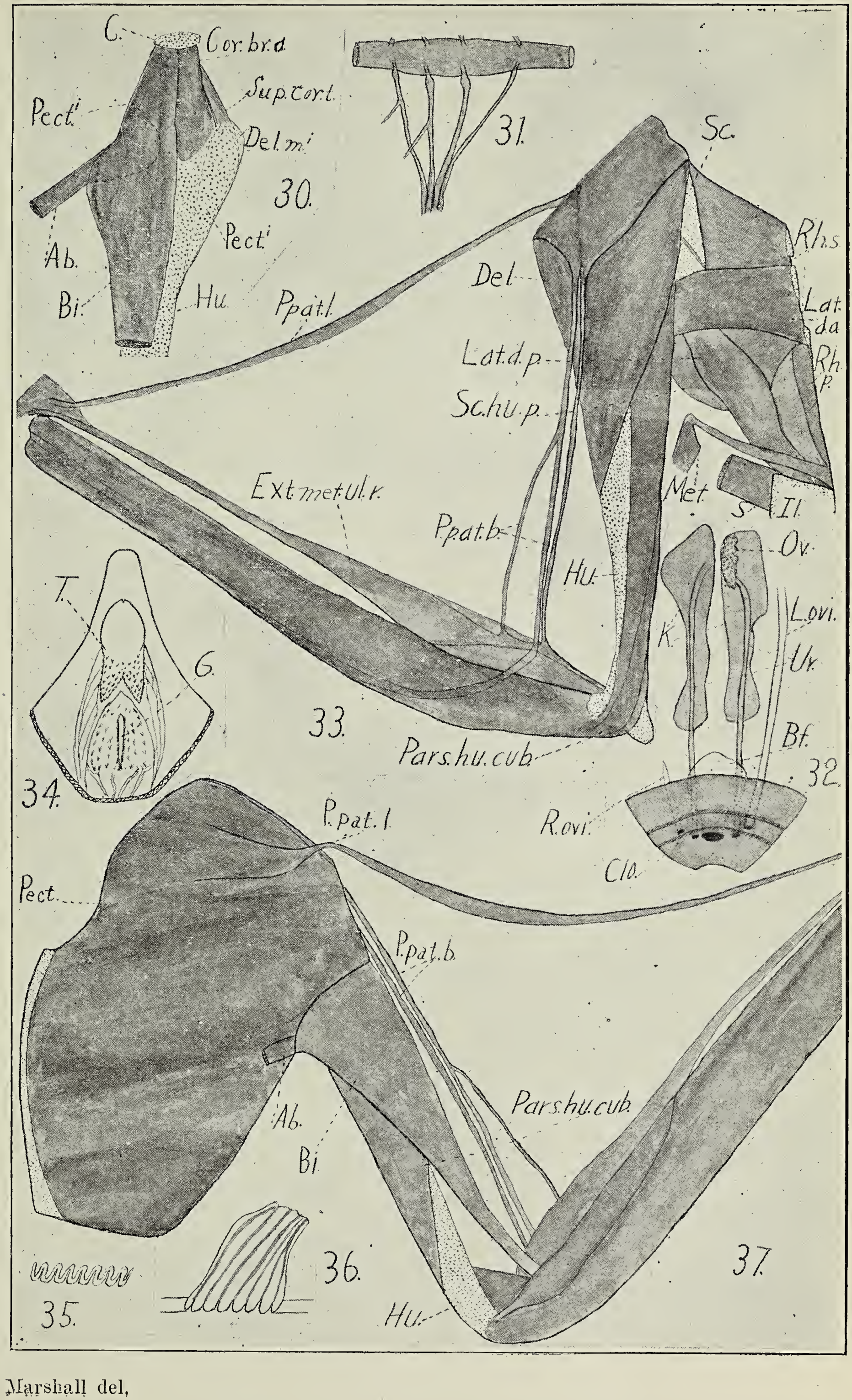

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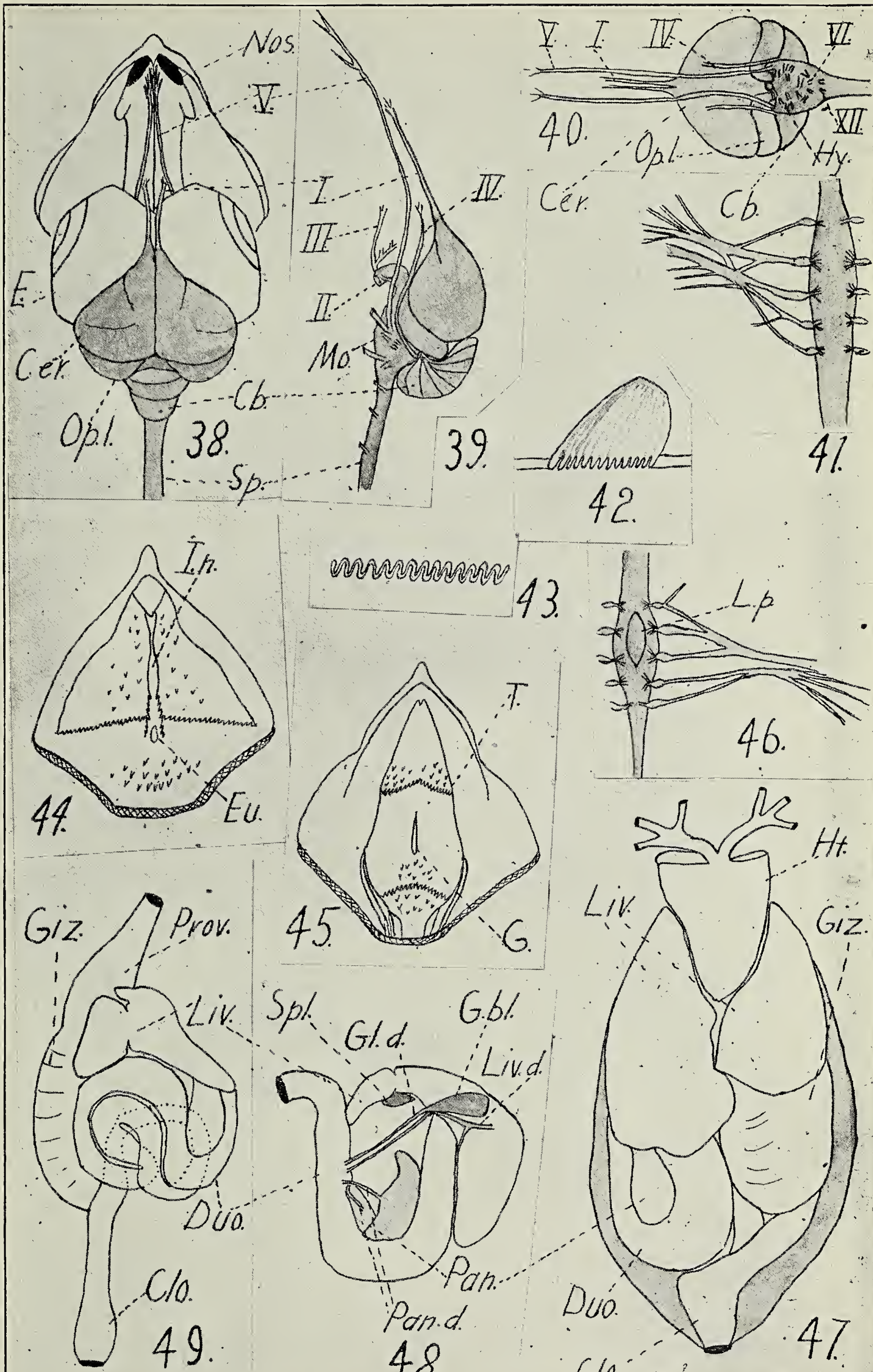

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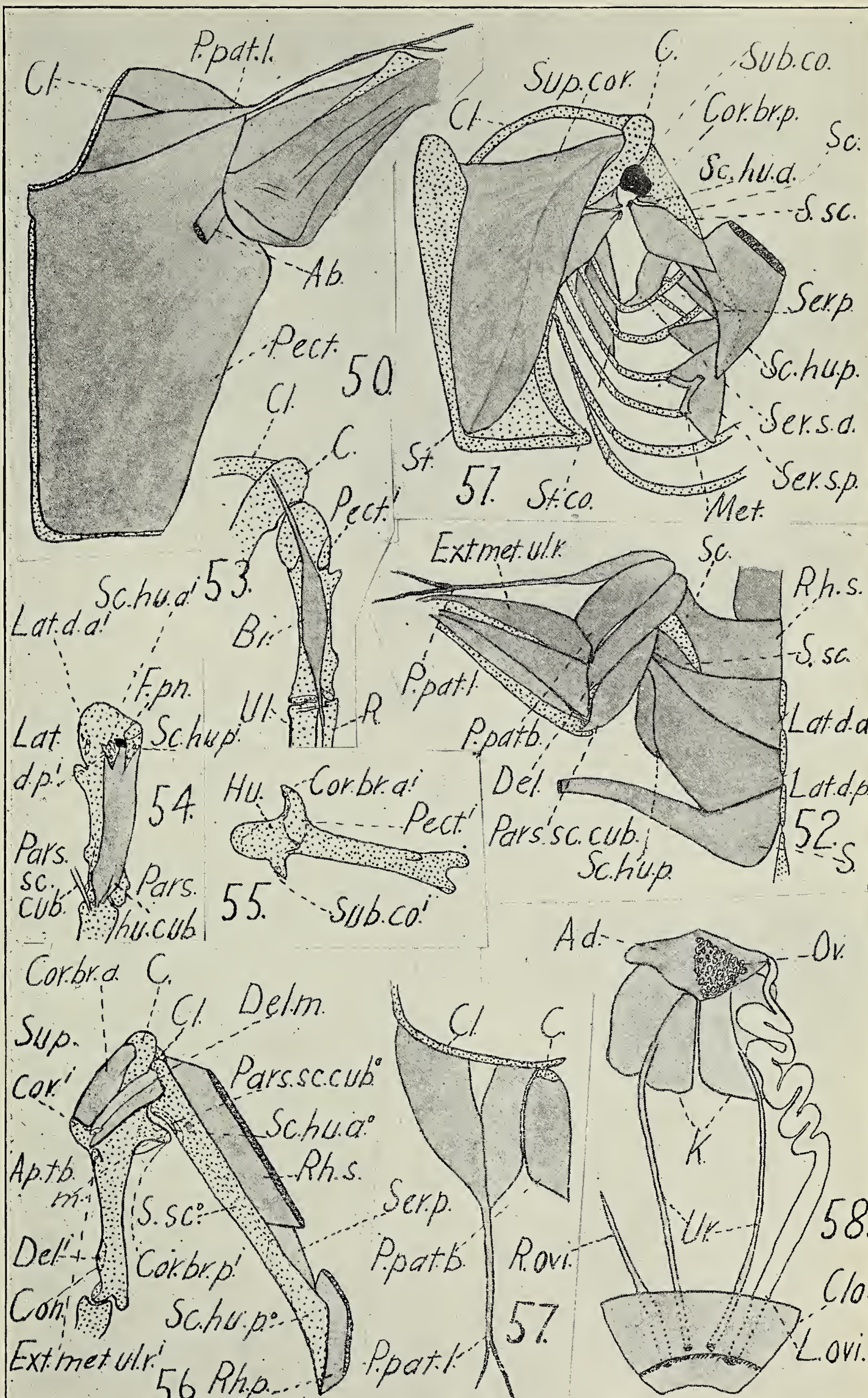

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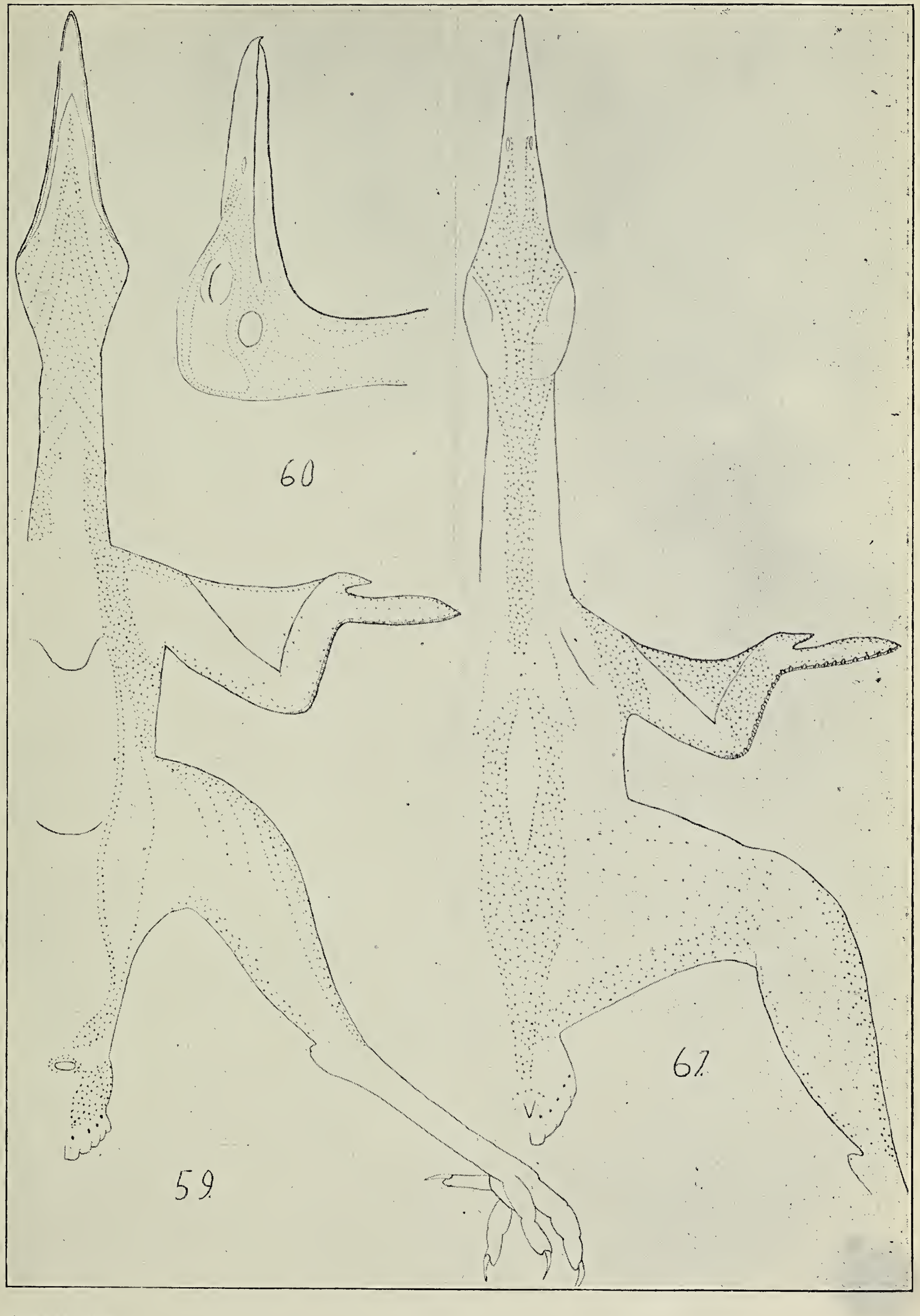

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Fig. 42. Lateral view of pecten of the eye.
Fig. 43. Pecten viewed from its free apex.
Fig. 44. Ventral view of roof of mouth.
Fig. 45. Dorsal view of floor of mouth.
Fig. 46. Dorsal view of sacral plexus.
Fig. 47. Ventral view of viscera.
Fig. 48. Postero-ventral view of viscera.
Fig. 49. Lateral view of viscera, showing intestinal convolutions. The dotted lines represent portions of the intestine covered by superficial folds.

PLATE VI.

Aeronautes melanoleucus.

Fig. 50. Superficial view of muscles of chest.
Fig. 51. Muscles of shoulder and chest.
Fig. 52. Superficial muscles of back and outer wing.
Fig. 53. Ventral view of left upper arm.
Fig. 54. Dorsal view of left upper arm.
Fig. 55. Median view of left upper arm.
Fig. 56. Muscles of wing and those of back inserting on it.
Fig. 57. Patagial muscles seen from the front.
Fig. 58. Female urogenital organs, ventral view.

PLATE VII.

Geococcyx californianus.

Fig. 59. Ventral view.
Fig. 60. Lateral view of head.
Fig. 61. Dorsal view.

THE BEGINNINGS OF THE TEXAS RAILROAD SYSTEM.

ALEXANDER DEUSSEN, M. S.*

I. THE NEED OF RAILROADS.

Texas possesses very few natural facilities for transportation. Her rivers for the most part are unnavigable, and the soil of her black, waxy prairies renders wagon transportation in wet weather impossible. Isolated from her sister States, her most important need has ever been an adequate system of transportation—a system that not only makes possible communication between distant points within her own borders, but also affords an outlet for her products through St. Louis, Memphis and Chicago by land, and through Galveston and New Orleans by sea.

These considerations were apparent to the earliest settlers. It is, therefore, not surprising to learn that attempts were made as early as 1836 to secure such railroad system.

This paper purposes to give an account of the beginnings of this system.

II. RAILROADS OF THE REPUBLIC OF TEXAS.

1. *Texas Railroad, Navigation & Banking Company.*

The Republic of Texas was but a few days old when its first railroad was chartered. This was in 1836, six years after the inauguration of the first steam railroad in this country. The charter created the Texas Railroad, Navigation & Banking Company, and authorized the corporation to connect the important Gulf ports of Texas with the rivers by canals, and to construct railroads whenever demanded by the public wants.[1] The corporators were Branch T. Archer and James Collingsworth—historic names in the annals of Texas.

These projects were never undertaken. The country was too much pre-occupied with civil conflicts; it had little time to engage in works of internal improvement. The rights granted were soon forfeited, and the Texas Railroad, Navigation & Banking Company passed into history.

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2. *Other Railroads.*

The Galveston & Brazos Railroad was chartered in 1838. W. S. Cooke, James F. Perry and others were authorized to construct turnpikes and railroads from Galveston Bay to Brazoria on the Brazos River, and to improve bays, rivers, bayous and creeks. This enterprise was intended to carry out on a more limited scale the plans of Archer and Collingsworth. Its ulterior object was to build up the city of Galveston by connecting this port with the fertile lands of the interior.

In 1839 a charter with similar powers was granted to parties in the interest of Houston to connect that city with Richmond, a town a few miles above Brazoria.

The Harrisburg Railroad & Trading Company was incorporated by parties in Galveston, and was given authority to connect Buffalo Bayou at Harrisburg, a point a few miles below Houston, with the Brazos River. The charter, although soon forfeited, suggested the later one, which found fruition in the completion of the Buffalo Bayou, Brazos & Colorado Railroad.[2]

No work was done under any of these charters. The Republic of Texas lived and died without ever hearing the whistle of a locomotive.

NOTES.

[1]Act of December 16, 1836, Gammel's "Laws of Texas," Vol. 1, p. 1188.

[2]The facts of this account are taken from an article by Donaldson in the Texas Almanac for 1868, pp. 119-121.

III. PROGRESS OF RAILROADS IN TEXAS, 1845-1856.

3. *First Railroads of the State.*

In 1846 two roads were chartered by the new State: The Lavaca, Guadalupe & San Saba, and the Colorado & Wilson Creek. These charters were soon forfeited.[1]

4. *Buffalo Bayou, Brazos & Colorado Railroad.*

In 1850 General Sydney Sherman, a veteran of the Texan War, organized the Buffalo Bayou, Brazos & Colorado Railroad Company, to succeed the Harrisburg Railroad & Trading Company, which had become defunct. J. F. Barrett, of Massachusetts, was elected president, William Hilliard of the same State was elected secretary and treasurer, and J. S. Todd, of Texas, was elected resident director. This was the first successful attempt to enlist the aid of Northern capital in the development of Texas railroads. A charter was secured from the Legislature, and authority was given to connect Buffalo Bayou at Harrisburg, the supposed head of successful navigation, with the Brazos and Colorado Rivers. Galveston was in this manner to become the chief outlet for the cotton producing counties of the State.[2]

Work commenced in 1851. By 1853 the road was completed twenty miles. In 1855 the line was opened to Richmond.

5. *Galveston & Red River Railroad.*

In 1848 Ebenezer Allen secured from the Legislature, in opposition to the wishes of the delegates from Houston, a charter for the Galveston & Red River Railroad. This charter authorized the construction of a railroad from Galveston Bay to the northern boundary of the State.

At the time of the passage of this act great consternation prevailed among the business men of Houston. Spurred on by the steady progress westward of the Galveston road, Houston negotiated with Allen for the commencement of the work at that city. Work was so begun in 1853,[3] and by 1855 the grading was completed to Cypress, twenty-five miles north of Houston.[4]

6. *Mississippi & Pacific Railroad.*

The discovery of gold in California in 1848 impressed upon the people of the United States the necessity of a trans-continental line to connect the shores of the Atlantic and Pacific oceans. It was realized that such a road could only be constructed with the aid of the National government. In response to the popular agitation for the trans-continental railroad, Congress ordered a survey made of the several routes proposed, to ascertain which was the most feasible.

Texans were naturally very eager for the construction of the line that would pass through their State—that is, the Southern. In 1850 a resolution was passed by the Third Legislature, providing that aid should be extended to such a National railroad.[5]

The prospect that a company owning the franchise for the construction of the Texas link of the road would enjoy many excellent opportunities for speculation and profit called many corporations into existence, bent on securing this grant. During the year 1852 five companies were chartered and were given authority to construct railroads from the east boundary to the Rio Grande River. These were the Texas Western, the Texas & Louisiana, the New Orleans, Texas & Pacific, the Vicksburg & El Paso, and the Texas Central.[6]

The Texas Western and the Vicksburg & El Paso were afterwards consolidated. A substantial bonus—10,240 acres of land for every mile of completed road—was offered to each of these.

In 1853 Governor Bell urged the Fifth Legislature to extend a more liberal reward for the construction of the trans-continental road.[7] Acting upon his suggestion, the Mississippi & Pacific Railroad was chartered. The act incorporating it directed the Governor to receive proposals from companies for its construction. The lowest bidder was to be granted the franchise. When complete, the railroad was to remain the property of the company for ninety-nine years. A large area of land was to be held in reserve for the company until the track was located. A new reserve was then to be created, extending thirty miles on each side of the right of way. After the construction of the first fifty miles, the corporation was to receive twenty alternate sections of land for every mile of completed road. A bond of $300,000 in gold was required to be deposited with the State Treasurer within sixty days after the signing of the contract, guaranteeing the construction of fifty miles within eighteen months.[8]

The Texas Western Company seeing here an opportunity to realize the purposes of its creation, had previously (during the pendency of the act) filed in the General Land Office a designation of its line along the proposed route of the Mississippi & Pacific.

The Atlantic & Pacific Railway Company was a corporation of New York, and Robert J. Walker, Secretary of the Treasury under President Polk, and at one time Governor of Kansas, and T. Butler King, formerly a member of Congress, were its directors and agents. This company determined to secure the sole franchise for the trans-continental road—not for the purpose of building it, however, but to gamble with its stocks and bonds. The first move was to buy up the charters already in existence, and to this end the Texas Western Company was paid $600,000 for its rights.[9] Thus were the purposes of the incorporation of the Texas Western accomplished.

When Governor Pease, who had succeeded Governor Bell, called for proposals to construct the road, only one bid was received. This was offered by the Atlantic & Pacific Company, and was accepted.

When it came to executing the contract, the resources and purposes of the Atlantic & Pacific Company were adequately ventilated. To meet the requirement of the deposit of the gold bond, the company offered stock of a Memphis bank. This being rejected by the Governor, the stock of the Sussex Iron Company of New Jersey was submitted. This was likewise refused. Seeing that these men were without means, the Governor annulled the contract.

Failing in their attempt to secure the franchise, they determined to prevent any other company from so doing. A reorganization was had under the Texas Western charter. This move effectually blocked any other company from offering proposals. When the Governor again called for them, none were received.[11]

When the Sixth Legislature convened in 1855, Governor Pease laid the matter before it. After a tedious debate an act was passed throwing the reservation open to settlement.[12] This in effect repealed the measure.

Subsequent events proved this to have been the proper course. The movement to build a Pacific railroad was premature. The country was too unsettled to attract private capital into such a stupendous undertaking. It was not until the National Government lent its aid that a trans-continental line was finally built.

NOTES.

[1]*Vide* my paper on "Land Grants to Railroads in Texas," Appendix D, p. 92.
[2]Act of February 11, 1850, "Laws of Texas," Vol. 3, p. 632.
[3]The action of the company in beginning at Houston was ratified by the Act of February 7, 1853, *Ibid*, Vol. 3, p. 1390.
[4]Donaldson, *Loc. cit.* pp. 121, 122.
[5]*Vide* my paper on "Land Grants to Railroads in Texas," pp. 49, 50.
[6]*Ibid*, Appendix D., p. 32.
[7]"The subject of a railroad to the Pacific Ocean is one that is now engrossing the attention of every part of our widely spread Union. To none is its location fraught with more important consequences than to our State, and I therefore again briefly but most earnestly recommend it to your serious consideration" —Message to the Fifth Legislature in the Journal of the House of Representatives, p. 15, *et. seq.*
[8]Act of December 21, 1853, "Laws of Texas," Vol. 4, p. 7.
[9]Governor Pease's Veto Message of the Act to amend the Charter of the Texas Western Railroad, July 7, 1856, In the Journal of the Senate of the State of Texas, Sixth Legislature, Adjourned Session, Austin, 1856, pp. 15-18.
[10]Governor Pease's Message to the Sixth Legislature, *Ibid*, p. 8.
[11]Letter of Governor Pease to the Senate Committee on Internal Improvements, Senate Journal, Sixth Legislature, Adjourned Session, Austin, 1856, p. 99.
[12]Debates of the Sixth Legislature in the State Gazette Appendix, Vol. 4, pp. 88-118.
[13]Message of Governor Pease to the Sixth Legislature, 1855, Senate Journal, p. 8, *et seq.*

IV. STATE AID TO RAILROADS.

7. *The First Subsidy.*

To the railroads chartered by the Republic of Texas no encouragement was extended. The Texas Railroad, Navigation & Banking Company and the Galveston & Brazos Company were required to pay for their rights of way across the State, but to the Houston & Brazos Company and the Harrisburg Railroad & Trading Company this right was donated. To the first three railroads chartered by the State no aid was extended. However, their charters were more liberal than the preceding. None of these roads were built.

In the East many States undertook to further the construction of railroads by extending the aid of the commonwealth. New York voted to her railroads something like $8,000,000, $5,000,000 of which was granted to the Erie Railroad. In addition, $30,000,000 was granted by the cities and counties.[1]

Presumably patterning after this policy, Texas passed an act in 1850 permitting the cities and counties along the route to subscribe to the capital stock of the San Antonio Railroad. Under the terms of this measure, $100,000 was subscribed by the city of San Antonio and the county of Bexar, making the first substantial bonus offered to a railroad in Texas.[2]

8. *Land Grants.*

In 1850 Congress granted to Illinois 2,500,000 acres of public domain, to be applied to the construction of the Illinois Central Railroad. By this means, this road was soon completed.

Texas followed the example of Illinois. She had an immense public domain of her own. In this respect she was unique in the sisterhood of States.[3] It is estimated that upon her entrance into the Union, she had 181,965,832 acres of unappropriated land.[4]

Realizing the necessity of aiding the private companies, she donated to the Henderson & Burkville Company in 1852, 5,120 acres of land for every mile of road it constructed. Similar donations were made to fifteen of the twenty-three railroads chartered between this date and January 1, 1856.[6] To the San Antonio Railroad, the La Salle & El Paso, the Buffalo Bayou, Brazos & Colorado, and the Galveston & Red River, all of which were chartered prior to 1852, 5,120 acres were also granted by subsequent acts.[7]

It was soon evident that these subsidies would not be sufficient. In view of this fact, the law of 1854 was passed granting 10,240 acres in alternate sections to the mile to every railroad that should construct twenty-five miles of road within the two succeeding years.

9. *Causes of the Failure.*

These measures did little to relieve the situation. Of the thirty-seven railroads chartered before 1856, twenty were entitled to receive land from the State. Of these twenty, only two were built by 1856. Of the 18,374 miles of railway in operation in the United States at that time, only forty were in operation in Texas.

This disappointing condition of affairs was almost entirely due to the scant settlement. In 1860 the population did not exceed 604,215, or 2.3 to the mile. The metropolis numbered 8,235 people.

Only five cities had over 2,500 inhabitants. One hundred and twelve of the 243 counties of Texas today contained not a single settler.[8]

It will be seen that the business in this State was not sufficient to make railroads paying investments. With opportunities for profit so remote, it was idle to expect capital to be invested in these enterprises.

The limited aid extended by the State thus far was accompanied with one result. The franchises were secured by men without means, who intended to use them not to build railroads, but to speculate with them. These charters were either disposed of to other speculators at a premium, or were used to defraud the people of their money.[9]

Assuming that the promoters were honest in their intentions to build the roads, it is evident that their only available resource was the capital the citizens of Texas could be induced to subscribe. And this was insufficient.

In 1858 the free capital was estimated at $2,745,493.[10] Its extreme paucity is further illustrated by the following incident, which is typical: When the Buffalo, Brazos & Colorado road proposed to extend its line from Richmond to Austin, a subscription was taken by the company from the citizens of Colorado, Fayette, Bastrop and Wharton counties. Only $54,025 was subscribed, and not all of this was collected. This was hardly sufficient to pay for five miles of road.[11] Yet the citizens of these counties were exceedingly anxious for railroad connection with the Gulf, and the Buffalo Bayou, Brazos & Colorado road was one that commanded more confidence than any other company in Texas.[12]

It is evident that any aid extended by the State short of the amount necessary to construct the roads must be accompanied by inevitable failure. If the roads were to be built, more aid was an absolute necessity.

10. *Agitation for State Ownership.*

(*a*) Public Works in Other States.

When the utility of railroads was first fully appreciated, many schemes of internal improvement were set on foot in the United States. Into private enterprises capital could not be lured; but into public enterprises it readily found its way. Internal improvements were possible only at first by using the machinery of the State.[13]

It was in this manner that many of the earlier improvements in the United States were constructed. Thus, the Erie canal was built in New York in the early 20's.[14] The first railroads of Pennsylvania were likewise built at a cost of over $40,000,000. Indiana and Illinois expended $15,000,000 each on similar projects. Michigan undertook State works at first. In Georgia, the Western Railroad, 130 miles in length, cost the people $5,000,000.[15] It was not until the profitableness of works of internal improvement was demonstrated in these States, that private capital sought them.

(*b*) Earlier Proposals for a State System.

There had been since the earliest times a faction in Texas that had contended for public works. In 1842 a railroad convention was held at Houston, and recommended the adoption of the State system.[16]

In 1850 John W. Dancy, who afterwards represented Fayette, Bastrop and Travis Counties in the Sixth Legislature, proposed the following plan: By means of the public domain and $5,000,000 then in the treasury, the State was to construct trunk roads running from Galveston and Matagorda Bays, and intersecting roads running east and west. This system would give direct connection with New Orleans, Vicksburg and Memphis. Slaves were to be used on these roads, and a permanent advantage would thus be gained, thought Mr. Dancy, in opening a new field for slave labor in the South.[17]

The advocates of public works, at first few, increased in numbers as the true state of affairs became apparent.[18] The futility of the attempts to attract private capital was beginning to be appreciated. The failure of the corporations gave force to the arguments. The Mississippi & Pacific fiasco in 1855 drove the lesson home. Says Governor Pease:

"The active capital in the hands of our citizens is insufficient to insure their (railroad) construction. * * * It can not be disguised that the population and business of the State are not such at this time as to promise the return of an immediate profit on the amount that may be invested in such enterprises."[19]

The men who espoused the cause of public works contended that no transportation system could be secured at any time within the near future unless the example of the East was followed, and the machinery of the State was used.

In 1855 and 1856 the agitation for internal improvements became especially violent. Railroads were the chief issue in the gubernatorial election of 1855. More liberal legislation was urged by the public press and public men. Conventions were held in many counties, and recommended liberal aid. In many communities it was warmly urged that the State plan be adopted.[20]

(*c*) Governor Pease's Plan.

Governor Pease was one among the number who came to believe that the capital necessary for the works could best be secured by using the credit of the State. In his message to the Sixth Legislature in 1855 he elaborated a scheme for internal improvements, and recommended its adoption by the State. The essence of this plan was as follows:

A general system of internal improvements, consisting of railroads, river improvements and canals, was to be built by the State with the aid of the public domain. Thirty million dollars of bonds were to be sold, the proceeds of which were to furnish the means for the immediate construction of the works. The interest on the bonds was to be defrayed by the levy of a small internal improvement tax, and the principal was to be redeemed from the proceeds of the sale of the public lands. In order to make the system permanent and to insure its successful completion all of its features—even the particular works to be undertaken—were to be incorporated in the Constitution.[21]

11. *The Loaning System.*

(*a*) History of the Loan Bill.

There were a great many men in Texas, on the other hand, who were bitterly opposed to State works, on the grounds of their costliness. While conceding the necessity for railroads, these men believed that the capital necessary for their construction could best be secured by the adoption of a more liberal policy on the part of the State toward the corporations then in existence.

When Texas was admitted to the Union, she claimed in addition to her present domain all of the territory of New Mexico east of the Rio Grande River and south of the present northern boundary of the State. During the Mexican War General Kearney took possession of this country. The North was opposed to relinquishing this area back to Texas, for fear of extending the slave territory. In satisfaction of her claims to this region, Texas received from the National government $5,000,000.[22] By Act of January 31, 1854, $2,000,000 of this $5,000,000 was set aside for the public schools and designated the Special School Fund.[23]

It was at once suggested that these funds should be applied to the construction of internal improvements. Governor Bell made such a recommendation in 1851, but it was not acted upon at this time. In 1853 Governor Pease recommended the establishment of a board of commissioners to make loans from these funds to the railroads, to aid in their construction.[24] This measure was defeated by the men who favored public ownership.

When the agitation for railroads became violent in 1855, such a measure was again introduced in the Legislature in opposition to the plan of Governor Pease, who had by this time embraced the policy of State ownership, and recommended its adoption by the State. After a tedious debate extending over the greater part of the session, this act was passed over the opposition of those men who favored public works. The agitation for government ownership thus came to naught.

(*b*) Terms of the Act.

According to the terms of the act, all the railroads then in existence were to be loaned $6,000 for each mile of road constructed, after the completion of the first twenty-five miles, and the grading of the second twenty-five miles. The Special School Fund, consisting of $2,000,000, was to be equally divided between the roads on the east and west sides of the Trinity River. The loans were to be made by a Board of School Commissioners, consisting of the Governor, the Comptroller and the Attorney General.[25]

12. *Resume.*

The method of securing railroads adopted by Texas was, therefore, the system of private corporations aided by the State. The aid offered consisted of 10,240 acres of land and a loan of $6,000 to the mile of road constructed. How efficient these measures were in promoting construction we shall learn in another chapter.

NOTES.

[1]Cyclopedia of Political Science, Political Economy and the Political History of the United States, edited by John J. Lalor, Vol. 3, p. 515.

[2]*Vide* my paper on "Land Grants to Railroads in Texas."

[3]Resolution of Congress, approved March, 1845, "Laws of Texas," Vol. 2, p. 1229.

[4]Report of the Commissioner of the General Land Office of the State of Texas upon the Findings of the Special Commission appointed under the Act of March 2, 1899, November 7, 1899, p. 4.

[5]Act of February 10, 1852, "Laws of Texas," Vol. 3, p. 1145.

[6]These were: the Texas Central, the Texas & Louisiana, the New Orleans, Texas & Pacific, the Texas Western, the Vicksburg & El Paso, the Brownsville & Rio Grande, the Galveston, Houston & Henderson, the Indianola & Victoria Plank, the Marshall Railroad, the Memphis, El Paso & Pacific, the Virginia Point & Austin, the Columbia, Wharton & Austin, the Sabine & Sulphur Springs, and the Chambers Terraqueous Transportation.

[7]*Vide* my paper on "Land Grants to Railroads in Texas," pp. 25-28.

[8]Twelfth Decennial Census of the United States.

[9]"If we pursue this course our railroad charters will cease to be offered for sale by individuals who have obtained them for the purposes of speculation. Those who wish to construct railroads will obtain charters without paying a premium to the persons who have induced the Legislature to pass them, and

we shall have no more companies organized without capital to impose upon the credulous and unwary, and stand in the way of those who have the disposition and means to construct railroads."—Message of Governor Pease to the Sixth Legislature, Senate Journal, 1855, p. 8.

[10]Report of the Comptroller of Public Accounts for 1858. The following were the elements of this estimate:

Land	$73,677,316
Town Lots	12,861,990
Negroes	71,912,496
Horses	11,583,247
Cattle	13,259,537
Capital	2,745,493
Miscellaneous	6,347,298
Total	$192,387,377

[11]Texas Almanac for 1859, p. 220.

[12]The condition of affairs is thus admirably summarized by the House Committee on Internal Improvements:

"It may be proper to advert to some of the causes that have hitherto delayed and prevented the construction of railroads in the State notwithstanding the liberal bonus of land. Some years back when most of our charters were granted, eight sections were pledged to the mile constructed. At that time the railroads in the Atlantic States had not approached the banks of the Mississippi or of the Gulf. A railroad to the Pacific Ocean was not regarded as a practicable undertaking, nor had it been ascertained that this work must pass through Texas. Our population was much more sparse and our products much less than now. Our railroads could not connect themselves with any of the great lines of travel connecting with the east web of railroads in the States east of the Mississippi, and it was evident that the freight and passenger travel within our own borders would not be sufficiently profitable to justify the investments of capital. Our lands were believed to be remote from navigable rivers and the low price of land certificates depreciated their value. A grant of sixteen sections per mile by the United States to railroads in the Northwestern States leading from Chicago, St. Louis, and other large market towns and, connecting with the railroads of the Atlantic cities, drew off from our State the attention of all persons disposed to engage in such undertakings; therefore, the hopes of our chartered companies, and citizens generally, were disappointed. At the last session of the Legislature the bonus was increased to sixteen sections, but unfortunately about that period the western nations of Europe engaged in a most expensive war so pressing that no new railroad enterprise could command the attention of capitalists either in the United States, London or Paris, so that another failure has attended the liberal offers of Texas." Journal of the Sixth Legislature of the House of Representatives, Part II, pp. 401-412.

[13]Poor's "Manual of Railroads for 1900," *Loc. cit.*, p. xxv.

[14]Encyclopedic Dictionary of American History, Vol. 1, p. 241.

[15]Cyclopedia of Political Science, Political Economy and the Political History of the United States, Vol. III, p. 49.

[16]Report of the Committee on Internal Improvements, Sixth Legislature, 1856, House Journal, Part II, pp. 401-412.

[17]Debates of the Sixth Legislature, Regular Session, Vol. 1, p. 156.

[18]Message to the Sixth Legislature, Senate Journal, 1855, p. 8, *et seq.* The situation and prospects are thus described: "We have chartered thirty-seven railroad companies and have held out greater inducements for their construction than were ever offered before by any government. It is now nearly four years since a bonus of eight sections of land was offered for each mile of road constructed, and nearly two years since the bonus was increased to sixteen sections a mile for each twenty-five miles. The result of these efforts has been that we have one road of about thirty miles in operation from Harrisburg on Buffalo Bayou to the neighborhood of Richmond on the Brazos River, and two others, the Galveston & Red River Railway, and the Galveston, Houston & Henderson Railroad in the course of construction, with a reasonable prospect, as I am informed, of completing twenty-five miles each by the 30th of January next in time to avail themselves of the bonus of sixteen sections. So far as I

have been able to learn, no other company is doing any work under its charter * * *

"The Buffalo Bayou, Brazos & Colorado Railroad Company will undoubtedly complete its road as far as Richmond during the present year. The Galveston & Red River Railroad Company, and the Galveston, Houston & Henderson Railroad Company expect to complete twenty-five miles of their respective roads by the 30th of January, 1856, so as to secure the bonuses of sixteen sections to the mile.

"These companies will then have to continue their roads at the rate of twenty-five miles a year or lose the benefit of the bonus of sixteen sections. If they fail to do this, the Harrisburg Company and the Henderson Company may still have the benefit of the bonus of eight sections, but the latter to secure even this, will have to construct an additional fifteen miles on or before the 1st of March, 1857, to save its charter.

"The Houston Company has already lost the benefit of the bonus of eight sections by failing to complete ten miles of its road within the time prescribed by its charter. It is possible that some of the other companies may be able to avail themselves of the sixteen section bonus, as only those which terminate on the Gulf coast, the Bays thereof, or on Buffalo Bayou, are subject to the provisions which require the construction of twenty-five miles on or before the 30th of January, 1856, though it is believed that few, if any of them, will ever build road enough to save their charters. It is not generally supposed that either of the three companies named will be able to construct their roads at the rate of twenty-five miles a year after the 30th of January next, so as to secure the sixteen section bonus unless they are assisted by a liberal loan of money from the State. We cannot therefore expect that much progress will be made for many years to come in the construction of railroads in this State by private corporations beyond the completion of these tracks already graded, unless such a loan shall be authorized, or that provision of the act which requires these companies to construct twenty-five miles a year is repealed, for it is generally conceded that they will not at present yield a sufficient profit to induce individuals to invest capital in them without the advantage derived from the land bonus."

[19]Message to the Fifth Legislature, Journal of the House of Representatives of the State of Texas, Austin, 1853, Part II, pp. 22-25.

[20]Report of the Committee on Internal Improvements, House Journal, Fifth Legislature, p. 186.

[21]The details of this plan will be gleaned from the following excerpts from Governor Pease's Message:

"The present is a favorable time to revise our legislation in regard to railroads generally. * * *

"What our citizens need is a general system of internal improvements by railroad, river improvements and canals that will extend its benefits to every section of the State as nearly as practicable, and give them a cheap transportation of their products to market. This I believe can be obtained within the next fifteen years by a judicious use of our public domain, aided by a moderate internal improvement tax, which will never be onerous to our citizens, and for which will be repaid ten fold in the increased value that such a system will give to their property, and the reduced rate at which they will be furnished transportation of their productions and their supplies.

"Our unappropriated public domain is estimated at about 100,000,000 acres. Suppose that one-half of it was valueless or unsuitable for cultivation, which is a large estimate, this will leave us 50,000,000 acres, which at seventy-five cents an acre is worth $37,500,000. This every one must admit is a small estimate of its value, and under a judicious system of sales, to be effected gradually as the wealth and population of the State is increased by the proposed improvements, it would undoubtedly sell for twice or three times that amount within fifteen years. Let us suppose that it would cost six cents an acre, which is a large price, for the gradual survey of these lands as it might be deemed advisable to bring them into market, the cost of surveying the whole hundred millions would be $6,000,000. This would leave $31,500,000 as their net proceeds to be applied to works of internal improvement. As this amount could be realized from them only by gradual sales through a course of years, in order to commence the system immediately, it would be necessary to anticipate their proceeds by the use of the credit of the State, to sustain which an internal improvement tax of fifteen cents on each $100 of the taxable property of the State would be required. Such a tax on the assessment for the year 1857, which is as early as the system could be commenced, would produce * * * $268,000 this would pay an interest of six per cent. on four and one-quarter million dollars. The same tax, allowing the increase in the value of our taxable property to be one-fourth less each year than it has been since the year 1846 (and it would without doubt be much greater), would produce in 1860 the sum of $337,000, which would pay an interest of six per cent. on six and one-quarter million dollars. This will enable us to use the credit of the State to the amount six and one-quarter million dollars before the close of the year 1860, without taking into account the annual earnings of the public works as they progress, which would be at least three per cent. on their cost, equal to one-half of the interest we would be paying on the debt. By that time we would be in receipt of a considerable amount each year from the sale of the public domain, increased in value by the improvements already made, and our works could proceed much more rapidly to completion. In this way we might expend from twenty-five to thirty million dollars upon a general system of internal improvements within the next eighteen years and at the end of that time the whole will have been paid by the proceeds of the sale of our public domain and the internal improvement tax. The State would be the owner of the works constructed and could reduce the price for transportation and travel to such rate as would keep them in repair and pay the expense of operating them, or to such rates, as in addition to the cost of keeping them in repair and operating them, would produce an annual income of three per cent. upon the cost. This income amounting to over $750,000 might be applied to the expenses of the government, or to extend the system until every neighborhood in the State would be furnished with ample railroad facilities. All this may be accomplished and the wealth of our citizens increased hundreds of millions, simply by a prudent use of our public domain and an annual tax of fifteen cents on each $100 of the taxable property of the State for the next fifteen years. The system of works should consist of railroads, improvements upon our navigable rivers and canals connecting the different bays and streams along our coast.

"Sixteen hundred miles of railroad can be so located as to accommodate every section of the State that is now inhabited, and so that no neighborhood (except the northwest corner of the State) that is not within a convenient distance of a navagible course or a canal shall be more than twenty-five miles from a railway.

"The average cost of building and equipping railroads in this State will not exceed $10,000 a mile if paid for with money when the work is done; at this rate sixteen hundred miles would cost $25,600,000. This amount deducted from thirty-one and a half million, the estimated sum to be derived from our public domain in the next fifteen years would leave $5,900,000, which could be applied to the improvement of our navigable rivers, cutting canals to connect all the bays and water courses along our coast from the Sabine and Rio Grande, and to any other object of public utility.

"This system to be successful must be made the permanent policy of the State and incorporated into our Constitution so as to be placed beyond reach of change by Legislation.

"The routes over which railroads are to be constructed, the rivers whose navigation is to be improved, and the canals which are to be cut, must be specified —the lands must be set apart as an internal improvement fund—the time and manner of their survey and sale must be fixed—the internal improvement tax must be levied—provision must be made that the credit of the State shall never be used to an amount beyond what the internal improvement tax and the net earnings of the public works will pay the interest of—and that the works specified shall all be carried on simultaneously until their final completion—all this must be done by constitutional provision—otherwise it is possible that future Legislatures may undertake other works before those designated shall have been completed, or may become impatient with the progress of the works and endeavor to hasten their completion by an increase of taxation, so as to make it oppressive, or by the use of the State credit beyond the means provided for sustaining it, and thereby defeat the whole system.

"Under this system, the improvements will progress towards completion simultaneously with the increase of population and the wealth of the State. Each mile of improvement will increase the value of the public lands and of individual property, and the ability of the State to prosecute the system will increase in the same ratio. * * * No system of internal improvements should be undertaken requiring an expenditure of money by the State, which would have to be supplied by taxation, until it has first been submitted to and received the sanction of the people. * * *.

"Should these views be acceptable to you, I shall interpose no obstacles to such constitutional measures as you may adopt to aid in the construction of railroads and in the improvement of our navigable rivers, if they shall seem likely to effect those objects * * *." Journal of the Senate of the State of Texas, Sixth Legislature, Austin, 1855, pp. 18-31.

[22]Robert's "The Political, Legislative and Judicial History of Texas for its Fifty Years of Statehood, 1845-1895," in Scarff's "A Comprehensive History of Texas," Vol. 2, pp. 21-29.

[23]"Laws of Texas," Vol. 3, p. 1461.

[24]Senate Journal, Fourth Legislature, Austin, 1851, pp. 31-33.

[25]House Journal, Fifth Legislature, Austin, 1853, Part II, pp. 22-25.

[26]"Laws of Texas," Vol. 4, p. 449.

V. RAILROAD REGULATION.

13. *Railroad Abuses.*

Though the agitation for public works and the abolition of private corporations failed, it was at least accompanied with some important results. The first attempts at railroad regulation, and the correction of railroad abuses came as a result of this agitation, and it cannot be said that the cause of railroads was not benefited thereby. The abuses to which reference is had were not unlike some that prevail today—abuses which the experience and legislation of three-quarters of a century is apparently powerless to check. A fair sample of some of these is the following:

When the Mississippi & Pacific contract was signed, it was agreed between the contractors and the Atlantic & Pacific Company that they were to be paid $200,000—to be later increased to $600,000—in Atlantic & Pacific stock. It was claimed by Mr. Lawhon that $20,000,000 of stock would have to be issued under this arrangement in order to net the $600,000. And upon this fictitious value the people were to pay dividends in the form of exorbitant tariff and passenger rates.[1]

The Buffalo Bayou, Brazos & Colorado Company was guilty of similar manipulations. After expending the money paid in the form of stock, the company resorted to borrowing. Ten per cent bonds were issued, $66,000 of which were sold at thirty to sixty cents on the dollar. The road when completed to the Colorado cost $1,040,793.[2] One-half the sum nominally expended should have been sufficient to complete the work. In order to make dividends on the stock, and to pay interest on the bonds, rates had to be levied two or three times higher than they normally should have been.[3]

The San Antonio & Mexican Gulf Railroad solicited subscriptions to its capital stock on an estimated cost of $14,000 to the mile. The contract was let at a cost of $27,000 to the mile. This exorbitant cost was due to the fact that the contractors agreed to take the bonds of the company in payment. The difference of $13,000 represented the discount at which the bonds had to be negotiated. Here again the people paid the difference. The produce of the country had to be taxed sufficient to pay the interest and principal on bonds which represented largely a fictitious value.[4]

14. *Governor Bell's Administration.*

The pernicious character of these abuses was recognized as early as 1853, for in that year Governor Bell writes in his message to the Legislature:

"Already some twenty or more charters have been granted by the State government for railroad purposes, and so far as I am advised, with few exceptions, * * * they have been unattended with the practical results anticipated, notwithstanding the liberal inducements offered. * * * Consideration of these facts has convinced me that in our zeal for internal improvements we have heretofore granted railroad charters indiscriminately. * * *

"I therefore recommend that no railroad shall be incorporated, except such as are clearly of primary importance to an extensive section of the State, and which would give the safest guarantee of its ability to comply with the terms of its charter."[5]

These recommendations were incorporated into a law in 1853—the first general law passed by Texas seeking to regulate railroads. This act contained the germs of all the future legislation on the subject of railroad regulation. Annual reports were required of the companies, giving detailed information as regards the operations of the roads. The Legislature reserved the right to fix a schedule of freight and passenger charges once in every ten years. No reduction of rates was to be made, however, unless the net profits for the preceding ten years had exceeded twelve per cent on the investment. Another provision having in view the absolute control of the companies, gave authority to the Legislature to acquire any railroad property at any time by paying the cost of the road, plus twelve per cent.

15. *Governor Pease's Administration.*

Governor Pease did not consider these measures comprehensive enough. He wished to make it impossible for companies to secure charters for speculative purposes, and he desired to protect the honest citizen and the State from imposition and loss. In his first message to the Fifth Legislature he recommended a course of action in regard to charters already granted, as follows:

"I * * * recommend that no extension of time shall be granted to any company unless satisfactory evidence is presented that it has actually commenced the construction of its road and that a sufficient amount of stock has been paid to * * * (insure) that the road will be completed. * * * The route and termination of the road * * * (should) be designated when this has not been done in the original charter, and if any further donations of land are made to such companies they should receive the patents only on the final completion of their road."[6]

No action was taken on these recommendations. However, in amendments to the charters of the San Antonio & Mexican Gulf and the Buffalo Bayou, Brazos & Colorado Railroads the privilege of building branches was rescinded.[7] Governor Pease in his message to the Sixth Legislature, advocating the State system, reiterated the recommendations of his first message, and urged the adoption of the necessary regulations in case the corporate system was continued. He failed in his attempt to establish the system of public works, but he determined to engraft these regulations in the charters of the companies. In this purpose he was successful.[8]

In December, 1855, the Galveston, Houston & Henderson Company applied to the Legislature for an extension of time. When the bill came up in the House an amendment was offered, reserving the right for the State to buy in this road at any time by paying to the company an amount equivalent to the value of the road plus ten per cent. It was held by the supporters of this amendment that the provision in the general law requiring the *cost* of the road to be paid to the company, instead of its value, destroyed the possibility of exercising control, since the road would be unprofitable to buy. They insisted, therefore, on its alteration. The relief was extended to this company, but no such right on the part of the State was asserted.[9] The company was required to keep its principal office in the State, to hold all elections, and to have a majority of the directors reside in Texas.[10] Similar terms were imposed on the Galveston & Red River Company and the Memphis, El Paso & Pacific Company when they applied for relief. Branching privileges were denied all three.

A bill granting relief to the Texas Western Railroad passed the Legislature at this time, but was vetoed by the Governor because it did not impose these conditions. This corporation was powerful enough to lobby this measure through at the adjourned session over the Governor's veto, and this company escaped without the onus of these restrictions. Branching privileges were denied, however.[12] The Henderson & Burkville Company likewise secured relief in spite of the Governor's veto.[13]

Six new companies were chartered by the Legislature during the year 1856, and the charters of all of these, with the exception of the Houston Tap road, contained these provisions. The Trinity Valley charter was vetoed by the Governor because it did not impose the new regulations. The franchise was not granted until 1860, by which time the observance of these conditions had become compulsory by general law.[14] The Jefferson & Dangerfield charter experienced similar vicissitudes, but never became a law.

In his retiring message to the Seventh Legislature, Governor Pease again deprecated the prevalence of loose methods in railway legislation, and urged the necessity of uniformity in granting charters.[15]

The people of the State had by this time become convinced of the soundness of his views, and showed less disposition to distrust his motives. Their representatives responded to the suggestions, and inaugurated uniformity by the passage of a general law. This was a supplementary act to the general regulating act of 1853. The termini of the routes were required to be designated, the principal office was required to be kept along the road, and the chief officers and directors were required to reside in Texas.[16]

The importance of these enactments, though little understood at that time, is thoroughly appreciated at this day. These laws doubtless protected the State from many evils from which it stood in need of protection. Though often violated in after years, they still exerted a wholesome influence on the railroad development. In them we must seek for the beginnings of our Railroad Commission and our salutary Stock and Bond law.

NOTES.

[1]Debates of the Sixth Legislature, Regular Session, Vol. 1, p. 177.

[2]Report of the Buffalo Bayou, Brazos & Colorado Railroad to the Comptroller for 1860.

[3]Debates of the Sixth Legislature, Regular Session, Vol. 1, p. 178.

[4]*Ibid*, Vol. 1, p. 178.

[5]Journal of the House of Representatives, Fourth Legislature, Austin, 1853, p. 15 *et seq.*

[6]Journal of the House of Representatives, Fifth Legislature, Austin, 1853, Part II, pp. 22-25.

[7]Acts of February 13, 1854 and February 4, 1864, "Laws of Texas," Vol. 4, p. 142 and 70.

[8]"No new charters should be granted over a route where a road is already being constructed, or near such route as materially to impair its value.

"Every railroad company should be required to hold all meetings for the election of its officers within the State, and have a majority of its directors resident citizens thereof, and also to keep its principal office for the management of its affairs within the State. * * *

"I am unwilling that any new charters shall be granted to individuals for their own benefit. If new charters are necessary, let such routes be selected as the wants and business of the country require, designate their points of commencement and termination, and grant charters to commissioners who shall be required to open books for the subscription of stock after giving public notice. No subscription should be received unless five per cent. thereof is paid at the time of subscribing, and whenever the percentage on the capital stock subscribed shall amount to $100; let the commissioners be authorized to call a meeting of the subscribers and hold an election for officers, after which the subscribers should become a corporation with all such powers as are set forth in the charter. The commissioners should have no right under the charter except as trustees for the benefit of the subscribers."—Journal of the Senate, Sixth Legislature, Austin, 1855, p. 18 *et seq.*

[9]Debates of the Sixth Legislature, Regular Session, Vol. 1, pp. 176-178.

[10]Act of July 24, 1856, "Laws of Texas," Vol. 4, p. 569.

[11]Acts of January 23, 1856, and February 4, 1856, *Ibid*, Vol. 4, p. 326, 328, 378.

[12]Act of August 16, 1856, *Ibid*, Vol. 4, p. 622.

[13]Act of January 24, 1856, *Ibid*, Vol. 4, p. 336.

[14]Senate Journal, Sixth Legislature, Austin, 1856, pp. 11, 12.

[15]*Vide* Journal of the House of Representatives, Tenth Legislature, Austin, 1857, pp. 38-41.

[16]Act of December 17, 1857, "Laws of Texas," Vol. 4, p. 987.

VI. RAILROAD PROGRESS, 1856-1860.

16. *Introductory.*

The progress of railroads in Texas has been traced down to 1856. Only two lines had then been constructed, aggregating forty miles. These were the Buffalo Bayou, Brazos & Colorado, and the Galveston & Red River Railroads. I purpose now to indicate the progress of railroads down to 1860, or the beginning of the Civil War.

17. *Buffalo Bayou, Brazos & Colorado Railroad.*

By 1856 the Buffalo Bayou, Brazos & Colorado Railroad had reached Richmond on the Brazos, a distance of thirty-two miles from its starting point. While the earnings of this section were much greater than those of the short section of twenty miles, still these were insufficient to make the road profitable. The country along the Colorado valley, on which its future mainly depended, would not continue to seek an outlet by it, unless it was quickly extended to this river.

The passage of the Loan Act in 1856 induced the company to undertake this extension. The route was surveyed and located to a point near Columbus on the Colorado River, forty-eight miles from Richmond. By December 8, 1857, twenty-seven miles had been graded under contract with Cooper & Company. Work under this contract then ceased on account of a lack of funds. A new contract was entered into with H. K. White & Company, and the work was resumed on the 1st of June of the following year. The road was completed and opened for business to East Bernard, fifty miles from Harrisburg, about April 1, 1859, and to Eagle Lake, sixty-eight miles from the starting point, by October 6, 1859. Seventy miles were completed soon after. Work on the road to the point near Columbus, eighty and one-half miles from Harrisburg, was in progress in 1860. The grading was completed, and the seventy-fifth mile finished on May 23rd. The inception of hostilities put a stop to further progress.

These seventy-five miles of road, completed before the Civil War, were built by the following means:

The amount realized from the issuance of capital stock was $311,702. The citizens of Colorado, Fayette, Bastrop, Travis and Wharton Counties donated $24,047.25. 718,080 acres of land were received from the State under the various land donation acts. Of these, 141,160 had been located and patented. 588,800 acres were disposed of, netting to the company $106,810.37, or about five and a half cents an acre.

The loans received from the school fund, under the terms of the acts of 1856 and 1858 amounted to $420,000.[1] $232,095.76 was secured from parties in Boston for which bonds were issued. In addition $215,208.89 was received by the company in the form of supplies, equipment, etc., for the payment of which notes were given.[2]

These amounts aggregated $1,209,846.27.[3]

18. *Houston & Texas Central Railroad.*

The beginnings of the Galveston & Red River Railroad have already been described. Nothing much was accomplished during the year 1853 owing to the sore financial straits of the company.

In 1855 a contract was closed for the construction of twenty-five miles of road. After many delays, and after the granting of an extension of time by the Legislature, this section was completed in 1856, and trains were then run to Cypress City daily.

With the permission of the Legislature, the company assumed the name of the Houston & Texas Central Railway Company.

In order to receive a loan from the school fund a contract was let for the completion of the second section. This was finished to Hempstead, a distance of fifty miles from Houston, in January, 1858. During the year 1859 work on the road progressed steadily. By October 1st of that year, seventy-five miles were in operation. In 1860 the line was completed to Millican, eighty miles from Houston. Construction was then supended on account of the war.

This company had great difficulty in securing funds with which to prosecute construction. In 1854 Paul Bremond, who had succeeded

Ebenezer Allen to the presidency, visited the Eastern States and Europe for the purpose of securing capital to carry on the enterprise. In this mission he was unsuccessful. After the first section of the road was built, some northern capitalists were induced to buy stock.

The amount realized by the company on the sale of stock was $778,675.00.[5] 512,000 acres of land were received from the State, but up to June 1, 1860, no money had been realized from its sale. $450,000 was received in the shape of loans from the school fund. In addition to the above the company owed $125,000 in the form of seven per cent. bonds, which had been created in favor of J. H. Wells & Company to replace an original mortgage of $1,000,000; and in the form of bills payable, $224,430.[6]

These sums aggregated $1,578,105.[7]

19. *Galveston, Houston & Henderson Railroad.*

The Galveston, Houston & Henderson Railway was chartered in 1853 to connect the cities designated in its name.[8] It was begun at Virginia Point, on the northern shore of Galveston Bay on March 1, 1854. The first section of twenty-five miles was completed in 1858. The charter required the construction of forty miles by the 1st of November of this year. This the company failed to do, and the franchise was in consequence forfeited. It was revived by the Legislature on the condition that the forty miles be finished by the 1st of November, 1859. The terms of this condition were complied with. In this same year a bridge was built over Galveston Bay by the city of Galveston, and donated to the company. A junction was effected with the Houston & Texas Central at Houston, and the line was opened between Galveston and Houston in 1860.

The only aid received by this company was the bridge across Galveston Bay. The city of Galveston issued bonds with which to construct this bridge, and permitted the company to use it. The corporation agreed to pay the interest on the bonds as it became due, and the principal at maturity. When these obligations were discharged, the bridge became the property of the company.

The amount received in the form of subscriptions to capital stock was $32,363.29. The indebtedness of the company at the time of the opening of the line was $387,969.24.[9]

20. *San Antonio & Mexican Gulf Railroad.*

The San Antonio & Mexican Gulf Railroad Company was chartered in 1850 to connect San Antonio with the Gulf.[10] In the spring of the year 1852 a survey of the road was made, and in

1853 it was put under contract. But the company lacking financial means was unable to make any progress. For two or three years it held out proposals to the little towns along the coast offering to start the road at the town making the largest donation. Inspired by the hope of a loan from the school fund, the company was reorganized in 1856, and a new charter was secured from the Legislature.[11]

A new contract was let for the building of the forty-five miles of road between Powder Horn and Victoria with a branch to Lavaca. Operations were soon suspended, however, on account of a lack of funds. In 1859 the road was sold to meet the liabilities incurred for iron and material used in construction. A new company was now organized to build a road between Lavaca and Victoria, the plan of extending to San Antonio being abandoned. By 1860 the road was graded between Lavaca and Victoria, and five and a half miles were put in running order.

This company had great difficulty in securing funds with which to carry on its work, as will be apparent from the foregoing recital. Two or three attempts were made to enlist the services of foreign capital, but these proved unsuccessful.

$320,000 was subscribed in the form of capital stock, $100,000 of which was subscribed by the city of San Antonio and Bexar County. It is interesting to note in this connection, however, that San Antonio never received any benefit from this subsidy, because the road never reached there. $47,470.00 of this capital stock was paid in the form of land. 64,000 acres of land were received from the State, but no money thus far been realized from sales.

The total available resources of the company, therefore, which had furnished the means of completing the five and a half miles of road was its capital stock of $320,000.[12]

21. *Houston Tap Railroad.*

While the Legislature had under consideration the Buffalo Bayou, Brazos & Colorado charter, the representatives from Houston would not give their support to the measure until an amendment had been inserted giving to Houston the privilege of tapping the road.[13] The steady progress westward of the Buffalo Bayou, Brazos & Colorado Company induced Houston to make an attempt to compete for the trade of the Colorado country by offering railroad connection with this city.

A charter for a tap road was secured by the corporation of Houston in 1856.[14] The city was authorized to levy a tax of one per cent. by consent of a majority of its voters. Bonds were authorized to be sold, the proceeds of which were to be used to construct the road. Under this authority the tax was voted almost unanimously, and the road was built during the year 1856.[15] It was sold to the Houston Tap & Brazoria Company in 1859 for $172,000, $130,000 of which was paid in the stock of the purchasing company, and $42,000 of which was paid in cash out of the loan from the State.[16]

22. *Southern Pacific Railroad.*

The early history of the Texas Western Railroad has already been touched upon in connection with the Mississippi & Pacific road. It was there stated that the sale of the charter was forced upon the Atlantic & Pacific Company by virtue of the Texas Western Company's preemption of the most available route. Failing to carry out its contract with the State, the Atlantic & Pacific Company reorganized under the Texas Western charter at Montgomery, Alabama, in 1854, and used this franchise in preventing any other corporation from building the Mississippi & Pacific road.

In 1856 the charter was amended, and the name of the company was changed to the Southern Pacific.[17] In this year work was begun on a branch line to Caddo Lake north of Marshall. Over this branch the track material for the main line was brought. By February 10, 1858, twenty miles were completed. Seven and one-half miles were added during the following year, and this marked the extent of the work done before the Civil War.

This company led a checkered existence. A few statements depicting its financial history will explain the slow progress made in railroad construction in Texas before the Civil War.

It issued over $14,000,000 in stock. The following were some of the purposes for which these enormous fictitious values were created:

The Sussex Iron Company of New Jersey was bought for $6,000,000 of the Texas Western stock, worth about $300,000. The Texas Western Company also transferred to Dr. Jeptha Fowlkes $8,000,000 of stock for bonds payable in one, two, three, four and five years, and secured by mortgages on swamp lands in Arkansas at the rate of five dollars an acre. Mr. Edwin Post entered into a contract with the Executive Committee by which he was permitted to subscribe for $2,000,000 of stock at any time. In April, 1857, the limit of stock sales was fixed at $12,000,000, although some $14,000,000 had already been issued. Mr. Post was paid 13,333 shares, worth about $66,666.66 to cancel his contract. Many other transactions on a smaller scale might be enumerated to illustrate this pernicious practice of issuing stock without obtaining anything of value in payment of it.

The amount of money actually expended in Texas did not exceed over $391,925.98. This seems to have been derived from the following sources:

The amount collected from stock sales did not exceed $27,000. The following record of loans is available:

King, Todd & Archer	$ 4,000 00
R. J. Walker	500 00
Stillman, Allen & Co., about	20,000 00
Parties in Marshall	10,000 00
Total	$34,500 00

The balance of the amount expended seems to have been derived from donations by the citizens of Texas.

By 1858 the company had become so burdened with debt, that it was sold out by the creditors under a deed of trust.[18] It was purchased for $40,000 in cash by Dr. Sanders of Marshall, and was in turn sold by him to the creditors. These parties effected a reorganization. They were soon involved in a controversy with the members of the old company who claimed that the sale was illegal.[19] Suit was brought by them against the new organization. At this juncture the State filed a suit for a forfeiture of charter because of the failure of the company to remove its general office to Texas and to file its annual report with the Comptroller.[20]

In September, 1860, another sale of the company took place. This sale freed it from encumbrances. All the difficulties were adjusted, and the original stockholders were again taken back into the company. The State suit against it was dismissed, and the troubles of the Southern Pacific Company were over for the time being.[21]

23. *Memphis, El Paso & Pacific Railroad.*

Another of the companies called into existence by the agitation for a southern trans-continental line was the Memphis, El Paso & Pacific, chartered in 1853.[22] It was the intention of this company to unite with the Texas Western at some point in the interior. While the Texas Western road would thus afford connection with the Mississippi at Vicksburg and New Orleans, the Memphis, El Paso & Pacific would afford connection with the Mississippi at Memphis and Cairo.

The efforts to secure funds at this time proved unsuccessful, and after a number of extensions of time had been granted, the charter was finally forfeited.

In 1856 a new charter was secured. Eight miles of public land on each side of the right of way was reserved in which the company could locate the sections of land it was entitled to under the act of 1854. This was the most liberal charter thus far granted by the State of Texas.

Work was begun in 1857 near Texarkana. Forty-seven miles were graded and made ready for the reception of iron. Engines and cars were purchased and delivered to the company by Red River steamers landing at Moore's Ferry on Sulphur Fork. A great overflow in Red River occurring about this time, added over a mile of timber to the raft then existing, and prevented further delivery of material. A branch road was therefore undertaken from Moore's landing to Jefferson, which would remove this difficulty. Five miles of this branch were completed before the War.[23]

The amount of money received from the sale of stock was $70,707.09. The only aid received from the State was certificates for 262,400 acres of land. 191,680 of these were alienated by 1861. In this connection it is interesting to note that the president's salary, amounting to $3000 a year, was paid in land certificates from May 9, 1856, to May 9, 1860.[24]

24. *Washington County Railroad.*

When a relief bill for the Galveston & Red River Railroad came before the Legislature in 1856, the branching privileges were restricted until the road reached Red River. This was fatal to the hopes of the citizens of Washington County, who had subscribed stock in the expectation that this company would build a branch from its main line through Washington County to Austin.[25]

Nothing daunted by this awkward legislative enactment, the planters of Washington County, who had amassed considerable wealth, determined to build a road of their own to connect their city of Brenham with Galveston direct.

A charter was applied for, and was secured on February 2, 1856. This charter created the Washington County Railroad. Work was commenced in July, 1857, at Hempstead on the Houston & Texas Central Railroad, and completed to Chappell Hill, a distance of eleven and a half miles, on May 1, 1859. The road progressed steadily during the succeeding years, and so fixed was the determination of these people that the section to Brenham was completed after the breaking out of hostilities.

The capital stock subscribed was $270,000, of which $160,000 was paid in. All of this was bought by the citizens of Washington County. The Loan Act authorized loans to be made only to the companies chartered previous to its passage. This excluded of course the road under consideration. By special act it was authorized to receive a loan.[26] Under this authority $66,000 was received. 112,640 acres of land were received, 100,000 of which were located in Harris, Liberty and adjoining counties. 12,160 of these acres were sold during the year 1860.[27] The indebtedness in 1860 was $160,000.

25. *Houston Tap & Brazoria Railroad.*

The Houston Tap & Brazoria Railroad was chartered in 1856 for the purpose of extending the Houston Tap road to Columbia on the Brazos River, thus opening up the great sugar producing section of the State. The grading was finished to Columbia in 1859, and the road was completed to that place in 1861. The city of Houston transferred to the company the Houston Tap road, as remarked in a previous place. Work on the western division between Columbia and Wharton was in progress in 1860 and 1861, but the outbreak of the war prevented its completion.[28]

The amount of capital stock subscribed was $380,000, nearly all of which was paid. This was almost entirely subscribed by the planters along the route. The county of Brazoria by authority of the Legislature donated to the company $100,000 in bonds. The company was extended permission to receive loans from the school fund,[29] and it received aid from this source to the extent of $300,000.[30] In addition it received from the State 64,000 acres of land, 35,840 of which were disposed of during the year 1860, yielding to the company $11,350.00. The indebtedness in 1860 was $411,560.01.[31] These sums aggregated $1,202,910.01. The cost of the road was about $10,000 a mile.

26. *Texas & New Orleans Railroad.*

New Orleans desired to compete with Memphis, Chicago and St. Louis for the trade of Texas. To accomplish this, the Texas & New Orleans Railroad between New Orleans and Houston was projected. This road was chartered under the name of the Sabine & Galveston Bay Railroad & Lumber Company on September 1, 1856.[32] At the same time a charter was granted by the State of Louisiana to the New Orleans & Opelousas Railroad to connect Berwicks Bay with the eastern terminus of the Sabine & Galveston Bay road at Orange.

Work was begun in the spring of 1858. During this year the line was partially graded between Houston and Liberty. In 1859 the name of the company was changed to the Texas & New Orleans.[33] By the 1st of August, 1860, the road was completed between Orange and Liberty, a distance of sixty-six miles.

During the year 1860 four loans were received from the school fund aggregating $430,500.[34] The cost of the road was about $30,000 a mile.

27. *Indianola Railroad.*

The spirit of rivalry for the trade of the interior which made Houston and Galveston such bitter enemies, had its counterpart in the enmity between Lavaca and Indianola. When the San Antonio & Mexican Gulf Railroad was chartered with its terminus at Port Lavaca, the citizens of Indianola undertook the construction of the Indianola Railroad. The company was chartered in 1858, to construct a road from Powder Horn Bayou to Austin. By act of 1860 the company was required to connect with the San Antonio & Mexican Gulf road within a year, and was authorized to sell to this company the roadbed then graded. The war put a stop to further operations.

The report of the Indianola Railroad to the Comptroller for the year 1860, showed $28,485 paid on its capital stock.

28. *Mexican Gulf & Henderson Railroad.*

In 1852 the Henderson & Burkville Railroad was chartered to connect Henderson in Rusk County with Burkville in Newton County.[36] This charter was amended in 1854 so as to allow the company to begin on the coast.[37] In 1856 its name was changed to the Mexican Gulf & Henderson Railroad.[38]

Work was begun in the spring of 1857 at Pine Island Bayou, eight miles north of Beaumont. The timber was cleared away and the roadbed grubbed for several miles. These operations were soon suspended. When the Eastern Texas Railroad was chartered it was required to pay $3000 to Ferguson, Alexander & Company for the work that had been done—a sad but typical commentary on the financial ability of these pioneer railway companies.

29. *Eastern Texas Railroad.*

The Mexican Gulf & Henderson Company was succeeded by the Eastern Texas Company. This road was chartered in 1858 to run from Sabine Pass to the northern counties of the State.[39] Fifty thousand dollars was required to be deposited by the company with the State Treasurer before any rights vested under the charter.

This sum was to be returned when twenty-five miles of the road were completed.

Grading was commenced some fifteen or twenty miles south of Beaumont with the purpose of making Sabine Pass the terminus. The road between these two places was completed in 1861. The $50,-000 deposit was never made.

30. *Aransas Railway.*

The Aransas Railroad was another fiasco of the times. The company was chartered in 1852 for the purpose of constructing turnpikes from Aransas Bay to Goliad.[40] In 1858 it was changed from a turnpike to a railroad company.[41]

The idea was soon conceived of turning this pigmy road into a trans-continental line. The company allied itself with a corporation organized in Washington City, and acting under a franchise from the Supreme Government of Mexico, the Washington company purposed to extend the Aransas road through Mexico to the Pacific Ocean. This constituted the so-called Central Transit Railroad.

How much of this magnificent scheme was realized? In 1858 a roadbed was opened across Live Oak peninsula near Aransas. In 1859 the grading across the shallow water separating the main land from deep water of Aransas Bay was completed; and these six or seven miles of embankment was all that ever materialized of the great Central Transit Railroad.

NOTES.

[1]Act of January 22, 1858, "Laws of Texas," Vol. 4, p. 529. This act amended the act of 1856 so as to allow companies to receive loans on the five miles of road after the completion of the first twenty-five miles.

[2]Published statements to the stockholders of the Buffalo Bayou, Brazos & Colorado Railroad on the condition of the company for the years 1858 and 1860. The entire equipment of the company consisted on the 1st of April, 1860, of six locomotives, three first-class passenger cars, two second-class passenger cars, mail and baggage cars, sixty-one platform and twenty box freight cars, and ten hand and rubble cars.

[3]The general account stood on April 1, 1860, as follows:

Construction accounts including profit and loss	$932,360 05	
Interest	132,699 25	
Expense	286,950 61	
Equipment	102,831 75	
Suspense account	3,456 43	$1,458,298 12
Land of Harrisburg	$151,014 60	
Land near Columbus, 1380 acres post oak	3,124 83	154,139 43
Due from sundry parties in suspense		5,556 45
Sundry balances, assets		12,602 48
		$1,630,596 48

Capital Stock		310,495 00
Subscription on extension, showing amount paid in in addition to $7,600 for which stock was issued	$31,647 25	
Subscriptions old from subscriptions in default	1,207 50	
		32,854 75
Land scrip, net amount of sales		106,810 37
Receipts—earnings of road to June 1, 1859	$192,354 32	
Receipts—earnings of road from June 1, 1859 to April 1, 1860, 10 months	111,510 43	
		303,864 75
Debt.		
State loan on 70 miles	$420,000 00	
Less amount paid into sinking fund	8,400 00	
		$411,600 00
Notes payable		215,208 89
Loans in Boston	235,675 76	
Less notes receivable applicable in payment	3,580 00	
		232,095 76
Sundry balances on suspense		17,666 96
		$1,630,596 48

[4]Act of September 1, 1856, "Laws of Texas," Vol. 4, p. 806.

[5]Report of the Houston & Texas Central Railway in the Texas Almanac for 1861, p. 234.

[6]Fourth Annual Report of the President and Directors of the Houston & Texas Central Railway Company to the Stockholders, 1857, p. 10.

[7]The account of the company stood on June 1, 1860, as follows:

Stock subscribed to June 1, 1860:	
Stock issued and fully paid	$ 458,200 00
Stock paid, but not issued	320,475 00
Due for stock in bills receivable	264,124 00
Total	$1,042,800 00
Construction account, buildings at Courtney and Navasota stations, platforms since last	$19,514 00
Right of way	187 51
Land from the State	1,608 00
Three locomotives	30,000 00
Cars and material for cars	14,815 00
Amount of bonds to the State of Texas	450,000 00
Amount of bonds, second mortgage	125,000 00
Amount construction	400,000 00
Amount bills payable	224,430 00
Due to the company over and above debts due by the company	44,562 00
Freight receipts from September 1, 1859, to June 1, 1860	198,809 00
Passenger	66,844 00
Mail	44,497 00
Repairs of all kinds	58,666 00
Buildings and platforms	14,289 00
————	30,000 00
Salaries	10,866 00
Transportation expenses	31,890 00
Wood including stock on hand	3,013 00
Total	$1,728,990 51

[8]Act of February 7, 1853, "Laws of Texas," Vol. 3, p. 1410.

[9]Report of the Galveston, Houston & Henderson Railroad Company to the Comptroller, 1860.

[10]Act of September 5, 1850, "Laws of Texas," Vol. 3, p. 814.

[11]Act of February 20, 1856, *Ibid,* Vol. 4, p. 414.

[12]The data for this history have been taken from "A Letter on the Condition and Prospects of the San Antonio & Mexican Gulf Railroad Company," dated New York, December 12, 1856, by William J. Clark, its President, to Messrs. George S. Waters, and Samuel J. Beals, New York; an "Exhibit of the San Antonio & Mexican Gulf Railroad," published in New York, 1860; and a "Letter of Messrs. Paschal, French and Wheeler to Messrs. Brassey, Wise, Napier, Simpson and Robinson," published at Austin, 1860.

[13]Debates of the Sixth Legislature, Regular Session, Vol. 1, p. 191.

[14]"Laws of Texas," Vol. 4, p. 329.

[15]Texas Almanac for 1858, p. 124.

[16]Second Annual Report of the President and Directors of the Houston Tap & Brazoria Railroad, Houston, 1859, p. 4.

[17]Act of August 16, 1856, "Laws of Texas," Vol. 4, p. 622.

[18]Report of the Committee of the Southern Pacific Railroad on the Present Condition of the Company and its Causes, Marshall, 1858, pp. 2-5.

[19]Report of Mr. Post to the Stockholders of the Southern Pacific Railroad, June 8, 1858, p. 3.

[20]Texas Almanac for 1859, p. 222.

[21]*Ibid,* 1860, p. 330.

[22]Act of February 7, 1853, "Laws of Texas," Vol. 3, p. 1433.

[23]Texas Almanac for 1868, pp. 136, 137.

[24]Report of the Memphis, El Paso & Pacific Railroad Company to the Comptroller for the year 1860.

[25]Debates of the Sixth Legislature, Regular Session, Vol. 1, p. 191.

[26]Act of January 22, 1858, "Laws of Texas," Vol. 4, p. 1255.

[27]Report of the Washington County Railroad to the Comptroller for the year 1859.

[28]Texas Almanac for 1858, p. 129.

[29]Acts of January 17, 1859, "Laws of Texas," Vol. 5, p. 47.

[30]*Vide* my paper on "Land Grants to Railroads in Texas," p. 14.

[31]Texas Almanac for 1851, pp. 231, 232.

[32]"Laws of Texas," Vol. 4, p. 744.

[33]Act of December 24, 1859, *Ibid,* Vol. 5, p. 49.

[34]Texas Almanac for 1869, p. 213.

[35]Act of January 22, 1858, "Laws of Texas," Vol. 4, p. 1232.

[36]Act of February 10, 1852, *Ibid,* Vol. 3, p. 1145.

[37]Act of January 27, 1854, *Ibid,* Vol. 4. p. 32.

[38]Act of January 24, 1856, *Ibid,* Vol. 4, p. 331.

[39]Act of January 21, 1858, *Ibid,* Vol. 4, p. 1181.

[40]Act of February 14, 1852, *Ibid,* Vol. 3, p. ——.

[41]Act of February 16, 1858, *Ibid,* Vol. 4, p. 1328.

VII. CONCLUSION.

This completes the account of Texas railroads before the Civil War. Fifty-one companies were chartered, but only fourteen roads were built. During a period of twenty-four years 284 miles of railway were constructed out of a total of 30,626 in the United States.

This survey should make clear the causes that occasioned these mediocre results. The lesson to be drawn from the narrative is the folly of the attempt to build railroads before a country is ready for them. Capital will not seek them until they are profitable. Limited State aid but serves to attract speculators. A few scattered miles of railroad are built, but the great percentage of chartered mileage is not. The people are defrauded of their scant wealth, and exorbitant issues of stocks and bonds eat up the profits of their produce.

APPENDIX A.

The following table shows by States and groups of States, the mileage of railroads at the close of the decennial periods, 1840, 1850, 1860, 1870.

States and Groups of States.	Length of Railroads—Miles.		
	1840	1850	1860
Maine	13.00	345.00	472.00
New Hampshire	37.30	467.00	661.00
Vermont	....	290.00	554.00
Massachusetts	305.49	1035.00	1264.00
Rhode Island	57.90	68.00	108.00
Connecticut	82.00	402.00	601.00
New England	493.69	2507.00	3660.00
New York	363.35	1361.00	2682.00
New Jersey	197.05	206.00	560.00
Pennsylvania	624.73	1240.00	2598.00
Delaware	39.10	39.00	127.00
Maryland	239.36	259.00	386.00
Middle Atlantic	1463.68	3105.00	6353.00
Ohio	49.00	575.00	2946.00
Michigan	118.90	342.00	779.00
Indiana	....	228.00	2163.00
Illinois	24.00	111.00	2790.00
Wisconsin	....	20.00	905.00
Central Northern	191.90	1276.00	9583.00
Virginia	284.71	481.00	1731.00
West Virginia	....	....	....
North Carolina	91.60	283.00	937.00
South Carolina	204.00	289.00	973.00
Georgia	275.00	643.00	1420.00
Florida	....	21.00	402.00
South Atlantic	1055.31	1717.00	5463.00
Alabama	....	183.00	743.00
Mississippi	46.00	75.00	862.00
Tennessee	....	....	1253.00
Kentucky	29.00	78.00	534.00
Louisiana	26.50	80.00	335.00
Gulf and Missippi Valley	101.50	416.00	3727.00
Missouri	....	....	817.00
Arkansas	....	....	38.00
Texas	....	....	307.00
Kansas	....	....	....
Colorado	....	....	....
Southwestern	....	....	1162.00
Iowa	....	....	....

States and Groupes of States.	Length of Railroads—Miles.		
	1840	1850	1860
Minnesota	....	....	....
Nebraska	....	....	....
Wyoming	....	....	....
Northwestern	....	....	665.00
California	....	....	23.00
Oregon	....	....	....
Nevada	....	....	....
Utah	....	....	....
Pacific	....	....	23.00
Total United States	3106.08	9021.00	30626.00

APPENDIX B.

The following table exhibits the progress made annually in railroad construction in the United States from 1849 to 1860.

Year.	Miles in Operation.	Increase of Mileage.
1849	7,365	1,369
1850	9,021	1,656
1851	10,982	1,961
1852	12,908	1,926
1853	15,360	2,452
1854	16,720	1,360
1855	18,374	1,654
1856	22,016	3,642
1857	24,503	2,487
1858	29,968	2,465
1859	28,789	1,821
1860	30,635	1,846

APPENDIX C.

The following table shows the miles of railway in operation in Texas at the end of each year, and the annual increase down to the Civil War.

End of the Year.	Miles in Operation.	Increase over Previous Year.
1854	32	..
1855	40	8
1856	71	31
1857	157	86
1858	205	48
1859	284	79
1860	307	23

APPENDIX D.

Table of Roads Chartered in Texas between 1836 and 1860.

Date of Charter.	Railroad.	Remarks.
By special Act. 1836		
Dec. 16....	Texas Railroad, Navigation & Banking Company	Charter forfeited.
1838		
May 24 ...	Galveston & Brazos.	Charter forfeited.
1839		
June 26 ...	Houston & Brazos	Charter forfeited.
1841		
Jan. 9	Harrisburg R. R. & Trading Co.	Charter forfeited.
1846		
May 8	Lavaca, Guadalupe & San Saba........	Charter forfeited.
May 11 ...	Colorado & Wilson Creek	Charter forfeited.
1848		
March 11 ..	*Galveston & Red River**	Became H. & T. C.
1850		
Feb. 5	Rio Grande Railway & Turnpike Co....	Charter forfeited.
Feb. 11 ...	*Buffalo Bayou, Brazos & Colorado*......	Became G. H. & S. A.
Feb. 8	Marshall Railway & Plank Road Co....	Charter forfeited.
Feb. 11 ...	LaSalle & El Paso...................	Charter forfeited.
Sep. 5	*San Antonio & Mexican Gulf*.........	Became G. W. T. & P.
Dec. 2	Brazos & Bernard Ry. & Plank Road Co.	Charter forfeited.
1852		
Feb. 10	Henderson & Burkville	Re-chartered in 1856.
Feb. 14	Aransas Railroad Co.	Charter forfeited.
Feb. 14	Texas Central	Charter forfeited.
Feb. 14	Texas & Louisiana	Charter forfeited.
Feb. 16	Brazos & Colorado	Charter forfeited.
Feb. 16	New Orleans, Texas & Pacific	Charter forfeited.
Feb. 16	*Texas Western, or Vicksburg & El Paso*	Became S. P.
Feb. 16	*Vicksburg & El Paso*	Became S. P.
1853		
Feb. 7	Brownsville & Rio Grande	Charter forfeited.
Feb. 7	Colorado Valley	Charter forfeited.
Feb. 7	*Galveston, Houston & Henderson*......	
Feb. 7	Indianola & Victoria Plank	Charter forfeited.
Feb. 7	Marshall Railroad	Charter forfeited.
Feb. 7	*Memphis, El Paso & Pacific*...........	Re-chartered Feb. 4, 1856. Became Sou. Transcon'l.
Feb. 7	Virginia Point & Austin	Charter forfeited.
Dec 21	Mississippi & Pacific	Charter forfeited.
1854		
Jan. 30	Columbia, Wharton & Austin	Charter forfeited.
Feb. 1	Tyler & Dallas	Charter forfeited.
Feb. 2	Jefferson Railroad	Charter forfeited.
Feb. 6	Sabine & Rio Grande	Charter forfeited.
Feb. 8	Gilmer & Sulphur Springs	Charter forfeited.
Feb. 9	Gulf Coast & Austin City	Charter forfeited.
Feb. 10....	*Brazos Branch*	Became Internat'l & Pac.
Feb. 11	Chambers Terraqueous Transportation..	Charter forfeited.
1856		
Jan. 26	Houston Tap	Became H. T. & B.
Feb. 2	*Washington County*	Became H. & T. C.

Date of Charter.	Railroad.	Remarks.
Aug. 16...	*Southern Pacific*	Was Texas Western.
Sept. 1	*Sabine & Galveston Bay*.............	Became T. & N. O.
Sept. 1	Huntsville Railroad	Charter forfeited.
Sept. 1	Powder Horn, Victoria & Gonzales.....	Charter forfeited.
Sept. 1	*Houston & Texas Central*	Was Galveston & Red R.
Sept. 1	Henderson & Logansport	Charter forfeited.
Sept. 1	*Houston Tap & Brazoria*	Became H. & G. N.
1858		
Jan. 21	*Indianola Railroad*	Became G. W. T. & P.
Jan. 21	*Eastern Texas*	
Feb. 16	Opelousas & Texas Western	Charter forfeited.
Feb. 16	*Columbus, San Antonio & Rio Grande*	Became G. H. & S. A.
1859		
Dec. 24	*Texas & New Orleans*	Was Sabine & Gal. Bay.

***Roads italicized were built.**

ON REPRODUCTION, ANIMAL LIFE CYCLES AND THE BIOGRAPHICAL UNIT.[1]

DR. THOS. H. MONTGOMERY, JR.[2]

A. *Reproduction as an act of excretion by the offspring.*

As the term is most broadly used, we mean by race a temporal succession of individuals. The termination of a race is probably not a function of any of its inherent qualities, but rather one of the external conditions in which it is placed, provided its constituent individuals continue their power of reproduction. That is, environmental conditions remaining favorable, and individuals continuing to procreate, a race should last indefinitely.

But individuals do not persist indefinitely, they meet with the dissolution that we know as death, or at least always some portion of them finds this end. The race continues simply because individuals before their death reproduce themselves. There may then be a direct causal connection between death and reproduction; and, as we shall try to show, reproduction takes place because there is death but need not be the cause of it.

Reproduction has been defined as growth beyond the normal mass. But this is not a valid statement, for reproduction is a regular and not an abnormal process and need not embody increase in mass. Mechanically it is the power of multiplication by division. Physiologically it is in part at least the action of the escape of a part from an empoisoned mass, as becomes evident when we compare its different forms.

The Protozoa afford three main kinds of reproduction, and they intergrade: sporulation, budding and fission. The first is that process where the Protozoan after repeated simultaneous or successive nuclear divisions breaks into numerous parts that separate from each other, leaving behind them a residual lifeless mass. Hitherto no particular importance seems to have been ascribed to this residuum, no importance in the nature of a probable cause at least, though it would seem to be demonstrated that a residuum is always left behind in such division. Yet most patently sporulation is the separation of individuals from a part that is inert and moribund. The residuum

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[1]Contributions from the Zoological Laboratory of The University of Texas, No. 82.

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represents a mass of waste products that have resulted from the metabolism of the parent individual, a part that becomes intoxined by the accumulation of excretions. Sporulation is, accordingly, an action of escape of uncontaminated parts from a mass that is empoisoned. Unless there were some such active escape of parts the whole would become poisoned, and the race meet its end. The initial stimulus to sporulation is then probably the effect of this residuum upon the remainder of the substance. We may say that such generation is an act of excretion by the offspring, in this case the spores—they rid themselves of these waste materials by moving away from them.

Sporulation is the kind of reproduction that is probably of most extensive occurrence in the Protozoa, and is especially characteristic of the multiform groups of the *Sarcodina* and *Sporozoa.* In it also the mode of nuclear division is frequently of a very simple kind of mitosis. For these reasons I have taken the stand that it is the most primitive kind of reproduction in the Protozoa, for budding is far less usual, may be entirely lacking in the life cycles of various groups, and is clearly a secondary mode of generation. And binary fission, though generally regarded as the primitive process, is far from being a simple act, for division into two approximately equal parts is an act of great precision, far more so than is sporulation, and so is the intricate preformation of parts before separation of the daughter individuals. Just as with increasing bodily specialization reduction in the number of parts frequently denotes progress toward a complexer condition, so division into exactly two parts may be an advance beyond division into many parts.

Fission results in the division of the parent into two parts, each of which continues to live; here there would then appear to occur generation not associated with death of any part. But the process of fission cannot repeat itself indefinitely for either it alternates with other kinds of reproduction that are associated with death, or else, as notably in the case of *Paramoecium*, it cannot continue without the application of a powerful stimulus associated with change of substance, such as increase or modification of food or an act of conjugation with another individual. Though no residuum is left behind in fission, yet there may be disintegration and probably death of some of the substance, as shown by the fragmentation and digestion of the macronuclei of the Ciliata. Even in fission therefore some part of the parent dies. Fission probably also subserves the ends of excretion by increasing the body surface.

Budding is the act where smaller parts are cut off from a larger one; in this case the parent individual can continue this process for only a limited time, and in the end a portion of the parent is left as a residuum that dies.

All three forms of reproduction of the Protozoa are, accordingly, methods by which the organism frees itself of harmful waste products, therefore modes of excretion on the part of the offspring.

On turning to the multicellular animals we find a distinction between portions that persist from generation to generation, the germ cells, the links in the chain of individuals, and portions that die, the body cells, a fruitful idea founded by Galton,[1] Nussbaum,[2] Brooks,[3] and particularly Weismann [4] and numerous later publications. But unicellular organisms are not entirely deathless and exactly comparable with the germ cells of the multicellular, for as we have just seen a portion of the Protozoan individual dies in the act of reproduction, and that portion, the residuum, is to be compared with the soma of a multicellular organism. Therefore we can say that the Protozoan differs from the Metazoan merely in not having its germ and soma disposed in different cells, and there is in reality no such radical distinction between the two as is generally contended.

In Metazoa there are two kinds of reproduction: sexual, which is generation by means of an egg cell whether that egg cell be fertilized or not; and asexual generation. Germ cells have much in common with Protozoan spores, and sexual reproduction is more or less, though not wholly, comparable with sporulation. Of the germ cells only the egg cells are reproductive, since they only have the power of division; the spermatozoa are simply fertilizing elements carrying the hereditable energies of the father, for they have lost the power of division and but for their hereditable qualities might be ranked with specialized body cells.

Now to understand the physiological cause of sexual reproduction, we must answer the question, which is by no means academic and incapable of empirical solution: what is the nature of the process that occasions the death of a portion of the individual, and what is the connection of this death with reproduction? Perhaps the best substantiated view, though I cannot say with whom it first originated or how general its acceptance may be, is that natural death of the individual results from self-poisoning. The waste products of metabolism, some of them toxic, accumulate in the tissues until there results a true intoxication of the latter. We may try to transcribe this into a little more definite physiological phrase: death follows on account

[1] A theory of Heredity, 1875, Contemporary Review, 27.
[2] Zur Differenzierung des Geschlechts im Tierreich, 1880, Arch. mikr. Anat., 18.
[3] The Law of Heredity, Baltimore, 1883.
[4] Ueber die Vererbung, 1883, Jena.

of the insufficiency of the excretion process, therefore the limit of life is a matter of excretion.

Excretion is a removal from the organism of harmful substances. That is a special excretory organ that excretes not only its own waste products but also materials collected from other organs. Just so long as a perfect excretion process is maintained the organism can survive. But with advance of age the process becomes impaired, in part because the extent of the excreting surfaces do not keep pace with the increase in mass. It is only necessary here, as an illustration, to indicate one series of phenomena, namely, the increasing deposition of pigments in the various tissues, particularly the outer skin and the nerve cells. Eisig[5] was the first morphologist to argue that pigments are excretory masses, and that they increase in amount with age. Such pigments present us with the most perceptible proof of the accumulation of waste within the body. The organism strives its utmost to accomplish perfect excretion. Most of the tissues have some power in this direction. As the individual increases in size it may develop a succession of more perfect excretory organs; thus in many groups of animals larval kidneys arise to be later replaced by more adequate permanent ones; there may even be a succession of three kidney systems as in certain Vertebrates and Annelids. Indeed it is a significant fact that when there is an exquisite larval stage unprovided with specific excretory organs, that larval body dies; this is evidenced by Echinoderms, Nemertines, Ectoprocta, and Enteropneusta. We may state that the organism replaces one excretory system by another just so long as it maintains active growth change, but that sooner or later the definitive organs become exhausted by the demands of the organisms, waste matter comes to be retained, therefore self-poisoning, then death result.

Now that part which dies is the most specialized part of the organism; in the case of the Protozoan it is the residuum, in the case of the Metazoan, the soma. We mean by ''specialization'' that a particular function is carried out at the expense of others; and the significance of ontogenetic specialization, or what is called differentiation, is that generalized parts become narrowed in function by the successive change or even loss of tendencies that they had at the start. Specialization need not imply greater complexity of structure or process, but rather increasing definite application of a particular part and process, entailing the elaboration or secretion of specific substances. In other words, the specialized portion dies because it has come to perform secretion at the expense of excretion. Thus Minot[6]

[5]Monographie der Capitelliden, Fauna und Flora des Golfes von Neapel, 16, 1897.

[6]On Heredity and Rejuvenation, 1896, American Naturalist.

was right in concluding: "Somatic cells are simply cells in which the activity of the hereditary impulse is inhibited in consequence of their senescence, or, in other words, differention;" but he failed to name the underlying factor of senescence, which is insufficiency of the excretion process.

Prior, however, to the complete death of this specialized part, the residuum or soma, a part or parts escape from the empoisoned mass and constitute the beginning of a new generation. Therefore the essential connection of death and reproduction is the separation of living matter from a dying portion. Generation may itself, accordingly, be considered an act of excretion on the part of the germ, for the latter separates from a mass vitiated by waste products. Though the body may appear to mechanically discharge the germs, and in the higher organisms has secondarily come to do so, the process therefore appears to pertain to the body, yet primitively the germs were the active movers in the act. The process is clearest in the Protozoan: in sporulation motile bodies automatically separate from an inert residuum, and are in no way discharged by the latter. In the Metazoa it is merely less simple in that the germs bring an indirect influence to bear upon the soma, that causes the soma to emit them. But in many Metazoa an automatic separation of germ cells from the body is still found to occur, as when by their accumulation in number and increase in size, in an Annelid or a Nemertine *e. g.*, they actively rupture the body wall; the same process holds for some cases of so-called viviparous birth.

Without doubt reproduction can be interpreted in a variety of ways, as it has in the past. Nevertheless the phenomenon is remarkable that the germ cells, either by their own locomotion or by extruding substances that stimulate the soma to their removal, separate from an intoxined part. Germ cells do not leave the body until it is in a relatively advanced condition, until specialization of parts has commenced. This phenomenon is given its just due when we conclude that reproduction is an act of excretion on the part of the offspring. In many of the lower animals, for instance most insects, the somatic individual may die soon after the act of generation, even though this may have effected no bodily lesion. Generally this has been interpreted to mean that the individual dies because of the harmful influences upon it of the act of generation. Yet such an explanation is quite askew; the germ cells leave the individual because the latter is on the road to death. For if a mature insect be prevented from procreating it will die notwithstanding. In some animals, on the other hand, the body does not die after one act of generation, but may live through a succession of them, extending even over a number of years; that is, it may possess periodic reproductive processes. One might object that in such a case reproduction and death are not associated, and that reproduction by germ cells seems to be combined with the state of greatest vigor of the organism. But even where the organism exhibits periodic reproductive activity, it has attained at its first reproductive act, even in extreme cases of neotenia, a relatively high degree of specialization. Definite functions are then to be sure in their state of ultimate perfection, the condition of division of labor at its maximum, and somatic energies in general at their fullest development. But the ability to become further specialized, which is the power of continuance of somatic differentiation, has quite or almost reached its limit. This goal is assuredly a critical stage for the organism, of cessation of constructive growth. And, more particularly, the organism has had to pay for this differentiation: it has accumulated in geometrically increasing amount harmful waste products that it can no longer successfully excrete. A little more and senile changes appear, in some organisms immediately, in other more gradually. When senescence, or what I have preferred to call self-poisoning, sets in more slowly, there is time given for a succession of reproductive periods. Therefore in *e. g.* a mammal which may have one or more reproductive periods a year through a number of years the first of these periods does not occur at the time of its greatest vitality, for even then its anabolic growth energies have begun to decline and self-intoxication has arisen. Here, accordingly, just as surely as in an insect, though perhaps not so apparently, the first act of generation, much more, therefore, the later ones, is a process of escape of germ cells from a body that is on the way to death.

We can agree with the conclusion of Weismann that the germ cells are essentially immortal, because they have unlimited powers of reproduction. But this conclusion does not explain why there should take place at particular intervals separation of germ cells from body cells, the act we know as sexual reproduction. To state that a specialized tissue cell can no longer reproduce the whole individual because it has lost determinants of the other parts, is logically permissible, but does not explain why tissue cells should not reproduce themselves indefinitely. If the determinant hypothesis be correct, which is a question apart from our present subject, the presence of the full number of determinants in a germ cell does not explain why germ cells should separate from the soma. Germ cells are rightly said to maintain a perpetual power of multiplication, because they remain generalized. But there is an easier and clearer way of comprehending generalization than by the construction of an elaborate determinant hypothesis; and that is, by concluding that generalization consists in the maintenance of a perfect excretion process. Cells that come to lack some part of their excretory power suffer a loss in some of their energies, and only those cells can continue to hold all hereditable energies that do not accumulate waste products.

In fact we find a number of acts performed by the germ cells that can be regarded as having excretory value and which are not found in body cells. Probably there are a variety of such processes, but only three will be mentioned here, and another a little later. One may well be the persistence in the nuclei of the germ cells of the full chromatin mass. The chromatin is proven to be such an important center of metabolism that loss of some portions of it from the nucleus cannot fail to impair some growth regulation by the latter, consequently probably lessen excretory activity. So far as we know only body cells suffer such loss of chromatin.[7]

A second, and perhaps the most important method the germ cells avail themselves of for avoiding intoxication is, as we have tried to show, their act of separation from the contaminated soma. And a third one is by the process of cleavage of the egg. Thus, the egg cell in providing for the nourishment of the embryo secretes the substances know collectively as yolk, sometimes in enormous quantity, and devotes a long period to their elaboration. But secretion is antithetic to excretion, therefore many waste substances must have accumulated in the cytoplasm of the egg during this process. In cleaving, the egg divides so that most of its cytoplasm and contained waste substances come to form body cells, whereby the line of germ cells become freed of this secretion and its waste accompaniments. The process of cleavage also by reducing the mass of the egg cells increases their surface extent and so facilitates excretion. In such ways as these the germ cells keep themselves permanently young, while body cells have no similar cleansing means.

The asexual reproduction of Metazoa is any form of generation other than by a single egg cell. The two kinds of it, budding and fission, may be compared respectively with budding and fission of the Protozoa. In Metazoa such generation is undoubtedly secondary and not primitive, for it is far less widespread than generation by egg cells and does not occur in most Vertebrates, Molluscs, Nema-

[7]The germ cells lose half of the number of chromosomes during the process of chromosomal reduction, but they retain in full one of each pair (kind) of chromosomes. Much oxychromation is lost from the nucleus in the prophase of the first maturation mitosis, as is well known particularly in the case of the maturation of the ovocyte and which occurs to lesser degree in that of the spermatocyte; but this loss is simply a discharge by the chromosomes of waste products formed during the growth period of the germinal cycle, and it is greater in the ovocytes because their growth period is longer.

todes, Rotatoria and certain smaller taxonomic groups. Yet we will find that it is present in some species where it is not commonly recognized. Its teleological value is to increase the number of individuals before the egg cells are sufficiently matured for that purpose, and it is in general reproduction by an immature stage. Its relation to sexual generation is somewhat obscure, but we may try to approximate it in the following way:

Products of asexual reproduction either may become sexually generative or they may remain sterile. The latter condition is much the rarer; it is illustrated by various infertile buds of certain Cnidaria, such as nematocysts, nutritive polyps, etc., and in Ectoprocta by the aberrant vibraculariae and aviculariae. In the majority of cases metazoan buds or their division products generate by egg cells, which implies either that such buds must have contained germ cells at the start, or that they originate within themselves germ cells *de novo,* therefore from tissue cells. Now it is possible that a germ cell should become somatically specialized to a slight extent, and later lose such somatic differentiation; thus in the wall of an Echinoderm blastula all the cells bear cilia, yet in the case of a female blastula some of these cells must be early generations of egg cells, and therefore such egg cells must have temporarily assumed a somatic character, the development of cilia. But that germ cells can arise from somatic cells with any very much higher grade of specialization than in the case mentioned, would seem to be quite doubtful in the light of our present understanding of the continuity of the germ cells and of the nature of somatic differentiation.[8] Accordingly, we will conclude that all buds that subsequently generate sexually must contain germ cells at the start; for is not the main criterion of a germ cell the maintenance of generalization, together with origin from a preceding germ cell? Now, buds may arise from parts of the organism that contain no gonads, no special centres of germ cell formation, which might seem strange and opposed to our conclusion that all buds of this kind must contain germ cells. This proves, on the contrary rather, that all germ cells of an organism need not be placed in specific germ glands, but that many of them may be diffusely scattered through the body. Such a wide dispersal is well known for the Sponges, and for other animals capable of budding we must conclude the presence of germ cells wherever buds are formed. In the embryos of Fishes, Beard has shown the occurrence of such cells even in the medullary tube and the intestine.

To align the phenomena of a sexual reproduction and regeneration

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[8]However, Child has recently shown that in cestodes muscular elements may become germ cells.

with his determinant theory, Weismann has been obliged to assume the transmission of reserve-determinants to whatever somatic cells may regenerate or bud. Such an argument is generally recognized as highly hypothetical and even improbable; it is the weakest side of the whole Weismannian theory. In our present discussion it is wisest to leave out of account the assumed determinants and to try to reason upon a more empirical basis. This has been done by Curtis,[9] who refers normal fission to the energies of undifferentiated embryonic cells that persist throughout the adult body, or occur at least in the greater part of it. This idea seems to me quite justifiable; and it is clearer and simpler than other explanations because instead of appealing to reserves of determinants or of referring the problem to polarity, it reasons from the existence of cells that can be empirically studied. In the Turbellaria the cells of the so-called parenchyme appear relatively undifferentiated, and occur throughout the body beneath the outer skin. From a similar tissue in the Nemertines, but which I preferred to call mesenchyme in order to show its similarity in function and origin with the similarly named tissue of Vertebrates, I found[10] that the germ cells appear to arise from a simple connective tissue that is of diffuse arrangement. We may simply enlarge the idea of Curtis and consider all such undifferentiated cells to be *in potentia* germ cells, and that such cells are the initial agents in all asexual reproduction. They are cells that have taken no part in the formation of definite gonads, but which at the same time have not become somatically specialized. In this connection the important discovery may be mentioned, made by Farmer, Moore and Walker,[11] and confirmed by Walker,[12] that the leucocytes may contain the reduced number of chromosomes, and even the form of the latter characteristic of the germinal chromosomes of the first maturation mitosis. This is an important instance of cells not placed in gonads exhibiting a characteristic of germ cells that has hitherto been supposed to be limited to definitive germ cells.

On this point of view, budding would differ from sexual reproduction mainly in this respect, that the point of departure of the new individual is a single or a number of immature germ cells (ones that are not ovotids or spermatozoa), and that these immature germ cells carry with them some somatic cells. Up to this time, so far as my memory serves me, the difference between these kinds of re-

[9]The Life History, the normal Fission and Reproductive Organs of Planaria maculata, 1902, Proc. Boston Soc. Nat. Hist., 30.

[10]On the Connective Tissues and Body Cavities of the Nemerteans, with Notes on Classification, 1897, Zool. Jahrb., 10.

[11]On the Cytology of Malignant Growths, 1896, Proc. Roy. Soc. London, 77.

[12]Observation on the Life-History of Leucocytes, 1906, *Ibid*, 78.

production has been regarded as a radical one, but our explanation shows that they have an important act in common, namely, separation of germ cells from a parental soma. The idea of a germ cell carrying body cells along with it need not appear strange; for the egg of a Mammal when it leaves the ovary takes with it the zona radiata, an envelope of follicular cells, while the eggs of numerous other forms, notably Annelids and Platodes, carry with them one or more nurse cells. In asexual reproduction the germ cells are immature, and maintain an envelope of different kinds of somatic cells.

Another resemblance of the two kinds of reproduction may be mentioned. Germ cells leave a dying soma, in the process of sexual reproduction. Metazoan buds separate from a parent, or residuum, that equally dies. One need simply call to mind the process of gemmule formation in Sponges and that of statoblast development in Phylactolaemata. Therefore both kinds of reproduction are in a sense acts of excretion by the newly arising individual, removal of waste products by separation from them, and in both the energies of germ cells may play the initial role.

B. *The Life-Cycles of the Metazoa.*

We arrive at one of the most fascinating subjects that it is the joy and privilege of the biologist to contemplate—that of the analysis of life cycles. But we may not rush at once *in medias res,* but rather approach the subject from the side of the relation of germinal to somatic cycles. In our present scanty knowledge of the phenomena the following thoughts can be considered little more than tentative.

The mature egg is the beginning of the new individual, and early in its cleavage comes the point of divergence of germ and body cells. Thence proceeds that division of labor of the multiplying cells that we know as their differentiation. But all cells of the germinal cycle do not become functional reproductive or fertilizing elements, however, for here, too, is a division of labor in that some germ cells become in a sense retarded and do not reach germinal maturity. Such retarded cells become primarily devoted to the mechanical protection and nutrition of their brethren; they are the cells of Sertoli in the testis, the follicular, nutritive and yolk-forming cells in the ovary. Different animals exhibit a great diversity of these, and every germ gland contains some kind of them. Physiologically they may be considered germ cells that have been overmastered by the other germ cells in the struggle for food. In their most primitive arrangement the germ cells are more or less dispersed, due sometimes to automatic locomotion. This diffuseness probably remains through most of the higher groups, as was argued earlier, but with racial advance those particular ones that are to become sexually reproductive in the individual that contains them get arranged into special germ glands or gonads. In those animals higher than the Coelenterata that have no large coelomic cavities these gonads are small sacs, consisting only of germ cells proper with the various kinds of nurse cells already mentioned. In animals higher than these a greater state of division of labor has taken place between the germ cells: the gonads are in the form of large sacs, known as coelomic sacs, and the cells of the germinal cycle have differentiated not only into germ cells proper and their nurse cells but also into peritoneal cells and the various derivatives of the latter. This is an application of the gonocoel theory to the germinal cycle in general. This theory, originated by Hatschek[13], Bergh,[14] and particularly Eduard Meyer,[15] regards the coelomic sacs of the higher animals as comparable with the gonads of the lower, and the latter, therefore the secondary mesoblast, as a composition of genital cells. It is one of the most lucid and comprehensive of morphological theories, and probably correct; at least there is little evidence that speaks against it.

The reason for mentioning this idea here is to show that in the multicellular body three main kinds of cells are to be distinguished with regard to their origin. These are: the definitive germ cells, those that pass through the whole germinal cycle; the somatic cells proper, those that early separated themselves from that cycle; and a third, somewhat intermediate, group of cells that start out along the path of the germinal cycle, but later lose the ability to reproduce the whole individual and become nurse and follicular cells as well as cells of the peritoneum and its derivatives. That is, what are commonly designated somatic cells, include besides somatic cells proper cells that are intermediate in character between these and germ cells proper.

This thought followed out comes to supplant, or rather modify, the earlier germ layer theory of Huxley and Kowalevsky. That concluded that in the ontogeny of the Metazoa, two primary layers are produced, the ectoblast and entoblast, and that in all ectoblast is homologus with ectoblast and entoblast with entoblast. This theory neglects the germ cells, on that account comes the need for the following modification. All Metazoa develop two primary somatic layers and besides these a germinal layer, secondary mesoblast if you will, whose cells

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[13]Embryonalentwicklung und Knospung der Pedicellina echinata, 1877, Zeit. wiss. Zool., 29.

[14]Die Excretionsorgane der Wuermer, 1885, Komos, 17.

[15]Studien ueber den Koerperbau der Anneliden, 1901, Mittheil. Zool. Stat. Neapel, 14.

are phylogenetically quite as old as those of the somatic layers though their arrangement into a particular tissue may be younger. From this germinal layer proceed first the definitive germ cells; second, cells later in segregation and definition than either the primary germ or somatic cells, having primarily the function of protecting and nourishing the germ cells, but some of which may later carry out more particularly somatic functions. The first distinction is, accordingly, between primary germ cells and primary somatic cells; the latter one between definitive germ cells and a second generation of somatic cells.

The occurrence of a group of cells more or less intermediate in character between true germ cells and true body cells leads one to suppose that the distinction between the former kinds may not be so great as is generally supposed. This conclusion is strengthened by the knowledge that definitive germ cells exhibit the same general responses, and have the same main metabolic activities, as the somatic cells. It is known that germ cells by their chemical discharges exert a profound influence upon the body; and, on the other side, there is no reason to suppose that germ cells do not react to stimuli proceeding from the body. The simple fact that every case of embryonic development affords an example of germ cells becoming somatic is itself indicative that there is no unbridgable distinction between these kinds of cells.

It would be out of place here to enter into a full discussion of the germinal cycles. It may simply be recalled that the line of the egg cells, the ovogenesis, essentially parallels the line of the sperm cells, the spermatogenesis, so that a particular generation in one can be compared with a particular generation in the other. On this point the intensive studies of recent years have confirmed the original conclusions by Henking[16] and Oscar Hertwig.[17] The particular process in each germinal cycle that distinguishes it from any somatic one is that in a certain generation, that of the first spermatocyte and first ovocyte, there transpires an intimate pairing of correspondent chromosomes; and this conjugation is succeeded in one of the two following cell divisions by a complete separation of every two chromosomes that had so paired. This is our present understanding of the question of "chromatin reduction." The separation of the elements of the bivalent pairs results from their position in the achromatic spindle; their prior conjugation, however, must have a deeper significance than merely to bring about this separation. The long

[16]Untersuchungen ueber die ersten Entwicklungsvorgaenge in den Eiern der Insekten, 1890, Zeit. wiss. Zool., 49.

[17]Vergleich der Ei- und Samenbildung bei Nematoden, 1890, Arch. mikr. Anat., 36.

continued and close juxtaposition of the elements of a pair must be of the nature of a true conjunction process, like that of two Protozoa, and it is to be regarded as the final and one of the most important parts of the fertilization process.[18] The conjugants must exert some influence upon each other, with probably an interchange of substance. This process may have the result that Maupas[19] argued to follow from conjugation in Ciliates, namely, a rejuvenation of the conjugants, and notwithstanding recent objections that have been urged to such a conclusion. For by such conjugation the chromosomes seem to be stimulated into new activity, which finds an expression in the energy of the subsequent growth period. It may even result that not only new growth energies become started in that way, but also a re-establishment of the perfect power of excretion. Therefore this might be still another means, to be added to the three previously mentioned, by which the germ cells maintain themselves against intoxication.

On proceeding to the somatic cycles proper, or rather to life cycles in the full meaning of the term, we would maintain the following theses. First, that in the Metazoa reproduction by the agency of single egg cells is more primitive than any other kind of generation. Second, that the condition of separated sexes is more primitive than the hermaphroditic one, the latter being not absence of sex but the union of two sexes in one individual. And third, that it is the more primitive process for the egg to be fertilized, in other words, that amphigony is more primitive than parthenogenesis. The foundation of these theses has been undertaken by me elsewhere.[20] In this book also the relations of the different kinds of reproduction and life cycles are more fully considered than can be done in the present place.

The cycle from the egg to the final mature stage may be either *continuous* or *discontinuous*.

Continuous are such life cycles that are complete within the bounds of one individual, and where all stages are of more or less uniform habit. The simplest conceivable form of such a cycle would be the *direct* one, when each stage from the egg onwards is a closer approximation to the adult condition and where there is no turning from a straight path. But it is doubtful whether any of the life histories known to us exhibit quite such simplicity. In most, if not in all, cases continuous life cycles are *indirect*, which happens when some younger stage shows a divergence from the immediate path to the adult, this may be visualized by an angular line, but a line without

[18]This explanation was first suggested in my paper, "A Study of the Chromosomes of the Germ Cells of Metazoa, 1901," Trans. Amer. Phil. Soc., 20.

[19]Le rejeunissement karyogamique chez les Cilies, 1889, Arch. Zool. exper. gener.

[20]The Analysis of Racial Descent in Animals, New York, 1906.

interruption. Such indirect development is very frequent, and is shown best in cases where there is incomplete larval development. Characteristic of continuous life cycles is the occurrence of generation by egg cells only, completion of the cycle in the course of one individual, and especially the complete transformation of every part of a younger stage into a part of a later one.

By *discontinuous* development, on the other hand, we would comprehend life cycles where there are breaks in the progress, in that either the cycle consists of two or more individuals, or that a younger stage develops organs that do not take part in the construction of the adult organism. Some of these cases have been grouped as alternation of generations. But that idea has come to combine and to some extent to confuse two different conditions, namely, succession of different kinds of reproduction, and succession of different kinds of somatic individuals. The second of these conditions is polymorphism and it need have no necessary connection with the first, because there may be succession of different modes of generation yet no polymorphism, as well as polymorphism associated with sexual generation only. Polymorphism is indeed a condition quite different and sometimes quite independent of occurrence of different kinds of generation, and therefore need not be associated with the idea of discontinuous development.

Three kinds of discontinuous life cycles may be distinguished: the *metagenetic*, the *heterogenetic*, and the *ekdytic.*

Metagenesis we employ in the original sense of Haeckel[21] as a life cycle consisting of two or more individuals with alternation of sexual and asexual reproduction. To be consistent we should apply the term to all kinds of such alternation and then will find it to be a much more general phenomenon than is usually supposed. One recalls at once the well known examples of budding hydroid and egg-producing medusa, the succession of buds and eggs in Bryozoa, Tunicates, Sponges, etc., where the distinction of individuals is patent to all. But one may also find cases that lead gradually from the state of obvious sharp distinction of individuals to one where metagenesis is still present even though it is difficult to discover more than one individual. Thus in some Cnidaria the process may become more or less masked, become hypogenetic to use another of Haeckel's terms; the medusa instead of being abstricted early from the polyp may be retained longer and longer, until it finally become reduced to no more than a reproductive organ, a gonophore. Yet such hypogenesis is only a somewhat obscure metagenesis. Then in a Siphonophore the individuals never become fully separated from each other, which has

[21]Generelle Morphologie der Organismen, 1886, Berlin.

led to the discussion as to the genetic significance of this compound organization. These are illustrations where the metagenesis has become to some extent secondarily suppressed.

But because the separation of individuals may not be very apparent in no way speaks against the occurrence of metagenesis, provided there are acts of budding or fission alternating with generation by eggs; this is the cardinal criterion. From a certain area of the Echinoderm larva the adult arises as a virtual bud; and in some species, as Johannes Mueller long ago discovered, the embryonic starfish may early separate from the larva, and the latter continue an independent existence for some time. Here there can be no question that the larva is a first individual that produces a second by budding. It is but a step from this to the case of the Nemertines: from four particular points of ectoblast of the Pilidium larva the adult body takes its origin; these points comprise only a small areal extent of the larva; and though in this case the larva does not continue to live after the formation of the worm embryo, it is nevertheless a first individual that generates a second by budding.

Few can hesitate to acknowledge the preceding to be cases of metagenesis. But, as Beard[22] has reasoned, the same should be concluded for a great variety of other cases that are generally not considered metagenetic. An Echinoderm larva that dies during the formation of the embryo, does not continue a separate existence, is also a case of metagenesis; for it is but a step from this example to the one previously mentioned. Among insects with a more or less complete metamorphosis the crawling larva becomes a quiescent pupa; then from a series of points of the hypodermis of the pupa the organs of the imago are formed, while all the remaining tissues of the pupa degenerate by histolysis and then become ingested by phagocytes. Therefore an adult Fly or Moth or Wasp is an individual quite different from the pupa, an individual produced asexually by the conjunction of a series of buds. This is in every sense as truly metagenetic as the development of a medusa from a polyp. Further, the recent studies of Woltereck[23] on the trochophore larvae of Annelidids show that the adult grows merely from an anterior and a posterior end of the larva, while the large and complex intermediate zone of the larva gives rise to no organs of the adult but dies down and is later discarded. Here is true metagenesis in Annelids: the adult is formed through budding by a larva. Yet how slow we have been to recognize these examples and similar ones as metagenetic!

In fact whenever in development there is discontinuity of process

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[22]On a Supposed Law of Metazoan Development, 1893, Anat. Anz., 8.
[23]Trochophora-Studien, 1902, Stuttgart.

in that certain parts of a larva do not become incorporated into the later body, we should regard that larva as a first individual that by asexual means produces a later one. Different life cycles exhibit a great range of degrees as to how large the bud is in proportion to the larva, but no sharp line can be drawn between the various degrees. Accordingly, there is no substantial difference whether the later individual arises as a small or as a large part of the earlier one. This shows how general a process metagenesis really is, how far from being the exception, and that life cycles are more complicated than generally thought.

By *larva* we mean a motile immature stage of habitude different from the adult, and two kinds of larvae are to be distinguished. There is the more primitive kind found in indirect continuous development, where every part of the larva passes over into a later structure, and where asexual reproduction does not occur. And there is the secondary, metagenetic, larva of discontinuous life cycles, where certain organs of the larva take no part in forming adult structures, and where, consequently, asexual generation occurs. This together with other considerations suggests that asexual generation is always associated with immaturity of the organism, because it precedes the stage that generates by an egg cell; it is a secondary process interpolated into the life cycle. This is in harmony with the contention of Claus[24], further elaborated by Brooks,[25] that in the development of metagenetic medusae the polyp is to be considered a larva that has secondarily become sedentary. In any metagenetic cycle the beginning is an egg cell, the end is that individual that again produces by eggs.

Metagenesis has originated from indirect continuous development in this way. The latter, it will be recalled, may be conceived of as a progression from the egg to the adult, in not a straight but an angular line, the angle representing a larval stage. Now if such a larva ceases to pass wholly over into the adult, therefore buds off the latter, the development becomes discontinuous at that point, another individual is added, there is a break in the development and metagenesis is established. The known embryogenies affords us a practically complete series of intergradations from the indirect continuous development to the metagenetic discontinuous.

Heterogenesis is the second kind of discontinuous life cycle. By it we mean a cycle composed of two or more successive individuals, some of which reproduce by unfertilized eggs, parthenogenetically, others by fertilized ones. There is alternation of the two forms of

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[24]Lehrbuch der Zoologie, 1885, 5te Aufl., Leipzig.

[25]The Life-History of the Hydromedusae, 1886, Mem. Boston Soc. Nat. Hist.,3.

sexual reproduction and not, as in metagenesis, of sexual and asexual. It is not true heterogenesis unless there is a succession of at least two generating individuals. Thus the queen of the Honey Bee, as Francois Huber proved,[26] normally lays fertilized worker eggs, then unfertilized drone eggs, then fertilized worker eggs again, but this is not true heterogenesis because normally only queens lay eggs, and not workers, reproduction being accomplished by a single individual.

Heterogenesis is well illustrated by digenic Trematodes, Rotatoria, and various Crustacea and Insects. It is discontinuous development because it embodies breaks between successive somatic individuals. The beginning of the cycle must be considered the fertilized egg, because of the primitiveness of amphigony; the termination of the cycle would therefore be that individual which produces eggs that need fertilization; these would be respectively the first and last stages of the cycle. The process of parthenogenesis would then be characteristic of stages intermediate between these. Thus while in metagenesis the secondary interpolation is asexual generation, in cases of heterogenesis it is parthenogenesis. Von Baer's idea of paedogenesis meant egg production by a larva; if instead of larva, which we have particularly defined, we substitute the term immature stage or immature individual, then we find that paedogenesis is a regular accompaniment of heterogenesis.

By ekdytic life cycles I have intended those in which an immature stage, that is not a larva, produces certain structures that are thrown off or moulted before maturity, and in which that immature stage is sedentary and enclosed. Such are the cases of viviparous animals where the young develop intraparentally, as well as cases of development within a strong egg shell whether the egg be within or without the parent. The conditions are the same in both, development within an enclosed space and consequent immobility of the embryo. In both also particular foetal or embryonic membranes are formed for mechanical protection, respiration and excretion; thus in a viviparous Vertebrate as well as in an oviparous insect an amnion and serosa are produced. Viviparity and oviparity are states only of the parent, not of the embryo; what induces the production of foetal membranes is not one of these conditions but growth within a closed cavity. This is discontinuous development because some temporary organs formed by the embryo, such as an amnion, serosa or allantois, are moulted at birth and take no part in forming the adult organism. It differs from metagenesis in that there is no sexual generation involved, for the parts thrown off do not compose a second individual and are structurally simpler than the embryo; and in that there is a quiescent

[26] Nouvelles observations sur les Abeilles, 1814, 2 me ed., Paris.

embryo producing special organs mainly for protection, respiration and excretion, instead of a motile larva forming organs directed towards locomotion and nutrition.

Complicated as some of the preceding life cycles are by themselves, they become still more intricate by entering into various combinations. Complex life cycles are well known in the Dicyemids, Cestodes, and digenic Trematodes. But it appears to have overlooked that just as complicated series are to be found in the Insects. For in some of the latter there is a resistent egg shell or chorion within which the embryo developes an amnion and serosa; that is ekdytic development; after hatching the larva becomes a pupa, and this gives rise to the adult by budding: that is metagenesis; then the succeeding imago may generate by unfertilized eggs and a later one by fertilized eggs: that is heterogenesis. To analyze complex life cycles into their various component processes should be one of the major aims of future embryological study.

C. *The Biological Unit.*

When one considers the various elements that enter into life cycles, the question naturally suggests itself: what is the unit here? Much might be written upon this matter, with long historical digressions and comparison of the other sciences, but without going to any such extent I would plead here very briefly for the right to consider the life cycle as the most expressive biological unit.

One of the earliest views was to consider qualities (as separate from structures) as the units composing living beings; this was the idea of Aristotle, and this is again what the modern students of hybridization are maintaining. With the spread of the Mosaic doctrine of Genesis the species came to be considered the unit, with the idea that there are so many of them to-day as there were in the beginning, and that the species as a whole was established at once. With the foundation of the theory of transmutation it followed that species are arbitrary groups, absolutely arbitrary if evolution is to be regarded as perfectly continuous, so that the idea of the individual changed first to the whole individual, using this word in the signification of person, second to some component of the individual. Before the time of the evolution theory Cuvier had employed the organ as the structural unit. Then after 1839, the cell has been generally granted that position, and perhaps to most biologists to-day the cell remains the physiological and structural unit. Later still portions of the cell came to be considered the units, as the pangenes of Darwin and de Vries, the bioplasts of Altman, the physiological units of Spencer, the biophores and determinants of Weismann, the molecular units of the physiologists, all of these being hypothetical; then empirically demonstrable elements such as the centrosomes or the chromosomes. The amplest units are those of certain palaontalogists, such as Hyatt, a unit being a phylum; and the units of certain students of environmental conditions, whereby an assemblage of interdependent species together with the environmental influences affecting them is taken as a unit of study.

With the manifold subdivisions of biology, the morphological, physiological, taxonomic and ethological, room is given for the establishment of most varied units depending upon the special problems of the thinker. In general we may say that two main methods are open: to establish the smallest possible units; or to establish more compound ones. The former method has the advantage of being more analytical, it permits us to subdivide our ideas so far as possible and to reduce all phenomena to the smallest conceivable energies and quantities. Thereby it is commonly supposed that we have explained matters, for we can go no further than the conceivable. But this method of unit formation has a disadvantage that is very serious in any empirical study: it introduces hypothetical quantities before there may be any necessity to conjure them. For when we argue from units that cannot be in any way experimentally studied, we have of course no experimental means of testing whether our conclusions are correct or not.

For these reasons it would appear to be the safest working plan not to resort to purely hypothetical units so long as there remain phenomena that can be experimentally investigated. Biology has an endless series of phenomena, *large* phenomena if such phrase might be used with propriety, many of these have been catalogued, and the relations of them should be determined as far as possible empirically before we resort to hypothetical aids. That is to say, it will be most fruitful to maintain units that are demonstrable, because at any point in the discussion of the problem we are able to point to an actuality.

Now if we select an empirical unit we will soon find that we cannot stop at anything less than the person, the whole organization. For a chromosome is merely a portion of a cell, not an individual capable of independent existence; similarly a cell is merely a subordinated part of a tissue, as this is of an organ; then all the organs are mutually interdependent. The whole person acts as one, not as the sum of many separated parts, it is the true biological individual. The very development of a nervous system, directed towards co-ordination of parts, is evidence of this.

Yet the biological unit cannot stop with the person, because a single person may lack certain qualities necessary either for its own existence or for the propagation of the race. For individuals proceding from the same parents are usually of different kinds, physiologically complemental to each other; this is shown by the commonest form of dimorphism, the sexual. Or we find still more dependence of the persons in such a case as the bee: the drones cannot reproduce or build the comb, workers cannot fertilize eggs and under normal conditions cannot lay them, the queens must be fed by the workers and like the drones take no part in the architecture of the nest. In such an example no single person is a complete individual, capable of maintaining its own existence and of continuing the race; but the sum total of them is a unit that accomplishes this.

Or again there may be successional polymorphism: a medusa produces only polyps, and a polyp is necessary to engender a medusa; were either of these persons annihilated the race would end. Therefore wherever there is discontinuous development, metagenetic or heterogenetic, one generation is closely dependent upon the preceding so that we can say here is division of labor extended over more than one generation. One would derive an entirely erroneous idea of a metagenetic medusa were he to study only the medusa stage or only the polyp, he should understand both and their connection.

In fact the only unit we can assume in our study to give the fullest expression to the polymorphism of individuals is the one which includes the whole life cycle and all the kinds of persons of each generation. This is the natural taxonomic unit of the lowest grade, an entirety and a microcosm in itself. It is the unit of the phylogenist as well as of the student of heredity, evolution and ethology. For it is the one that gives the fullest expression to the phenomena of division of labor and reproduction. We may construct higher groupings out of it, or we may analyze it into its successive components: (1) generations, (2) persons, (3) embryonic stages, (4) qualities, structures, substances and energies.

Certainly the life cycle is a natural unit, and it may be found more comprehensive and fruitful than any hypothetical unit that has been conceived.

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PAPERS PRESENTED AT REGULAR MEETINGS.

JANUARY 19, 1906.

"The Theory of Color Perception," Dr. Warner Fite, Instructor in Philosophy in the University of Texas.

FEBRUARY 23, 1906.

"The Elements of a Practical Education," Dr. S. E. Mezes, Professor of Philosophy and Dean of the College of Arts, University of Texas.

"The General Polygon," J. S. Brown, Professor of Mathematics in the Southwest Texas Normal School, San Marcos.

MARCH 23, 1906.

"The Indebtedness of the German Language to the Latin," Dr. Sylvester Primer, Professor of Germanic Language in the University of Texas.

"The Agglutinative Origin of Verb Inflection," Dr. Edwin W. Fay, Professor of Latin in the University of Texas.

APRIL 27, 1906.

"The Spacial Conception of the Blind," Dr. Franz J. Dohmen, Honorary Fellow in Mathematics in the University of Texas.

"Vulcanicity and Earthquakes," Dr. Frederic W. Simonds, Professor of Geology in the University of Texas.

JUNE 1, 1906.

"Paving Brick," Thomas U. Taylor, Professor of Engineering and Dean of the Department of Engineering, University of Texas.

"Notes on the Use of Trypsin in the Treatment of Cancer," Dr. Henry Winston Harper, Professor of Chemistry in the University of Texas.

"Notes on Color Photography," Dr. Henry Winston Harper, Professor of Chemistry in the University of Texas.

"A Polygon of Fifteen Sides," Joseph S. Brown, Professor of Mathematics in the Southwest Texas Normal School, San Marcos.

FORMAL MEETING, JUNE 12, 1906.

"The Uro-Genital Organs of the North American Lizards" (by title), Mr. Barney Brooks, Professor of Chemistry, Coronal Institute, San Marcos.

OCTOBER 26, 1906.

"What is Matter?" the Annual Address of the President, Dr. Sidney E. Mezes, Professor of Philosophy and Dean of the College of Arts, University of Texas.

NOVEMBER 24, 1906.

"Food Adulteration," Dr. George S. Fraps, State Chemist and Professor of Chemisty in the Agricultural and Mechanical College of Texas, College Station.

FORMAL MEETING, DECEMBER 26, 1906.

"The Solar System," Dr. H. Y. Benedict, Professor of Applied Mathematics in the University of Texas.

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TRANSACTIONS

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TOGETHER WITH THE PROCEEDINGS FOR THE SAME YEAR.

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CONTENTS.

Transactions:

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[ANNUAL ADDRESS BY THE PRESIDENT.]

THE RESISTIVE POWERS OF THE ANIMAL ORGANISM.

DR. JAS. E. THOMPSON.*

My deep appreciation of the honor conferred on me by this learned society constrains me to attempt to follow the example of former presidents in reading an address as free as possible from abstruse technicalities.

Nevertheless, it is perhaps excusable, if I claim the privilege of educational and professional bias and allow myself to review some phases of scientific work that are exercising the minds of biologists and pathologists at the present epoch.

These problems have more a medical and surgical interest than a peculiar scientific one, but I believe that their biological bearings will relieve them of monotony and bring them within the grasp of all of the members of the association.

My theme today is "The Resistive Powers of the Animal Organism." By this I mean the correlation of physiological processes that is necessary for the continuation of life.

In order to review the subject in a systematic manner, it will be necessary to consider the physiological processes under two distinct and different conditions: (1) When affected by *normal* stimuli of ordinary or excessive intensity. (2) When affected by *abnormal* stimuli, such as would be produced by the action of micro-organisms and their toxins.

It is only within comparatively recent years that the study of physiological pathology has received the attention that its importance demanded. Previously, pathology was studied in its grosser aspects, as pathological anatomy, by inspection of the actual organs, either by the naked eye or microscopically, without much attention being paid to the altered physiological conditions responsible for such changes. Gradually, however, by the close application of physics and chemistry to the study of pathology, diseased processes were found to be logical results of altered physiological conditions; and, further, it was found that

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definite alterations in physiological processes inevitably produced the same pathological changes.

Thus hepatic congestion and "nutmeg liver" occur with mathematical certainty as the result of valvular disease of the heart, when the leaking valves act so imperfectly as to allow the pressure from the contracting heart muscles to pass backwards into the venous system; and, again, cardiac hypertrophy will follow as a physical necessity, when it is necessary to raise vascular tension to a point sufficiently high to enable a chronically inflamed kidney to excrete a proper quantity of urine.

By degrees, the pathologist became a physicist, a physiologist, a chemist, and an anatomist rolled into one; or, to speak more correctly, men who possessed special training in these directions inevitably drifted into pathology.

Although new pathology has made immense strides, we are still at the very threshold of knowledge. Yet work of such marvelous accuracy is being accomplished in every branch, and particularly at the present time in the problems concerned with metabolism, that the future is full of hope.

It is generally conceded that physiological activity is the result of chemical action; and that life ends at the exact moment when chemical action ceases in the animal cell. Therefore, it must be held dogmatically that all animal energy is derived from chemical sources. These chemical processes are of necessity very complex, and at the present time we are able to formulate them approximately only. Thus we know that by hydration proteids are changed into peptones, and that the reversal of the process, viz., dehydration, results in the reformation of proteids. Yet the constitution of proteids is so complex that chemical formulæ to represent the changes that occur during metabolism can only represent the processes in a very incomplete manner.

As will be shown later on when dealing with the action of the toxins and antitoxins on the proteid matter of animal protoplasm, our knowledge is more limited still, and to enable us to express even the most primitive ideas of their chemical combinations, we make use of fantastic formulæ and still more fantastic diagrams.

In the lowest forms of animal life we find the anatomical structure of the simplest possible nature, yet adequate to carry on all necessary physiological functions. Thus, in the amœba, respiration, digestion, reproduction, and locomotion are all carried on by a simple unicellular organism. As we ascend the animal series, we find in the simpler multicellular forms, a special adaptation of certain cells to perform particular functions; as in the hydra, where arrangement exists similar to that of the three primitive layers of the embryo of a highly developed animal, the outer layer (ectoderm) serving as a protective, tactile, and offensive covering, the inner layer as a digestive covering, while the middle layer is contractile to enable the animal to change its position for various purposes. These three primitive layers are adequate for all needs in the hydra, but more highly developed animals have modified them enormously to meet the needs of their particular environment, until we have most complex organs, resulting from these modifications.

Yet, however highly specialized an organ becomes, it is always more or less dependent on the other organs of the body for its proper working. With some organs the connections may be apparently of the slenderest, yet there is always some condition that will call for the help of an apparently useless organ. Physiological interdependence is the mainstay of life, without which chaos and dissolution would speedily result.

It is a remarkable feature of animal life that, even where organs differ materially in anatomical structure, as, for example, in the gills of fishes, and the lungs of mammals, the retention of function is most tenacious. And even in animals of the same species (as in the alimentary canal of mammals) where great anatomical differences are seen, physiological function is retained with the greatest tenacity in corresponding parts.

A moment's thought will convince that this retention of function was necessary for the preservation of life. For during the course of development, the changes in the anatomical structures of an organ could occur with impunity as long as the physiological function remained the same. But, if a coincident marked and sudden change of physiological function became necessary, the other dependent organs would have been unable to respond, and death would have resulted.

Under ordinary circumstances, then, the correlation of the physiological activities of the separate organs of the body is perfectly balanced. Each organ is capable of performing a certain amount of work, and the assistance rendered by the other organs is proportional. Yet, under abnormal stimulation, each particular physiological activity is capable of being increased considerably until a point is reached, which has at times been designated as the breaking strain. This condition of excessive activity can only be produced by drawing on the physiological reserve of the tissues. In conditions of health every organ possesses considerable reserve. Ocular manifestation is present in the case of muscular contraction, where under great strain or intense excitement muscular contraction is possible to limits previously undreamed of. Pathologically, it is observed in all the tissues of the body, including the secreting glands. In vavular heart disease, it is in the early stages, the means by which the organ succeeds in propelling the necessary quantity of blood into the system, although the balance of power is finally restored by another process, namely, compensatory hypertrophy.

Of course, the call on this reserve power produces a wasteful metabolism in the tissue cells, and, if the call is too prolonged, we reach a point spoken of as the breaking strain, where the organ fails completely to carry on extra work and is often unable to functionate at all. It is rather difficult to understand what this represents chemically, but it has been compared to the phenomenon of supersaturation. If a supersaturated, hot solution of Glauber's salts be allowed to cool and be kept perfectly quiet without vibration, it will remain fluid, but if shaken or touched with a glass rod, or a crystal be dropped into it, the whole immediately crystallizes. It has also been compared to coagulation, for it is found that a totally exhausted muscle which has drawn extensively on its physiological reserve falls immediately into a condition of rigor mortis after the animal dies or is killed.

The central nervous system possesses physiological reserve to the highest degree, and, being highly organized tissue, it responds like a highly-bred animal to calls on this reserve until it is exhausted; and then, as Abrahams has aptly expressed it, like a man who has been living on his capital, there comes a day when the funds are exhausted and the tissues are bankrupt.

The chemical changes occurring in the neurons as a result of excessive mental activity, are little understood. We know, however, that their complexity increases with education, and, pari passu, there arises a greater vulnerability, which is always increased by overwork, particularly if the patient has suffered from syphilis or has been addicted to the excessive use of alcohol. An astonishingly large proportion of insane people suffering from general paralysis have been men and women of unusual mental power and activity.

Let us now turn our attention to some of the chemical processes by which organs are able to produce secretions necessary for the continuation of life.

Commencing with the alimentary canal, we find that the very foods introduced are teeming with micro-organisms, which, far from being hurtful, are as necessary probably as those found at the rootlets of plants. The digestive juices themselves are destructive to the structures that produce them, if there be any injury to the epithelium. Thus the gastric juice has the power of digesting injured and necrotic mucous membrane, and exerts a very deleterious effect on the duodenal mucous membrane, if the acid chyme fails to be neutralized by the alkaline bile and pancreatic juice. Further, the secretions of the pancreas are a source of danger to the gland itself, if they are retained as a result of obstruction of the duct, as is shown by the appearance of acute inflammation of the gland with necrosis, where Vater's ampulla is blocked by a biliary calculus.

And, curiously enough, the products of digestion, particularly the peptones, are themselves of a poisonous nature, producing symptoms of an extremely toxic nature, if they are injected into the blood. Fortunately, under normal conditions, they are changed into innocuous compounds by hepatic metabolism.

The liver probably holds the highest place as an organ peculiarly adapted to defend the system from the entrance of hurtful products. Its functions are twofold, (1) metabolic and (2) toxicidal. The proper performance of both functions is absolutely necessary, and, although the metabolic function is the primary and more essential, still it is safe to say that if the toxicidal powers were annulled even temporarily, an extremely dangerous state would ensue, because all the toxin, both living (bacteria) and dead (ptomaines), which during health passes along the portal system of veins from the alimentary canal to the liver, where it is rendered harmless by the activity of the liver cells, would, under the altered conditions, pass directly into the systemic circulation.

Turning now our attention to the chemical characteristics of the secreting glands, we find that recent discoveries have revealed processes of such minute complexity as to excite wonder at the marvelous smoothness of the machinery. I refer to the "hormones," or the chemical messengers, which are carried by the blood stream to various glands in which they excite specific secretion. Many of these are known, but probably the most important is that responsible for the secretion of trypsinogen by the pancreas. This subject has been extensively studied by Starling, and the following short description will suffice. It is found that the active cells of the duodenum and small intestine manufacture a specific substance called "prosecretin." This is transformed by the action of the acid chyme into a substance called "secretin," which, being taken up by the blood stream, passes to the pancreas, where it exercises a specific effect, producing a free flow of pancreatic juice containing trypsinogen. Trypsinogen is never secreted without the presence of secretin in the blood circulating through the pancreas; and the injection of secretin into the blood of an animal will, in a very short time, cause a free flow of pancreatic juice containing trypsinogen, whether the duodenum contains chyle or is empty. As soon as the pancreatic juice reaches the small intestine the contained trypsinogen causes the flow of a ferment called "enterkinase," which again reacts on the trypsinogen, producing trypsin, which possesses the power of turning proteids into peptones.

In addition to the production of enterkinase, an alkali is poured out (probably bicarbonate soda), which neutralizes the acid chyme, which neutralization is a signal for the apening of the pylorus and the passage of still more chyme into the intestine, after which the process commences afresh.

The study of these "hormones," or chemical messengers, is a particularly interesting one; especially so as it has completely annihilated the school of nervous physiology.

Much interesting work has been done in this direction, and at a time when we are so concerned over the physiological effects of animal extracts and antitoxins, it might be wise to mention other important observations on the subject.

It has been found that the enlargement of the breasts which occurs during pregnancy is due to a hormone secreted by the fœtus. It has long been known that if abortion occurs in the early stages of pregnancy, the breasts return to their normal condition, without milk being formed; whereas, if the fœtus is removed in the later stages, lactation occurs just as if labor at term had resulted. Previously it had been recognized that nervous influence was not responsible for lactation, because the spinal cord in pregnant bitches could be divided without interfering with lactation; furthermore, in some clinical cases of complete crushing of the spinal cord in pregnant women, lactation occurred after labor just as usual. Therefore, the possibility of a hormone being the cause was considered. Starling cleared this matter up by finding that he could produce a stimulation of mammary secretion in virgin rabbits by injecting an extract obtained from the bodies of fœtal rabbits.

Again, it has been found that testicular secretion is absolutely necessary for the production of male characteristics. If the vasa deferentia are divided and the testicles left in place, male characteristics are still developed although the procreative power is destroyed. But on the other hand, where castration is performed in early life, the individual never develops male peculiarities, as revealed by the high-pitched voice and the scanty growth of hair on the face. In animals, as Shattuck and Seeligman have shown, the results of experimentation are remarkable. In sheep and fowls double castration resulted in the non-appearance of the male characteristics, viz., the growth of horn and spurs; while double vasotomy (the testicles not being interfered with) did not effect the growth of these particular male appendages. Further, in cases where the testicles were removed, the growth of male features could be secured by the grafting of testicular tissue into the abdomen (Abrahams).

Another interesting line of experiment has been opened up in finding that the corpus luteum is responsible for the proper fixation of the impregnated ovum to the uterine walls. It has been found that, if an ovary with its corpus luteum is removed in the earliest stages of pregnancy, the ovum fails to become fixed and consequently is passed out from the uterine cavity; whereas, if the same ovary and corpus luteum are removed when half the period of pregnancy has passed, the fœtus remains attached. From which, it is concluded, that a hormone is formed in the corpus luteum.

Lastly, I may mention the possibilities of the development of this "hormone" principle to other organs. Take the kidney as an example. It is quite within the range of possibility that the kidney produces an internal secretion that materially affects the metabolism of the human body and profoundly influences the processes that result in the formation of the nitrogenous substances, which it eventually excretes from the blood. Clinically we meet with some cases of uræmia that do not conform to the usual type, as regards the excretion of urinary constituents. In some cases the urine is normal in quantity, and a twenty-four hours' specimen shows that the amount of urea is not lessened, and that the usual amount of solids is being passed. Yet, the patient is suffering from constitutional symptoms of a uræmic type, and in some cases death results. These cases are hard to understand, and it has been suggested that the kidney produces an internal secretion which is essential to health, and that certain uræmic cases may result from a lack of this secretion. It does seem probable that a gland so concerned with getting rid of waste products of metabolism ought to be connected directly with the organ or tissues most concerned in the metabolic processes. And if the hypothesis is correct, the kidney may by means of a "hormone" be able to influence the liver in its metabolism.

In some forms of pancreatic disease sugar has been observed in the urine (diabetes). Careful investigation of the phenomenon has led many observers to credit the pancreas with being the producer of an internal secretion, which regulates the formation of glucose in the body according to the needs of the tissues. Absence of this substance (ferment or otherwise) is said to allow an undue quantity of glucose to pass into the circulation from the liver, and this, not being needed for purposes of nutrition, is excreted by the kidneys.

Finally, let us consider the functions of the secretions of the ductless glands, concerning which so much has been written of recent years.

Thyroid secretion is known to be absolutely necessary for the continuance of life. In order that health may be maintained, the amount of thyroid secretion absorbed must be regulated with the greatest care. In adults, excessive secretion produces a disease known as "Grave's Disease," which is characterized by symptoms of overstimulation of the nervous system, accompanied by irregular and rapid action of the heart; a disease that often terminates fatally unless the excessive secretion is arrested, either spontaneously or artificially (by operation). On the contrary, diminished secretion produces a disease known as "myxœdema," which is characterized by symptoms the direct antithesis of the former, viz., sluggish intellect and slow, weak pulse; a disease which in its turn ends fatally, unless thyroid secretion is supplied artificially.

Again, at different periods of life, the thyroid secretion subserves different needs. In early life it seems to be necessary as a stimulant to the growth of the common tissues, such as bone and the connective tissues; and its absence results in the lack of growth and the production of cretinism. Almost all the cretinoid dwarfs have total absence of the thyroid, and in those whose thyroids appear to be normal, or who have a goitre, the secretion is always deficient. In later life it seems to be required for the development of the finer tissues, such as those of the nervous system.

Our knowledge of the suprarenal bodies is rather more limited. Physiologically, we know that an extract can be obtained from it that acts strongly on the muscular tissue generally, but especially on that of the heart and the blood-vessels. As the therapeutic agent this quality has been utilized and as adrenalin it is extensively used, both surgically and medically, to stop and prevent hemorrhage and as an adjunct in the treatment of shock to close the smaller blood-vessels and raise the general blood-pressure. Langley has shown that its effects are identical with those produced by stimulating one or other sympathetic nerve, and has suggested that its internal secretion may be the controlling agent of the sympathetic nervous system. Disease of these suprarenal glands (tuberculosis) is responsible for Addison's disease, characterized by gradual and progressive muscular weakness, anæmia, gradual exhaustion, and death. In the majority of cases it is associated with a brown pigmentation of the skin. Experimentally, in dogs and rabbits it has been found that the removal of both glands is invariably followed by death, preceded by symptoms closely resembling those of Addison's disease.

The pituitary body has been especially studied in connection with the disease known as acromegaly. This is characterized by an increase in size of the bones of the face, hands, and feet. In addition, the lips become thick and the hair and skin coarse, and the patient eventually becomes lethargic, reminding one somewhat of myxœdema. In all cases the pituitary body has been found affected, in some instances being the seat of a tumor.

This disease has been ascribed to the absence of an internal secretion. It has been found experimentally that injection of an extract of the pituitary body causes contraction of muscle like suprarenal extract. Just what effect this body has on animal life, we can not tell. There seems to be some connection between it and the thyroid, because it is found that after extirpation of the thyroid the pituitary body increases in size. Also that complete thyroidectomy can be done without serious symptoms if the operation be performed in successive stages so as to allow the pituitary body to hypertrophy. Again, cases of myxœdema and sporadic cretinism are often associated with marked hypertrophy of the pituitary body. (Lazarus-Barlow.)

The second part of this discourse deals with the "acquired defenses," or the correlation of physiological processes brought about to meet abnormal stimuli. Entailing, as it must, some description of the state known as immunity, it would be unwise to attempt more than a brief sketch of the problems concerned.

Immunity is usually divided into three varieties, viz., (1) natural, (2) acquired, and (3) hereditary. Whichever of these is present, the tissues possess the power of repelling infection, either by destroying it completely or rendering it harmless through chemical combination.

If it be a living organism, it is destroyed by one of two methods: (a) Either by the bactericidal properties of the blood serum or of the other body fluids (bacteriolysis); or (b) by the activity of the living cells, which attack it, ingest it and digest it (phagocytosis). But, if on the contrary the infection be a soluble toxin, then the process of rendering it harmless must be a purely chemical one.

It will perhaps facilitate matters if we discuss the question under the above mentioned heads, and first investigate the processes by which the tissues resist the attacks of living micro-organisms.

In studying the action of blood serum on micro-organisms, many curious facts have been discovered. It was naturally believed that fresh blood serum would form an excellent culture medium for most micro-organisms, which flourish at the expense of the human body. On the contrary, experiment demonstrated that fresh serum actually hindered and in some instances destroyed cultures of most organisms, whether pathogenic or non-pathogenic. This property, which seems to be possessed to a certain degree by most serums, gradually disappears as it ages, until eventually it forms as good a cultivating medium as any other albuminous compound of similar constitution. This germicidal property varies greatly with serums of different animals, and even with the serum of the same species of animals, but it is rarely absent. The same property is possessed to a certain extent by the other fluids of the body. Thus the peritoneal fluid possess it, and if a cultivation of attenuated typhoid bacilli be injected into the peritoneal cavity of a guinea pig it occasionally happens that the whole culture is destroyed, as it were, explosively, by the bactericidal action of the peritoneal fluid.

We have good reason to believe that human peritoneal fluid possesses this same quality to a certain degree.

Now, although most serums possess this general bactericidal power, it is found that by the use of special means specific powers can be given them whereby they can become bactericidal to a high degree against any particular organisms.

The following explanation of the process has been taken from the concise description of Lazarus-Barlow:

"If a substance A be introduced into the blood or tissues of an animal, that animal produces another substance which is antagonistic to A, and which is recognizable in its blood serum. Thus, if bacteria of a certain kind are injected into an animal, the blood serum of that animal in course of time comes to possess the power of dissolving that same species of bacteria (bacteriolysis). So, too, if a toxin be injected, the blood serum comes to possess antitoxic properties; if red blood corpuscles from one species of animal Y are introduced into the body of another animal of a different species Z, the serum of Z comes to possess the power of dissolving Y's corpuscles (hæmolysis). Similarly blood serum may be prepared which possess leucolytic, tricholytic, spermatoxic, nephrotoxic, or hepatoxic powers by treating an animal with leucocytes, ciliated epithelium, testicular, renal, or liver substance, respectively."

And further, not only can we succeed in producing serums with marked cytolytic powers, but we can produce at will serums with marked powers in other directions. Thus by injecting a rabbit with human serum, we can produce in the rabbit's serum a body capable of coagulating the albumin in human serum. This is called a precipitin. And in addition we can produce bodies preventing coagulation, anti-coagulins, and bodies which induce agglutination or clumping of bacteria, blood corpuscles, and other bodies.

This method of increasing the bacteriolytic power of the blood serum or rendering the animal more resistive to the attacks of organisms, has been recognized for many years; and, although its exact specific workings were far from being understood, the common practice in the East of inoculating patients with smallpox virus to protect them against subsequent attacks of the disease was a practical recognition of this principle. It has been known for centuries that inoculation of disease gives immunity for considerable periods of time, sometimes for life; and we find that in most instances the serum of patients thus *artifically* made immune exercises a marked bacteriolytic property on the organisms of the disease to which their immunity applies. This principle of producing artificial immunity was worked out by Pasteur in the case of anthrax, by finding that a mild attenuated culture of the anthrax bacillus, which was not virulent enough to cause death, was able to impart to an inoculated animal powers of resisting the invasion of a virulent culture; and that by repeated inoculations of the milder virus, the degree of resistance to the strong virus could be raised to a very high limit.

However, although this method of direct inoculation with the organisms of the virus was successfully carried out, it was found to be rather dangerous; and, as a substitute, it was found that inoculation with the toxin of the germs would produce similar results. By this method the organisms were filtered away and the filtrate, containing the poisons produced by the growth of the organisms, was employed. (This was the basis of the first tuberculin made by Koch that caused such consternation in 1890 and that proved such a lamentable failure.)

Further, it was found that if toxin free from organisms was repeatedly injected into an animal it could be rendered immune to the action of the bacteria forming the toxin; and if the serum of this animal so immunized was injected into man, he in turn became resistive and at times immune to the action of organisms.

The methods by which an animal is successfully immunized against a given micro-organism are two in number. We can employ either the micro-organisms or the culture fluid from which the organisms have been carefully filtered. But a difference results in the serum if only one method is employed. If we use the organisms only, the serum gains marked bacteriolytic powers, but seems to have very little power of neutralizing the toxin that the bacteria produce. If, however, the filtered culture is used, the blood serum possesses both bacteriolytic and antitoxic properties. Therefore, as both these properties are essential, it is the rule to immunize an animal by injecting both bacteria (living or dead) and the filtered culture also.

From the above it will be gathered that whatever the nature of the immune substance may be, it can not be single, but must consist of two substances at least, possessing, respectively, bacteriolytic and antitoxic properties.

Returning to the second method by which bacteria can be destroyed, we are led to a discussion of the rôle played by the living cells of the tissues in resisting the attacks of micro-organisms. The phenomena observed were first carefully described by Metschnikoff, whose earnest investigations laid the foundation of the phagocytosis theory. This observer, who has worked out the part played by the cells of the body in resisting the attacks of organisms, believes that the white cells of the blood and the fixed cells of connective tissue actually attack the organisms, ingest them, and destroy them. In short, he believes they are the main agents by which they are destroyed and gave to them the name "phagocytes." This theory has been strenuously attacked to such effect that Metschnikoff has been forced to admit that the phagocytes are not the sole agents of bacterial destruction, but that the fluids of the body, particularly the blood serum, possesses this power to a marked degree. Yet he persistently affirms, and supports it with proof, that this particular quality of the blood serum is derived from phagocytes, which part with their digestive substance by undergoing solution in the serum (phagolysis).

As we have no space to enter into a prolonged discussion of this subject, it may suffice to say that probably phagocytosis does not play such a prominent primary part in the destruction of organisms as was once thought, but plays rather a secondary one in giving the final coup de grâce (Lazarus-Barlow), when the anti-bacterial and antitoxic substances have rendered the organisms less formidable and less toxic.

The study of the effects of soluble toxins carries us into the very heart of the question. Even when the tissues are apparently fighting living bacteria, they are in reality fighting the toxins the bacteria are manufacturing; and, although the bacteria may be destroyed and digested, their toxins may yet be so poisonous as to destroy life. It is probably true that many toxins play the part of chemical compounds, which are harmful to protoplasm, without combining with it strongly. These are easily divorced from their combination and excreted from the body by means of the kidneys. But other poisons form strong combinations with protoplasm, so strong in fact, that divorce is difficult and often impossible. As an example of a weak combination, we may cite the toxin of diphtheria; as an example of the strong, that of tetanus.

These combinations of toxins and protoplasm have often been graphically represented by the benzene ring, where the loosely attached atoms of hydrogen can be replaced by the toxin. But this method, although it gives us a mental picture of combination, gives us no insight whatever into the exact nature of the union. We know so little of the accurate chemical formulæ of toxins that we are absolutely unable at present to express satisfactorily their combinations with the complicated albuminous compounds.

The most philosophical explanation of these combinations yet presented to us is the theory of Ehrlich, in which he has represented diagrammatically the changes which occur in protoplasm when brought into chemical contact with toxins. Earlier in this paper while describing the bactericidal power of serum it was mentioned that it could be increased to a high degree by injecting into the blood of animals toxins produced by bacteria; and, further, that the bactericidal power could be increased in a particular direction by injecting the poison of a particular species, so that finally the serum would become intensely destructive to that species. In this way an animal could be rendered artificially immune to this particular organism. It was also pointed out that a difference was present in the serum, according as the toxins alone or bacteria (living or dead) were used; injections of the latter (bacteria) giving to the serum a bacteriolytic power only, whereas injections of the former (toxins) make it both bacteriolytic and antitoxic. From which it was argued that at least two substances are produced, possessing, respectively, bacteriolytic and antitoxic properties. It was to elucidate the nature of these substances that Ehrlich advanced his theory. He taught that certain cells possessed lateral chains or receptors (like the loosely combined atom of H in the benzene ring), which are necessary to the nutrition of the cell on account of their affinities for albuminous substances. (Fig. 1, R.) By means of these receptors the protoplasm was able to enter into combination with albuminous substances circulating in the blood and necessary for normal metabolic processes. He argued that these receptors were just as likely to enter into combination with the molecules of the toxin, which then worked destruction on the cell.

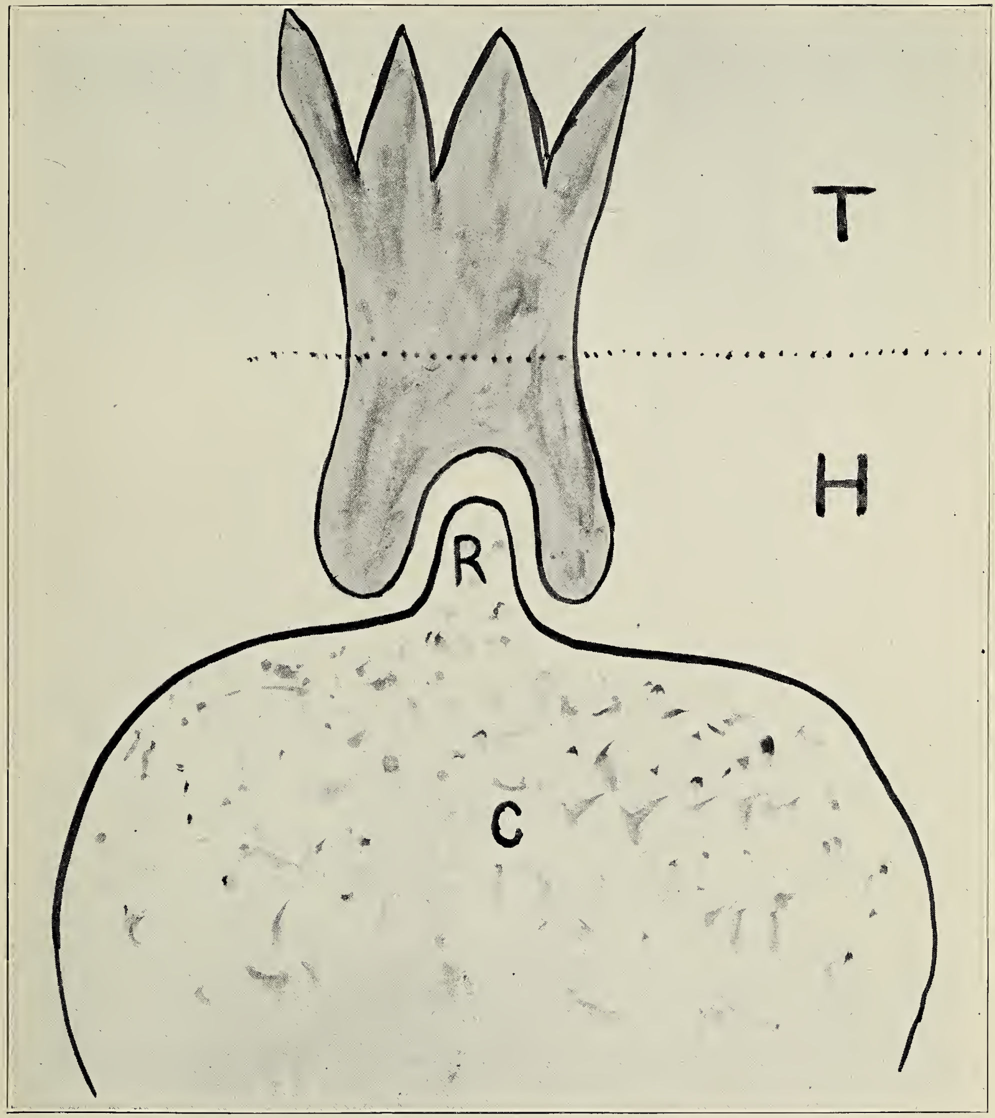
Further, each protoplasmic molecule is capable of forming a great number of side chains, and a separate chain for each poison. Also each receptor is capable of anchoring one single body whatever its nature—albumin, peptone, or toxic (Barlow). Now it is found that the bodies to be anchored consist of two groups possessing different affinities. The one group contains molecules capable of combining with the receptor, which combination fixes the toxin group firmly to the protoplasm, allowing the other group to exert its poisonous influence on the cell. The group that fixes the toxin molecule to the receptor is called the "haptophore," and the other the "toxphore." (Fig. 1, H and T.)

If the toxophoric group is very poisonous, the cell is destroyed entirely, but if the cell is slightly damaged it seeks to repair the defect by the formation of fresh receptors. If these receptors are formed in great excess, they are shed and pass into the general circulation. They form the "*antitoxin.*" (Fig. 2.) By this theory it is easily understood how a person may become immune.

The toxin molecule that gains access to the blood may be unable to enter into combination with the cell, for two reasons, (1) the blood may be full of antitoxin, i. e., a vast number of free receptors may be present, on which the haptophoric group seizes, thus fixing the toxophore, which is then unable to come into contact with the protoplasm of the tissue cells (Fig. 2), or (2) there may be no fixed receptors of a suitable shape for the haptophore to combine with, in which event the toxin, being unable to find a suitable soil, is excreted by the kidneys.

(Fig. 3.) In either case, the toxin would be powerless to combine with the protoplasm.

Also it is easy to understand how immunity can be acquired rapidly by the introduction of antitoxin. For the antitoxic serum supplies the blood of the patient with receptors that its own blood does not yet possess, and the toxin molecules combine with these receptors.



Thompson del.

Shows a cell (C) with receptor (R) uniting with the Haptophoric Group (H) of the toxin molecules.
T represents the Toxophoric Group.

Thompson del.

Shows numerous Receptors, many of which shed into the blood where they unite with Haptographic Groups of Toxin Molecules, thus rendering them unable to combine with the cell protoplasm and produce harm.

Thompson del.

Shows Receptors of different shapes, to represent diagrammatically the power of uniting with Toxins of different natures.

A THEORY OF FERMENTS AND THEIR ACTION.

J. W. McLaughlin, M. D.

The marvelous discoveries in science and the rapid advances along all lines of knowledge, which have been made in this age of wonderful progress, have inflicted upon suffering man an immense mass of printed matter, good, bad and worse—mostly worse—which in the main it would be sinful to call scientific and libelous to call literature.

Whether I am unconsciously adding to this mass of rubbish in attempting to exploit a new theory of ferments and their action remains to be seen. To be frank, I must admit that I have seriously questioned the propriety, to say nothing of the wisdom, of submitting to this audience a paper involving, as it does, new, perhaps untenable, concepts along lines of science. It will, of course, be no sufficient excuse, should you decide that my theory is wrong, to say that it is a result of long and patient investigation and but for this fact it would not have been read on this occasion.

I was lead into a study of the phenomena of fermentation some thirty years ago by endeavoring to fathom the mysteries of therapeutic energy, and the means and methods which nature uses in protecting man from, and in some cases curing him of, certain infectious diseases. The marked resemblance, in morphologic characters and in biologic habit, which ferment micro-organisms bear to pathogenic micro-organisms, and the striking analogies in structure, in reactions, and in special activities, that enzymes bear to toxins, impressed me with the thought that fermentation and infection, in their modus operandi, are identical, or nearly identical, processes. I, therefore, sought to learn the nature of ferments and how they act, in order to apply this knowledge to the elucidation of the nature of toxins and their action; but my investigations in the literature of fermentation did not extend far until it became plain to me that science knew no more of ferments than she did of toxins, and in order to interpret the analogies of the two processes, in the present state of our knowledge, theory must be recast along new lines.

The phenomena and causes of fermentation have been interesting objects of study since early times—centuries ago—and it is, therefore, impossible, in a brief paper, to present in historical review the leading facts which have been acquired, and discuss in detail even the most prominent theories of fermentation which have lived, flourished for a brief time, and died, during this period.

Prior to the time of Lavoisier and his epoch-making work so little was known of chemistry that this subject did not to any considerable extent, enter into the speculations of the time regarding fermentation; the external features of the process excited more interest than did the internal causes of the phenomena. Stahl, the author of the Phlogistin theory, impressed by the marked disturbance of particles in fermenting fluids, and by the evolution and escape of gas during fermentation, conceived a theory of action in which fermenting particles were assumed to have an internal motion which they transmit to quiescent bodies in contact, and by this means cause them also to undergo fermentation. This theory was generally accepted and dominated public thought on this subject until, many years later, it was displaced by the chemical theory of Lavoisier. This distinguished chemist, impressed with the chemical features of the process and apparently oblivious to its ferment features, claimed that alcoholic fermentation consisted in a chemical conversion of sugar into alcohol and carbon dioxide; the means by which the conversion was brought about was entirely ignored. Of course, Lavoisier knew that sugar could not ferment itself into alcohol and carbon dioxide, and that an outside force was needed to induce the chemical change; but this subject did not receive his attention, and it was not until some time later that the subject of an outside force was taken up by Gay Lussac, a pupil of Lavoisier, who theorized that this force is oxygen.

As time passed the field of observation in this department of science became greatly enlarged; improvements in the microscope and in microscopic lens greatly increased the magnifying power of the instrument, and led to the discovery that alcoholic fermentation is constantly associated with the presence of microscopic cells, later shown to be yeast cells. Besides, the field was enlarged by the discovery of other kinds of fermentation than the alcoholic, and of other ferments than yeast cells; the existence of non-living ferments (enzymes) was discovered during this period.

The important work that Schwann, Hoffman, and others accomplished should be noticed in this connection. Having first determined that an infusion of meat, sterilized by heat and hermetically sealed, would not decompose, but that decomposition did occur when ordinary air was permitted access, Schwann arranged his apparatus so that air could enter the flask containing the sterile meat infusion, but in doing this must pass through a glass tube heated to whiteness so that all living substances the entering air contained would be killed. He found when these precautions were taken that the free entrance of air did not cause the meat infusion to decompose, and he concluded therefrom, first, that oxygen does not supply the force (as claimed by Gay Lussac) that causes the decomposition of sugar; and, second, that the force is supplied by living substances which the air carries—living ferments:

Hoffman determined further, that yeast did not ferment grape sugar except when the sugar and yeast are in immediate contact. He ascertained this fact by interplacing in a vessel filled with grape juice a membranous or cotton filter, which he found quite sufficient to limit the fermentation which occurred when yeast was placed in the juice on one side, to that side of the vessel, notwithstanding that the juice, and all soluble matters it contained, could readily pass through the filter.

The significance of these experiments seems not to have been appreciated at the time, as the chemical theories of Lavoisier and of Gay Lussac continued to fill the scientific mind. But many years later Lavoisier's theory was overshadowed by the more brilliant and comprehensive hypothesis of Liebig. The essential feature of Liebig's "Decomposition Theory" is, that the internal motions of decay, in the cells of an albuminous body undergoing decomposition, may be imparted to other albuminous bodies in contact and cause them also to undergo decomposition by exciting motions of decay in their cells. If the energy that causes substances to ferment is derived alone from the internal motions in cells undergoing decay and death, living cells as such can have no place in Liebig's theory of fermentation; in fact, the long and bitter controversy that took place between Liebig and Pasteur grew out of this question; Liebig holding that living cells did not in any manner influence alcoholic fermentation or its results, while Pasteur held that alcoholic fermentation is strictly a biologic process which living yeast cells alone are capable of inducing.

Pasteur not only repeated and verified the experimental work of Schwann, Hoffman and of other observers, but he greatly added to this work until he succeeded in getting together a mass of facts in support of the claim, that the conversion of sugar into alcohol and carbon dioxide in alcoholic fermentation is due solely to the presence of living yeast cells, that no ground was left for the opposition to stand upon. But the struggle did not end here, the rôle that yeast cells play in causing the sugar molecules to dissociate had not yet been decided. Pasteur concluded from his observations, that the yeast cells accomplish this feat by taking oxygen, which the cells require, from the sugar molecules, and thereby causing their dissolution. He held that yeast cells when immersed in grape juice could not get from the outside air the oxygen they require for respiration, and must, therefore, get it from the sugar molecules; that "life without air" enabled the yeast to decompose the sugar molecules, which recombine into alcohol and carbon dioxide.

Liebig's theory, notwithstanding its great popularity, was not universally recognized as a comprehensive theory of fermentation for the reason that "life without air" could not apply to non-living ferments; and since Buchner has recently shown that filtered juice of the yeast plant, obtained by subjecting yeast cells to hydraulic pressure and passing the expressed juice through a Berkefeld filter, is still capable of fermenting sugar, Pasteur's "life without air" theory will no longer apply to living ferments. Another objection to Pasteur's conception is founded upon the fact that free exposure of yeast to air does not to any considerable degree lessen the capacity of the yeast to ferment sugar. "If yeast also causes fermentation in the presence of oxygen, it follows that we can not correctly say that it is the absence of oxygen which forces it into an intense transformation of its metabolism, in the direction of alcoholic fermentation."

Green carried the biologic conception of ferments to the extreme of concluding that non-living enzymes, as well as living ferment cells, in fact all ferments, are vital structures and their actions are vital actions; thus carrying the whole matter beyond the reach of scientific investigation. The fallacy of this claim is clearly made evident by the work of von Bermaik and Bredig, who have shown that metals under certain conditions may be identical in action with enzymes. Simon ("Physiological Chemistry") says, "We know that properties which are supposedly characteristic of enzymes are possessed also by certain elements which are found only in the inorganic world. The most notable property of the enzymes is their ability to effect an amount of change which is out of all proportion to the quantity of enzyme present, and the fact that the enzyme itself apparently does not enter into the reaction. These properties, however, are common to certain metals and their oxides. Bredig and von Bermaik say 'that a gram atomic weight (193 grammas) of colloidal platinum diffused through 70,000,000 litres of water shows a perceptible reaction on more than 1,000,000 times the quantity of hydrogen peroxide; and H. C. Jones demonstrated that the reduction that here takes place is a mono-molecular reaction.'

"Curiously enough, the analogy between the action of such metallic solutions and the enzymes goes further. Finely divided palladium, platinum, iridum, osmium, etc., thus have the power of inverting cane sugar, like one of the enzymes (invertase), and certain poisons, such as hydrocyanic acid, sulphuretted hydrogen, carbon disulphide and mercuric chloride, which inhibit, or even suspend, the action of enzymes entirely, exert a similar influence upon the colloidal solution of platinum."

Naegeli took the important step (Oppenheimer, "Ferments and Their Action") "of substituting molecular and atomic vibrations for Liebig's chemical decomposition." "He assumed that the vibrations of the atoms in a molecule could be increased by the corresponding vibrations of a second substance that, by mere contact with this substance, a disruption of the molecule of the first substance was brought about without the catalytic agent which induced the decomposition being itself affected."

Just how atomic and molecular vibrations develop specific ferment energy is not stated in Naegeli's theory, but the failure to develop this feature is not the fault of the concept—that ferment action is in some way causatively associated with atomic and molecular vibrations—but rather to the author's failure to carry this concept to its logical conclusions.

The modern theory of physical phenomena—the electron theory—may actually or potentially (since the electron theory is yet in its initial stage) contain the true explanation of the phenomena of fermentation. But I venture to assert that the electron theory will not disprove the concept, that the form of energy which structure gives to matter is derived from movements of the atoms within molecules, and until this is done I can see no existing cause for a serious conflict between the electron and the biophysical theory. My reading leads me to believe that in substituting electro-magnetic waves of the modern theory of light for the mechanical ether waves of the undulatory theory of light, the important optical principles which were worked out by Young, Fresnet, and Foucault remain as true today as they were when the undulatory theory, of which these principles are products, was the theory of light that was almost universally accepted by men of science. Why, then, should substituting electro-magnetic waves for mechanical ether waves, produced by atomic motions, disturb the conclusions of the biophysical theory in regard to the origin and nature of molecular energy, since the ether waves in both instances are caused by motions of ponderable matter?

When the electron theory is viewed from its distal end, it will be seen that all material substances are resolvable into systems of electrons; and as electrons have no material existence, since an electron is assumed to be nothing more than a local distortion, stress, or condition of the universal ether, and since the material nature of ether is itself questioned, it will apparently be a difficult task for mortal man to construct a theory of ferments and their action out of a conception so extremely attenuated. But when the electron theory is viewed from the opposite direction, the problem appears more tangible. We then have atoms, molecules, and ether to deal with, and are not called upon to puzzle our brains in trying to reason out how something may be created out of nothing.

The following summary of facts and conclusions, and, in some instances, the language of their expression, in regard to the electron theory, has been taken from "Modern Theory of Physical Phenomena," by A. Riggi, translated by A. Trowbridge, 1904. The atomic constitution of electricity is a concept of the electron theory. "Every molecule of an electrolyte may break up into two ions, that is, into two atoms or groups of atoms having equal charges of opposite sign"; thus when sodium chloride is dissolved in water many of its molecules become dissociated, that is, they become separated into ions—a positive ion of sodium and a negative ion of chlorine. And "when the electrodes connected with the poles of a battery are immersed in the salt solution, the ions, obeying the law of electric force, are set in motion and pass to their respective electrodes where they give up their charges and become neutral atoms." "When the ions arrive on the electrodes and become neutral atoms, the electrons enter into the circuit and constitute the current."

Electrolytic dissociation, that is, a separation of electrons from atoms by the expenditure of energy, which varies according to its chemical nature, seems to be limited to the separation of negative electrons from neutral atoms; and "since the structure of material atoms is such as to permit the negative electrons, which form a part of them, to vibrate freely while the positive part remains fixed, the neutral atom is conceived to consist of one portion which has a positive charge, and of one or more negative electrons which vibrate around it, like the satellites about a planet, held in their orbits by electric force."

"The undulatory theory of light demands the existence of a medium capable of propagating its waves; a substance distributed everywhere throughout interstellar and interplanetary space, and throughout interatomic space as well." It has recently been determined that light waves can be considered as electro-magnetic waves, which differ from the Hertzian waves only in numerical values. "But to complete the electromagnetic theory of light, so that it may serve to explain certain phenomena which result from the action of ponderable matter on the ether, Lorentz had the fortunate idea to consider the electro charges of atoms with the atoms themselves." "If merely the positive charges take part in light vibrations, and magnetic forces generated by their motions are taken into account, one arrives at an electro-magnetic theory of light capable of explaining those phenomena which eluded the theory based simply on the formula of Maxwell or of Hertz."

The separation of molecules into ions seems to be a prerequisite to the electron theory, and as this phenomena is limited almost exclusively to electrolytes, the explanation of ferment action does not logically fall within the scope of the electron theory since neither ferments nor their substrates are electrolytes. But be this as it may, the only grounds for conflict between the electron theory and the biophysical theory, that comes within the range of my vision, grow out of a possible difference in dynamic effect between waves produced in the ether by ponderable atoms and the electro-magnetic ether waves. But even this difficulty seems to disappear "when the atoms are considered in connection with their electro charges."

FERMENTS AND THEIR ACTION.

Fermentation is a process which has both a chemical and a physical side; the chemical side takes note of the nature of the material changes wrought in the substrate by the ferment, and of the end results of the reaction. The physical side of the process takes note of the nature and source of ferment energy, and the means of its transmission. Since ferment energy is conserved and transmitted by material substances, called ferments, which do not appear in the chemical equations they induce and add nothing from their own substance to the decomposition products of the reactions, the nature of these bodies and the source and nature of the specific energy they transmit are subjects of the greatest importance. Chemistry has endeavored to prove that ferments are definite chemical compounds, but so far has signally failed to separate the ferments from the proteids with which they are united, or to find a chemical test by means of which a ferment may be recognized; and until these objects are accomplished the chemical nature of ferment must remain a matter of surmise. Oppenheimer ("Ferments and Their Action") says, "Of the ways and means by which these *peculiar forms of energy* develop their activity we have not the slightest trustworthy idea. We must simply resolve to regard ferment actions as special phenomena of the ominous catalytic processes from which their differentiation is required by the fact that they are *produced by living cells. Catalytic action* is nothing more than a scheme of despair under which we may group chemical reactions which, while possessing a certain similarity in their course, can not, without further knowledge, be explained by our simple chemical theories."

I will not enter into a discussion of the various and conflicting theories of the nature of ferments and their action which have been advocated in the past, since they range in scope from the hypothesis that enzymes are chemical bodies, and that failure to separate them in a pure state is due solely to insufficient chemical knowledge, to the extreme view that ferments are not material—that they are properties of matter, as heat and magnetism are, or centers of force, but have no material structure. A discussion of these theories would needlessly prolong the time of your patience and throw no additional light upon the subject of this paper.

THE BIOPHYSICAL THEORY OF FERMENTS AND THEIR ACTION.

A comprehensive consideration of the phenomena of fermentation from all viewpoints in past and present time; the analogies that exist between ferment phenomena and the phenomena of infection and immunity; the insufficiency of existing theories to explain the nature and action of ferments; the uniqueness of ferment energy and the mystery of its source, led me to believe that a solution of the problem, how ferments develop special energy and do special work, could only be found in the molecular structure of matter. The development of this idea into a comprehensive theory, which serves not only to explain the nature of ferments and their action, but the nature of toxins and their action as well, was a process of slow and tedious development. The theory is predicated upon the concepts that the energy of a molecule is the sum of energy of its atoms, and that molecular energy is derived from ether waves produced by inherent vibratory motions of atoms within molecules.

Accepting the statements of Julius Thompson in the introduction of his "Thermo-Chemical Investigation," that "theoretical chemistry is based upon the molecular theory, according to which all matter is made up of molecules, and these molecules of atoms. The physical state of bodies depends upon the arrangement and motions of the molecules, the other physical and chemical properties depend upon the kind and number of atoms in the molecule, upon their arrangement and relative motions. The suggestions of J. Clerk Maxwell ("Encyclopedia Britannica," article "Atom") that "Atoms exist of various kinds having their various periods of vibration, either identical, or so nearly identical that our spectroscopes can not distinguish them." The same kind of atoms, say of hydrogen, have the same set of periods of vibration, whether we procure the hydrogen from water, from coal or from meteoric iron. And of Lord Kelvin, who, in his vortex hypothesis, not only attributes to each kind of atom its distinctive motion, but postulates that the motion of the atom is the sole character which distinguishes it from other atoms, I will mentally picture molecular structure and the source of molecule energy as I see them.

ATOMS.

Atoms may or may not be ultimate parts of matter. It is quite sufficient, to satisfy the biophysical theory, to regard atoms as the smallest parts of matter that are capable of entering into chemical combination, since it is the behavior or properties of the atoms which concern our investigation, rather than the question of divisibility. It is believed that atoms possess, among other properties, that of constant motion in time, periods, and in other characters perhaps, which characterize each species or kind of atom, one kind from another. The phenomena of spectroscopy are made intelligible by this hypothesis.

MOLECULES.

Molecules are regarded as the smallest part of a compound which are capable of retaining the properties of the substance; when divided beyond this point molecules are broken up into atoms. It is believed that the number and kind of atoms which compose a molecule, and the spatial relations of its atoms, are factors which determine both the nature and the energy of the molecule.

THE UNIVERSAL ETHER.

Existence of a universal ether which pervades all space (interstellar, interplanetary, intermolecular, and interatomic), and receives, conserves, and transmits as energy the ether waves produced by the motions of ponderable matter, is accepted as it must be to explain the phenomena of the universe.

WAVE INTERFERENCE.

The mutual neutralization of the waves of light, as seen in "Newton's Rings," when the crest of one wave falls upon the trough of another, or the neutralization of two sound waves, one by the other, afford example of the action of an important principle in nature, of wide application, which Sir John Herschel says, "For beauty, simplicity, and extent of application has hardly its equal in the whole circle of science." This principle or law of wave interference plays an exceedingly important rôle in the biophysical theory. An instance of this is the adjustment of antagonisms between the interatomic ether waves of a molecule and the conversion of antagonistic into adjusted waves—molecular waves—which, it is believed, give molecules the potential energy that structure gives to matter. The molecular ether waves which result from interference and adjustment represent, first, the number and kind of atoms within the molecules; second, the order of their arrangement or stereo-chemical configuration of the molecules; and, third, molecular energy, the particular form of which will vary with the structure of the molecule. When considered in this light, a new meaning is given to the term molecular structure and energy. We mentally behold a number of atoms arranged in characteristic groups, and vibrating in distinctive periods, imparting their own motions to the ether as ether waves, which are warring waves that finally adjust their antagonisms, and then become the source of energy that structure gives to matter. And since the character of the molecular waves will vary to a fraction with variations of structure, the specific energy of the molecule will likewise vary. Hence it follows from this scheme that the specific energy of ferments and toxins is a result of stereochemical configuration of their molecules.

But something more than specific energy is necessary to give a molecule dynamic power; the principle of interference requires that opposing waves shall coincide in definite ways before potential energy becomes active or dynamic energy, hence the energy of a ferment or toxin is manifested only upon substances whose molecular waves it can influence—either exaggerate, lessen or destroy. Upon all other substances the energy of the ferment is powerless to excite fermentation.

We know that an open piano with raised pedal, in a closed room, will respond accurately note for note with notes made upon a violin. This is because the periods of vibration of the strings which respond are the same in both instruments, all other strings are silent. It is just so with the ether waves of molecules, they must be timed alike in periods of vibration that the energy of one may be manifested upon the other, otherwise there will be no action.

The following remarks by Professor Tyndall—"New Fragments"—are apropos in a discussion of this subject. "A group of atoms drawn and held together by what chemists term affinity is called a molecule. The ultimate parts of all compound bodies are molecules. A molecule of water, for example, consists of two atoms of hydrogen, which grasp and are grasped by one atom of oxygen.

"When water is converted into steam, the distance between the molecules is greatly augmented, but the molecules themselves continue intact. We must not, however, picture the constituent atoms of any molecule as held so rigidly together as to render intestine motion impossible. The interlocked atoms have still liberty of vibration, which may, under certain circumstances, become so intense as to shake the molecules asunder. Most molecules, probably all, are wrecked by intense heat, or, in other words, by intense vibratory motion; and many are wrecked by very moderate heat of the proper quality. Indeed, a weak force which bears a suitable relation to the constitution of the molecule can by timely savings and accumulations accomplish what a strong force out of such relations fails to achieve. The sensation of light is produced by a succession of waves which strike the retina in periodic intervals; and such waves impinging on the molecules of bodies agitate their constituent atoms. These atoms are so small and, when grouped to molecules, are so tightly clasped together that they are capable of tremors equal in rapidity to those of light and radiant heat. To a mind coming freshly to these subjects the numbers with which scientific men here habitually deal must appear utterly fantastical; and yet to minds trained in the logic of science they express most sober and certain truth. The constituent atoms of molecules can vibrate to and fro millions and millions of times in a second. The waves of light and radiant heat follow each other at similar rates through the luminiferous ether. Further, the atoms of different molecules are held together with degrees of varying tightness—they are timed, as it were, to notes of different pitch. Suppose, then, that the light waves or heat waves impinge upon an assemblage of such molecules, what may be expected to occur? The same as when a piano is opened and sung into. The waves of sound select the strings which respectively respond to them—the strings, that is to say, whose rates of vibration are the same as their own. Of the whole series of strings these only sound. The vibratory motion of the voice imparted first to the air is taken up by the strings. It may be regarded as *absorbed,* each string constituting itself thereby a new center of motion; thus also as regards the tightly locked atoms of molecules on which waves of light or heat impinge. Like the wave of sound just adverted to, the waves of ether select those atoms whose periods of vibration synchronize with their own periods of recurrence, and to such atoms they deliver up their motion. It is thus that light and radiant heat are absorbed.

"I have spoken of molecules being wrecked by a moderate amount of heat of the proper quality; let us examine this point for a moment. Let a quantity of the vapor of nitrite of amyl be introduced into a wide glass tube along its axis. (Prior to the entry of the beam, the vapor is invisible as the purest air.) When the light enters, a bright cloud is immediately precipitated on the beam. This is entirely due to the waves of light, which wreck the nitrite of amyl moleucles, the products of decomposition forming innumerable liquid particles which constitute the cloud. Many other gases and vapors are acted on in a similar manner. Now the waves that produce decomposition are by no means the most powerful of those emitted by the sun. It is, for example, possible to gather up the ultra-red waves into a concentrated beam, and to send it through the vapor like a beam of light. But, though possessing vastly greater energy than the light waves, they fail to produce decomposition. Hence the justification of the statement already made, that a suitable relation must subsist between the molecules and the waves of ether to render the latter effective.

"I have stated, without proof, that where absorption occurs the motion of the ether waves is taken up by the constituent atoms of the molecules. It is conceivable that the ether waves, passing through an assemblage of molecules, might deliver up their motion to each molecule as a whole, leaving the relative position of the constituent atoms unchanged. But the long series of reactions represented by the deportment of nitrite of amyl vapor does not favor this conception; for, were the atoms animated solely by a common motion, the molecules would not be decomposed. The fact of decomposition, then, goes to prove the atoms to be the seat of absorption. They in a great part take up the energy of the ether waves, whereby their union is severed and the building material of the molecules is scattered abroad."

CONCEPTION OF A FERMENT.

which, by means of atomic movements, stereo-chemical configuration of its molecules and the arrangement of the molecules in the compound, is capable of developing ferment energy and of transmitting this to a vulnerable substrate with which the ferment is in contact.

The structural features which distinguish ferment from non-ferment substances are, first, the kind of atoms and their spatial relations in the molecule—that is, the arrangement of the atoms in the molecule in characteristic groups; second, the arrangement of the molecules in the substance so that an exaggerated surface, in proportion to weight and mass, is exposed to molecular action.

All substances that possess these features should have ferment potential energy, whether the substance be a living micro-organism, an enzyme, a proteid, or a metal. Nature has supplied ferment properties to certain species of micro-organisms seemingly to perpetuate the ferment, as this function of the micro-organism is distinct from and is not necessary to the functions which maintain the life of the cell, nor to the other vital functions of the micro-organism. Not only may living cells possess ferment function or property, but non-living cells (enzyme cells) proteid cells, and some metals in molecular division also possess it. Recent biologic investigations have shown that proteids of all kinds, when taken from one species of animal and hypodermically injected into another species of animal, manifest specific ferment action, that is, they cause certain specific chemical changes to occur in the proteids of the blood of the animal treated, with a development of end products which respond in a definite manner when brought in contact with the identical substance injected, but only when this is obtained from the same species of animal as the one which furnished the proteid injected. The relation in specific qualities between the proteid injected and the products of its reaction furnishes evidence that proteids under certain conditions are special ferments; while ferment activities of colloidal solutions of platinum, which differ from the metal in larger pieces solely in the enormous surface exposed in proportion to weight and mass, is evidence that the arrangement of molecules in a substance that will expose a relatively large surface to molecular energy is a necessary factor in the composition of ferments.

THE SUBSTRATE.

The relations in specific features that exist between a ferment and its substrate, and a ferment and its decomposition products, have been subjects of observation and of much discussion; but the causes of these relations have never been satisfactorily determined. A great advance in our knowledge of the nature of these relations was, however, made by Emil Fischer when he showed that sugars which are chemically alike do not respond to the action of the same ferment. Maltase, for example, splits up all the a-glucosides, but has no power on the b-glucosides; while another ferment—emulsion—breaks up the b-glucosides and has no influence on the a-glucosides. The two series of glucosides—the alpha and beta series—are chemical isomers, that is, the molecules of both series contain the same kind and number of atoms, but the atoms occupy different spatial relations in the molecules of the two kinds of glucosides. Now Emil Fischer says that it is this matter of difference in spatial relations, which the atoms of the two series occupy, that causes them to respond differently to the action of the same ferment. But no clear explanation of this fact has been given, and it remains for the biophysical theory to point out how spatial arrangements of atoms in molecules may affect their vulnerability to ferments. The rationale of this has already been gone into in describing how and why molecular energy is determined by molecular structure. It may, however, be necessary to a clear understanding of the theory, to repeat that ferment energy of a molecule is an expression of its ether waves, but such energy is potential, and can not, therefore, do work until the molecules of a ferment are brought in contact with the molecules of another substance, a substrate, whose ether waves they may influence, in response to the principle of interference; when this occurs the potential energy of the molecules is converted into dynamic energy. Maltase ferments the alpha series of glucosides for the reason that the ether waves of the ferment and the glucosides coincide, and it does not ferment the beta series because there is no coincidence of ether waves, in this case, between maltase and the glucoside. The substrate to a ferment can not, therefore, be an indifferent substance; on the contrary, the principle of interference requires that the molecular structure of the substrate shall bear a definite relation to the ferment in a stereochemical configuration of its molecules, since a definite relation in character, periods, and phase of molecular waves of ferment and substrate is required that potential wave energy may be converted into dynamic wave energy; in other words, that ferment work may be accomplished. The specific nature of ferment or recombination products, which result from the specific action of a ferment on its substrates, goes without saying since no other kind of products could occur under these conditions.

Fermentation may then be regarded as a physico-chemical contest between the ferment and the substrate; a contest which is carried on by means of their respective molecular waves, and one that will continue, sometimes forwards and backwards, until an equilibrium of the contending forces is reached through recombination products which antagonize the ferment action, and will finally arrest the process.

How decomposition, or if permitted to use a more descriptive term, recombination, products of a ferment reaction establish an equilibrium of forces that will arrest fermentation will now be answered, and in the same connection an effort will be made to show that the striking analogies which exist between the action of enzymes, toxins, and toxalbumins, are due to an equal similarity, if not identity, in the source and nature of the energy which these bodies manifest.

We have learned that alcoholic fermentation consists in the conversion of grape sugar of grape juice into, practically, alcohol and carbon dioxide; and that this is accomplished by the ferment of yeast. It is a matter of fact that alcohol is an antiferment to this process, and will stop it when 12 to 15 per cent of alcohol has accumulated. That alcohol alone is the inhibiting cause is proved by the arrested fermentation starting up when part of the alcohol is removed, to again stop when the required per cent has again accumulated. There may be both sugar and yeast present, but there will be no fermentation while 15 per cent of alcohol intervenes. These facts are interpreted by the biophysical theory, as follows: A molecular wave contest between the yeast ferment and sugar molecules is made necessary by their contact, and by the coincidence in time, crest and trough of their waves. The molecular waves of the ferment, falling in a timely way millions of times a second upon the molecular waves of the sugar, increase their energy, and swing the sugar atoms further and further apart until they are finally swung beyond their affinities and become dissociated, and the sugar decomposed. But since nascent atoms speedily combine along lines of least resistance, the dissociated sugar atoms obey this chemical law and enter into recombination products. But let us consider what influences determine the combining lines of least resistance in this reaction. The wave energy of the yeast, that decomposed the sugar, is a determining influence in the recombination that must be considered.

It is quite evident that the atoms can not recombine into sugar or into any substance whose molecular structure too nearly resembles sugar; in fact, other things being equal, the less similarity in wave characters between ferment and the recombination products, the less will be the resistance to combination. Hence lines of least resistance are offered to substances whose wave periods are unlike those of the sugar in phase, and whose energy may be antagonistic to that of the yeast; such substances are necessarily antibodies which tend, through interference, to immunize the sugar against the yeast, by equalizing the forces of the two substances.

The marked resemblance which the phenomena of fermentation bear to the phenomena of infection naturally inclines the mind to conclude that these analogies arise from a similarity, or identity, in the nature and modus of the causes which underlie and determine both processes. The features which correlate the phenomena and their causes will appear more clearly by comparing the phenomena and causes of alcoholic fermentation as given with those of diphtheria. Diphtheria is an infectious disease, caused indirectly by a pathogenic micro-organism—the diphtheria bacillus. When this bacillus is inoculated into a non-immune animal, or is grown in an artificial culture material, it develops a poisonous toxin—the diphtheria toxin—which is the essential cause of diphtheria. When the toxin finds a vulnerable substrate (proteid molecules) in the blood and tissue juices of the animal—man and horse—the substrate is decomposed, and the dissociated atoms of the substrate combine into antitoxin—a specific antibody—which neutralize the energy of the toxin, and cures the patient. Now toxin occupies the relation to the diphtheritic process, that yeast ferment does to alcoholic fermentation, one dissociates the vulnerable molecules of the blood serum, which recombine into a specific antibody-antitoxin; the other dissociates the vulnerable sugar atoms, which recombine into alcohol, etc.; the alcohol is a specific antibody to the ferment-antiferment, while antitoxin is the specific antibody to diphtheria toxin-antitoxin.

SPECIFIC ANTIBODIES.

A development of specific antibodies as end products is a phenomenon that is by no means limited in its occurrence to the alcoholic fermentation in fermentative processes, nor to the diphtheric infection in the infectious processes; on the contrary, it is a common feature of both fermentation and infection. Furthermore, a development of specific antibodies serves to distinguish the simple chemical reaction from the more complicated chemical plus ferment, and chemical plus pathogenic reactions. Besides, specific antibodies play an important rôle in immunizing the living organism against injury by the action of ferments that are normal to the living organism, and, indeed, are necessary to the normal performances of its functions; and against injury by the action of pathogens—disease-producing "germs" of infectious diseases.

Professor Wells, of the University of Chicago, "Chemical Pathology," 1907, says, "Injection of enzymes into animals leads to the appearance of substances in the serum of the animals that antagonize the enzymes. The principles involved are quite the same as in the immunization of animals against bacterial toxin, or against foreign proteids." "It seems highly probable that the resistance of the body tissues to digestion by their own enzymes and by the enzymes of one another depends in some way upon the presence of anti-enzymes in the cells and tissue fluids." "Weinland has demonstrated that certain intestinal worms contain a strong anti-trypsin, to which he attributes their ability to live bathed in pancreatic juice without being digested. Similar properties have been ascribed by other observers to the cells of the mucosa of the stomach and the intestines."

The anti-enzymic property of the blood serum, acquired by inoculations of enzymes into the animals, is highly specific (v. Esler). "This fact permits us to distinguish between enzymes of apparently similar nature, but of different origin." Artificial immune serum has been obtained against trypsin, pepsin, lipase, emulsin and fibrin ferment.

ACQUIRED IMMUNITY.

It is a matter of common observation that a single attack of an infectious disease will, in many instances, temporarily or permanently immunize the patient against a recurrence of the disease. It is also generally known that vaccinations with a modified virus of the disease will immunize against smallpox and hydrophobia. But it is less generally known that specific immunity against a great number of different kinds of infectious diseases may be acquired by repeated inoculations of small, then gradually increasing, doses of modified specific virus (toxins and pathogens) of the disease, and when these apparently different means of inducing acquired immunity are analyzed that they all lead to the same end—the production of specific antibodies in the blood serum of the animal treated.

There yet remains an important phenomenon of immunity that strongly confirms my contention, that the underlying causes of fermentation, infection, and immunity, are essentially the same. I refer to the fact that neither inoculated ferments nor pathogens "take," except in animals that are not immune to these bodies. All are acquainted with the fact that vaccination against smallpox will not "take" in immunes, and, therefore, feel that immunity formerly acquired has not been lost if vaccination fails to develop the characteristic pustule. This instance but represents a general rule which the term immunity itself implies. The reason why ferments and pathogens do not take when inoculated into immune persons is readily understood when the fact is recognized that, in accordance with the principle of interference, ferment and pathogen molecules can disrupt and recombine into specific antibodies only those substrates whose molecular waves coincide in certain definite ways with the ferments or pathogen, as the case may be, and since the related substrate (homologous proteid molecules of the blood serum) is destroyed or changed in molecular structure, be immunization, the related ferment or pathogen, as the case may be, is incapable of causing specific action in the blood of person immune to this substance.

PHAGOCYTOSIS.

Among the several kinds of leucocytes or white blood corpuscles, and some of the fixed tissue cells also, are to be found cells whose chief function seems to be the removal of dead and foreign matters from the blood and tissues of the body. These cells are commonly known as phagocytes, and a theory of immunity, and a very popular theory, is based upon the claims that the phagocytes defend the body against infection by devouring, actually englobing and digesting, invading pathogenic bacteria. I do not propose to discuss the phagocytic theory of immunity except to say, that the opposite behavior of phagocytes towards infectious bacteria in immune persons as against their behavior towards the same bacteria in non-immune persons, has presented a puzzle which those of the phagocytic school of immunity have failed to solve. I mention this phenomenon at this time because it confirms the accuracy of the contention, that the presence in the blood serum of a vulnerable substrate is absolutely essential to pathogenesis, and that the absence of either factor—pathogen or substrate—is fatal to the process. To illustrate, it is an established fact that the phagocytes of a person who has been made immune to a given infectious disease will attract towards themselves, and will devour the specific bacteria of this disease which the blood may contain. On the other hand, when the same species of bacterium is inoculated into the body of a person who has not been made immune to this disease the phagocytes will not attack, but will be driven from the field and may be destroyed by the bacteria. In the first instance—according to the teaching of the biophysical theory—the pathogenic bacteria are innocuous to the immune person, and to his phagocytes as well, for the reason that during the process of his previous immunization certain homologous proteid molecules of his blood, which constitute the substrate vulnerable to the species of bacterium, were either destroyed or the atomic structure was changed in such manner that the specific vulnerability to the bacteria was lost. Under these conditions no infection can follow the introduction of the bacteria; there can be no development of toxins or toxalbumins, and the phagocytes will, therefore, destroy the bacteria as they do other innocuous, positive chemotactic substances. In the second instance, both conditions necessary to pathogenesis are present (the infectious bacteria and a vulnerable substrate), infection will, therefore, occur with a development of toxin or toxalbumins, and the phagocytes will be driven from the field by the bacteria poisons, and may be destroyed by the same agents.

OPSONINS.

A new and fascinating treatment of infectious diseases has recently come into vogue and seems to be rapidly gaining in popularity. This treatment is based upon a specific power in making pathogenic bacteria susceptible to phagocytic destruction, that opsonin is said to possess.

Only a few years ago we were taught by Metschnikoff and his school that the phagocytes of our serum were the sole defenders of our bodies from infection by invading pathogenic bacteria. More recently, under the teaching of Wright and Douglass, we are led to believe that the phagocytes alone can not accomplish this work, but must be assisted by opsonin. It is claimed that opsonin first weakens the resisting power of the bacteria, and not until then can phagocytes take the bacteria in and destroy them—that neither opsonin alone nor phagocytes alone is able to destroy the bacteria, but when both are present their combined action not only kills the bacteria but causes them to be taken in and digested by the phagocytes. This claim is based upon the fact that serum assumed to contain opsonin loses its bactericidal power when it is heated to 55° C., but the lost function is restored by the addition of a little fresh serum; the serum that is added need not be native serum, since serum from alien species will do as well. The opsonists say that heating the serum destroyed its opsonin and the phagocytic power of the leucocytes, and that the restoration of these functions by the addition of fresh serum is due to the opsonin the serum contained. We may, at least, learn from these phenomena, since the addition of alien serum will restore bactericidal power to overheated serum, that neither the serum nor its opsonin are specific in their action.

The opsonic explanation of the phenomena named, beautiful and attractive as it appears, is not the only one, nor, as I view it, the one in harmony with known physiological functions, that is capable of interpreting the facts upon which the opsonic theory is based. I will try to show that opsonic phenomena, so-called, are the phenomena of immunity acquired against pathogenic bacteria, and that opsonin is a new name for an old acquaintance—alexin.

The serum of persons who have been made immune to a species of pathogenic bacteria is bactericidal to this species; the bactericidal action is specific. When this serum is heated to 55° C., it loses its bactericidal power, but this can be restored to it by the addition of fresh serum, either native or alien. This shows that immune serum must contain two substances on which its bactericidal power depends, and that one of these is destroyed by heating to 65° C. These two substances are called alexin, or complement, and immune body. Alexin is a normal constituent of serum; it may enter into chemical combinations with certain elements or their ions; it is non-specific in its action, and may be destroyed by heating to 55° C. It appears, therefore, that the characteristics of alexin are identical with those of opsonin. The other substance contained in the serum of persons made immune to a species of pathogenic bacterium is named immune body; this is not a normal constituent of serum; is found only in immune or partially immune serum; is specific in its action; is not destroyed by heating to 55° C.; responds to no revealing chemical test, and is a proteid in its structure and a ferment in its action.

Now, since the bactericidal power of serum depends on the presence and combined action of both alexin and immune body, the nature of this relation should be pointed out. Ehrlich's side-chain theory affords a chemical explanation, but the one that most appeals to me is one that interprets the reciprocal action of alexin on immune body to be that of an activator on a ferment.

Enzymes, which play an important rôle in the phenomena of life, have their activities conserved and regulated to the needs of the organism by the stimulating or restraining action of bodies the organism contains that are called activators and hormones. For example, hydrochloric acid, secreted by the glands of the stomach, is an activator that converts inactive pepsinogen into active pepsin; inactive trypsinogen is converted into active trypsin by entero-kinase, its activator; while the amount of trypsin secretion is regulated by secretin, its hormone. These are a few of many similar function regulators by means of which the organism co-ordinates and controls functions which otherwise may become dangerous. From my viewpoint immune body is an activator that stimulates into activity the ferment action of alexin, which destroys the bacteria. It is not necessary to assume that the increased number of bacteria that phagocytes take in when inoculations of a vaccine are made is due to an increase in the opsonic content of the serum, since it has been fully established that the number of a species of bacteria the phagocytes of the blood will take in is a matter of immunity the animal has acquired against this species of bacteria—the phagocytes of an immune person will take in a great number of the bacteria, while the phagocytes of a non-immune person will take in very few or no bacteria.

There is another important and suggestive phase to this subject, the explanation of which seems to afford strong evidence in favor of the biophysical theory. It is this, inoculations, whether made of bacteria, toxins, ferments, or proteids, do not cause a development of antibodies (immune bodies), or, if you please, opsonins in the serum and tissue juices of immune persons; these develop only when inoculations are made in person who are non-immune to the substances inoculated. These facts do not seem susceptible to explanation except upon the hypothesis that the reactions which occur in these processes are those of ferments on vulnerable substrates, and since such substrates are either destroyed or thrown out of commission through a loss of vulnerability by the action of the bacteria, ferments, toxins, or proteids, in the acquirement of immunity, a development of antibodies can not follow inoculations while the immunity of the animal organisms continues to exist. There is still another phase to this subject, and a very remarkable one, that has only recently received much notice. I refer to the deadly effect that an infinitesimal dose—1-10 c.c.—of horse serum (a harmless substance) will produce when inoculated into a guinea pig which has been made sensitive to horse serum by a previous inoculation of 1-250 or even 1-10,000 c.c. of serum when the interval of time between the doses was as much as ten days.

Horse serum is practically innocuous to the guinea pig and to other animals when given in a single dose, or in repeated doses when given at short intervals; in fact, the latter method will immunize the animal. But when an interval of ten days to as many months is permitted to elapse between the inoculations the second dose will kill the pig in a brief time, even though the dose does not exceed 1-10 c.c. This extraordinary phenomenon appears susceptible to but one interpretation, that of ferment action. It is fortunate that horse serum does not react with the serum of man as it does with the serum of the guinea pig; if it did the world would be deprived of the benefits of one of its most beneficent discoveries—the antitoxin treatment of diphtheria.

A suggestive feature of the toxicating of horse serum for the guinea pig by the administration of small, sensitizing doses of serum is the specificity of the reaction. Horse serum in quantity as small as 1-250 c.c. can alone sensitize a guinea pig to the extent that it will be killed by a second dose of the serum,—even the 1-10 c.c. when given after the period of incubation has passed. It is claimed that guinea pigs have been slightly sensitized to horse serum by the administration, subcutaneously and by feeding methods, of large quantities of the sera of animals other than the horse, but this result does not disprove the statement, that sensitizing a guinea pig to horse serum is quantitively a specific reaction. But the sensitizing reaction is not limited to horse serum and guinea pigs, since it has been accurately duplicated when other sera have been introduced into alien animals. Aside from the sensitizing feature of the process, the reaction that follows the introduction of a serum into an alien animal differs apparently in no respect from that already mentioned which follows the introduction of a ferment, toxin, or proteid into the blood of a non-immune animal; and further than this, the relations that exist between the serum of the horse and that of the pig, indicated by the term "alien," and between a pathogen and the blood serum of man, indicated by the term "non-immune," relations which are necessary to the reactions that occur, affords evidence, seemingly conclusive, that the reactions in these processes is that which take place between a ferment and its substrate. The great importance of these facts, which have been revealed to us by recent experimental work in biology of the blood, their present value to man, and, I am confident, the far greater future value that a clearer insight into their nature will disclose, will reveal many of the hidden mysteries of life—among others those of proteid synthesis, immunity and metabolism. When the day arrives in which all these things shall come to pass the mind of man will be impressed, more than it is now, with the sublime truth of the Divine saying "The blood thereof is the life thereof."

SOIL FERTILITY AND PHOSPHORIC ACID.

G. S. Fraps, Ph. D.*

The development of agricultural chemistry is intimately connected with the theories concerning the nature of soil fertility. In the beginning or the rudimentary stages of agricultural chemistry, it was believed that plants, like animals, lived upon organic matter. To feed plants and to maintain soil fertility, the soil must be filled with organic matter—manure. The mineral matter contained in plants—the ash—was not essential, but acted as a stimulant. Such was the humus theory, as it was called, a theory which, like all theories generally held, contained something of truth, though in itself erroneous. The application of sufficient manure to the soil goes far towards maintaining soil fertility, though not for the reason contained in the theory.

The great German chemist, Justus von Liebig, directed his attention to chemistry in its application to agriculture, and in 1843, published a book in which the humus theory was demolished on theoretical grounds. In its place was set up the mineral theory, according to which the mineral matters taken from the soil were the essential constituents for fertility. The experimental proofs for this theory were not long in being produced. Liebig himself, as an object lesson, transformed a barren, sandy piece of land near Giessen, Germany, into a beautiful garden, entirely by means of mineral manures. Plants were grown in water solutions of mineral salts without any organic matter whatever, and they grew vigorously and produced seed. By leaving out one or the other elements from the water solution and observing the growth of the plant, it was soon established which elements were essential to the growth of the plants and which were only useful, or of no use at all.

Modern agricultural chemistry may be said to begin with this book of Justus von Liebig. We may trace directly from it the field experiments of the young John Lawes at his manor place of Rothamsted, England—his discovery of the effect of treatment with sulphuric acid upon the manural effects of mineral phosphates, his patent on the process, and, incidentally, the fortune he made from it. We find the experiments continued, with the aid of Henry Gilbert; honors were heaped upon them—they are now Sir John Lawes and Sir Henry Gilbert; Rothamsted is the most famous experimental place in the world,

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and finally it is endowed as an experiment station by Sir Lawes, in order that the experiments which have been carried on in the same field and in the same way for fifty years may be continued and enlarged.

But this was not the only effect of the book of Justus von Liebig. Other men experimented and the theory was developed. The foundations for our great fertilizer industry were laid, an industry which in this country alone markets a product selling for tens of millions of dollars each year—and thereby causes an increase of at least twice as much in the value of our agricultural products. Truly, if he who makes two blades of grass to grow where but one grew before is a benefactor to humanity, how shall we find words to express the greatness of Justus von Liebig and those who aided in the practical development of this great theory! For we find sands once worthless, barren and generally good for nothing, now green with their rich spoil of lettuce or cabbage or potatoes, or red with the strawberry or tomato, or bearing heavy crops of pineapples. Indeed, many of our largest and most successful truck growers consider a soil only as something in which to put fertilizers.

I do not think that any one will dispute that certain elements are necessary to the life of plants—carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium and iron; and of these, carbon is furnished in the carbon dioxide of the air and hydrogen and oxygen as water.

Of the seven elements which are taken from the soil, and are essential to the life of plants, three appear to be always present in sufficient quantity, namely, iron, sulphur and magnesium, while enough of the other four may not be present. These four are nitrogen, phosphorus, potassium and calcium, and one of these, calcium, appears to be needed by the soil rather than by the plant, when it is needed at all. Nitrogen, phosphorus and potassium, then, may not be furnished by the soil in sufficient quantity to produce a good crop, and the addition of the lacking elements in suitable forms will have a decided effect upon production. Upon this fundamental basis has been developed the fertilizer industry. Fertilizers are applied to the soil to supply the plant with the phosphoric acid, potash or nitrogen, which is needed in the soil.

It is a matter of great importance to ascertain whether a given soil or class of soils is deficient in plant food, and the extent of their deficiency. It is obviously a waste to supply phosphoric acid, potash and nitrogen to soils which do not need them, or to apply a mixture of the three in unsuitable proportions. If we knew the needs of the various types of soils, and the requirements of different crops, we would have a working basis to aid the individual in his applications of plant food to the soil.

To determine the needs of the soil for plant food is not, however, a simple matter. The chemical analysis of a soil, while it affords indications, is not certain, especially in soils long in cultivation. For example, the rice soils of Texas contain from 500 to 800 pounds of phosphoric acid per acre in the surface foot, but the application of twenty-eight pounds phosphoric acid in acid phosphate has a great effect upon the yield. There is plenty of phosphoric acid in the soil, but not sufficient of it is in such forms that plants can take it up, hence the decided effect of the addition of a comparatively small quantity of phosphoric acid that plants can take up. Ordinarily chemical analysis shows the amount of plant food in the soil, but it does not distinguish between that which the plant can take up and that which it can not. Hence while this chemical analysis shows the possibilities of a soil under good treatment, it does not show the immediate needs of the soil.

Another method of ascertaining the need of a soil for plant food is by means of field tests. A field is selected uniform in all respects, and it is divided into plots, say one-tenth acre each in size. These plots are treated alike in all respects, excepting that they receive different fertilizers. The yield of the crop planted is taken as a measure of the effect of the various applications.

Plot experiments are subjected to vicissitudes of the weather, the depredations of insects, and other variable conditions. A soil which appears uniform may really be variable in depth or chemical composition. Heat and cold, moisture and drought, affect the crop, and the controlling influence in the development of the plant may be, at various periods during the season, other than the plant food in the soil. For these reasons the results of plot experiments are often irregular, contradictory and unsatisfactory. Yet, if carried on for a sufficient number of years, and when properly planned and conducted, plot experiments give results which can be secured by no other means of experimentation, and the ultimate test of laboratory conclusions must be the field.

Plot experiments are expensive, require considerable time, and the results are applicable only to the kind of soil under experiment. The results of such experiments should be correlated with the various types of soil before general application is made of the results. Too often field experiments on one kind of soil are applied to soils entirely different.

Another method of ascertaining the need of the soil is by pot experiments. In these experiments, the soil is mixed thoroughly and portions of ten pounds or more placed in pots, and plants grown therein. For example, if we desire to ascertain whether or not a given soil is deficient in phosphoric acid, we would compare the crop produced by complete plant food with the crop made in the same soil without phosphoric acid. The difference between the two shows the effects of the phosphoric acid.

A pot experiment can be arranged so that the soil and the plant food are controlling factors in the growth of the plant. The results are secured comparatively quickly. For certain problems it is unequaled.

How far the results of pot experiments can be applied to the field is an open question. In the field the plant has a larger quantity of soil to draw from; soils may appear more deficient in pots than they do in the field. Further the depth of the soil is a factor. That the same soil six inches deep in one place and twelve inches deep in another affords different amounts of plant food is too obvious for discussion. In some cases the subsoils must be considered. Some subsoils may supply plant food, while others do not. It is merely my intention to indicate the complexities of the problem which confronts us.

The last method for studying the plant food of the soil which I shall mention is by chemical analysis with weak solvents. This method appears promising. Like pot experiments, the same difficulties would meet us in applying the results as with pot experiments.

The Texas Experiment Station has been conducting pot experiments upon typical soils from various sections of the State. These experiments show the needs of the soil, in itself, for plant food. The results of a number of these experiments have been published in our Bulletin No. 99. As a rule, the soils of Texas are very much in need of phosphoric acid.

We are also studying the chemical methods for determining the needs of the soil for phosphoric acid, and we have had some success, in spite of the complexity of the problem. I wish to explain, briefly, how difficult this problem is.

We have found, in the first place, that soils may contain compounds which are equally soluble but which are unequal in the readiness with which they give up their phosphoric acid to plants.

We have found, in the second place, that soils may withdraw from solution a part of the phosphoric acid which weak acids have dissolved. Different soils have different absorbing powers. Two soils may contain equal quantities of phosphoric acid of equal value to the plant, and yet, on account of this peculiar absorbing power of the soil, the quantity of phosphoric acid which is dissolved from the two soils may be widely different. I have one soil which absorbs 95 per cent of the phosphoric acid put in the weak acid solution.

We have found, in the third place, that the same compound of phosphoric acid may have different value to the same plant in different soils.

In spite of these difficulties, which we are subjecting to a thorough study, we are making progress. We have been testing our soils for their needs for phosphoric acid and other plant food by means of pot experiments. But for certain types of soils which give up less than a certain quantity of phosphoric acid to weak solvents, we shall no longer make pot experiments to test for deficiency in phosphoric acid. We are satisfied to say that such soils are highly deficient in this form of plant food.

Our work must be continued in other and richer soils, but when I say that soils in these classes are widely distributed in the South, you will appreciate the step forward we have made on the long road we have yet to travel before we reach the solution of the problems concerning the phosphoric acid in the soil.

LORD MONBODDO, A PRECURSOR OF THE DARWINS.*

May M. Jarvis, M. A.†

In his history of the evolution idea,[1] Osborn considers only two pre-Darwinian Englishmen, Francis Bacon and Erasmus Darwin, to be worthy of mention. Bacon's chief contribution lay in proposing a method for ascertaining the natural system of the Universe, rather than in speculation on the Universe itself. He was one of the first to observe that mutability of species is merely the accumulation of variations; he stressed the importance of studying variations; called attention to the fact that artificial selection takes advantage of natural fluctuations; mentioned transitional forms; and advised that there be founded an institute for experiments on metamorphoses of organs and the causes of variations in species.

Osborn credits Erasmus Darwin with several original theories; he believed in the spontaneous generation of the lowest forms, but a natural development, through millions of years, from these to the highest animals. He called attention to the struggle for existence, just missing the connection between this and the survival of the fittest; he conceived the ideas that modifications spring from within by reactions of the organism, and that acquired characters are transmitted, thus anticipating Lamarck's theories.

It is surprising that we should credit all of Erasmus Darwin's vague theories, and yet overlook an earlier writer so voluminous as James Burnet. This author, better known as Lord Monboddo, was a prominent lawyer of Edinburgh who occupied his spare time with metaphysics and philosophy. He was a special creationist, and an advocate of the Greek nature-in-systems idea; but he added a doctrine of the evolution of the human race from a brute to a civilized stage, reaching its culmination with the ancient Athenians and deteriorating to modern conditions, which seems entirely original. Perhaps his devotion to classical learning has blinded readers to his real worth; at any rate, it was left to his biographer, William Knight,[2] to class him among the evolutionists.

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*Contribution from the Zoological Laboratory of the University of Texas, No. 88.

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[1]From the Greeks to Darwin, New York, 1899.

[2]Knight, Wm.: *Lord Monboddo and Some of His Contemporaries,* New York, 1900.

Knight's volume contains an interesting account of the life and personality of this eighteenth-century lawyer-philosopher, an estimate of his work, and a portion of his correspondence—that art being much cultivated by him and his friends. Monboddo preached the "ancient philosophy" of Plato and Aristotle, extending their theories, adding new ones, and supporting them by such evidence as he could procure from historians' and travelers' tales—and he was a remarkably gullible man in this respect, his favorite explanation for his credulity being that he does not see why he should suspect an author of lying just to make people stare—and his conclusions appear surprisingly modern to anyone whose acquaintance with theories of evolution is limited to more recent writers.

Knight refers to these conclusions; mentions Monboddo's "prevision of future theories as to the origin of man, and his ascent or descent from lower types"; his opinion "that man was originally an animal, without speech, reason, or affection; * * * and that all the higher attainments of the human race * * * were the mere results of long experience, continuous struggle, and artifice"; and his doctrine of the origin of language, the basis for which is the ancient metaphysical solution of the origin of ideas. But the root-principle of his teaching, according to Knight's estimate, was the ascent and progress seen in nature, from the inorganic through the organic up to man, a progress which the human species has passed through.

These comments seem promising, and at Prof. Montgomery's suggestion I have examined Monboddo's reference to evolution more thoroughly than Knight did, as contained in the former's *Antient Metaphysics.*[3] The results, which follow, may prove much less interesting than the task itself, because it is quite impossible to reproduce Monboddo's charm without the actual presence of the big leather-bound books; they are of value chiefly as a small addition in the search for pre-Darwinian evolutionists. A quotation from the third volume, which appeared in 1784, indicates the trend of Monboddo's thoughts (p. 5, 1-11):

"Man is undoubtedly at the top of the scale of Being here on earth, which we may observe rises by gradual ascent, according to the different degrees of excellency of the Beings that compose it. Those of the lowest kind are the mere elements of Fire, Air, Earth, and Water. Next to these is the Mineral, of nature more various and more excellent, but without that distinction of parts of different kinds, and serving different purposes, which we call Organization. By the addition of this the

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[3]*Antient Metaphysics*, or, *The Science of Universals*, 40, Vol. I, Edinburgh, 1779; II, London, 1782; III, London, 1784; IV, Edinburgh, 1795; V, Edinburgh, 1797; VI, Edinburgh, 1799. This was published anonymously.

Vegetable becomes more excellent than the Mineral, being of more various and artificial structure, and, consequently, having more of Intelligence displayed in it. The Animal, having besides Organization, Sensation, Appetites, and Desires, is of a nature still more excellent; and, last of all, comes Intellect, which is so much superior to all the other things I have named, that Man, who possesses it, may be said to be the God of this lower world."

Man is a system by himself, composed of elemental, vegetable, animal, and intellectual parts; as an individual he is originally "a Vegetable, coming, probably, like other Vegetables, from eggs"; he becomes gradually a perfect animal, and then the intellectual part follows, "by slow degrees even among us, but by degrees infinitely slower when he could not be formed, as we are, by example and instruction." The idea in this last clause, of development through education, bears curious resemblance to the "social heredity" recently suggested by J. Mark Baldwin as a factor in development.[4] This observable individual development, coupled with the recorded facts relating to the progress in "the arts" and in the use of clothing, houses, fire, and speech, among uncivilized races, suggests a similar development of the human species; and Monboddo proceeds to elaborate the theory, as follows:

He defines the natural state of mankind as the original condition of the race, from which human progress began; "it is to be observed, that this progress did not go on at the same time among all the inhabitants of the different parts of the earth; on the contrary, we are sure from history, that some nations were no better than mere animals. But what I say is, that all nations must be supposed to have been, at some time or another, in that state, in which we know that some have been, and some are at this day." (III, p. 28.) His proofs are descriptions of peoples in various stages of development, his authorities for his statements ranging from Herodotus and Justin to any sailor with a strange tale to tell. He produces, inductively, descriptions of several stages.

Man in the natural state was a mere animal, lacking the use of his intellect, it being latent within him; hence he was without clothing, as, for example, the orang-outang and the New Hollanders, and without houses, like the ancient Scythians; he was unacquainted with the use of fire or even of speech. He was a solitary brute, living in caves, feeding on the natural fruits of the earth, walking on all-fours, and presenting a variety of forms—and here Monboddo, to support his statements, goes off in a wild citation of men with tails, and men with one median eye, and giants, and dwarfs, that reminds the reader of Kip-

[4] *Development and Evolution*, New York, 1902.

ling's adjutant crane, and the mad antics with which that otherwise dignified bird interspersed his solemn discourses.

Man's first step in the progress toward civilization was to learn the use of his own body; "And," to quote again, "he must have begun by erecting himself, without which he could not have had the advantage of the length of his body for attack or defense, or for the practice of the several arts of life. Besides, it gave him the *os sublime*—enabled him to look at his native seat, the Heavens—and gave that dignity to his appearance which was suitable to an animal that was destined to govern on this earth." (IV, p. 35.) The use of the hands followed this, and then the art of swimming. Monboddo considers these to be acquired, and not instinctive, habits, because children learn them with such difficulty, and because of certain examples of men in this "second stage of the natural state," as he calls it, who lacked some or all of these abilities; he names, among others, the orang-outang, and "Peter, the Wild Boy." This youth was captured when about thirteen years old in the woods of Hamelin, in Germany; he was entirely ignorant of the habits of his species, not having learned even to walk erect; under tutorship he attained a fair degree of understanding, although not to more than three words of articulate speech. Monboddo terms this experience "a brief chronicle or abstract of the history of human nature from the mere animal to the first stage of civilized life." Man, at this point in his development, added hunting and fishing to his methods of procuring food, the animal diet tending to make him fierce and warlike, instead of gentle, tractable and friendly, as he is by nature.

Further progression came with the habit of herding together, like the beavers, in order to carry on "some work jointly for the behoof of the whole herd." For successful communal efforts, language was necessary; but Monboddo balks at the idea of its gradual development, because he thinks it was "not possible that man, without some supernatural assistance, could have invented an art, of which even the practice, after it is invented, is very difficult to be learned, and can hardly be learned at all, except in our earliest and most docible years." (IV, p. 41.) But the art became established, through, presumably, divine aid; a fixed habitation, and agriculture as the chief means of subsistence, were adopted; and then followed man's "invention and cultivation of the arts and sciences, by which only he can make any progress in this life, toward regaining the state from which he has fallen."

Coincident with this material progress was the mental development, which took place both racially and individually, according to the following outline: Monboddo begins with Aristotle's definition of man as "a comparative Animal (that is, an animal who has the faculty of Comparing), who has also the capacity of acquiring Intellect and Science, and who is Mortal." (IV, p. 14.) His conception of mental evolution is the history of this "Comparative faculty."

Knowledge begins with corporeal objects, or the objects of sense, and the first operation of the mind is the comparison of these objects; by which comparison man, like other animals, finds some objects more acceptable than others, and chooses them, being guided either by his senses or by the instinct which prompts him to choose what is fittest for the preservation of the individual and of the species. The second and third mental operations, which are also exercises of the comparative faculty, and also common to man and to the brute, are the perception that several qualities, as perceived by the several senses, are joined in one object, and the recognition of an object upon seeing it for the second time. Further than this the animal mind, it seems, can not go; the road parts between man and brute, and we follow the processes of the purely human intellect.

By comparing the thing with itself, man discovers the principal or characteristic qualities of an object, abstracting and separating these from its other qualities, and thus forming the particular idea of the thing under observation. A generalization of ideas follows. "We discover that the *one* which we have found in one individual is to be found in *many*. And thus we form the idea of a species, then of a genus, and so on. * * * We still use * * * Generalization and Abstraction; for we must both generalize the species, and abstract from it the specific differences in order to form the idea of a genus." (IV, p. 17.)

"I think I have shown," Monboddo summarizes, "that both intellect and science are derived from that faculty of comparison, which Aristotle has made the first thing in the Definition of Man, and which, by our having the capacity to carry it further than the brute, makes us Intelligent and Scientific creatures. * * * In this state of our existence, we know not the essence of anything. * * * What we know, therefore, is all in system, which is constituted by the relations and connections of things to one another. And thus, by ascending from lesser to greater systems, we may come at length to the contemplation of the system of the Universe and its great Author, which, to the intellectual mind, is the beatific vision. And here we may observe the order and regularity of that system, by which man is connected with the brute, and how he begins where the brute ends, that is, with comparing an object of sense with itself, so as to discover what is principal and predominant in it. So that there is here, as well as in other parts of nature, a chain where no link is wanting, and where everything is connected with everything." (*Antient Metaphysics,* Vol. IV, pp. 18-19.)

It seems never to have occurred to Lord Monboddo to wonder why the Author of the Universe should have troubled Himself to create all things in related systems; had the question been asked him, he would probably have replied that the Divine Mind desired the pure joy of seeing beauty in the work of His hands, and "Beauty consists in order and arrangement" (V, p. 118), as goodness consists in the capacity to fulfill the purpose for which it was intended.

However firm Lord Monboddo's decision in regard to the doctrine of special creation, he deserves credit as one of the writers who helped to keep alive the evolution theory. He was prominent among those eighteenth-century philosophers who revived the Greek evolution ideas in theoretical form; one of the men who struggled in the "dim speculation" stage of the discovery of the law, and whose labors profited Charles Darwin so richly when he "came in for the proof" in the middle of the next century.

FOSSIL TRACKS IN THE DEL RIO CLAY.

J. A. Udden, Ph. D.*

While examining the Del Rio clay in its typical exposures in the bluffs south and east of Del Rio in Texas three years ago, I found some tracks in layers of a fine sandstone which occur at a distance of about forty feet below the Buda limestone. The latter rock has been eroded away from the edge of the bluff, but it is apparently not very far away to the southeast, and loose boulders of it occur on top of a hill south of the town of Del Rio. A well is reported to have gone down through more than 200 feet of clay, and this is the minimum thickness of the formation in this locality. A considerable part of the clay is red from the presence of oxide of iron. The uppermost twenty feet of the formation contains calcareous layers, in which *Exogyra arietina* and *Nodosaria texana* are profuse. Sandy layers occur farther down and attain a thickness from six inches to a foot. They show occasional ripple marks, and in places they were seen to occupy small erosional hollows in the underlying clay. They consist of fine and clean sand, apparently sorted by repeated washing during the transportation on the old sea bottom. These ledges, which contain the tracks, are evenly laminated and the laminæ are notably straight, weathering occasionally in thin plates.

The tracks consist of two rows of oval depressions, the distance between the center of the two rows being about half an inch, and the distance between two successive depressions in the same line being a little less. They are represented in the accompanying Figure 1, which is a photograph of one of the specimens secured. Several specimens were noted, and for some distance in the exposed ledge they could be found at a particular level in the rock. They bear a perfect resemblance to tracks made in sand by small crawfish, and it may deserve notice that small fragments of decapods are occasionally found in the Del Rio formation, though they were not noticed in this locality.

Another locality where I noted the same tracks was in the bed of Sycamore creek, at its forks near the northwest corner of survey No. 6, in block 5 of the International & Great Northern Railroad lands in Kinney county.

In the same sandy layers at various localities I observed another kind of markings, which I ascribe to the formation of ice crystals on muddy flats. These consist of branching patterns of straight lines usually from one to six inches in length. A slab with imperfect speci-

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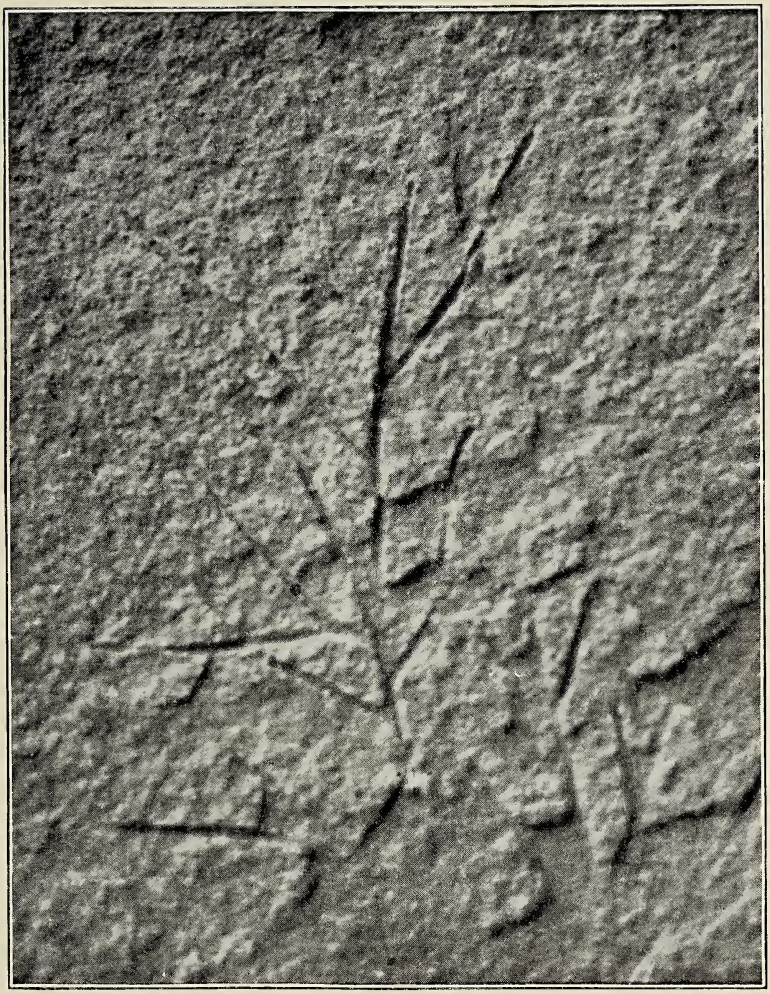
mens is shown in Figure 2. I have observed the latter marks in a number of localities in West Texas. They are quite frequent in some localities in the Eagle Ford shales, having been noted in Ochinaga, Mexico; at Terlingua, in Brewster county, Texas; and also in Kinney county.

The evidence of contemporaneous erosion in connection with these sandy layers and the occurrence of these indications of the presence of ice, shows that shallow-water conditions prevailed during the making of the Del Rio clay. This is also indicated by the behavior of the formation on a large scale, for it is quite changeable in thickness. To the northwest of Del Rio it thins out, and in the uplands on either side of Devil's river, about thirty miles north of this town, it runs out entirely for some distance.

Fig. 1.

Udden del.

Fossil tracks on a layer of sandstone in the Del Rio clay.



Udden del.

Fossil frost cracks (?) on a sandy stratum in the Del Rio clay.

SOME FIGURES ON THE COST OF PASSENGER AND FREIGHT TRAIN SERVICE.

R. A. Thompson.*

In 1906, fourteen of the principal railroads of Texas, aggregating more than 76 per cent of its mileage, filed suits in the Federal District Court, enjoining the freight rates and tariffs of the State Railroad Commission. These suits were dismissed upon motion of the plaintiffs in 1908.

Incidental to securing evidence with which to defend these suits, the Commission issued orders requiring the several railroads to file with it statements showing the "cost and performance of locomotives" and "cost and statistics of train service," giving separately the data relating to the passenger, freight, work-train and switching services, annually for the six years ending June 30, 1906. An additional general order was issued in 1907 requiring all of the railroads in the State to file monthly reports, on forms issued and prescribed by the Commission, beginning July 1, 1906, containing substantially the same information as the first orders. The Commission desired particularly to arrive at some estimate of the actual cost of operating and maintaining the several classes of train service, particularly the passenger and freight.

In pursuance of these orders the railroads involved in the suits filed the statements required as far as they were able. Some of them stated that they had not been keeping their accounts in such form as would enable them to make even a fairly accurate segregation of the several items of expense, as between the several classes of service, and others, on account of records having been destroyed, could not comply with the orders for the full time required.

From ten of these railroads, however, the Commission secured data that was to some extent satisfactory and which enabled it to arrive at a fair estimate of the actual and relative costs of the principal items of passenger and freight train services. For the reason that a uniform system of keeping these accounts had not been used by the railroads the division of some of the expenses, as between the different services, was made by some of the railroads upon arbitrary bases, such as the train-mile, car-mile, etc., and were not accurately correct to this extent. Also the methods of charging certain expenses under the several heads were not uniform, and gave results that appear to differ widely. This refers particularly to the cost of train service, other than locomotive.

Chief Engineer Railroad Commission of Texas.

The summaries, however, reflect with a fair degree of accuracy the average cost of train service, and show the variation in cost for the several years of the seven-year periods ending June 30, 1907, and also show the increase in train and car loading and performance.

The tables below give the summaries of this cost and statistical data, for each of the ten railroads, compiled from the annual and monthly statements submitted by them to the Commission. These roads lie entirely within the State of Texas, and in 1901 aggregated 6411 miles, or about 63 per cent of its mileage. In 1907 they aggregated 7623 miles, or about 61 per cent of the railroad mileage of the State. They are representative railroads, including both long and short lines—those with light and those with heavy traffic—and those varying as to maximum grades, curvature, physical condition and equipment. The ten railroads considered are the following, viz.:

	Mileage, June 30, 1901.	Mileage. June 30, 1907.
Fort Worth and Rio Grande Railway.........	146.16	195.88
Galveston, Harrisburg and San Antonio Railway	917.00	1336.37
Houston and Texas Central Railroad.........	507.75	789.01
Houston East and West Texas Railway.......	191.00	190.94
International and Great Northern Railroad....	837.40	1106.00
Missouri, Kansas and Texas Railway of Texas..	1069.92	1121.72
St. Louis Southwestern Railway of Texas.....	640.30	679.68
San Antonio and Aransas Pass Railway.......	687.40	723.80
Texas and New Orleans Railroad............	373.95	441.06
Texas and Pacific Railway..................	1040.31	1038.16
Total	6411.19	7622.62

Under the several heads of cost are contained all of the expenses directly incident to the operation and maintenance of the trains of each class of service, passenger and freight. No roadway or other general expenses are included. They are such expenses as, under a proper system of keeping accounts, can be charged directly to, or divided with a fair degree of accuracy between, the passenger and the freight service, and give the actual and relative costs of each. The variation in the costs of service for the different railroads, per train-mile, per car-mile, per passenger-mile and per ton-mile, indicates to a considerable degree, the effects of density and kind of traffic, roadbed characteristics, quality of motive power and equipment, proximity to fuel supply, and other conditions which affect the relative expense of operating and maintaining train service.

Tables Nos. 1 and 2 give the average cost, charging the expenses under twelve general heads, of the passenger and freight train services of each railroad for periods varying from four to seven years, ending June 30, 1907. The cost of "locomotive service" and "other train service" is given separately and then summarized, and the total cost per train-mile, per car-mile, per passenger-mile and per ton-mile for each railroad, and the average for all of them, shown. These tables also show the average number of cars per train, the train-miles and car-miles per ton of coal consumed, and the ratio between the loaded and empty freight cars hauled, for each railroad and for all of them.

Tables Nos. 3 and 4 show the variation in the average total cost of passenger and freight train service, per train-mile, of each railroad and for all of them, for each year of the periods given. Tables Nos. 5 and 6 give the same information per car-mile, and Tables Nos. 7 and 8 indicate the actual expenses per revenue passenger-mile and per revenue ton-mile.

Table No. 9 shows the "average number of cars per passenger train" of each railroad and all of them, for each year of the periods ending June 30, 1907, and Table No. 10 gives the same information relative to freight trains. In the latter case all empty freight cars have been reduced to a loaded car basis, i. e., five empties rated as two loads.

Table No. 11 shows the average number of revenue passenger carried "per train" and "per car," and the average number of revenue tons of freight "per train" and "per car," by all of the ten railroads during each year, 1901 to 1907, inclusive.

It will be observed from these tables that, comparing the year 1907 with 1902 (the year 1902 is selected for this comparison as so few railroads are shown for 1901), the cost per passenger train-mile has increased from 36.78 to 42.70 cents, an increase of 16.1 per cent. The cost per passenger car-mile has increased from 7.12 to 7.78 cents, or 9.3 per cent. The cost per 100 revenue passenger-miles has decreased from 87.41 to 78.72 cents, a decrease of 9.9 per cent. The average number of passenger cars hauled per train has increased from 5.17 to 5.49, or 6.4 per cent. The average number of revenue passengers carried per train has increased from 42.1 to 54.2, or 28.8 per cent, and the number carried per car has increased from 8.1 to 8.9, or 22.2 per cent.

In the case of freight trains, comparing 1907 with 1902, the average cost per train-mile, for the ten railroads, has increased from 58.01 to 77.58 cents, an increase of 33.7 per cent. The average cost per car-mile, "equal to loads," has increased 3.65 to 4.38 cents, or 20.0 per cent. The average cost per 100 revenue ton-miles has increased from 28.24 to 32.21 cents, or 14.1 per cent. The average number of cars handled per train, "equal to loads," has increased from 15.83 to 17.70, or 11.8 per cent. The number of tons of revenue freight has increased from

204.2 to 249.9 tons per train, or 22.4 per cent, and from 12.9 to 13.6 tons per car, "equal to loads," or 5.4 per cent. On the average for the entire periods, 1901 to 1907, inclusive, the empty freight car mileage was 50 per cent of the loaded car mileage.

The increase in the several items of train expense, comparing the year 1907 with 1902, of both the passenger and freight train services is shown by the following tables:

PASSENGER TRAIN SERVICE PER TRAIN-MILE.

Item.	1902.	1907.	Increase.	Per cent increase.
A. Cost of Passenger Locomotives.				
1. Repairs on locomotives	5.13	5.70	0.57	11.1
2. Wages of engineers and firemen	5.92	6.52	0.60	10.1
3. Wiping and handling	1.68	2.13	0.45	16.8
4. Stores (oil, tallow and waste)	0.38	0.39	0.01	2.7
5. Fuel for locomotives	9.51	11.90	2.39	25.1
6. Other expenses	1.04	1.19	0.15	14.4
Total	23.66	27.83	4.17	17.6
B. Other Passenger Train Expenses.				
1. Repairs on cars	5.41	5.52	0.11	2.0
2. Wages of trainmen	5.15	5.70	0.55	10.7
3. Supplies (oil, grease and waste)	0.30	0.31	0.01	3.3
4. Heating and lighting cars	0.72	1.00	0.28	38.9
5. Cleaning cars	1.01	1.25	0.24	23.8
6. Other car expenses	0.53	1.09	0.56	105.6
Total	13.12	14.87	1.75	13.3
Grand total (cents)	36.78	42.70	5.92	16.1

FREIGHT TRAIN SERVICE PER TRAIN-MILE.

Item.	1902.	1907.	Increase.	Per cent increase.
A. Cost of Freight Locomotives.				
1. Repairs of locomotives	7.57	8.97	1.40	18.5
2. Wages of engineers and firemen	8.18	10.17	1.99	24.3
3. Wiping and handling	1.94	2.58	0.64	33.0
4. Stores (oil, tallow and waste)	0.53	0.44	0.09*	17.0*
5. Fuel for locomotives	19.51	22.65	3.14	16.1
6. Other locomotive expenses	1.28	1.57	0.29	22.6
Total	39.01	46.38	7.37	18.9
B. Other Freight Train Expenses.				
1. Repairs on cars	10.12	16.72	6.60	65.2
2. Wages of trainmen	7.96	13.05	5 09	63.9
3. Supplies (oil, grease and waste)	0.45	0.58	0.13	28.9
4. Other expenses	0.47	0.85	0.38	80.9
Total	19.00	31.20	12.20	64.2
Grand total (cents)	58.01	77.58	19.57	33.7

*Decrease.

TABLE NO. 1.

COST AND STATISTICS OF PASSENGER TRAIN SERVICE "PER TRAIN-MILE" FOR PERIODS ENDING JUNE 30, 1907.

1. *Cost of Locomotive Service (in Cents).*

Name of railroad.	Period ending June 30, 1907.	Repairs on locomotives.	Wages of engineers and firemen.	Wiping and handling locomotives.	Stores; oil, tallow and waste.	Fuel for locomotives.	Other supplies and accounts.	Total.
Ft. W. & R. G.	6 years..	6.87	5.51	1.36	1.18	12.02	0.18	27.12
G. H. & S. A.	6 years..	8.51	6.82	2.05	0.45	13.79	1.20	32.82
H. & T. C.	5 years..	6.39	5.97	1.94	0.25	7.88	0.69	23.12
H. E. & W. T.	4 years..	4.60	5.16	1.32	0.23	8.07	0.75	20.13
I. & G. N.	7 years.	4.71	6.37	1.68	0.32	9.44	1.49	24.01
M. K. & T.	7 years..	3.33	5.91	1.32	0.27	9.48	0.77	21.08
St. L. S. W.	7 years..	5.11	6.44	1.15	0.37	10.94	0.28	24.29
S. A. & A. P.	7 years..	3.93	5.88	1.61	0.26	6.66	0.83	19.17
T. & N. O.	6 years.	6.45	6.04	1.92	0.39	9.72	0.52	25.04
T. & P.	7 years..	7 01	6.32	2.98	0.53	9.77	1.80	28.41
Average		5.51	6.21	1.86	0.37	9.81	1.06	24.82

2. *Cost of Other Train Service (in Cents).*

Name of railroad.	Period ending June 30, 1907.	Repairs on passenger cars.	Wages of trainmen.	Train supplies; oil, grease and waste.	Heating and lighting cars.	Cleaning cars.	Other car and train expenses.	Total.
Ft. W. & R. G.	6 years..	4.60	6.41	0.26	0.72	1.83	0.14	13.96
G. H. & S. A.	6 years..	8.14	6.28	0.18	1.40	1.65	1.07	18.72
H. & T. C.	5 years..	5.36	6.55	0.08	1.08	1.51	1.31	15.89
H. E. & W. T.	4 years..	4.16	5.37	1.10	1.01	2.58	0.62	14.84
I. & G. N.	7 years..	4.67	4.45	0.24	0.73	1.19	0.42	11.70
M. K. & T.	7 years..	3.07	6.01	0.12	0.61	.....	1.03	10.84
St. L. S. W.	7 years..	5.14	4.94	0.29	1.12	1.59	0.69	13.77
S. A. & A. P.	7 years..	3.78	5.58	0.45	0.54	1.40	0.41	12.16
T. & N. O.	6 years..	7.42	6.85	0.18	1.02	1.65	0.84	17.96
T. & P.	7 years..	6.32	5.19	0.72	0.91	1.35	0.51	15.00
Average		5.19	5.59	0.31	0.88	1.15	0.75	13.87

3. *Summary of Cost and Statistics.*

Name of railroad.	Period ending June 30, 1907.	Total cost of passenger train service (in cents).			Average number cars per train.*	Average number revenue passengers carried.		Average number train-miles per ton of coal.†	Average number car-miles per ton of coal.†
		Per train-mile.	Per car-mile. *	Per 100 passenger miles.		Per train.	Per car.*		
Ft. W. & R. G.	6 years..	41.08	8.48	86.25	4.84	47.6	9.8	23.66	112.0
G. H. & S. A.	6 years..	51.54	7.26	81.27	7.10	63.4	8.9	21.42	152.2
H. & T. C.	5 years..	39.01	7.24	80.45	5.39	48.5	9.0	28.70	154.4
H. E. & W. T.	4 years..	34.97	5.77	65.54	6.06	53.4	8.8	29.80	180.3
I. & G. N.	7 years..	35.71	7.52	96.87	4.75	36.8	7.7	26.69	127.0
M. K. & T.	7 years..	31.92	6.63	80.74	4.81	39.5	8.2	24.11	116.0
St. L. S. W.	7 years..	38.06	8.12	117.56	4.69	32.4	6.9	24.26	113.7
S. A. & A. P.	7 years..	31.33	6.65	90.78	4.71	34.5	7.3	37.21	175.8
T. & N. O.	6 years..	43.00	7.50	74.46	6.16	57.7	9.4	25.41	156.4
T. & P.	7 years..	43.41	8.05	87.93	5.39	49.3	9.1	23.96	129.2
Average		38.69	7.34	86.98	5.27	44.5	8.4	25.29	133.4

*All cars handled in passenger trains included.
†Fuel oil included and rated, four (4) barrels of oil equal to one (1) ton of coal.

TABLE NO. 2.

COST AND STATISTICS OF FREIGHT TRAIN SERVICE "PER TRAIN-MILE" FOR PERIODS ENDING JUNE 30, 1907.

1. *Cost of Locomotive Service (in Cents).*

Name of railroad.	Period ending June 30, 1907.	Repairs on locomotives.	Wages of engineers and firemen.	Wiping and handling locomotives.	Stores; oil, tallow, waste, etc.	Fuel for locomotives.	Other supplies and accounts.	Total.
Ft. W. & R. G	6 years..	7.80	8.30	1.56	1.26	19.93	0.25	39.10
G. H. & S. A.	6 years..	11.35	9.47	2.11	0.44	27.71	1.89	52.97
H. & T. C.	5 years..	9.49	9.00	2.16	0.31	18.78	1.24	40.98
H. E. & W. T.	4 years..	8.16	9.17	1.70	0.36	15.49	1.00	35.88
I. & G. N.	7 years..	8.60	8.64	1.71	0.37	16.87	1.53	37.72
M. K. & T.	7 years.	5.81	8.86	2.22	0.52	18.89	1.45	37.75
St. L. S. W.	7 years..	11.05	12.43	1.76	0.76	26.34	0.41	52.75
S. A. & A. P.	7 years..	6.31	8.57	1.63	0.32	17.12	1.27	35.22
T. & N. O.	6 years..	10.74	11.03	3.00	0.47	20.87	1.06	47.17
T. & P.	7 years..	9.19	8.08	3.15	0.69	17.84	1.72	40.67
Average		8.88	9.13	2.28	0.52	20.43	1.44	42.68

2. *Cost of Other Train Service (in Cents).*

Name of railroad.	Period ending June 30, 1907.	Repairs on freight cars.	Wages of train-men.	Train supplies; oil, grease, waste, etc.	Other car and train expenses.	Total.	Number of empty freight car-miles per 100 loaded car-miles.
Ft. W. & R. G.	6 years..	8.20	9.60	0.36	0.26	18.42	69
G. H. & S. A.	6 years..	17.51	9.98	0.42	0.49	28.40	37
H. & T. C.	5 years.	13.42	10.40	0.31	1.84	25.97	45
H. E. & W. T.	4 years..	10.61	9.32	2.72	0.23	22.88	57
I. & G. N.	7 years..	15.39	11.51	0.34	0.70	27.94	48
M. K. & T.	7 years..	7.71	7.24	0.32	1.12	16.39	54
St. L. S. W.	7 years..	17.75	11.65	0.55	0.32	30.27	55
S. A. & A. P.	7 years..	8.13	10.19	0.39	0.38	19.08	61
T. & N. O.	6 years..	28.02	13.68	0.48	0.53	42.71	61
T. & P.	7 years..	10.31	10.56	1.04	0.45	22.36	53
Average.		13.31.	10.14	0.55	0.72	24.72	50

3. *Summary of Cost and Statistics.*

Name of railroad.	Period ending June 30, 1907.	Total cost of freight train service (in cents).			Average number cars per train.*	Average number tons of revenue freight.		Average number train-miles per ton of coal.†	Average number car-miles per ton of coal* †.
		Per train-mile.	Per car-mile.*	Per 100 revenue ton-miles.		Per train.	Per car.*		
Ft. W. & R. G.	6 years..	57.32	5.83	62.01	9.90	93.1	9.4	14.19	140.5
G. H. & S. A.	6 years..	81.37	3.98	23.58	20.43	345.1	16.9	11.98	244.7
H. & T. C.	5 years..	66.95	3.94	27.45	17.26	244.1	14.1	13.30	226.4
H. E. & W. T.	4 years..	58.76	4.71	33.56	12.50	175.1	14.0	15.10	188.3
I. & G. N.	7 years..	65.66	3.46	30.20	18.82	217.3	11.6	15.08	284.0
M. K. & T.	7 years..	54.15	3.34	27.94	16.21	193.8	11.9	11.60	187.9
St. L. S. W.	7 years..	83.02	6.06	54.04	13.70	153.6	11.2	9.96	136.4
S. A. & A. P.	7 years..	54.31	4.12	41.17	13.19	131.9	10.0	15.70	207.1
T. & N. O.	6 years..	89.88	4.59	29.87	19.57	300.9	15.4	13.40	262.3
T. & P.	7 years..	63.03	3.99	35.75	15.80	176.2	11.0	12.98	205.0
Average.		67.40	3.98	30.53	16.91	220.8	13.1	12.69	214.7

* Loaded freight car basis. Empty freight cars included and rated five empties equal to two (2) loads.

† Fuel oil included and rated four (4) barrels equal to one (1) ton of coal, used by locomotives.

TABLE NO. 3.

TOTAL COST OF PASSENGER TRAIN SERVICE "PER TRAIN-MILE" (IN CENTS).

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G	*	40.21	40.50	41.34	35.78	39.03	49.21	41.08
G. H. & S. A	*	53.57	43.93	58.52	55.75	46.79	53.28	51.54
H. & T. C	*	*	37.40	36.93	40.88	37.82	42.71	39.01
H. E. & W. T	*	*	*	39.38	36.22	31.57	32.13	34.97
I. & G. N	31.65	33.24	33.92	36.83	36.36	36.88	39.29	35.71
M. K. & T	26.06	26.65	30.00	32.67	33.38	33.97	37.33	31.92
St. L. S. W	31.79	32.82	36.48	38.23	40.81	42.05	43.02	38.06
S. A. & A. P	32.90	33.51	30.53	30.55	30.95	31.89	30.80	31.33
T. & N. O	*	37.79	40.93	43.47	45.62	44.62	45.79	43.00
T. & P	38.35	42.58	42.78	43.95	44.12	43.52	47.11	43.41
Average	32.16	36.78	36.85	39.49	39.88	39.00	42.70	38.69

*No reports filed.

TABLE NO. 4.

TOTAL COST OF FREIGHT TRAIN SERVICE "PER TRAIN-MILE" (IN CENTS).

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G	*	44.14	56.17	57.79	57.86	59.37	66.85	57.52
G. H. & S. A	*	62.89	83.40	91.03	91.42	77.67	87.71	81.37
H. & T. C	*	*	65.79	68.58	67.62	63.37	69.21	66.95
H. E. & W. T	*	*	*	60.16	59.95	55.44	59.69	58.76
I. & G. N	53.43	57.25	62.81	68.71	68.67	69.97	72.37	65.66
M. K. & T	45.38	46.25	50.82	54.05	55.86	54.48	67.77	54.14
St. L. S. W	62.67	67.04	83.62	87.45	85.16	93.50	99.79	83.02
S. A. & A. P	49.71	53.16	55.85	60.87	52.76	49.83	57.28	54.31
T. & N. O	*	68.78	96.30	94.57	82.47	95.86	105.40	89.88
T. & P	49.51	60.21	61.69	63.43	65.15	64.01	76.82	63.03
Average	50.35	58.01	67.08	71.41	71.71	68.33	77.58	67.40

*No reports filed.

TABLE NO. 5.

TOTAL COST OF PASSENGER TRAIN SERVICE "PER CAR-MILE" (IN CENTS).

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G	*	8.52	8.30	9.01	8.31	7.67	9.23	8.48
G. H. & S. A	*	7.98	6.42	7.91	6.65	6.90	7.84	7.26
H. & T. C	*	*	7.40	7.17	7.69	6.70	7.26	7.24
H. E. & W. T	*	*	*	6.85	6.07	5.32	4.84	5.77
I. & G. N	6.78	6.99	7.40	7.47	7.49	7.82	8.12	7.51
M. K. & T	5.84	5.96	6.32	6.59	9.86	7.03	7.24	6.63
St. L. S. W	6.68	6.83	7.58	8.43	8.70	9.03	9.31	8.12
S. A. & A. P	7.52	7.57	6.76	6.81	6.35	5.74	6.26	6.65
T. & N. O	*	6.19	6.50	6.86	7.31	7.54	7.41	6.96
T. & P	7.37	7.77	8.05	8.27	8.04	7.98	8.64	8.05
Average	6.78	7.12	7.09	7.51	7.37	7.32	7.78	7.34

*No reports filed.

TABLE NO. 6.

TOTAL COST OF FREIGHT TRAIN SERVICE "PER CAR-MILE" (EQUAL TO LOADS) † (IN CENTS).

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G	*	4.32	3.81	5.39	5.72	6.34	7.41	5.49
G. H. & S. A	*	3.87	4.10	4.59	4.31	3.31	3.88	3.98
H. & T. C	*	*	3.72	4.22	4.00	3.59	4.14	3.94
H. E. & W. T	*	*	*	5.24	4.71	4.23	4.74	4.71
I. & G. N	2.86	3.16	3.51	3.67	3.42	3.65	3.83	3.46
M. K. & T	2.66	2.88	3.34	3 48	3.39	3.35	4.23	3.34
St. L. S. W	4.83	5.18	6.20	6.42	6.06	6.53	6.94	6.06
S. A. & A. P	3.75	4.07	4.42	4.74	4.01	3.67	4.15	4.12
T. & N. O	*	3.64	4.94	5.25	4.60	4.41	4.96	4.59
T. & P	3.35	3.94	4.02	3.91	3.92	3.95	4.68	3.99
Average	3.21	3.65	4.03	4.31	4.05	3.82	4.38	3.98

† Includes empty freight cars rated 5 equal to 2 loaded freight cars.
* No reports filed.

TABLE NO. 7.

COST OF PASSENGER TRAIN SERVICE "PER 100 REVENUE-PASSENGER MILES (IN CENTS).

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G	*	106.51	106.43	101.00	84.94	71.11	74.38	86.25
G. H. & S. A	*	88.97	84.57	72.73	71.56	74.50	82.15	81.27
H. & T. C	*	*	92.21	91.55	82.54	72.28	69.15	80.45
H. E. & W. T	*	*	*	97.46	69.02	55.52	49.18	65.54
I. & G. N	86.99	98.46	103.17	112.38	97.68	95.16	88.83	96.87
M. K. & T	77.38	80.13	92.10	87.00	91.19	78.19	70.40	80.74
St. L. S. W	94.51	102.92	120.52	141.37	125.05	128.45	111.59	117.56
S. A. & A. P	100.00	103.18	99.58	106.40	90.62	76.46	74.82	90.78
T. & N. O	*	61.64	62.31	73.94	88.56	83.96	75.54	74.46
T. & P	83.34	83.33	102.42	99.49	90.29	85.13	78.76	87.93
Average	85.70	87.41	94.19	96.89	89.23	82.21	78.72	86.98

* No reports filed.

TABLE NO. 8.

COST OF FREIGHT TRAIN SERVICE "PER 100 REVENUE TON-MILES" (IN CENTS).

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G	*	49.93	58.26	58.30	65.76	71.72	64.67	62.01
G. H. & S. A	*	22.58	22.52	24.70	27.24	19.59	24.64	23.58
H. & T. C	*	*	28.17	29.93	28.92	24.47	26.28	27.45
H. E. & W. T	*	*	*	42.71	35.22	27.28	32.43	33.56
I. & G. N	27.07	28.70	30.50	32.16	30.67	31.30	30.02	30.20
M. K. & T	21.51	23.75	27.07	28.97	30.61	29.06	35.09	27.94
St. L. S. W	46.15	46.49	57.23	57.01	53.82	56.55	58.46	54.04
S. A. & A. P	41.61	45.08	45.02	43.50	39.89	35.33	38.97	41.17
T. & N. O	*	24.32	31.47	32.58	32.29	28.54	30.53	29.87
T. & P	32.10	37.70	36.16	36.17	35.60	34.76	38.81	35.75
Average	29.39	28.24	30.33	31.62	32.26	28.42	32.21	30.53

* No reports filed.

TABLE NO. 9.

AVERAGE NUMBER OF CARS "PER PASSENGER TRAIN."

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G.	*	4.72	4.89	4.59	4.31	5.09	5.40	4.84
G. H. & S. A.	*	6.73	6.85	7.59	8.38	6.79	6.82	7.10
H. & T. C.	*	*	5.06	5.15	5.32	5.64	5.88	5.39
H. E. & W. T.	*	*	*	5.75	5.96	5.93	6.64	6.06
I. & G. N.	4.67	4.75	4.59	4.84	4.85	4.71	4.83	4.75
M. K. & T.	4.46	4.48	4.75	4.96	4.90	4.83	5.16	4.81
St. L. S. W.	4.76	4.81	4.82	4.49	4.69	4.66	4.62	4.69
S. A. & A. P.	4.37	4.63	4.52	4.48	4.87	5.10	4.92	4.71
T. & N. O.	*	6.11	6.30	6.17	6.24	5.92	6.18	6.16
T. & P.	5.20	5.48	5.31	5.31	5.49	5.45	5.45	5.39
Average	4.74	5.17	5.20	5.28	5.41	5.33	5.49	5.27

*No reports filed.

TABLE NO. 10.

AVERAGE NUMBER OF CARS (EQUAL TO LOADS) † "PER FREIGHT TRAIN."

Name of railroad.	1901	1902	1903	1904	1905	1906	1907	Average
Ft. W. & R. G.	*	10.21	10.53	10.73	10.01	9.36	9.00	9.90
G. H. & S. A.	*	16.26	20.34	19.85	21.19	23.49	22.37	20.43
H. & T. C.	*	*	17.69	16.30	16.91	17.64	16.72	17.26
H. E. & W. T.	*	*	*	11.44	12.77	13.13	12.57	12.50
I. & G. N.	18.71	18.02	17.87	18.73	20.05	19.19	18.90	18.82
M. K. & T.	16.93	16.03	15.17	15.54	16.49	16.54	16.79	16.21
St. L. S. W.	12.97	12.92	13.50	12.63	14.07	14.30	14.37	13.70
S. A. & A. P.	13.29	13.05	12.63	12.85	13.16	13.54	13.78	13.19
T. & N. O.	*	18.92	19.50	18.00	17.92	22.25	21.27	19.57
T. & P.	14.78	15.30	15.33	16.21	16.60	16.16	16.40	15.80
Average	15.67	15.83	16.65	16.61	17.34	17.90	17.70	16.91

*No reports filed.
† Empty cars included and rated five empties equal to two loads.

TABLE NO. 11.

AVERAGE LOADING OF PASSENGER AND FREIGHT TRAINS AND CARS.

For the ten railroads given above.

Year ending June 30.	Average number of revenue passengers.		Average number of revenue tons of freight.	
	Per train.	Per car.	Per train.	Per car. †
1901	37.5	7.9	171.3	10.9
1902	42.1	8.1	204.2	12.9
1903	39.1	7.5	221.2	13.3
1904	40.8	7.7	225.8	13 6
1905	44.7	8.3	218.1	12.5
1906	47.4	8.9	240.5	13.4
1907	54.2	9.9	249.9	13.6
Average	44.5	8.4	220.8	13.1

† Equal to loads; five empties rated as two loads.

The summary of the foregoing tables, covering the cost and statistics of both the passenger and freight train services, of the ten Texas railroads mentioned, for the years 1901 to 1907, inclusive, may be briefly stated as follows:

PASSENGER TRAINS.

	Cents.
Cost of service per train-mile	38.69
Cost of service per car-mile	7.34
Cost of service per 100 revenue passenger miles	86.98
Average number of cars per train	5.27
Average number of revenue passengers per train	44.50
Average number of revenue passengers per car	8.40
Average number of train-miles per ton of coal	25.29
Average number of car-miles per ton of coal	133.40

FREIGHT TRAINS.

	Cents.
Cost of service per train-mile	67.40
Cost of service per car-mile (equal to loads)	3.98
Cost of service per 100 ton-miles of revenue freight	30.53
Average number of cars per train (equal to loads)	16.91
Average number of tons of revenue freight per train	220.80
Average number of tons of revenue freight per car (equal to loads)	13.10
Average number of train-miles per ton of coal	12.69
Average number of car-miles (equal to loads) per ton of coal	214.70

The aggregate cost of 169,452,481 train miles, including both passenger and freight trains, was $95,177,928, or an average of 56.17 cents per train mile.

THE LAW OF THE FALL OF RIVERS AND THE VALUE OF THE DEDUCED CURVES IN RIVER IMPROVEMENTS.

F. Oppikofer, C. E.

The idea that the formation of a river bed is largely influenced by the inclination of the river to follow a certain curve is not new.

The cycloid, the curve of quickest descent, appears to be the lawful basis of all river formations. In other words, any river will in the course of time—geological time, in some instances—from the source to the mouth, if undisturbed, form a cycloid. True, no river profile investigated by me had formed this curve to perfection as, in some cases, sufficient time had not passed for the waters to wear off rock formations or the stream emptied into the main river or sea before coming to the zero point of its curve.

Small falls and shoals, as occurring in the Trinity and Brazos, constitute in the total length but insignificant deviations; in fact, the surface of any high water in these streams forms the cycloid to perfection. While probably few rivers present an unbroken or unfinished curve, the fact that time and nature will accomplish this, should be the guide in all permanent river improvements.

To demonstrate the practical value of this discovery, the Mississippi may be used as an example. By computing the cycloid of this river from source to gulf and placing this curve over the plotted existing profile, any deviation would show at a glance where nature intends to fill or scour; also how near this river has arrived at the zero point of its curve, or how much farther the delta will form gulfwards to reach the zero of the cycloid.

The effect of cut-offs could be studied. A cut-off in the middle would, while deepening the upper reaches, develop a shoaling in the lower parts. The data for researches has been meager, but studies of profiles of some rivers in Switzerland and this country tend to prove the existence of this law.

The computed curve of surface of high water of the Mississippi River from Cairo, Illinois, to Fort Jackson, a distance of 1050 miles, with a fall of 315 feet, varies only a few feet from the recorded high water by the United States engineers, and the zero of the curve comes about 250 miles gulfwards, the ultimate mouth of the river.

PROCEEDINGS

OF

THE TEXAS ACADEMY OF SCIENCE

FOR 1907.

THE TEXAS ACADEMY OF SCIENCE.

ORGANIZED JANUARY 9, 1892.

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Committee on Publication.

DR. J. E. THOMPSON. MR. R. A. THOMPSON. DR. F. W. SIMONDS.

PAPERS PRESENTED AT REGULAR MEETINGS.

January 26, 1907.

(1) "Fighting Asiatic Cholera," (2) "The First Ascent of Mount Isarog," Captain T. J. Dickson, Chaplain, Twenty-sixth Infantry, U. S. A., Fort Sam Houston, San Antonio.

March 7, 1907.

"The Transformation of Radium," Dr. Eugene P. Schoch, Adjunct Professor of Chemistry, University of Texas, Austin.

Formal Meeting, June 10, 1907.

"The Beginnings of the Texas Railroad System" (by title), Alexander Deussen, M. S., Instructor in Geology and Mineralogy, University of Texas, Austin.

"The Trisection of an Angle by Three Different Curves" (by title), Joseph S. Brown, M. S., Professor of Mathematics, Southwest Texas State Normal School, San Marcos.

October 15, 1907.

"The Resistive Processes of the Human Body," annual address by the President, Dr. James E. Thompson, Professor of Surgery, Department of Medicine, University of Texas, Galveston.

November 15, 1907.

"Local Sewage Disposal and River Polution," E. C. H. Bantel, Adjunct Professor of Engineering, University of Texas, Austin.

"Notes on the Mistletoe," Harlan H. York, M. A., Instructor in Botany, University of Texas, Austin.

"Our Present Knowledge of Aboriginal Man," an address, Dr. L. M. Keasbey, Professor of Political Science, University of Texas, Austin.

December 6, 1907.

"Observations on the Numerical Relations of the Sexes," Dr. T. H. Montgomery, Jr., Professor of Zoölogy in the University of Texas, Austin.

"A New Apparatus for the Electrolysis of Hydrochloric Acid," Mr. J. B. Lewis, University of Texas, Austin.

"The Making of a Sheet of Paper," an illustrated lecture, Dr. William T. Mather, Professor of Physics, University of Texas, Austin.

REPORT OF LIBRARIAN, 1907-1908.

In June, 1907, by agreement between the Academy and the Regents of the University of Texas, the library of the Academy was given to the University on certain conditions, which are stated elsewhere in full.

This library, accumulated since 1892, now fills about two hundred and fifty linear feet of shelving, nearly all of this material consisting of unbound scientific journals, transactions, etc., of learned societies sent in exchange for the *Transactions*. Some of these sets are complete for the years since the exchange began, but the greater part are imperfect owing to the loss of numbers or volumes. During the past year the University Library has spent $16 in purchasing missing numbers, and has sent the following volumes to the bindery:

London *Geographical Journal*, vol. 4 to date, 26 volumes.

St. Louis Academy of Sciences, *Transactions*, vol. 2 to date, 16 volumes.

Proceedings of the Royal Society, vol. 56 to date, 26 volumes.

Journal of the Franklin Institute, vol. 122 to date, 45 volumes.

Zeitschrift für Ethnologie, vol. 35 to date, 5 volumes, and *General Index*, 1 volume.

The *Journal* and *Proceedings* of the American Academy of Natural Sciences, Philadelphia, complete from vol. 1 to date, 60 volumes.

Johns Hopkins Hospital *Bulletin*, vol. 8 to date, 11 volumes.

Proceedings of the Boston Society of Natural History, vol. 26 to date, 8 volumes, completing the set in the University Library.

Atti della R. Accademia delle scienze di Torrino, vol. — to date, 15 volumes.

Some of the above sets have been bound and are now in the library, and the rest will be bound by September 1. Other sets are ready for the bindery and still others are being made ready by securing missing numbers; but there is not enough money available to justify more binding this year. The average cost of binding is about $1.00 a volume.

The purchase of printed catalogue cards by the University Library for each article in the current volumes of many of the Academy sets is under consideration. To add these cards to the general catalogue would mean that workers on any particular subject would have their attention called to helpful articles in these journals, of which they otherwise would not be likely to know.

The sending of current *Transactions* to societies and institutions on the Academy's exchange list has been done by the University Library, and copies of past *Transactions* have been sent to several institutions to complete their files. A special effort is made to supply complete files to Texas libraries and institutions.

A list of the institutions maintaining exchange relations with the Academy is appended to this report.

Respectfully submitted,

P. L. WINDSOR,
Librarian.

INSTITUTIONS TO WHICH THE TRANSACTIONS ARE SENT IN EXCHANGE.

EUROPE.

AUSTRIA.

Wien.—Kaiserl. Akademie der Wissenschaften; K. K. Geologische Reichsanstalt.

BELGIUM.

Bruxelles.—Académie Royale des Sciences, des Lettres et des Beaux-Arts.
Liege.—Société Royale des Sciences.
Uccle.—Observatoire Royal de Belgique.

BOHEMIA.

Prague.—Kön. Böhm. Gesellschaft der Wissenschaften.

ENGLAND.

Cambridge.—Cambridge Philosophical Society.
London.—British Museum Library; The Royal Society; Royal Geographical Society; South London Entomological and Natural History Society.
Manchester.—Manchester Literary and Philosophical Society.

FRANCE.

Marseille.—La Faculté des Sciences de Marseille.
Paris.—Bibliothêque Nationale; Bibliothêque du Muséum d'Histoire Naturelle.
Toulouse.—Académie des Sciences, Inscriptions et Belles-lettres; Université de Toulouse, Bibliothêque.

GERMANY.

Berlin.—Berliner Anthropologische Gesellschaft.
Giessen.—Oberhessische Gesellschaft für Natur- und Heilkunde.
Halle.—Naturforschende Gesellschaft.
Kiel.—Der Naturwissenschaftliche Verein.
Leipzig.—Die Naturforschende Gesellschaft.
Rostock.—Verein der Freunde der Naturgeschichte in Mecklenburg.

HUNGARY.

Budapest.—Magyar Tudományos Akadémia.

IRELAND.

Belfast.—Natural History and Philosophical Society.
Dublin.—Royal Dublin Society; Royal Irish Academy.

ITALY.

Livorno.—L'Associazione "Mathesis."
Palermo.—Circolo Matematico.
Pisa.—Società Toscana di Scienze Naturali.
Portici.—R. Scuola Superiore d'Agricoltura. (Laboratorio di zool. generale e agraria).
Torino.—Reale accademia delle scienze; Rivista di Matematica.

NETHERLANDS.

Haarlem.—La Société Hollandaise des Sciences.

PORTUGAL.

Lisboa.—Academia Real das Sciencias; Real Observatorio de Lisboa; Société Portugaise de Sciences Naturelles.
Porto.—Academia Polytechnica do Porto.

RUSSIA.

Helsingfors.—Finskoie Uchonoie Obshchestvo.
Kazan.—Physico-Mathematical Society.
St. Petersburg.—Imper. Akademia Nauk.

SCOTLAND.

Edinburgh.—Royal Society.
Glasgow.—The Philosophical Society of Glasgow.

SWEDEN.

Göteborg.—Kongliga Vetenskaps och Vitterhets Samhälle.
Stockholm.—Kongliga Svenska Vetenskaps Adamemien.
Upsala.—Universitet Mineralogisk-Geologisk Institutionen.

SWITZERLAND.

Bern.—Naturforschende Gesellschaft.
Zurich.—Naturforschende Gesellschaft.

ASIA.

JAPAN.

Sapporo.—Sapporo Natural History Society.
Tokyo.—Tokyo Mathematico-Physical Society; Zoological Society of Tokyo.

INDIA.

Calcutta.—Indian Museum.

AFRICA.

CAPE COLONY.

Cape Town.—South African Philosophical Society.

NORTH AMERICA.

CANADA.

Halifax.—The Nova Scotia Institute of Science.
Montreal.—The Natural History Society.
St. Johns.—The Natural History Society of New Brunswick.
Toronto.—The Canadian Institute; The University of Toronto, Library.

MEXICO.

Mexico City.—Comision de Parasitologia; Institute Geologico de Mexico; Sociedad Mexicana de Geografia y Estadistica; Société Scientifique, "Antonio Alzate."

Tacubaya.—Comision Geodésica Mejicana; Observatorio Astronomico Nacional.

UNITED STATES.

CALIFORNIA.

Berkeley.—University of California Library. Exchange Dept.

Los Angeles.—Los Angeles Public Library.

San Francisco.—California Academy of Science.

COLORADO.

Colorado Springs.—Colorado College Scientific Society.

Denver.—Colorado Scientific Society.

CONNECTICUT.

New Haven.—Yale University Library.

DISTRICT OF COLUMBIA.

Washington.—Library of Congress; Smithsonian Institution; U. S. Dept. of Agriculture Library; U. S. Geological Survey Library; Washington Academy of Sciences.

ILLINOIS.

Chicago.—Chicago Academy of Sciences; Field Columbian Museum; John Crerar Library.

Urbana.—Illinois State Laboratory of Natural History.

INDIANA.

Indianapolis.—Indiana Academy of Science; Indiana Department of Geology and Natural Resources.

IOWA.

Davenport.—Davenport Academy of Sciences.

Des Moines.—Iowa Academy of Science.

KANSAS.

Lawrence.—Kansas University Library.

Topeka.—Kansas Academy of Science.

MAINE.

Portland.—Portland Society of Natural History.

MARYLAND.

Baltimore.—Johns Hopkins Hospital; Johns Hopkins University Library.

MASSACHUSETTS.

Boston.—American Academy of Arts and Sciences; Boston Public Library; Boston Society of Natural History.

Cambridge.—Harvard University Library.

Salem.—Essex Institute.

MICHIGAN.

Ann Arbor.—Michigan University Library.

MINNESOTA.

Minneapolis.—Minnesota Academy of Natural Science; Minnesota Geological Survey.

MISSOURI.

Jefferson City.—Missouri State Geological Survey.
St. Louis.—Missouri Botanical Garden; St. Louis Academy of Science.

NEBRASKA.

Lincoln.—Nebraska Academy of Sciences.

NEW YORK.

Brooklyn.—Brooklyn Conchological Club; Brooklyn Institute of Arts and Sciences; N. Y. Entomological Society.
Buffalo.—Buffalo Society of Natural History.
Ithaca.—Cornell University Library.
New York City.—American Museum of Natural History; Columbia University Library; New York Academy of Sciences; New York Botanical Garden; New York Entomological Society.
Rochester.—Rochester Academy of Science.

OHIO.

Cincinnati.—Lloyd Library of Botany, etc.
Oberlin.—Oberlin College Library.
Granville.—Denison Scientific Association.

PENNSYLVANIA.

Philadelphia.—American Philosophical Society; Franklin Institute; Pennsylvania University. Exchange Bureau.
Pittsburg.—Carnegie Library; Carnegie Museum.

TENNESSEE.

Nashville.—Tennessee University Library.

TEXAS.

Austin.—Texas State Historical Association; Texas State Library.
Brownwood.—Carnegie Library.
Cleburne.—Carnegie Library.
College Station.—A. and M. College, Library.
Corsicana.—Carnegie Library.
Dallas.—Carnegie Library.
Denton.—College of Industrial Arts, Library.
El Paso.—Carnegie Library.
Fort Worth.—Carnegie Library.
Galveston.—Rosenberg Library.
Georgetown.—Southwestern University Library.
Houston.—Carnegie Library.
Lockhart.—Clark Library.
San Antonio.—Carnegie Library; Scientific Society of San Antonio.

Temple.—Carnegie Library.
Terrell.—Carnegie Library.
Tyler.—Carnegie Library.
Waco.—Baylor University Library; Carnegie Library; Texas Christian University Library.
Waxahachie.—Sims Library.

VIRGINIA.

Charlottsville.—Virginia University Library.

WISCONSIN.

Madison.—Wisconsin Academy of Sciences, Arts, and Letters; Wisconsin Geological and Natural History Survey; Wisconsin University Library.
Milwaukee.—Public Museum of the City of Milwaukee; Wisconsin Natural History Society.

SOUTH AMERICA.

ARGENTINA.

Buenos Aires.—Deutsche Akademische vereinigung; Jardin Zoologico; Museo de Educacion; Museo nacional de historia Natural.
La Plata.—Universidad Nacional, Biblioteca.

BRAZIL.

Rio de Janeiro.—Museu Nacional de Rio de Janeiro.

CHILE.

Santiago.—Biblioteca Nacional.

URUGUAY.

Montevideo.—Museo Nacional.

AUSTRALIA.

QUEENSLAND.

Brisbane.—Royal Society of Queensland.

VICTORIA.

Melbourne.—Royal Society of Victoria.

REPORT OF TREASURER, 1907-1908.

Date.		Amount.	
	Receipts.		
June 11, 1907	To balance cash on hand	$ 166 79	
Oct. 16, 1907	From S. E. Mezes, 150 reprints, Vol. IX	4 55	
Oct. 21, 1907	Miss Marshall, 150 reprints, Vol. IX	11 00	
Nov. 8, 1907	T. H. Montgomery, 150 reprints, Vol. IX	6 50	
June 8, 1908	dues, fellows and members, 1907-1908	176 00	$364 84
	Expenditures.		
Aug. 8, 1907	To express charges on plates, Vol. IX	$ 45	
Aug. 18, 1907	express charges on plates, Vol. IX	1 15	
Sept. 7, 1907	Barnes-Crosby Co., 7 half-tones, Vol. IX	37 35	
Oct. 8, 1907	stamps for Secretary and Treasurer	5 00	
Oct. 11, 1907	Austin Ptg. Co., 500 copies, Vol. IX	142 15	
	450 reprints (3 papers)	22 05	
	cards and circulars	3 50	
Oct. 24, 1907	stamps for Treasurer	3 00	
Oct. 24, 1907	100 mailing envelopes for Transactions	1 00	
Oct. 26, 1907	stamps for Treasurer	2 00	
Nov. 13, 1907	stamps for Treasurer	1 00	
Nov. 19, 1907	stamps for Vice-President	4 20	
Nov. 19, 1907	C. M. Miller, painting sign for Vice-President	2 00	
Dec. 18, 1907	Stamps for Vice-President, and banner	3 25	
Dec. 18, 1907	L. W. Gruber for operating lantern	2 00	
Dec. 21, 1907	Austin Ptg. Co. for programs, cards, etc	11 25	
Feb. 11, 1908	Austin Ptg. Co., 2000 envelopes	4 50	
Feb. 20, 1908	L. W. Gruber for operating lantern	2 00	
April 1, 1908	Austin Ptg. Co. for programs, etc	5 25	
May 6, 1908	stamps for Treasurer	1 10	
May 7, 1908	stamps for Secretary	1 50	$255 70
June 8, 1908	To balance cash on hand		$109 14

R. A. THOMPSON, TREASURER.

CONSTITUTION OF THE TEXAS ACADEMY OF SCIENCE (AS AMENDED JUNE 12, 1899, JUNE 10, 1901, AND DECEMBER 27, 1901).

ARTICLE I.—NAME.

SECTION 1. This Association shall be called "THE TEXAS ACADEMY OF SCIENCE."

ARTICLE II.—OBJECTS.

SECTION 1. The objects of the Academy are: To advance the natural and exact sciences, both by research and discussion; to promote intercourse between those who are cultivating science in different parts of the State; and especially to investigate and report on any subject of science or industrial art, when called upon by any department of the State government.

ARTICLE III.—MEMBERSHIP.

SECTION 1. The Academy shall consist of Members, Fellows, and Patrons.

SEC. 2. In order to become a member, the applicant must be recommended in writing by two Members or Fellows, approved by the Council, and elected by ballot of the Society. In order to be elected, two-thirds of the ballots must be affirmative.

SEC. 3. Fellows shall be elected by the Council from such of the Members as are professionally engaged in science, or have in any way advanced or promoted science.

SEC. 4. Anyone who contributes to the funds of the Academy the sum of five hundred dollars shall be classed as a Patron.

ARTICLE IV.—OFFICERS.

SECTION 1. The officers of the Academy shall consist of a President, a Vice-President, an Honorary Secretary, a Treasurer, and a Librarian. They shall be elected from the Fellows by a ballot of the Academy at the June meeting of each year.

SEC. 2. The officers of the Academy, together with the Past Presidents and three Fellows, to be elected by the Academy at the June session in each year, shall constitute a Council for the transaction of such business as may be assigned to them by the Constitution and By-Laws of the Academy.

SEC. 3. The President of the Academy, or, in case of his absence, the Vice-President, shall preside at the meetings of the Academy and of the Council; shall nominate all committees except such as are otherwise specially provided for; shall refer investigations required by the State government to members especially conversant with the subject, and report to the Academy at its next formal meeting; and, with the Council, shall direct the general business of the Academy.

SEC. 4. The Honorary Secretary shall conduct the correspondence, advise with the President and Council in cases of doubt, and make a report at the formal meeting in June of each year.

It shall be the duty of the Secretary to give notice to the members of the place and time of all meetings, of all nominations for membership, and of all proposed amendments to the Constitution.

The minutes of each meeting shall be duly engrossed before the next meeting, under the direction of the Secretary.

SEC. 5. The Treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the Council may require. He shall collect all dues from the members, and keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the June session of each year.

ARTICLE V.—MEETINGS.

SECTION 1. There shall be two formal meetings of the Academy each year, one of which shall be held in June, at Austin, and the other within Christmas week at any place selected by the Council.

SEC. 2. The ordinary meetings of the Academy shall be at Austin during the months of October, November, January, February, March, April, and May, the place and dates to be fixed by the Council.

SEC. 3. The meetings of the Local Sections may be provided for in the "rules for their government."

ARTICLE VI.—PAPERS.

SECTION 1. Intimation of the business of each meeting shall be given to each member by means of a printed card.

SEC. 2. No title of a paper can appear on the card before the paper itself, or an abstract of it, has been approved by the Council or the Secretary.

SEC. 3. The Academy may provide for the publication, under the direction of the Council, of proceedings, memoirs, and reports.

SEC. 4. The advice of the Academy shall be at all times at the disposal of the State government upon any matter of science or art within its scope.

ARTICLE VII.—ASSESSMENTS.

SECTION 1. The admission fee for a Member shall be two dollars, and the admission fee for a Fellow five dollars, or an additional three dollars on promotion to Fellowship.

SEC. 2. The annual assessment shall be one dollar.

ARTICLE VIII.—ALTERATION OF THE CONSTITUTION.

SECTION 1. No part of this Constitution shall be amended or annulled, except after notice given at a formal meeting, and approval by two-thirds of those voting at the succeeding formal meeting.

ARTICLE IX.—LOCAL SECTIONS.

SECTION 1. Local Sections of the Academy may be established by the Council on receipt of a request to do so signed by ten members of the Academy in good standing residing in the territory within which the Local Section is desired.

SEC. 2. Such Sections shall appoint their own officers and committees, and may make any rules for their government not inconsistent with the Constitution and By-Laws of the Academy.

SEC. 3. The place of headquarters and definite territory selected by each Local Section within which its membership must reside will be subject to the approval of the Council.

SEC. 4. Any Local Section may be dissolved by the Council for good and sufficient cause.

BY-LAWS.

CHAPTER 1.—MEMBERSHIP.

1. No person shall be accepted as a Member or Fellow unless he pays his initiation fee and the dues for the year within three months after notification of his election.

2. An arrearage in payment of annual dues shall deprive a Member or Fellow of taking part in the management of the Society and of receiving the publications of the Society. An arrearage for one year shall be construed as a notification of withdrawal.

CHAPTER 2.—ELECTION OF MEMBERS.

1. Nominations for membership may be made at any time in due form to the Honorary Secretary.

2. The form of the nomination of Members shall be as follows:

In accordance with his desire, we respectfully nominate for membership in the Texas Academy of Science—

Full name: ....

Address: ....

Degrees, if any: ....

Occupation: ....

Branch of science engaged in, work already done, and publications, if any:

....

Signed by two Members, or Fellows.

The Honorary Secretary will bring the nominations before the Council at its first meeting thereafter, and the Council will signify its approval or disapproval of each nomination.

The Honorary Secretary shall have lists or cards printed and sent to each Member, giving name of each nominee and such information as may be necessary for intelligent voting.

The Members and Fellows receiving the list will signify their approval or disapproval of each nominee, and return list to the Honorary Secretary.

At the next meeting of the Council, the Honorary Secretary will present the lists and the Council will canvass the returns and declare the results at the next succeeding meeting of the Academy.

CHAPTER 3.—COMMITTEE ON PUBLICATION.

The Council shall appoint a Committee on Publication, consisting of three members, of which the Honorary Secretary shall be chairman ex officio, who shall decide upon the value of articles submitted to them for publication, and in case of doubt be authorized to call upon any member of the Society who is specially familiar with the branch of science treated of for assistance in such determination.

If the paper is accepted, the author must deposit with the Honorary Secretary a sufficient sum to defray publication charges, at a rate not exceeding $2.00 per octavo page, and pay for all cuts or illustrations.

(At present the Academy bears a part of the expenses of publication.)

CHAPTER 4.—ORDER OF BUSINESS.

1. Call to order by Presiding Officer.
2. Statements by President.
3. Report of Council.
4. Report of Treasurer.
5. Election of Officers.
6. Declaration of results of election of Officers.
7. Reports of Committees.
8. Announcements.
9. Unfinished Business.
10. New Business.

At the monthly meetings the order of business shall be:

1. Call to order by the President.
2. Statements by the President.
3. Presentation of memoirs, and discussion.
4. Report of Council.
5. Announcements.

CHAPTER 5.—ELECTION OF OFFICERS AND OTHER MEMBERS OF THE COUNCIL.

(Added April 12, 1895.)

The Honorary Secretary shall send to each member a circular letter including a list of the Fellows, with a request to send in a ballot nominating each officer and other members of the Council. The ballot must be received by the Honorary Secretary by May 15. The Council will select two from the three nominees receiving the highest number of nominations for each position, and prepare a ballot to be sent to each member of the Academy in time to permit his vote being received previous to the June meeting, at which time the votes will be counted.

CHAPTER 6.—PERMANENT MEMBERS.

(Added January 11, 1896.)

Any Member of the Academy may become a "Permanent Member" on payment of fifty dollars; all "Permanent Members" to be free from all subsequent assessments.

The money received from this source shall be invested as a permanent fund, the interest of which may be used towards paying for the printing of the transactions of the Academy or for such other purposes as the Council may determine.

CHAPTER 7.—PROXIES.

(Added October 3, 1899.)

A proxy may be used at a meeting of the Council only when necessary to constitute a quorum, and such proxy may be held only by a duly elected member of the Council.

LIST OF PATRONS, FELLOWS AND MEMBERS.

PATRONS.

Brackenridge, Geo. W., Member Board of Regents, University of Texas, San Antonio.

Halsted, Mrs. Geo. Bruce, Greeley, Colorado.

Total, 2.

FELLOWS.

Askew, H. G., Expert Statistician for Texas Railroads, Austin.

Bailey, Dr. Jas. R., Adjunct Professor of Chemistry, University of Texas, Austin.

Ball, Dr. O. M., Professor of Botany and Mycology, Agricultural and Mechanical College, College Station.

Bantel, Edw. C. H., Adjunct Professor of Civil Engineering, University of Texas, Austin.

Battle, Dr. W. J., Professor of Greek, University of Texas, Austin.

Benedict, Dr. H. Y., Professor of Applied Mathematics, University of Texas, Austin.

Bray, Dr. Wm. L., Professor of Botany, Syracuse University, Syracuse, New York.

Brooks, Mr. Barney, Student, Medical Department Johns Hopkins University, Baltimore, Maryland.

Brown, Prof. J. S., Professor of Mathematics, Southwest Texas Normal School, San Marcos.

Bruce, Dr. W. H., Principal North Texas State Normal School, Denton.

Callaway, Dr. Morgan, Jr., Professor of English, University of Texas, Austin.

Carter, Dr. W. S., Dean of Department of Medicine and Professor of Physiology, University of Texas, Galveston.

Charlton, Prof. O. C., President Texas Female College, Bryan.

Cooke, Dr. H. P., Galveston.

Curtis, Geo. W., Manager Burrus Mill and Elevator Company, Fort Worth.

Deussen, Alex., Instructor in Geology, University of Texas, Austin.

Dohmen, Dr. Franz J., Cambridge, Mass.

Dumble, E. T., Consulting Geologist, Southern Pacific Company, Houston.

Ellis, Dr. A. Caswell, Associate Professor of Science and Art of Education, University of Texas, Austin.

Ferguson, A. M., Superintendent Texas Seed Breeding Farms, Sherman.

Fraps, Dr. Geo. S., State Chemist, Agricultural and Mechanical College, College Station.

Garrison, Dr. Geo. P., Professor of History, University of Texas, Austin.

Halley, Prof. R. B., Professor of Science, Sam Houston Normal Institute, Huntsville.

Halsted, Dr. Geo. Bruce, Professor Mathematics, State Normal School, Greeley, Colorado.

Harper, Dr. W. H., Professor of Chemistry, University of Texas, Austin.

Harrington, Dr. H. H., President Agricultural and Mechanical College, College Station.

Hartman, Carl, Superintendent Public Instruction, Travis County, Austin.
Herff, Dr. Ferdinand, San Antonio.
Heusinger, E. W., Secretary San Antonio Scientific Society, San Antonio.
Hilgartner, Dr. H. L., Austin.
Hill, Dr. Homer B., Austin.
Hill, Dr. Robert T., Consulting Geologist, 25 Broad Street, New York City.
Houston, Dr. David F., Chancellor Washington University, St. Louis, Missouri.
Howard, Dr. Wm. R., Professor of Medicine, Fort Worth University, Fort Worth.
Jarvis, Miss May M., University of Texas, Austin.
Keasbey, Dr. L. M., Professor of Political Economy, University of Texas, Austin.
Keiller, Dr. Wm., Professor of Anatomy, University of Texas, Galveston.
Kuehne, Mr. J. M., University of Texas, Austin.
Lefevre, Prof. Arthur, Superintendent of Public Schools, Dallas.
McClendon, Dr. J. Y., Professor of Zoology, University of Missouri, Columbia, Missouri.
McDaniel, Dr. A. C., San Antonio.
McFarlane, Dr. Alexander, Victoria Avenue, Chatham, Ontario, Canada.
Mackensen, Prof. B., Professor of Science, San Antonio High School, San Antonio.
Marshall, Miss Margaret E., Bonham, Texas.
Mather, Dr. Wm. T., Professor of Physics, University of Texas, Austin.
McLaughlin, Dr. J. W., Austin.
Mezes, Dr. Sidney E., President University of Texas, Austin.
Mitchell, J. D., Victoria.
Montgomery, Dr. Edmund, Hempstead.
Montgomery, Dr. Thos. H., Professor of Zoology, University of Pennsylvania, Philadelphia, Pennsylvania.
Nagle, Prof. Jas. C., Professor of Civil Engineering, Agricultural and Mechanical College, College Station.
Paine, Dr. J. F. Y., Professor of Obstetrics and Gynecology, University of Texas, Galveston.
Pearce, Prof. Jas. E., Principal High School, Austin.
Porter, Dr. Milton B., Professor of Mathematics, University of Texas, Austin.
Potts, C. S., University of Texas, Austin.
Prather, Jno. K., Mining Engineer, El Paso (permanent address, Waco).
Primer, Dr. Sylvester, Associate Professor Germanic Languages, University of Texas, Austin.
Puryear, Prof. Chas., Professor of Mathematics, Agricultural and Mechanical College, College Station.
Rall, Dr. E. E., Instructor in Science and Art of Education, University of Texas, Austin.
Reichman, Dr. Fritz, Superintendent of Weights and Measures, State of New York. (Permanent, care W. and L. E. Gurley, Troy, New York.)
Rice, Prof. C. D., Adjunct Professor in Mathematics, University of Texas, Austin.
Rucker, Miss Agusta, Medical Department, Johns Hopkins University, Baltimore, Maryland.
Schoch, Dr. E. P., Adjunct Professor of Chemistry, University of Texas, Austin.
Simonds, Dr. F. W., Professor of Geology, University of Texas, Austin.
Smith, Dr. A. J., Professor of Pathology, University of Pennsylvania, Philadelphia, Pennsylvania.

Sutton, Dr. W. S., Professor of Science and Art of Education, University of Texas, Austin.

Taylor, Prof. Thos. U., Dean of Department and Professor of Civil Engineering, University of Texas, Austin.

Thompson, Dr. Jas. E., Professor of Surgery, University of Texas, Galveston.

Thompson, R. A., Chief Engineer, Railroad Commission of Texas, Austin.

Wilkinson, Judge A. E., Reporter of Supreme Court of Texas, Austin.

Windsor, Phineas L., Librarian, University of Texas, Austin.

Work, Dr. Cree T., President Industrial College for Women, Denton.

York, H. H., Instructor in Botany, University of Texas, Austin.

Total, 73.

MEMBERS.

Anderson, A. E.

Baker, R. H., President Trinity and Brazos Valley Railway, Austin.

Barry, F. B., with Allyn and Bacon, Dallas.

Bennett, Dr. T. J., Austin.

Blake, Prof. J. C., Professor of Chemistry, Agricultural and Mechanical College, College Station.

Bliem, Dr. M. J., San Antonio.

Breihan, E. W., Professor of Physical Sciences, High School, Austin.

Brooks, R. C., Superintendent Water, Light and Power Plant, Austin.

Brown, R. L., Attorney at Law, Austin.

Clark, Jas. B., Proctor and Secretary Board of Regents, University of Texas, Austin.

Clement, Prof. W. W., Principal Temple High School, Temple.

Cline, Dr. J. L., U. S. Weather Bureau Service, Corpus Christi.

Connerly, R. H., Clerk Court of Civil Appeals, Austin.

Corrigan, C. S., Chief Engineer, Galveston Wharf Co., Galveston.

Daniel, Dr. F. E., Austin.

Decherd, Dr. Geo. M., Austin.

Decherd, Miss Mary E., Tutor in Mathematics, University of Texas, Austin.

Duggan, Dr. Malone, San Antonio.

Estill, Miss A. Julia, Teacher of Science, High School, Fredericksburg.

Evans, Major Ira H., Austin.

Giesecke, Prof. F. E., Professor of Drawing, Agricultural and Mechanical College, College Station.

Glasscock, B. L., Fellow in Chemistry, University of Pennsylvania, Philadelphia.

Graham, J. W., Austin.

Graves, Dr. M. L., Professor of Medicine, University of Texas, Galveston.

Gregory, T. W., Attorney at Law, Austin.

Hargis, O. D., Mining Engineer, Viesca, Coahuila, Mexico.

Harper, Dr. W. A., Austin.

Hexter, J. K., Victoria.

Hill, Clyde W., University of Texas, Austin.

Hirsch, A., 911 West Johnson St., Madison, Wisconsin.

Holliday, Dr. Margaret R., Physician; Lecturer on Education, University of Texas, Austin.

House, E. M., Austin.

Howard, E. E., Assistant Engineer, Waddell & Harrington, Bridge Engineers, Kansas City, Missouri.

Howe, J. M., Civil Engineer, Houston.
Hubbard, Prof. L. H., Professor Belton High School, Belton.
Hudson, Dr. S. E., Austin.
Hunnicutt, W. H. P., Draughtsman State General Land Office, Austin.
Jones, W. Goodrich, Temple.
Junkin, Prof. T. P., Instructor in Mathematics, Agricultural and Mechanical College, College Station.
Kahn, Samuel, Consulting Engineer, Gas and Electric Company, San Antonio.
Lacey, Mr. Howard, Kerrville.
Leisewitz, Mrs. J. M., Matron Grace Hall, Austin.
Lewis, J. B., Teacher of Science, Victoria.
Lowber, Dr. J. W., Pastor Christian Church, Austin.
Maxey, Jno. W., Civil Engineer, Houston.
McCallum, Prof. A. N., Superintendent Austin Public Schools, Austin.
McLaughlin, Dr. J. W., Jr., Austin.
McVea, J. C., Assistant Engineer, Houston & Texas Central Railroad Co., Ennis.
Metzenthin, W. E., Adjunct Professor of German, University of Texas, Austin.
Miller, C. H., Attorney at Law, Austin.
Miller, E. T., Department of Economics, Harvard University, Cambridge, Massachusetts.
Miller, T. S., General Attorney, Missouri, Kansas & Texas Railway, Dallas.
Moore, Dr. Jno. T., Galveston.
Morgan, Prof. J., Principal Dallas Public Schools, Dallas.
Neville, W. R., Jr., Austin.
Oppikofer, F., U. S. Engineer, Department of Texas, Tarpon.
Ostrander, F. C., Instructor Romance Languages, University of Texas, Austin.
Pantermuehl, R. C., Teacher of Physics, Dallas High School, Dallas.
Parker, R. D., Resident Engineer, Houston & Texas Central Railroad, Ennis.
Pittuck, Prof. B. C., Box 115, Dallas.
Reedy, J. H., Professor of Natural Science, Southwestern University, Georgetown.
Seltzer, H. K., Engineer, Union Bridge and Construction Co., Kansas City, Missouri.
Sisk, B. F., Instructor in English, University of Texas, Austin.
Smith, Noyes D., Austin.
Smith, R. F., Associate Professor of Mathematics, Agricultural and Mechanical College, College Station, Texas.
Stanfield, S. W., Professor of Science, Southwest Texas Normal School, San Marcos.
Sublette, G. W., City Engineer, Minneapolis, Minnesota.
Thayer, Dr. A. E.
Udden, Dr. J. A., Professor of Geology, Augustana College, Rock Island, Illinois.
Warfield, Dr. Clarence, San Antonio.
Wells, Dr. E. H., Professor of Natural Science, Baylor Female College, Belton.
Whitis, Miss Mary, Principal Whitis Preparatory School, Austin.
Whitten, Miss Harriet V., Teacher of Science, Industrial College for Women, Denton.
Williams, Mason, Attorney at Law, San Antonio.
Wilmot, Dr. E. P., President Austin National Bank, Austin.

Winkler, E. W., Chief Clerk, Department of Agriculture, State of Texas, Austin.
Wipprecht, Walter, Bryan.
Worrell, S. H., Mining Engineer, Chihuahua, Chihuahua, Mexico.
Wright, Dr. W. K., University of Chicago, Chicago, Illinois.
Yothers, W. W., Box 165, Orlando, Florida.

Total, 80.
Grand Total, 155.

TRANSACTIONS

OF THE

Texas Academy of Science

FOR 1908 AND 1909

Together With the Proceedings for
the Same Years

VOLUME XI

AUSTIN, TEXAS, U. S. A.
Published by the Academy
1911

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COMMITTEE ON PUBLICATION.

E. P. Schoch.
F. W. Simonds.
Edw. C. H. Bantel.

AUSTIN:
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1911

CONTENTS.

TEXAS ACADEMY OF SCIENCE

[Annual Address by the President.]

A STUDY OF THE RUST PREVENTING POWER OF CERTAIN ELECTROLYTES.

E. P. SCHOCH.*

We here in the South are so far removed from centres of commercial manufacture that we do not perceive clearly the problems connected with raw and manufactured materials, and this may be largely responsible for the fact that we do not appreciate, or foster, science as much as the people of manufacturing communities do. In the hope of increasing the scientific interest in our midst, I have decided to bring to your attention the study of one of the greatest technical problems of this day, the rusting of iron, and the possibility of its economic prevention. Although it is customary, on occasions of this sort, to leave one's own narrow domain of activity, and to discuss a subject of general import, I prefer to go to the other extreme and offer to this honorable body, not only a subject in which I am specially interested, but offer for publication only such matter which I have had the good fortune to learn directly from experiment, and which, it is hoped may possibly help in a small degree to solve the problem studied.

During the last two years it has been shown that the rusting of iron is a process that takes place in *several* definite steps, and that it is purely an electrolytic phenomenon. The details of the *proof* as well as of the phenomenon, are admirably told by A. S. Cushman in a publication that is accessible to every one—namely Bulletin No. 30, Office of Public Roads, U. S. Dept. of Agriculture—and the style of the presentation is such that practically every one interested in the subject may read it intelligently. Hence only an outline of the main points need be given here. Whenever iron rusts, one or more spots on its surface act as the negative poles of a battery cell, where the metal dissolves in the water on its surface to form *ions,* and one or more other spots near by act as positive poles—where hydrogen ions from the water are liberated as gaseous hydrogen. The latter process is facilitated by access of air, the oxy-

*Associate Professor of Chemistry, University of Texas, Austin.

**This experimental study formed the basis of a general address on "The Problem of the Rusting of Iron."

gen of which oxidizes the free hydrogen, or, as it is commonly called, depolarizes the positive pole. The subsequent oxidation of the ferrous compound in solution to the insoluble ferric oxide, and its migration toward the positive pole, which produces the "pitted" appearance of the surface—these are unessential, secondary phenomena.

A little consideration shows that rusting would be prevented if no moisture were allowed to touch the surface. This is much more difficult to accomplish than it might appear to be, because oils and paint films even, are permeated by moisture. The next possibility for the prevention of rusting is the manufacture of an iron which is so homogeneous that there is little tendency for different spots on its surface to develop into postive and negative poles respectively. In this direction a great deal of success has been attained through the co-operation of the great iron and steel manufacturers and the scientific men who have been investigating these problems. Closely connected with this attempt is the attempt to find an alloying material which would reduce the dissolving tendency of the iron—the solution tension, as it is technically called. Thus alloys of iron with 1-2 per cent of nickel rust at a rate which is only 1 to 5 per cent of the rate at which pure iron rusts. Most additions, however, increase the rate of rusting, so that it is thought that absolutely pure iron may not rust at all—an idea that appears to be proven by the experiments of J. Kreusler (Berichte der Deutsch phys. Ges., 6:344), who found that the pure iron he had obtained was not attacked by muriatic acid. The "lost art" fairy tale has also introduced itself into this subject: at Delhi, India, there is an iron shaft that has stood there since 900 B. C., without any protective coating, and it has not rusted in the least; yet iron articles of modern manufacture exposed to the same atmospheric influences have rusted quite readily. It is naturally suspected that the iron in the column was manufactured by a method which yielded a better iron than that obtained by our modern methods. Whether or not it will be possible to manufacture a non-rusting iron or iron alloy, is something that the future will have to solve; but there seems to be little hope for any great discovery in this direction.

Another possibility that suggests itself for the prevention of rusting, is the transformation of the surface by means of chemical or electro-chemical action so as to render it passive—i. e., inactive. When iron is dipped into nitric acid of a certain concentration, the surface seems to be transformed so that the acid does not attack it, although under other commonly occurring conditions a very vigorous action takes place. Dipping iron into a solution of chromic acid has the same effect; and again, when it is made the anode in certain electrolytes, and a sufficiently large current is passed, then the iron does not dissolve, but oxygen is evolved on its surface, just as would be the case with a platinum or gold pole. The surface of the iron retains this *passive* condition fairly indefinitely if it is taken out of the solution and the surface is washed and dried. The question arises: is it possible to transform the surface by this means so that it may resist corrosion permanently? and another question is: since iron frequently must be used in contact with water and salt solutions, is it possible to find certain salts which, when added to the solution, may affect the surface so that it may be kept permanently passive? These are the particular questions that I have addressed myself to in connection with my experiments and concerning which I wish to report here.

In brief, the detail of the experimental procedure was the following: A clean, definitely measured portion of metal surface (several samples each of wrought iron, cast iron, and steel were tried) was exposed to *anodic* action under conditions which assured uniform distribution of the current over the surface.

Different electrolytes were employed (See list below) and the liquid was admitted to the pole and stirred in such a manner that during any one determination the composition of the solution in contact with the surface remained absolutely the same—it was not changed by the products of the electrolysis, because these were removed by passing the electrolytes through the apparatus in a continuous stream. In all experiments air was removed at the beginning and excluded during the progress of the experiment, because oxygen is the particular substance the action of which upon the surface produces the phenomenon of passivity. The current density and the corresponding electric potential of the metal under observation were recorded. The solutions used were sulphates, chlorides, nitrates, fluorides, chromates, chlorates, bromates, iodates, perchlorates and hydroxides. These were used in definite concentrations. Some of these solutions were also used with the addition of definite slight amounts of alkali or of acid. Also several mixtures of two electrolytes were employed.

The behavior of the metals under these conditions showed conclusively that the passive condition is due to a cover formed by the liberated oxygen. It is quite certain now that a very thin coat of metal oxide at least is produced, and this together with a film of oxygen gas which is held by this oxide coat as a skeleton, protects and isolates the metal surface from the electrolyte. However, this coating is never homogeneous, and at the "cracks" or interstices the metal is exposed to the electrolyte and undergoes the usual action.

The protected inactive spots and the active spots together form little short circuited galvanic cells, and whenever the operating current is cut off, the action of these "cells" gradually "discharges" the protected spots, and thus the whole surface gradually becomes active again. This regaining of the active conditions takes place even with those salts which heretofore were thought to render the surface permanently passive—namely, hydroxides and chromates.

In connection with this work the fact revealed itself that the action at the anode depends specifically upon the particular ion that comes in contact with the anode; every ion has a specific tendency to effect both metal dissolution and oxidation, but the ratio of these two tendencies differs with different ions. Some ions, such as chromation, iodation, hydroxylion, etc., have a much greater tendency to oxidize than to dissolve the metal; while with chloridion, sulphation, etc., the reverse is the case. While the results are of more particular importance in connection with the problem of the details of interaction between a solution and a solid, they are also of importance in connection with the problem under discussion, because whenever iron—whether passivized or not—is exposed to a salt solution, "cells" are formed between spots of different potential on its surface, particularly between the active and the inactive spots on a passive surface, and it is readily seen from the above that the result of the action of these cells depends upon all the specific anions present—naturally, also upon their relative proportions. Hence, when a solution contains many common ions, such as sulphation, chloridion, etc., which have a great specific tendency to produce metal dissolution and a relatively slight tendency to anodic oxidation, then the electrolytic action between different poles on an iron surface would be such that very soon nearly the whole surface would be rendered active; while in the presence of ions of the opposite tendency, the reduction of the oxide surface would take place very slowly, and a balance would finally be established between the rate of this reducing action and the rate of direct oxidation of the surface by contact with air, or with the salt itself if this is a chromate or iodate—i. e., a substance which is capable of oxidizing other substances. Hence, when such a substance as a chromate, etc., alone is present, it has been found that the corrosion of the iron did not proceed appreciably. However, when, *in addition* ions of a larger "metal-dissolving tendency" are present, then this inhibiting action of chromates, etc., may be more or less completely nullified—depending upon the relative proportion between the different salts.

Thus the final conclusion is plain—neither passivizing by any means whatever, nor the addition of "rust inhibiting" salts to a solution may serve to protect iron from rusting whenever it comes in contact with aqueous solutions of the common salts such as sulphates, chlorides, etc., which exert in anodic action a relatively great tendency toward metal dissolution.

Details concerning the apparatus and experimental results as well as detailed discussion of the bearing of these facts upon the theories of electrolysis and corrosion may be found in the following publications which have been sent out from time to time from this laboratory. Of course it is needless to say that my work on this subject is still in progress.

Am. Chem. J. 41:226.

Am. Chem. J. 41:232.

Jour. Phys. Chem. 14:665.

Jour. Phys. Chem. 14:720.

References to publications by other workers on this subject will be found in the above publications.

Chemical Laboratory, The University of Texas, Oct. 1908.

LIST OF PARASITIC BACTERIA AND FUNGI OCCURRING IN TEXAS.

FREDERICK DEFOREST HEALD AND FREDERICK ADOLPH WOLF.

THE PARASITIC FUNGI OF TEXAS.

1. *Historic Introduction.*

The literature on Texas Botany shows that the great majority of workers busied themselves with the collection and study of the flowering plants (see "Bibliography of Texas Botany," in Rep. Mo. Bot. Garden, 18:201-206. 1907). Of 88 titles mentioned in the above Bibliography, only three are concerned with fungi.

Some of the earlier collectors, while studying the phanerogamic flora, picked up a few specimens of fungi. These collections were recorded in 1878, in the first attempted report on "The Fungi of Texas," by M. C. Cooke (8). This list included 149 species, a considerable number of them being new. They are credited to the following collectors:

Ravenel	78	species
Wright	55	"
Lindheimer	8	"
Drummond	3	"
Pope	2	"
Bigelow	1	"
Total	149	species

The above list includes many saprophytic forms as well as parasitic forms, and is small considering the size of the state and the great diversity of conditions represented.

In connection with the investigation of diseases of cattle, H. W. Ravenel, of South Carolina, visited Texas in the spring of 1869, and made collections at Houston, Galveston, Corpus Christi and Indianola. According to his own summary (38), his fungous collections included the following:

Hymenomycetes	64
Ascomycetes	151
Gasteromycetes	13
Hyphomycetes	26
Coniomycetes	28

The above record shows a total of 282 species collected, while it will be seen from reference to the summary of Cooke's report that only seventy-eight species of Ravenel's collection were included. The remainder of Ravenel's specimens were never reported as far as the writers have been able to learn, but duplicates of a considerable number are in the Ellis collection. Twenty-five new species were described by Cooke (9) from collections made by Ravenel at Houston and Galveston.

In 1890, Jennings published a list of ninety-five species of parasitic fungi collected mainly in the vicinity of College Station (24). The works of the two botanists mentioned constituted the only extensive lists of Texas Fungi up to the time when the writers began their work in the spring of 1909, although various other workers had added to the knowledge of Texas Fungi. Notable among these should be mentioned Long (26, 27, 28), whose work added largely to the knowledge of the rusts, his collections being made for the most part in the vicinity of Austin.

Scattered references to Texas fungi will be found in the mycological writings of various authors and the works by Arthur (2), Clinton (6), and Murrill (29, 30), in their respective fields, give some references to Texas fungi not recorded elsewhere. Various workers in the U. S. Department of Agriculture have made collections in Texas, and a limited number of Texas parasitic species, destructive to economic plants, are mentioned in Orton's annual summaries of "Plant Diseases in the United States" (31-36).

In the spring of 1909, the writers, in co-operation with the Bureau of Plant Industry of the U. S. Department of Agriculture, began a Plant Disease Survey of the area designated as the San Antonio-Austin area. This area included the territory within a radius of one hundred miles of San Antonio, and collections were made at many points.

Parasitic species occuring on both wild and economic plants were collected but the principal attention was given to the cultivated crops. As a result of this work forty-one new species have been described and a total of two hundred and ninety-three species on one hundred and ninety-three different hosts have been recorded. They are distributed as follows:

On Tree Fruits	30	species
" Small Fruits	7	"
" Truck Crops	33	"
" Cereals and Field Crops	13	"
" Forage Crops and Grasses	25	"
" Trees and Shrubs	90	"
" Greenhouse and Garden Plants	27	"
" Wild Plants	68	"

The new species are described in the complete report (21) and also in Mycologia (22). The complete report (21) contains figures illustrating practically all of the new species while the article in Mycologia includes short Latin diagnoses in addition to the more lengthy English descriptions.

The present list includes all of the parasitic fungi and bacteria (parasitic on plants) which are known to occur in Texas as far as the writers have been able to determine. It is quite probable that further work will show that some recorded species have been overlooked, but the list at least represents a working basis for further study of an exceedingly interesting region.

A short bibliography has been added and the figure in parenthesis after the locality given in the list, refers to the publication in which the species has been recorded as occurring in Texas. As far as possible we have attempted to use current nomenclature and as a result many of the species recorded by Cooke and Jennings appear under their more recently accepted synonyms.

All of the species of rusts collected during the Plant Disease Survey of the San Antonio-Austin area were determined by Mr. F. D. Kern of Purdue University, Lafeyette, Indiana, for which the writers make grateful acknowledgement.

2. *Summary of Species Recorded.*

Bacteria	11	species
Chytridiales	2	"
Peronosporales	11	"
Hypocreales	2	"
Exoascales	1	"
Perisporales	20	"
Dothidiales	2	"
Sphaeriales	8	"
Phacidiales	1	"
Pezizales	3	"
Sphaeropsidiales	64	"
Melanconiales	31	"
Hyphomycetales	113	"
Ustilaginales	27	"
Uredinales	94	"
Agaricales	7	"
Mycelia Sterila	3	"
Total	400	"

LIST OF PARASITIC BACTERIA AND FUNGI OCCURRING IN TEXAS.

BACTERIA.*

1. Bacillus pyrocyanus P. & D.
   On Begonia sp. San Antonio. (21)
2. Bacillus Sorghi Burr.
   On Sorghum vulgare Pers. and var. Boerne, New Braunfels, Sabinal, Elgin, Bastrop, Seguin, Stockdale, Flatonia, Floresville, Lockhart, Cotulla. (21)
3. Bacillus amylovorus (Burr.) DeToni.
   On Pyrus communis L. Austin, San Antonio, Boerne, Elgin, Lockhart, Nursery, Cuero, Stockdale, Flatonia, Hallettsville. (21)
4. Pseudomonas Malvacearum Erw. S.
   On Gossypium herbaceum L.
   San Antonio, Boerne, Beeville, Elgin, Bastrop, Lockhart, San Marcos, Sabinal, Hondo, Luling, Seguin, Georgetown, Round Rock, Victoria, Nursery, Cuero, Stockdale, Gonzales, Flatonia, Yoakum, Hallettsville, Falfurrias. (21) Texas. (31-36)
5. Pseudomonas Pruni Erw. S.
   On Prunus sp. and Amygdalus persica L.
   Uvalde, San Marcos, San Antonio, Kerrville, Beeville, Elgin, Nursery, Gonzales. (21)
6. Pseudomonas campestris (Pammel) Smith.
   On Brassica oleracea. (cauliflower) Texas (31, 36)
   On Brassica oleracea. (cabbage) Texas. (31, 36)
7. Pseudomonas Phaseoli Smith.
   On Phaseolus vulgaris L. and Phaseolus lunatus L.
   San Antonio, Austin, Stockdale, Uvalde. (21)
8. Pseudomonas tumefaciens, Smith & Townsend.
   On Amygdalus persica L. Uvalde, Round Rock.
   On Malus malus (L.) Britton. Llano.
   On Pyrus communis L. Llano. (21)
9. Bacterial spot.
   On Pelargonium sp. Austin. (21)
10. Bacterial spot.
    On Capsicum annuum L. Uvalde. (21)
11. Bacterial twig canker.
    On Prunus sps. San Antonio, Austin, Seguin. (21)

*Exclusive of species parasitic on man and domestic animals.

Order Chytridiales.

12. Synchitrium fulgens Schrtr.
    On Oenothera sinuata L. College Station. (24)
13. Synchitrium Taraxaci DeBy. & Wor.
    On Engelmannia pinnatifida Torr. & Gray., Coll. Sta. (24)

Order Peronosporales.

14. Albugo bliti (Biv.) Kuntze.
    On Amaranthus albus L., A., retroflexus L., and A. spinsous L. Austin, San Marcos, Uvalde, Luling, Victoria, Stockdale, Llano, Lockhart, Falfurrias. (21)
15. Albugo Froelichiae Wilson.
    On Amaranthaceae. Texas. (51)
16. Albugo ipomoeae-panduranae (Schwein.) Swingle.
    On Convolvulus hermannioides Gray. Austin. (21)
    On Ipomoea batatas L. San Antonio, Llano, Beeville, Elgin, Uvalde, Nursery, Yoakum. (21)
    On Ipomoea sps. Austin, Lockhart, Seguin, Georgetown, Round Rock, San Marcos, Elgin, Flatonia, Stockdale, Gonzales. (21)
17. Albugo platensis Speg.
    On Boerhavia sps. San Antonio, New Braunfels, Bastrop, Lockhart, Cotulla, Seguin, Victoria, Nursery, Cuero, Stockdale, Gonzales, Kennedy. (21)
    On Mirabilis Jalapa L. Austin. (21)
18. Albugo Portulaceae (DC.) Kuntze.
    On Portulaca oleracea L. and
    On Portulaca lanceolata Engl. Beeville, Bastrop, Luling, Cuero, Stockdale, Falfurrias. (21)
19. Basidiophora entospora Rose & Cornu.
    On Carduaceae. Texas (50)
    On Rudbeckia fulgida Ait. College Station. (24)
20. Peronospora Nicotianae Speg.
    On Nicotiana sp. Texas. (51)
21. Peronspora parasitica (Pers.) DeBy.
    On Arabis sp. College Station. (24)
    On Brassica Rapa L. Austin. (21)
    On Lepidium Virginicum L. Austin. (21)
22. Plasmopora viticola (B. & C.) Berl. & De Toni.
    On Vitis sp. Austin. (21)
    On Vitis sp. College Station. (24)

23. Pseudoperonspora cubensis (B. & C.) Rostew.
 On Cucurbitaceae. Texas (50)
 Cucumis Anguria L. College Station. (24)
24. Rhysotheca Gerani Peck.
 On Geraniaceae. Texas (50)
 On Geranium Caroliniaum L. Austin. (21)
 On Geranium Caroliniaum L. College Station. (24)

Order Hypocreales.

25. Balansia hypoxylon (Pk.) Atkinson.
 On Stipa leucotricha Trin. Austin. (21) Texas. (4)
26. Neocosmospara vasinfecta (Atk.) Erw. Smith.
 On Vigna siniensis Hassk. Texas. (35)

Order Exoascales.

27. Exoascus deformans Berk.
 On Amygdalus persica L. College Station. (24)

Order Perisporiales.

28. Asterina minor E. & E.
 Houston. (8)
29. Asterina orbicularis B. & C.
 On Ilex opaca Ait. Texas (8)
30. Asterina Wrightii B. & C.
 On Cucurbitaceae. Texas. (8)
31. Dimerosporium pulchrum Sacc.
 On Cornus., Fraxinus, etc. Texas. (13)
32. Dimerosporium Parkinsoniae Heald & Wolf.
 On Parkinsonia aculeata L. Austin, Seguin, Gonzales, Hallettsville. (21)
33. Erysiphe Cichoracearum DC.
 On Ambrosia artemisaefolia L. (24)
 On Ambrosia trifida L. San Marcos. (21)
 On Helianthus sp. San Antonio. (21)
 On Verbena officinalis L. College Station. (24)
 On Xanthium strumarium L. College Station. (24)
34. Erysiphe galeopsidis DC.
 On Stachys Drummondii Benth. Austin. (21)
35. Erysiphe graminis DC.
 On Bromus unioloides Willd.
 On Panicum sanguinale L. College Station. (24)

36. Erysiphe Polygoni DC.
   On Polygonum sp. San Marcos, San Antonio. (21)
   On Oenothera laciniata Hill. Austin. (21)
   On Lupinus Texensis Hook. Austin. (21)
   On Oenothera sinuata L. College Station. (24)
   On Phaseolus vulgaris L. San Antonio. (21)
   On Pisum sativum L. Austin. (21)
37. Erysiphe sp.
   On Prospopis glandulosa Torr. Austin, Beeville, Uvalde, San Marcos, Cotulla, Luling, Seguin, Cuero, Stockdale, Gonzales, Hallettsville, Falfurrias, Skidmore, Kennedy, Floresville. (21)
38. Microsphaera Alni (Wallr.) Wint.
   On Syringa sp. Austin. (21)
   On Gleditschia triacanthos L. College Station. (24)
39. Microsphaera diffusa Cooke and Peck.
   On Symphoricarpos sp. Austin. (21)
40. Microthyrium Smilacis Not.
   On Smilax sp. Houston. (8)
41. Perisporium Wrightii B. & C.
   On Opuntia sp. Austin, Elgin, Round Rock. (21)
42. Podosphaera leucotricha (E. & E.) Salm.
   On Malus Malus (L.) Britton. Austin. (21)
43. Sphaerotheca Humuli (DC.) Burr.
   On Rosa sp. San Antonio, Austin. (21)
   On Gilia rubra (L.) Heller. Austin. (21)
44. Sphaerotheca pannosa (Wallr.) Lev.
   On Rosa sp. Austin. (21)
45. Uncinula circinata C. & P.
   On Acer saccharinum L. Tyler. (24)
   On Sapindus marginatus Willd. Austin. (21)
46. Uncinula macrospora Peck.
   On Ulmus alata Michx. Llano. (21)
47. Uncinula necator (Schw.) Burr.
   On Vitis sp. Texas. (42) College Station. (24)
48. Uncinula polychaeta Berk. & Curt.
   On Celtis reticulata Torr. Austin, Georgetown, Cuero. (21)

Order Dothidiales.

49. Phyllachora graminis (Pers.) Fckl.
   On Andropogon argyraceus Schult. Austin. (21)
   On Andropogon saccharoides Sw.

On Chrysopogon nutans (L.) Benth.
On Panicum dichotomum L. College Station. (24)
On Panicum Texanum Buckl. Austin, Elgin. (21)

50. Plowrightia morbosa (Schw.) Sacc.
On Prunus sp. College Station. (24)

Order Sphaeriales.

51. Cyanospora albicedrae Heald & Wolf.
On Sabina sabinoides (H. B. K.) Small. (20)
Austin and everywhere the mountain cedar is present.

52. Glomerella Gossypii Edgerton.
On Gossypium herbaceum L. Bastrop, Lockhart, Luling, Seguin, Victoria, Stockdale, Gonzales, Yoakum. (21)

53. Glomerella rufomaculans (Berk.) Sp. & Von Sch.
On Pyrus communis L. Kerrville, Nursery, Gonzales, Flatonia. (21)
On Malus Malus (L.) Britton. Tyler, Denison. (24)

54. Gnomonia ulmea (Schw.) Thum.
On Ulmus alata Michx. Austin, Llano. (21).
On Ulmus Americana L. Round Rock. (21)
On Ulmus crassifolia Nutt. New Braunfels, Uvalde, Seguin, Elgin. (21)

55. Guignardia Bidwellii (Ell.) Viala & Rav.
On Ampelopsis quinquefolia Michx. Coll. Sta. (24)
On Vitis sps. Austin, San Antonio, Brenham, Kerrville, Boerne, Beeville, Bastrop, Luling, Georgetown, Round Rock, Gonzales, New Braunfels, Elgin, Lockhart, Yoakum, Hallettsville. (21) College Station. (24)

56. Mycosphaerella Fragariae (Tul.) Lind.
On Fragaria. Austin, Beeville. (21) Coll. Sta. (24)

57. Stigmatea gregaria Cooke.
On unknown leaves. Texas. (9)

58. Valsa leucostoma (Pers.) Fr.
On Prunus armeniaca L. Round Rock. (21)
On Amygalus Persica L. San Antonio, Kerrville, Boerne, Beeville, Elgin, Bastrop, Lockhart, Seguin, Round Rock, Victoria, Nursery, Stockdale, Gonzales, Flatonia, Yoakum, Austin. (21)
On Prunus sp. Austin, Kerrville, Beeville, Seguin, Round Rock, Victoria, Stockdale, Gonzales. (21)

Order Phacidiales.

59. Rhytisma erythrosporum B. & C.
On Quercus Virginiana Mill. Austin. (21)

Order Pezizales.

60. Pseudopeziza Medicaginis (Lib.) Sacc.
On Medicago sativa L. San Marcos. (21)
61. Sclerotinia fructigena (Pers.) Schroet.
On Prunus sp. Austin.
On Amagdylus Persica L. Austin, San Antonio.
62. Sclerotinia Libertiana Fuckel.
On Lactuca sativa L. Texas. (36)

Order Sphaeropsidiales.

63. Actiononema Rosae (Lib.) Fr.
On Rosa sp. (cult.) College Station. (24) Austin, Victoria, Stockdale, Falfurrias. (21)
64. Aschochyta Cycadina Scalia.
On Cycas revoluta Thunbg. Beeville. (21)
65. Ascochyta Smilacis E. & M.
On Smilax bona-nox L. College Station. (24)
66. Coniothyrium Fuckelii Sacc.
On Rosa sp. (Cult.) Austin, San Antonio. (21)
67. Coniothyrium olivaceum var. grandiflorae Sacc.
On Magnolia grandiflora L. Georgetown. (21)
68. Diplodia aurantii Catt.
On Citrus trifoliata L. Nursery, Falfurrias. (21)
69. Diplodia sycinia Mont. var. Syconophila Sacc.
On Ficus carica L. Beeville, Luling. (21)
70. Diplodia Zeae Schwz.
On Zea Mays L. College Station. (24)
71. Hendersonia arundinacea (Desm.) Sacc.
On Phragmites phragmites (L.) Karst. New Braunfels. (21)
72. Hendersonia foliorum Fckl.
On Pyrus communis L. College Station. (24)
73. Hendersonia foliorum viburnum Sacc.
On Viburnum prunifolium. Austin. (21)
74. Hendersonia magna Cooke.
On Herbaceous stems. Houston. (8)
75. Hendersonia Opuntiae Ell. & Ev.
On Opuntia sp. Austin, Falfurrias, Round Rock. (21)

76. Kellermannia Yuccogena Ell. & Kell.
On Yucca filamentosa L. Sabinal. (21)
77. Leptothyrium carpophilum Pass. M
On Pyrus communis L. Cuero, Hallettsville. (21)
78. Leptothyrium dryinum Sacc.
On Quercus aquatica Walt.
On Quercus Chapmanni Sarg. College Station. (24)
79. Macrophoma Fici Alm. & Cam.
On Ficus carica var. Austin.
80. Macrophoma Candollei (Berk. & Br.) Berl. & Vogl.
On Buxus sempervirens L. New Braunfels, Georgetown. (21)
81. Macrophoma Phoradendri Wolf.
On Phoradendron flavescens Pursh. & Nutt. Huntsville, Texas. (52)
82. Marsonia Quercus Peck.
On Quercus sp. Elgin, Victoria, Stockdale, Flatonia. (21)
83. Melasmis Acerina Lev.
On leaves, Texas. (8)
84. Phleospora adusta Heald & Wolf.
On Clematis Drummondii T. & G. New Braunfels, Austin, Llano, Beeville, Sabinal, Hondo, Bastrop, Seguin, Georgetown, Gonzales, Kennedy. (21)
85. Phleospora Mori Lev.
On Morus tartarica London.
On Morus latifolia Poiret. College Station. (24)
86. Phleospora multimaculans Heald & Wolf.
On Juglans nigra L. Austin, Victoria, Stockdale, Gonzales, Flatonia, Falfurrias. (21)
On Juglans regia L. Austin, Falfurrias. (21)
On Platanus occidentalis L. Austin, Brenham, New Braunfels, Llano, Victoria, Gonzales, Floresville. (21)
87. Phlyctaena Smilacis Cooke.
On Smilax sp. Texas. (9)
88. Phoma helvolum B. & C.
On leaves. Texas. (8)
89. Phoma hysteriforme Cooke.
On herbaceous stems. Texas. (8)
90. Phoma hysteroidea B. & Br.
On reeds. Houston. (8)
91. Phoma sp.
On Citrus trifoliata L. Beeville, Floresville. (21)
92. Phyllosticta Aesculi Ell. & Mart.
On Aesculus octandra Marsh. Seguin, Austin. (21)

93. Phyllosticta Ampelopsidis Ell. & Mart.
On Parthenocissus quinquefolia (L.) Planch. Austin, New Braunfels. (21)
94. Phyllosticta biformis Heald & Wolf.
On Diospryros Texana Scheele. Llano, Austin. (21)
95. Phyllosticta Bumeliifolia Heald & Wolf.
On Bumelia lanuginosa Pers. Austin. (21)
96. Phyllosticta concentrica Sacc.
On Hedera helix L. Austin, New Braunfels, Stockdale. (21)
97. Phyllosticta congesta Heald & Wolf.
On Prunus sps. Boerne. (21)
98. Phyllosticta Ipomoeae E. & K.
On Ipomoea sps. Austin, Seguin, Victoria. (21)
99. Plyllosticta juliflora E. & B.
On Prosopis juliflora DC. Austin. (21)
100. Phyllosticta Lagerstroemiae E. & E.
On Lagerstroemia indica L. Beeville, Flatonia, Luling. (21)
101. Phyllosticta Labruscae Thum.
On Ampelopsis tricuspidata Sieb. & Zucc. Austin. (21)
102. Phyllosticta micropunctata Cooke.
On Persea Borbonia (L.) Spreng. Houston. (9)
103. Phyllosticta ovalifolia Brum.
On Ligustrum sp. San Antonio. (21)
104. Phyllosticta Orontii Ell. & M.
On Nymphaea advena Soland. Von Ormy, Georgetown. (21)
105. Phyllosticta Smilacis E. & E.
On Smilax bona-nox L. Austin, Boerne, Round Rock, Hallettsville. (21)
106. Phyllosticta Verbesinae Heald & Wolf.
On Verbesina Texana Buckl. Seguin. (21)
107. Phyllosticta Wistariae Sacc.
On Wistaria sp. Austin. (21)
108. Piggotia Fraxini B. & C.
On Fraxinus viridis Michx. College Station. (24)
109. Sacidium Gleditschiae Lev.
On Gleditschia sp. Texas. (41)
110. Septoria ampetina B. & C.
On Vitis vulpina L. Texas. (8)
111. Septoria Caryae E. & E.
On Hicoria pecan (Marsh) Britton. Austin. (21)
112. Septoria Chrysanthemi Car.
On Chrysanthemum sinense Sabine. Austin. (21)

113. Septoria Jatropae Heald & Wolf.
On Jatropa stimulosa Michx. Austin. (21)

114. Septoria Lycopersici Speg.
On Lycopersicum esculentum Mill. Austin, Llano, Uvalde, Nursery. (21)

115. Septoria Magnoliae Cooke.
On Magnolia grandiflora L. Texas. (9)

116. Septoria marginata Heald & Wolf.
On Rulac Texana (Pax.) Small. Beeville, Lockhart, Seguin, Austin, Luling, San Marcos. (21)

117. Septoria musiva Peck.
On Populus deltoides Marsh. Lockhart, San Marcos. (21)

118. Septoria pertusa Heald & Wolf.
On Sorghum halepense L. Luling, Flatonia. (21)

119. Septoria populicola Peck.
On Populus deltoides Marsh. Austin, Victoria, Gonzales. (21)

120. Septoria Rubi West.
On Rubus villosus Ait. & Var. Llano, Floresville. (21)
On Rubus sps. Austin, San Antonio, Brenham, Boerne, New Braunfels, Luling, Seguin, Georgetown, Victoria, Gonzales, Flatonia. (21)

121. Septoria Speculariae B. & C.
On Specularia perfoliata DC. Texas. (8)

122. Septoria submaculata Wint.
On Fraxinus sp. Austin. (21)

123. Septoria Tecomiae E. & E.
On Tecoma radicans Juss. Austin. (21)

124. Septoria vestita B. & C.
On Cucurbita sp. Texas. (8)

125. Sphaeropsis Malorum Peck.
On Malus Malus (L.) Britton. Austin, Kerrville, Boerne, Nursery, Stockdale, Gonzales. (21) College Station. (24)
On Pyrus communis L. Boerne, Austin, Georgetown, Nursery, Stockdale, Hallettsville. (21)

126. Stagonospora gigantea Heald & Wolf.
On Agave Americana L. Austin, San Antonio, Boerne. (21)

Order Melanconiales.

127. Colletotrichum Bromeliacearum Birge.
On Tillandsia recurvata L. Austin.

128. Colletotrichum Bromi Jennings.
On Bromus unioloides Willd. College Station. (24)

129. Colletotrichum caulicolum Heald & Wolf.
On Phaseolus vulgaris L. Uvalde. (21)

130. Colletotrichum gloeosporioides Penz.
On Citrus aurantium L. (Beeville. (21)
On Citrus Medica L. var. Limon L. Austin. (21)
On Citrus trifoliata L. Austin, Cuero, Falfurrias, Gonzales, Nursery. (21)

131. Colletotrichum gloeosporioides vr. Hederae Pass.
On Hedera helix L. San Antonio, Gonzales, Flatonia. (21)

132. Colletotrichum Lagenarium (Pers.) Ell. & Hals.
On Cucumis melo L. Beeville. (21)

133. Colletotrichum Lindemuthianum (Sacc. & Mgn.) Bri. & Cav.
On Phaseolus vulgaris L. Austin, San Antonio, Llano. (21)

134. Colletotrichum lineola Cda.
On Sorghum vulgare. Skidmore, Victoria, Nursery, Kerrville, Beeville, Gonzales, Yoakum. (21)

135. Colletotrichum lineola Cda. var. halepense H. & W.
On Sorghum halepense L. Round Rock, Austin, Falfurrias, Yoakum, Floresville. (21)

136. Colletotrichum nigrum Ell. & Hals.
On Capsicum annuum L. Uvalde. (21)
On Cucurbita sp. (Simlin). Uvalde. (21)

137. Colletotrichum sp.
On Solanum melongena L. Austin. (21)

138. Coryneum Kunzei Corda.
On Quercus sp. Texas. (8)

139. Cylindrosporium defoliatum Heald & Wolf.
On Celtis Mississippiensis Bosc. New Braunfels, Austin, Elgin, Bastrop, Lockhart, San Marcos, Cotulla, Luling, Seguin, Georgetown, Victoria, Cuero, Stockdale, Gonzales, Flatonia, Yoakum. (21)
On Celtis reticulata Torr. Beeville, Sabinal. (21)

140. Clyndrosporium griseum Heald & Wolf.
On Sapindus marginatus Willd. Kerrville, Llano, Bastrop, San Marcos. (21)

141. Cylindrosporium Lippae Heald & Wolf.
On Lippia ligustrina Britton. Llano. (21)

142. Cylindrosporium Padi Karst.
On Prunus armeniaca L. Austin, Nursery. (21)
On Prunus sps. Austin, San Antonio, Brenham, Kerrville, Boerne, New Braunfels, Llano, Beeville, Elgin, Bastrop, Luling, Seguin, Georgetown, Round Rock, Victoria, Nur-

sery, Stockdale, Cuero, Gonzales, Flatonia, Hallettsville. (21)

143. Cylindrosporium solitarium Heald & Wolf
On Robinia pseudacacia L. Austin, Georgetown. (21)

144. Cylindrosporium tenuisporum Heald & Wolf.
On Ulmus alata Michx. Austin. (21)

145. Cylindrosporium viridis E. & E.
On Fraxinus sp. Gonzales. (21)

146. Gloeosporium Aquilegiae Thum.
On Aquilegia sp. Beeville, Austin. (21)

147. Gloeosporium decipiens E. & E.
On Fraxinus viridis Michx. College Station. (24)

148. Gloeosporium lagenarium Pass. var. foliicolum E. & E.
On Citrullus vulgaris Schrad. College Station. (24)

149. Gloeosporium leguminum (Cke.) Sacc.
On Prosopis glandulosa Torr. Austin, San Antonio, Beeville, Elgin, Bastrop, Lockhart, San Marcos, Uvalde, Hondo, Cotulla, Luling, Seguin, Stockdale, Floresville, Gonzales. (21) Galveston. (9) (*Discella leguminum* Cke.)

150. Gloeosporium Liriodendri E. & E.
On Liriodendron tulipifera L. New Braunfels, Seguin. (21)

151. Gloeosporium lunatum E. & E.
On Opuntia sp. San Antonio, Austin, Llano, Hondo, Georgetown, Round Rock. (21)

152. Gloeosporium melongenae Ell. & Hal.
On Solanum melongena L. Austin, Uvalde. (21)

153. Gloeosporium nervisequum (Fkl.) Sacc.
On Platanus occidentalis L. Tyler, New Braunfels, Bastrop, San Marcos, Georgetown, Flatonia, Hallettsville, Falfurrias. (21)

154. Gloeosporium sp.
On Acer saccharinum Wang. Victoria, Flatonia. (21)

155. Pestalozzia funerea Desm.
On Taxodium distichum (L.) Rich. Victoria, Gonzales. (21)

156. Pestalozzia Guepini Decm.
On Lagerstroemia indica L. Beeville, Flatonia, Luling. (21)

157. Pestalozziella Yuccae Karst. & Har.
On Yucca rupicola Scheele. Austin. (21)

Hyphomycetales.

158. Alternaria Solani (E. & M.) J. & Gr.
On Solanum tuberosum L. San Antonio, Kerrville. (21)

159. Alternaria Violae Gall.
On Viola odorata L. San Antonio, Uvalde. (21)
160. Botrytis cinerea Pers.
On Cucurbita sp. (Simlin). Austin. (21)
161. Cercospora adusta Heald & Wolf.
On Ligustrum Californicum Hort. Falfurrias, Floresville. (21)
162. Cercospora Althaeina Sacc.
On Althaea rosea Cav. Austin. (21)
On Modiola multifida Moench. College Station. (24)
163. Cercospora Asparagi Sacc.
On Asparagus officinalis L. Victoria, Floresville. (21)
164. Cercospora atricincta Heald & Wolf.
On Zinnia sp. San Antonio, Victoria. (21)
165. Cercospora atromarginalis Atk.
On Solanum Carolinense L. Austin, Gonzales. (21)
166. Cercospora aurantia Heald & Wolf.
On Citrus aurantium L. Falfurrias. (21)
167. Cercospora Bellynckii (West.) Sacc.
On Vincetoxicum sp. Austin. (21)
168. Cercospora Beticola Sacc.
On Beta vulgaris L. Austin, San Antonio, New Braunfels, Sabinal, Georgetown. (21) College Station. (24)
On Spinacia oleracea Mill. Austin. (21)
169. Cercospora Bloxami B. & Br.
On Brassica oleracea L. Georgetown. (21)
170. Cercospora Bolleana (Thum.) Speg.
On Ficus carcia L. Austin, Luling, Seguin, Georgetown, Victoria, Cuero, Stockdale, Gonzales, Hallettsville. (21)
171. Cercospora brachiata E. & E.
On Amaranthus spinosus L. Kennedy. (21)
172. Cercospora Brunkii E. & Gall.
On Pelargonium sp. (cult.) Brazos County. (24)
173. Cercospora canescens Ell. & Mart.
On Phaseolus lunatus L. Georgetown. (21)
174. Cercospora Capsici Heald & Wolf.
Capsicum annuum L. Cuero. (21)
175. Cercospora Catalpae Wint.
On Catalpa sp. New Braunfels, Luling, Falfurrias. (21)
On Catalpa speciosa Warder. College Station. (24)
176. Cercospora catenospora Atk.
On Sambucus Canadensis L. San Marcos. (21)
177. Cercospora cercidicola Ell.

On Cercis occidentalis Torr. Kerrville, Austin, Georgetown. (21)

178. Cercospora Chenopodii Fres.
On Chenopodium ambrosoides L. var. anthelminticum Gray. College Station. (24)

179. Cercospora Chrysanthemi Heald & Wolf.
On Chrysanthemum sp. (cult). San Antonio. (21)

180. Cercospora Citrullina Cooke.
On Citrullus vulgaris Schrad. Hempstead, Beeville, Luling, Victoria, Alice, Nursery, Stockdale, Flatonia, Yoakum, Hallettsville. (21)

181. Cercospora Cornicola Tracy & Earle.
On Svida sp. Austin, San Antonio, San Marcos, Seguin, Victoria, Gonzales, Flatonia, Hallettsville. (21)

182. Cercospora Crataegi Heald & Wolf.
On Crataegus sp. Gonzales. (21)

183. Cercospora cruenta Sacc.
On Vigna sinensis Hassk. Beeville, Luling, Flatonia, Yoakum. (21)

184. Cercospora Cucurbitae E. & E.
On Cucurbita sp. (Cushaw.) Brenham. (21)
On Cucurbita foetidissima H. B. K. New Braunfels, Llano, Elgin, Lockhart, Austin, Sabinal, Luling, Seguin, Floresville. (21)

185. Cercospora Diantherae E. & K.
On Dianthera Americana Bl. Austin. (21)

186. Cercospora Elaeagni Heald & Wolf.
On Eleagnus sp. (imported). Floresville. (21)

187. Cercospora Fici Heald & Wolf.
On Ficus carica L. Victoria, Cuero, Flatonia, Hallettsville. (21)

188. Cercospora flagellaris Ell. & Mart.
On Phytolacca decandra L. Austin, Brenham, New Braunfels, Elgin, Bastrop, San Marcos, Cuero, Stockdale, Gonzales, Flatonia, Yoakum. (21)
On Rivina laevis L. Austin. (21)

189. Cercospora floricola Heald & Wolf.
On Yucca rupicola Scheele. Austin. (21)

190. Cercospora Fraxinites E. & E.
On Fraxinus sp. Victoria. (21)

191. Cercospora fuliginosa E. & K.
On Diospyros Kaki L. New Braunfels, Victoria, Georgetown, Stockdale. (21)

192. Cercospora fulvella Heald & Wolf.
On Verbesina Texana Buck. Austin. (21)
193. Cercospora glandulosa E. & Kell.
On Ailanthus glandulosus Desf. New Braunfels, Austin. (21)
194. Cercospora Gnaphalicea Cooke.
On Gnaphalium sp. Houston. (9)
195. Cercospora Gossypina Cke.
On Gossypium herebaceum L. Sabinal, Luling, Flatonia, Nursery, Gonzales, Skidmore, Kennedy. (21)
196. Cercospora Hydrocotyles E. & E.
On Hydrocotyle umbellata L. Van Ormy. (21)
On Hydrocotyle verticillata Thunb. Georgetown. 21)
197. Cercospora Kaki E. & E.
On Diospyros Kaki L. Gonzales, Hallettsville. (21)
198. Cercospora lanuginosa Heald & Wolf.
Bumelia lanuginosa Pers. Luling, Flatonia. (21)
199. Cercospora Ligustri Roum.
On Ligustrum Japonicum Thumb. Austin. (21)
200. Cercospora Lippae E. & E.
On Lippia nodiflora Michx. College Station. (24)
201. Cercospora Lythracearum Heald & Wolf.
On Punica granatum L. Beeville, Victoria, Cuero, Flatonia, Falfurrias. (21)
On Lagerstroemia indica L. Austin. (21)
202. Cercospora Mali E. & E.
On Malus Malus (L.) Britton. Gonzales. (21)
203. Cercospora macromaculans Heald & Wolf.
On Syringa sp. Kerrville. (21)
204. Cercospora Malachrae Heald & Wolf.
On Malachra capitata L. Victoria. (21)
205. Cercospora Medicaginis Ell. & Ev.
Medicago denticulata Willd. College Station. (16)
On Medicago sativa L. San Marcos, Victoria, Gonzales. (21)
206. Cercospora menispermi E. & Holw.
On Cebatha Carolina (L.) Britton. Sabinal, Bastrop, San Marcos, Luling, Seguin, Round Rock, Gonzales, Floresville. (21)
207. Cercospora minima Tracy & Earle.
On Pyrus communis L. Victoria, Nursery, Cuero, Gonzales, Flatonia, Hallettsville, Falfurrias. (21)
208. Cercospora Missouriensis Wint.
On Morus rubra L. Austin, Beeville, Falfurrias, Cuero, Floresville. (21)

209. Cercospora Moricola Cooke.
On Morus rubra L. Llano, Luling, Seguin, Victoria, Nursery, Stockdale, Hallettsville. (21)
210. Cercospora Nasturtii Pass.
On Roripa Nasturtium (L.) Rusby. Austin. (21)
211. Cercospora nepheloides Ell. & Holw.
On Eustoma Russellianum (Hook.) Griesb. Austin. (21)
212. Cercospora Nicotianae E. & E.
On Nicotiana repanda Willd. Austin. (21)
213. Cercospora obscura Heald & Wolf.
On Cynara Scolymus L. Beeville. (21)
214. Cercospora pachypus Ell. & Kell.
On Helianthus sp. Hondo. (21)
215. Cercospora personata (B. & C.) Ellis.
On Arachis hypogaea L. Brenham, Elgin, Luling, Nursery, Stockdale, Hallettsville. (21)
On Cassia occidentalis L. College Station. (24)
216. Cercospora perniciosa Heald & Wolf.
On Cephalanthus occidentalis L. Victoria, Austin. (21)
217. Cercospora Physalicola Ell. & Barth.
On Physalis sp. New Braunfels. (21)
218. Cercospora Polygonacea E. & E.
On Polygonum sp. Cuero. (21)
219. Cercospora Prosopidis Heald & Wolf.
On Prosopis glandulosa Torr. Uvalde, Luling, Gonzales, Falfurrias, Kennedy, Floresville. (21)
220. Cercospora pustula Cooke.
On Parthenocissus quinquefolia (L.) Planch. Austin, New Braunfels. (21)
221. Cercospora rhoina E. & E.
On Schmaltzia lanceolata (Gray) Small. Austin, Georgetown. (21)
222. Cercospora Ricinella Sacc. & Berl.
On Ricinus communis L. Flatonia, Hallettsville, Falfurrias, Austin. (21)
223. Cercospora Rosicola Pass.
On Rosa sp. Austin, Seguin, Georgetown, Victoria, Gonzales. (21)
224. Cercospora Rubi Sacc.
On Rubus sps. (Dewberry). Elgin, Bastrop, San Marcos, Luling, Round Rock, Victoria, Nursery, Cuero, Flatonia, Yoakum, Hallettsville. (21)
225. Cercospora Salicina E. & E.

On Salix sp. New Braunfels, Victoria, Falfurrias, Floresville. (21)

226. Cercospora Smilacina Sacc.
On Smilax bona-nox L. New Braunfels, Llano, Elgin, Uvalde, Bastrop, Lockhart, Cotulla, Luling, Seguin, Georgetown, Round Rock, Gonzales, Flatonia, Yoakum, Hallettsville. (21)

227. Cercospora Smilacis Thumb.
Smilax bona-nox L. College Station. (24)

228. Cercospora sordia Sacc.
On Tecoma radicans Juss. Bastrop, Victoria. (21)

229. Cercospora Sorghi E. & E.
On Sorghum halepense L. Flatonia, Hallettsville, Gonzales. (21)

230. Cercospora Texensis E. & G.
On Fraxinus viridis Michx. College Station. (24)

231. Cercospora toxicodendri Ellis.
On Rhus toxicodendron L. College Station. (24)

232. Cercospora Vernoniae Ell. & Kell.
On Vernonia sp. Austin, Seguin, Georgetown. (21)

233. Cercospora Vignae Racil.
On Vigna sinensis Hassk. San Antonio, Beeville, Elgin, Uvalde, Austin, Victoria, Nursery, Cuero, Gonzales, Flatonia, Yoakum, Floresville, Hallettsville. (21)

234. Cercospora Violae Sacc.
On Viola cucullata Gray. College Station. (24)
On Viola odorata L. Beeville, Austin, Lockhart, Seguin, Victoria, Georgetown, Cuero, Flatonia. (21)

235. Cercospora Viticis E. & L.
On Vitex agnus-castus L. Nursery. (21)

236. Cercospora viticola (Ces.) Sacc.
On Vitis sps. Austin, Tyler, Boerne, New Braunfels, Llano, Beeville, Bastrop, San Marcos, Luling, Seguin, Victoria, Nursery, Cuero, Stockdale, Gonzales, Flatonia, Hallettsville, Floresville. (21)

237. Cercospora Xanthicola Heald & Wolf.
zales, Yoakum, Hallettsville, Kennedy, Austin. (21)

238. Cercospora n. s. (not named).
On Begonia sp. College Station. (24)

239. Cercosporella reticulata Peck.
On Solidago sp. Elgin. (21)

240. Cladosporium carpophilum Thm.

On Amygdalus Persica L. Elgin, Austin, Beeville, Georgetown. (21) Texas. (36)

241. Cladosporium fulvum Cke.
On Lycopersicum esculentum Mill. College Station. (24)

242. Cladosporium Viticolum Viala.
On Vitis sps. College Station. (24)

243. Clasterosporium diffusum Heald & Wolf.
On Hicoria pecan (Marsh.) Britton. Victoria, Gonzales, Yoakum, Hallettsville. (21)

244. Exosporium concentricum Heald & Wolf.
On Euonymus Japonicus Thumb. San Marcos, Austin. (21)

245. Fumago vagans (?) Pers.
On Bumelia languinosa Pers. Austin. (21)
On Casaba. New Braunfels. (21)
On Fagara Clava-Herculis (L.) Small. Austin. (21)
On Gardenia jasseminoides Ellis. Austin. (21)
On Vitis sps. Luling. (21)

246. Fusarium sp.
On Lycopersicum esculentum Mill. Texas. The cause of "Wilt." (36)

247. Fusarium sp. (?)
Callistephus hortensis Cass. Austin. (21)
On Dianthus caryophyllus L. San Antonio, Austin. (21)

248. Fusarium sp. (?)
On Citrullus vulgaris Schrad. New Braunfels, Austin, Beeville (common). (21)

249. Fusicladium effusum Wint.
On Hicoria pecan (Marsh.) Britton. Kerrville, Uvalde, Seguin. (21)

250. Helminthosporium giganteum Heald & Wolf.
On Capriola Dactylon (L.) Kuntze. Falfurrias. (21)

251. Helminthosporium Ravenelii Curtis.
On Sporobolus indicus (L.) R. Br. College Station. (24)

252. Helminthosporium Sorghi Schw.
On Sorghum halepense (L.) Pers. College Station. (24)

253. Helminthosporium turcicum Pass.
On Sorghum halepense. Bastrop, Luling, Elgin, San Antonio, Sabinal, Austin. (21)
On Sorghum vulgare Pers. Sabinal, Luling, Falfurrias, Lockhart. (21)

254. Heterosporium gracile Wallr.
On Iris sp. Austin. (21)

255. Oospora scabies Thaxter.
On Solanum tuberosum L. San Antonio. (21)
256. Ovularia maclurae Ell. & Langl.
On Toxylon pomiferum Raf. Gonzales. (21)
257. Macrosporium compactum Cooke.
On Ricinus sp. Houston. (9)
259. Macrosporium Cucumerinum E. & E.
On Cucumis melo L. Austin, Hallettsville. 21)
259. Macrosporium sp.
On Gossypium herbaceum L. Nursery. (21)
260. Macrosporium nigricantium Atk.
On Gossypium herbaceum L. Texas. (32)
261. Macrosporium sp.
On Cucurbita sp. (Cushaw). Beeville. (21)
262. Myxosporium Diedickei Syd.
On Morus alba L. Georgetown. (21)
263. Periconia pycnospora Fres.
On Ligustrum Californicum L. College Station. (24)
On Hibiscus grandiflorus Michx. College Station. (24)
264. Piricularia grisea (Cke.) Sacc.
On Echinochloa colona (L.) Link. Uvalde. (21)
On Panicum Texanum Buckl. Kennedy. (21)
On Syntherisma sanguinale (L.) Dulac. Uvalde. (21)
265. Ramularia Cassiaecola (Ell. & Kell.) Heald & Wolf.
On Cassia occidentalis L. Beeville, Stockdale, Cuero, Yoakum, Hallettsville. (21)
266. Ramularia Celtidis Ell. & Kell.
On Celtis Mississippiensis Bosc. Lockhart, Georgetown, Austin, Hallettsville. (21)
On Celtis reticulata Torr. Beeville, Luling, Gonzales, Kennedy. (21)
267. Ramularia Cephalanthi (Ell. & Kell.) Heald.
On Cephalanthus occidentalis L. Luling, Uvalde. (21)
268. Ramularia Hedericola Heald & Wolf.
Hedera helix L. San Marcos. (21)
269. Ramularia Momordicae Heald & Wolf.
On Momordica balsamina L. Falfurrias. (21)
270. Ramularia obovata Fkl.
On Rumex obtusifolius L. College Station. (24)

Order Ustilaginales.

271. Cinctractia Taubertiana (Henn.) Clinton.
On Rynchospora sp. Texas. (6)

272. Doassansia deformans Setch.
On Sagittaria sp. Texas. (6)
273. Entyloma australe Speg.
On Physalis sp. Texas. (6)
On Physalis pubescens L. College Station. (24)
274. Entyloma speciosum Schrot. & P. Henn.
On Alopecurus geniculatus L. Texas. (6)
275. Graphiola Phoenicis Pait.
On Chamaerops sp. College Station. (24)
On Phoenix dactylifera L. Beeville, Victoria, Flatonia. (21)
276. Melanopsichium Austro-Americanum (Speg.) T. Beck.
On Persicaria sp. Texas. (6)
277. Sorosporium consanguineum Ell. & Ev.
On Aristida sp. Texas. (6)
278. Sorosporium Syntherismae (Peck) Farl.
On Cenchrus tribuloides L. Texas. (6)
On Cenchrus sp. Skidmore. (21)
279. Spacelotheca Ischaemi (Fkl.) Clinton.
On Andropogon Torreyanus Hack. Texas. (6)
280. Sphacelotheca Reiliana (Kuhn.) Clint.
On Sorghum vulgare L. San Antonio, Uvalde, Bastrop, San Marcos, Seguin, Victoria, Stockdale, Gonzales, Hallettsville, Austin. (21) Panhandle. (35)
281. Sphacelotheca Sorghi Burr.
On Sorghum vulgare L. New Braunfels, Llano, San Antonio, Uvalde, Sabinal, Hondo, Bastrop, Luling, Seguin, Victoria, Gonzales, Austin. (21) Panhandle. (35)
282. Urocystis Anemones (Pers.) Winter.
On Anemone Caroliniana Walt. Austin. (21) (6)
On Anemone decapetela Ard. (6)
On Anemone Virginiana L. Texas. (6)
283. Ustilago Avenae (Pers.) Jens.
On Avena sativa L. Texas. (6) Austin, San Antonio, San Marcos. (21)
284. Ustilago hypodytes (Schlecht.) Fries.
On Xanthium sp. Luling, Georgetown, Nursery, Cuero, Gon-
On Stipa leucotricha Trin. Austin. (21)
On Distichlis spicata (L.) Greene. Texas. (6)
285. Ustilago nuda (Jens.) Kell. & Swingle.
On Hordeum sp. (cult.) Austin. (21)
286. Ustilago Oxalidis Ell. & Tracy.
On Oxalis stricta L. Austin. (21)

287. Ustilago pustulata Tracy & Earle.
On Panicum virgatum L. Texas. (6)

288. Ustilago Rabenhorstiana Kuhn.
On Syntherisma sanguinale (L.) Dulac. Texas. (6)

289. Ustilago striaeformis (Westend.) Niessl.
On unknown grass. Texas. (6)

290. Ustilago Tritici (Pers.) Rostr.
On Triticum vulgare L. Austin. (6) (21) Texas. (36)

291. Ustilago Uniola E. & C.
On Uniola gracilis Mich. (U. laxa). Texas. (6)

292. Ustilago Zeae (Beckm.) Unger.
On Zea mays L. Austin, Kerrville, New Braunfels, Uvalde, Hondo, Cotulla, Seguin, Flatonia. (6) (21)

293. Tilletia rugispora Ellis.
On Paspalum plicatulum Michx. College Station. (6) (21)

294. Tilletia Texana Long.
On Hordeum nodosum L. Austin. (7)

295. Tolyposporium globuligerum Beck. & Br.
On Homalocenchrus hexandrus (Sw.) Kuntze. Texas. (6)

296. Tolyposporella Brunkii (Ell. & Gall.) Clinton.
On Andropogon argyraceus Schult. College Station. (6) Austin. (21)

297. Tolyposporella Chrysopogonis Atk.
On Sorghastrum nutans (L.) Nash. Texas. (6)

Order Uredinales.

298. Aecidium Callirrhoes E. & K.
On Callirrhoe involucrata Gray. College Station. (24)

299. Aecidium chryopsidis Ell. & Anders.
On Gutierrezia Texana Torr. & Gray. Victoria, Gonzales. (21)

300. Aecidium Gossipi Ell. & Ever.
On Gossypium herbaceum L. Falfurrias. (21)

301. Aecidium Houstonianum Schw.
On Houstonia minima Beck. College Station. (24)

302. Aecidium oldenlandianum Tracy.
On Houstonia augustifolia Michx. Austin. (21)

303. Aecidium Ranunculacearum D. & C.
On Anemone Caroliniana Walt. Austin. (21)

304. Aecidium roesteloides E. & E.
On Malvaceae . Texas. (1)

305. Aecidium Xanthoxyli Pk.
On Xanthoxylum Carolinianum Lam. College Station. (24)
On Fagara Clava-Herculis (L.) Small. Elgin, Austin. (21)

306. Bubakia Crotonis (Cooke) Arthur.
On Croton Texensis (Kl.) Muell. Luling, Georgetown, Round Rock, Falfurrias, Victoria, Cuero, Stockdale, Flatonia, Yoakum, Skidmore, Austin. (21)

307. Coleosporium Elephantopodis (Schw.) Thum.
On Elephantopus tomentosus L. Texas. (2)
On Elephantopus Carolinianus Willd. College Station. (24)

308. Coleosporium Ipomoeae (Schw.) Burr.
On Calonyction aculeatum (L.) House. (Ipomoea bona-nox L.)
On Pharbites hederacea (L.) Choisy. (Ipomoea hederacea Jack.)
On Pharbites purpurea (L.) Voigt. Texas. (2)

309. Coleosporium Solidaginis (Schw.) Thum.
On Doellingeria sericicarpoides Small.
On Euthamia leptocephala (T. & G.) Greene.
On Solidago flexicaulis L. Texas. (2)

310. Coleosporium Tereinthinaceae (Schw.) Arthur.
On Silphium asperinum Hook.
On Silphium scaberrinum Ell. Texas. (2)

311. Coleosporium Vernoniae B. & C.
On Vernonia guadalupensis Heller. Texas. (2)
On Vernonia sps. Austin. (21) College Station. (24)

312. Gymnoconia Peckiana (Howe) Franz.
On Rubus sp. Collected at Huntsville, Texas, by Prof. Carl Hartman.

313. Gymnosporangium exiguum Kern.
On Sabina sabinoides (H. B. K.) Small. Fredericksburg. (25) Austin. (21)

314. Gymnosporangium globosum Farl.
On Sabina Sabinoides. Austin. (21)
On Crataegus sp. Austin. (21)

315. Gymnosporangium macropus Lk.
On Crataegus spathulata. College Station. (24)
On Juniperus Virginiana L. College Station. (24)

316. Gymnosporagium sp.
On Pyrus communis L. New Braunfels. (21)

317. Melampsora Biglowii Thum.
On Salix sps. Austin. (21) College Station. (24)

318. Melampsora Medusae Thum.
On Populus balsamifera L. College Station. (24)
On Populus deltoides Marsh. Austin. (21) (24)

319. Neoravenellia Holwayi (Dietl.) Long.
On Prosopis juliflora (Sw.) DC. Austin, Denton, College Station, Texarkana. (27)

320. Peridermium Ephedrae Cooke.
On Ephedra antisiphylitica Meyer. Texas. (7)

321. Peridermium fusiforme Arthur & Kern.
On Pinus palustris Mill. Cleveland. (3)

322. Physopella Fici (Cast.) Arthur.
On Ficus Carica L. Austin, Falfurrias. (21) College Station. (24)

323. Phragmidium mucronatum Fr. Texas. (8)

324. Phragmidium disciflorum (Tode) James.
On Rosa sp. San Antonio, Austin. (21)

325. Pileolaria Toxicodendri (Berk. & Rev.) Arthur.
On Rhus radicans L. (2)
On Rhus Toxicodendron L. Austin. (21) College Station. (24).

326. Puccinia Arundinaria Schw.
On Arundinaria sp. Votaw. (40)

327. Puccinia Asparagi DC.
On Asparagus officinalis L. Austin. (21)

328. Puccinia ballotaeflora Long.
On Salvia ballotaeflora Benth. San Marcos. (26)

329. Puccinia cassipes B. & C.
On Ipomoea sps. Austin, San Marcos, Victoria, Flatonia. (21)

330. Puccinia cognata Syd.
On Verbesina Virginica Benth. Austin. (21) (26)
This was described by Long (26) as a new species under the name of Puccinia similis.

331. Puccinia conclusa Thum.
On Cyperus sp. College Station. (24)

332. Puccinia Cooperiae Long
On Cooperia pedunculata Herb. Austin. (26)

333. Puccinia coronata Corda.
On Avena sativva L. College Station. (24) San Antonio, (21)

334. Puccinia Cryptotaeniae Pk.
On Cryptotaenia Canadensis DC. College Station. (24)

335. Puccinia Dichondrae Berk.
On Dichondra repens Forst. College Station. (24)

336. Puccinia Diplachnes Arthur.
On Diplachnis dubia (H. B. K.) Benth. Big Springs. (1)

337. Puccinia emaculata Schw.
On Triodia sesleroides (Michx.) Nash. College Station. (24)
338. Puccinia farinacea Long.
On Salvia farinacea Benth. Austin. (26) (21)
339. Puccinia graminis Pers.
On Avena sativa L. Austin, San Antonio. (21)
On Chrysopogon nutans (L.) Benth.
On Eragrostis capillaris (L.) Nees. College Station. (24)
On Phalaris intermedia Bosc.
On Triticum sativum Lam. Austin, San Antonio, Kerrville. (21) Texas. (36)
340. Puccinia Gonoboli Rav.
On Vincetoxicum sp. Austin. (21)
341. Puccinia Helianthi Schw.
On Helianthus sps. Austin, San Antonio, Seguin, Flatonia, Cuero. (21) College Station. (24)
342. Puccinia heterospora B. & C.
On Abutilon Texense T. & G. Austin, San Antonio. (21)
343. Puccinia Houstoniae Syd.
On Houstonia angustifolia Michx. Austin. (47)
344. Puccinia Hydrocotyles (Link.) Cke.
On Hydrocotyles umbellata L. Von Ormy. (21)
345. Puccinia Jamesiana (Pk.) Arth.
On Bouteloua sp. Falfurrias. (21)
346. Puccinia lobata B. & C.
On Sida lepidota. Texas. (8)
347. Puccinia Longiana Syd.
On Ruellia tuberosa L. Austin. (47)
348. Puccinia Oxalidis Diet. & Ellis.
On Oxalis sp. Texas. (23)
349. Puccinia Pinaropappi Syd.
On Pinaropappus roseus Less. Austin. (47)
350. Puccinia purpurea Cke.
On Sorghum halepense L. Austin. (21) College Station. (24)
On Sorghum saccharatum Moench. College Station. (24)
351. Puccinia Pyrrhopappi Syd.
On Sitilias multicaulis (DC.) Greene. Austin. (21)
352. Puccinia Ruelliae (B. & R.) Lagerh.
On Ruellia tuberosa L. Austin, Beeville. (21)
354. Puccinia sessilis Schneid.
On Nothoscordum striatum (Jacq.) Kunth. College Station. (24)

354. Puccinia Smilacis Schw.
Smilax bona-nox L. College Station. (24) Austin, San Marcos. (21)

355. Puccinia Sorghi Schw.
On Zea Mays L. Austin, Kerrville, Boerne, New Braunfels, San Antonio, Elgin, San Marcos, Gonzales, Flatonia, Yoakum. (21)

356. Puccinia Tomipara Trel.
On Clematis Drummondii T. & G. Austin. (21)

357. Puccinia Xanthi-Ambrosiae B. & C.
On Ambrosia trifida L. Austin. (21)
On Parthenium hysterophorus L. Kennedy. (21)

358. Puccinia Xanthi Schw.
On Xanthuim sp. Austin, Beeville, Lockhart, San Marcos, Hondo, Luling, Seguin, Georgetown, Victoria, Gonzales, Kennedy, Floresville. (21)

359. Puccinia Ximenesiae Long.
On Verbesina encelioides Gray. Austin. (26)

360. Ravenelia Arizonica E. & E.
On Prosopis juliflora (Sw.) DC. Falfurrias. (21) Abilene. (27)

361. Ravenelia fragrans Long.
On Mimosa fragrans Gray. Austin. (27)

362. Ravenelia Longiana Syd.
On Cassia Roemeriana Scheele. Austin. (27) (47) Llano. (21)

363. Ravenelia papillifera Syd.
On Cassia Lindheimeriana Scheele. Austin. (2, 48)

364. Ravenelia Texensis Ell. & Gall.
On Desmanthus Jamesii T. & G. (2)
On (?) Acuan Jamesii (T. & G.) Kuntze.
On Desmanthus. College Station. (24) (27)

365. Ravenelia versatilis Dietel.
On Acacia Greggii Gray. Uvalde. (21) Gillespie Co. (27)

366. Systingophora Hieronymi (Speg.) Arthur.
On Vachellia Farnesiana (L.) W. & A. Texas. (2)

367. Tranzchelia cohaesa (Long) Arth.
On Anemone decapetala Ard. Austin. (2, 26)

368. Tranzchelia punctata (Pers.) Arth.
On Amygdalus Persica L. Austin, San Marcos, Nursery. (21) Texas. (2)
On Padus serotina (Ehrb.) Ag. Texas. (2)
On Prunus Americana lanata Sudw.

On Prunus domestica L.
On Prunus hortulana Bailey. Texas. (2)
On Prunus sps. Austin, Cuero. (21)

369. Uredo Helianthi Sz.
On Helianthus annuus L. College Station. (24)

370. Uredo Hibisci Syd.
On Malvaviscus Drummondii T. & G. Austin. (21)

371. Uredo oxalidis Lev.
On Oxalis violacea L. College Station. (24)

372. Uromyces appendiculatus (Pers.) Unger.
On Phaseolus vulgaris L. Hempstead. (24) Uvalde. (21)
On Vigna Sinensis Hassk. Luling. (21)

373. Uromyces caryophyllinus (Schr.) Schroet.
On Dianthus Caryophyllus L. Austin. (21)

374. Uromyces dactylidis Otth.
On Festuca tenella Willd.
On Hordeum pratense Huds. College Station. (24)

375. Uromyces Dolicholi Arthur.
On Dolicholus Texanus (T. G.) Vail. San Angelo. (3)

376. Uromyces Euphorbiae C. & P.
On Euphorbia sps. San Antonio, Austin, Lockhart. (21)

377. Uromyces Gaurinus (Pk.) Snyder.
On Gaura coccinea Nutt. Austin. (21)

378. Uromyces heydsari-paniculati (Schw.) Farl.
On Meibomia sp. Texas. (8) Austin. (21)

379. Uromyces Medicaginis-falcatae (DC.) Wint.
On Medicago Sativa L. San Antonio, Cotulla. (21)

380. Uromyces myristica B. & C.
On Euphorbia sp. Texas. (8)

381. Uromyces Nothoscordi Syd.
On Nothoscordum bivalve (L.) Britton. Austin. (21)

382. Uromyces Polygoni (Pers.) Fkl.
On Polygonum sps. College Station. (24) San Marcos. (21)

383. Uromyces pulcherrimus B. & C.
On Abutilon sp. Texas. (8)

384. Uromyces Rudbeckiae Arth. & Holw.
On Rudbeckia fulgida Ait. College Station. (24)

385. Uromyces Spegazzinii (De T.) Kern.
On Commelina Virginica L. Austin. (21)

386. Uromyces Texensis B. & C.
On Ruellia sp. Texas. (8)

387. Uromyces Trifolii (Hedw.) Lev.
On Trifolium Carolinianum Michx. College Station. (24)

Austin. (21) Specimens of this fungus have also been received from Prof. Carl Hartman of Huntsville, Texas.

388. Uromyces sp.
On Syntherisma sanguinale (L.) Dulac. Falfurrias. (21)

389. Uropyxis Amorphae (A. M. Curt.) Schrot.
On Amorpha fruticosa L. Texas. (2)

390. Uropyxis Texana (Holw. & Long) Arthur.
On Mahonia trifoliata (Moric) Fedde. Austin. (2)

Order Agaricales.

391. Corticium vagum B. & C. var. Solani Burt.
On Daucus carota L. San Antonio. (21)
On Gossypium herbaceum L. Austin. (21)
The cause of seedling disease known as ''sore shin.''
On Pastinacea sativa L. San Antonio. (21)
On Solanum tuberosum L. San Antonio. (21)

392. Inonotus Juniperus Murrill.
On Juniperus sp. Texas (type). (29)

393. Inonotus Texanus Murrill.
On Prosopis sp. (type). Austin. (29)

394. Polyporus adustus (Willd.) Fr.
On Liquidambar Styraciflua L. East Texas. (49)

395. Propolyporus Texanus Murrill.
On Juniperus sp. Texas. (29)

396. Pyropolyporus Robiniae Murrill.
On Robinia pseudacacia L. Texas. (29)

397. Stereum prinatum B. & C.
On living trees. Houston. (8)

Mycelia Sterila.

398. Ozonium omnivorum Shear.
On Amagdylus Persica L. Texas. (31, 34)
On Carum Petroselinum Benth. San Antonio. (21)
On Ficus carica L. New Braunfels, Beeville. (21)
On Gossypium herbaceum L. Boerne, Beeville, Elgin, Bastrop, Lockhart, San Marcos, Sabinal, Hondo, Luling, Seguin, Georgetown, Victoria, Cuero, Stockdale, Gonzales, Flatonia, Yoakum, Hallettsville, Falfurrias, Alice, Skidmore. (21) College Station. (37) Texas. (31, 32, 34, 35)
On Hibiscus esculentus L. New Braunfels. (21)
On Hibiscus syriacus L. Austin, New Braunfels. (21)

On Malus Malus (L.) Britt. Texas. (34)
On Medicago sativa L. Beeville. (21) College Station. (11) Texas. (31. 32, 33)
On Phaseolus vulgaris L. Uvalde. (21)
On Pyrus communis L. Texas. (34)
On Robinia pseudacacia L. Georgetown. (21)
On Vigna sinensis Hassk. Beeville, Uvalde. (21)

399. Rhizoctonia sp.
On Hibiscus esculentus L. San Antonio. (21)
On Solanum melongena L. San Antonio. (21)

400. Unnamed species on the roots of cotton. Falfurrias. (21)

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ACTIVE PHOSPHORIC ACID AND POT EXPERIMENTS.

(Contribution from the Texas Agricultural Experiment Station.)

By G. S. Fraps.*

The problem of establishing a chemical method which shall determine what plant food is needed by the soil is an exceedingly important one to the agricultural chemist and to the practical farmer. If it should be possible, in the laboratory, to ascertain exactly the needs of the soil for plant food, chemical analysis could determine the kind of fertilizer which should be added to produce the best results, and this would undoubtedly be of vast practical importance.

EFFECT OF CHEMICAL CONSTITUENTS ON SOIL FERTILITY.

Before entering upon the solution of this problem, it is well to consider whether the chemical constituents of the soil are the only factors which control the supply of food to the plant. If chemical composition is not the only factor, we must then consider how these other factors influence one another, and what information the chemical analysis can give us. If chemical analysis cannot give us all the information we desire, how much information can it give us? Obviously, if we know our limitations we shall be less liable to disappointment in applying our results.

The conditions of moisture in the soil undoubtedly affect the absorption of plant food. A poor soil well supplied with moisture may provide more plant food, for a time, at least, than a much better soil under less favorable moisture conditions. Physical conditions undoubtedly affect the supply of plant food to the roots. Particles of plant food enclosed in lumps of soil may be useless for the purpose of the plant. Of what avail is a subsoil rich in plant food if the roots cannot penetrate into it and secure the *food?*

In the case of nitrogen, we know well that the chemical nature of the nitrogenous material is only a minor factor in supplying the plant with food. The great bulk of the nitrogen is inactive and useless to plants. It must first be converted into ammonia and nitrates before it is of service. Bacteria performs this conversion and temperature, moisture and physical conditions of the soil retard or accelerate their activity. Nitrates are very soluble and may be washed from the soil. Bacteria which transform nitrates and ammonia into compounds of little service to the plant are also active in the soil. Hence the amount of nitrogen at the disposal of the plant is the

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resultant of complex forces, among which the chemical nature of the nitrogenous compounds of the soil is only one.

The phosphoric acid and potash of the soil are subjected to a less number of factors, and the plant food at the disposal of the plant probably depends to a greater extent upon the nature of the compounds present, but other factors undoubtedly enter in and affect the results.

Another matter which must enter into consideration is the difference in the power of different plants to withdraw plant food from the soil. The exact relation of various plants in this respect has not been worked out, even for a single form of plant food, but undoubtedly there is a difference in assimilative power and a great difference. This must be taken into consideration in applying results of chemical analysis.

The action of fertilizers upon a given soil depends somewhat upon the season, on the physical character of the soil, the previous treatment of the soil, and upon the rotation of crops to be grown as well as on the chemical nature of the soil.

Hence the chemical analysis of a soil cannot tell us exactly the best fertilizer to be used for a given soil and a given crop.

The chemical analysis of a soil thus can give us only a limited amount of information, yet such information is very valuable.

ACTIVE PHOSPHORIC ACID.

Nitrogen and phosphoric acid are the two most important forms of plant food for the South. Phosphates are used in enormous quantities for fertilizing purposes and their use is no doubt due to a need of the soil which it is profitable to supply. By active phosphoric acid is meant the phosphoric acid extracted from the soil by N-5 nitric acid. Other solvents have been proposed and tested, but this one appears to be the most suitable. Chemical tests have been made by us to ascertain the nature of the information given us by this solvent. Full details are presented in Bulletin 126 of the Texas Experiment Station.

By tests with mineral phosphates, it was found that fifth-normal nitric acid dissolves calcium phosphate completely, but dissolves mineral aluminum phosphates or basic ferric phosphates only to a slight extent. It thus distinguishes between these two classes of compounds in the soil.

But the solvent may not distinguish between minerals having unequal values to plants. Soils may contain equal quantities of phosphates soluble in fifth-normal nitric acid, and yet give up unequal quantities of phosphoric acid to plants on account of differences in the mineral phosphates present.

We must, therefore, be cautious in comparing soils of widely dissimilar origin or nature.

The phosphoric acid *extracted* from the soil is not the same as that *dissolved*, since the soil has the power to withdraw phosphoric acid even from acid solution. The fixing power of the soil is a matter which must be given careful consideration in applying the results of contain phosphates which are soluble in the acid, but inaccessible to plant roots.

Carbonate of lime, etc., which are dissolved by the solvent may contain phosphates which are soluble in the acid, but inaccessible to plant roots.

POT EXPERIMENTS.

Pot experiments are more suitable for testing the needs of soils for plant food in comparison with chemical solvents, than field experiments. They are much less expensive and more easily conducted.

Weather conditions which destroy or injure field tests are rendered of little effect. Insect pests may be excluded. The soil tested is prepared so that it is uniform, and placed under favorable physical condition, so that the condition which controls the growth of the plants is the plant food. Controlling conditions in the field are variable.

METHOD OF WORK.

Five kilograms soil were placed in a Wagner pot which had previously received 2 kilograms gravel. To one pot was added 2 1-2 grams acid phosphate, 1 gram nitrate of soda, and 1 gram sulphate of potash. To another pot was added nitrate of soda and sulphate of postash. A comparison of the growth of the crop in these two pots shows the effect of phosphoric acid. Other pots were included in this work, but the description of them is foreign to the purpose of this article. Each pot received the same weight of seed, and equal amounts of water. The water content was maintained during the growth of the crop by adding a sufficient quantity three times a week to restore the loss of weight. The pots were kept in glass or canvas houses. At the end of the period, the crops were harvested, dried, weighed, and in many cases, subjected to analysis.

DEFICIENCY OF SOILS.

The weight of the crop without phosphoric acid divided by the weight with phosphoric acid, gives the extent of deficiency. If the unfertilized crop is 50 per cent or less of the fertilized crop, the soil is regarded as very deficient (DD); and if more than 90 per cent, not deficient (S).

Several crops were sometimes grown on the same soil. In finally deciding on the deficiencies for soils, all crops grown upon the soil were considered, and also any other circumstances which may have affected the conclusions.

We have divided the soils into groups, according to their content of active phosphoric acid. Group 1 contains soils having less than 10 parts active phosphoric acid per million; group 2, less than 20; group 3, less than 30 and so on.

The results of our pot tests are combined in table I, in which the number of soils decided to be very deficient, deficient and not deficient, are given. Also the percentages of the total number in the group is given.

Of the 38 soils containing less than 20 parts per million of active phosphoric acid, we find 32 highly deficient, five deficient, and one sufficient. The sufficient soil had only one pot experiment made on it, with mustard, and the results might very possibly have been deficient had more tests been made.

Soils containing 20 parts per million, or less, of active phosphoric acid are highly deficient in phosphoric acid.

Considering the table further, we find that the percentage of very deficient soils decreases rapidly from 87 per cent in the first group to 14 per cent in the fourth, after which it decreases slowly to the 11-19 group, after which there is a sudden increase. One soil, however, makes a great difference in the percentage in these groups.

Table I.—Number and Percentage of Deficient Soils Grouped According to Content of Active Phosphoric Acid.

	Number of Soils.			Percentage of Soils in Group		
	DD	D	S	DD	D	S
No. 1	13	2	..	87	13	..
2	19	3	1	83	12	4
3	7	10	1	39	55	6
4	1	5	1	14	71	15
5-6	1	4	2	14	57	28
7-8	2	13	..	13	87	..

9-10	1	5	2	13	63	24
11-19	1	5	5	9	45	46
32-42	2	..	4	33	..	66
	—	—	—	—	—	—
Total	48	47	16			

The percentage of non-deficient soils increases with fair regularity throughout the table, though there are some breaks, notably in group 7-8, all soils in which are deficient.

In groups 3 to 10 are fifty soils, twelve of which are very deficient, 37 are deficient, and six appear to yield sufficient phosphoric acid. That is to say, about eleven per cent are not deficient. The average corn crop without phosphoric acid is from 34 to 71 per cent of that with phosphoric acid. We feel justified in drawing the following conclusions.

Soils containing from 30 to 100 parts per million of phosphoric acid soluble in N-5 nitric acid, are, as a rule, deficient in phosphoric acid, and the extent of their deficiency is related to the quantity of active phosphoric acid.

Group 11-19 contains only eleven soils. Nearly fifty per cent are not deficient. We draw the following conclusions, subject to modification when a larger number of soils are studied:

Soils containing from 100 to 200 parts per million of active phosphoric acid are possibly deficient in phosphoric acid, the chances being even that they are, or are not.

Group 32-42 contains only six soils. Such soils are likely *not* to be deficient in phosphoric acid, but this conclusion is likewise subject to modification from further study.

SUMMARY AND CONCLUSIONS.

The active phosphoric acid of the soil appears to be related to the needs of the soil as shown by pot experiments. A number of factors must be taken into consideration in applying these results.

THE MIDDLE AND UPPER EOCENE OF TEXAS.

E. T. Dumble.*

In the Tertiary section as determined by the work of the Geological Survey of Texas, we recognized no Eocene deposits of later age than the Claiborne, which stage was divided into four substages based primarily on lithological differences, but afterward found to be also valid divisions paleontologically. These substages were called the Marine, Yegua, Fayette and Frio.

The principal observations on which the three upper divisions were based were made west of the Brazos river. More recent work through the coast country has shown the correctness of the proposed divisions not only in this territory and in Northeastern Mexico, but also east of the Brazos, where for several years some confusion has existed by reason of incorrect correlation made of certain beds found there with those of our western section.

In the Third Annual Report of the Geological Survey of Texas, Mr. W. Kennedy, in his paper on this Section from Terrell to Sabine Pass gives the details of the section as he made it from the Angelina river to Corrigan along the line of the H. E. & W. T. Ry. He describes the Lufkin or Angelina county deposits as extending from the Angelina river southward across the Neches river and the Fayette sand as extending from the south side of the Neches, where it overlay the Angelina beds, southward to and beyond Corrigan, where it was overlain by the Flemming clays. Later, when the Yegua beds were differentiated along the Brazos drainage, the Angelina beds were correlated with them, owing to their position above the recognized Marine beds and below the supposed Fayette, and the Flemming beds were called Frio.

Fuller collections made by Mr. A. C. Veatch from near the base of the supposed Fayette south of the Neches river resulted in the finding of a Jackson fauna and Prof. G. D. Harris, who determined these fossils, in his report on the Geology of Louisiana, classed our supposed Fayette as Jackson and assigned the Flemming-Frio to the base of the grand Gulf of Oligocene. This apparently conflicted with our former grouping of the Fayette and Frio with the Claiborne.

As there was no question but that the beds in Western Texas, to which these names were originally given, contained Claiborne fossils in abundance and did not contain forms connecting them with the Jackson, I had an examination made of the region between Nac-

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ogdoches and Corrigan to ascertain why such a differeence should occur, with the following results:

The base of the Yegua is found resting on the Marine in the vicinity of Lanana north of the Angelina , in the banks of which river it is well exposed. Along the line of railroad south of the river there are few exposures of any kind and the contact between the Yegua and overlying Fayette, which is somewhere in the vicinity of Lufkin, or just south of that town, is not visible. East of the railroad, however, the white sandstones are visible in the creeks, form the country rock around Homer, and eastward, toward the Angelina, they have their usual development. Similarly the contact of the Fayette and Fio is concealed directly on the line of railway, but can be found to the east and west of it. This contact should cross the railroad between Diboll and Emporia, and the clays of the Frio are well shown in the Neches river section, and southward to their contact with the beds now known to be of Jackson age.

It is proven, therefore, that the deposits between the Angelina and the Neches along this line are not, as we originally understood them, a single group of clays equivalent to the Yegua, but two groups of clay deposits separated by beds of sandstone which, taken together, are the direct continuations stratigraphically of the Yegua, Fayette and Frio of the western region. So far as known, they are practically unfossiliferous in this vicinity.

The Corrigan beds, as Kennedy called the sands which overlie the Frio as now determined, are therefore later than any previously recognized Eocene deposits, and the reference of them to the Jackson by Prof. Harris, as well as his reference of the Flemming beds to the Oligocene, does not in any way conflict with the earlier determinations of the western section.

Having decided this, we made an effort to find similar beds of later age west of the Colorado, and to that end careful examinations were made along the Colorado itself and several of the streams west of it, but in no case did we find a trace of any deposits between the real Frio clay and the overlying Oakville. In some places the Oakville entirely overlaps the Frio and is in direct contact with the Fayette.

It would seem, therefore, that the deposits of Jackson age or Upper Eocene and the overlying Oligocene deposits in Texas are confined to the territory lying between the Brazos and Sabine rivers, and that if they were deposited west of the Brazos they have either been eroded or are covered by the Oakville overlap.

THE CARRIZO SANDS.

E. T. Dumble.

The Carrizo sandstone was first described by Mr. J. Owen from the exposure around Carrizo Springs, Dimmit County, Texas. He gave the beds a thickness of 200 feet, the base being composed of gray and brown sandstone locally firm enough for building material and the upper part a red sandstone which gives a characteristic color to the soil.

Mr. W. Kennedy found a series of sands in Cass County which he described as the Queen City beds from their exposure near that place. These comprise red and white sands, the red appearing as red blotches on the white, and have a thickness of 70 feet at this locality. No fossils were found.

Further work demonstrated the fact that these two beds were part of a single deposit, and from their relations to the underlying beds in Cass County, they were considered to be the upper member of the Lignitic stage of the Eocene, and were so described.

More recent examinations in Western Texas and Northeastern Mexico have brought out facts which disprove this reference and connect them more clearly with the Claiborne stage.

In a recent study of the Rio Grande region, Mr. W. Kennedy finds that in this section, instead of being somewhat similar in composition to the top of the Marine beds and lying in apparent conformity with them, as in Eastern Texas, the Carrizo sands are here materially different from the underlying Lignitic, and that while the Lignitic shows a rather strong dip for the Tertiary, the Carrizo sandstones lie at a very gentle inclination. Indeed, these sandstones not only lie uncomfortably on the Lignitic, but overlap both it and the underlying Midway, and are found resting upon the Escondido or upper Cretaceous sediments in many places.

A bluff on the Rio Grande between the Penitas and Caballero creeks shows the Midway at the base, with its characteristic fossils overlain unconformably by about 70 feet of the Lignitic, and this in turn is overlain unconformably by the Carrizo sandstones.

A bluff a mile below the mouth of Penitas creek shows the Carrizo sands resting unconformably directly upon the Midway without any appearance of Lignitic.

There are numerous good exposures along Amole and Juanes creeks to the Ciga del Macha, a range of hills which extend southward some forty miles. In this region there are several points where the Carrizo sands rest directly upon the uppermost beds of the Cretaceous, the Lignitic and Midway both being entirely absent. In all this territory the Carrizo sands have a wide development and form the body of many of the hills.

Along the Rio Grande the upper margin of the Carrizo sands is found just below the mouth of Espada creek, where the ripple marked micaceous sands with iron concretions which mark its culmination, are conformably overlain by the lignite bearing sands and greenish clays, carrying palmetto leaves and other fossil plants, which here form the base of the Marine beds and grade upward into beds containing the Marine fossils which distinguish that substage further east.

We have therefore in the Carrizo sands, as devloped on the Rio Grande, a series of sands of very different character from the earlier deposits which make up the Midway and Lignitic or Lower Eocene, and which rests unconformably upon them. Its materials are more nearly those of the succeeding Marine beds, with which it is apparently in conformity.

From these facts it will be seen that the Carrizo sands are not a part of the Lignitic, as formerly supposed, but that in reality they correspond both in position and composition with the Buhrstone of the Alabama section, of which we therefore consider them the equivalent, and form the base of the Claiborne series or the Middle Eocene.

THE INFLUENCE OF SCIENCE UPON GERMAN LITERATURE, BASED ON HAECKEL'S WELTRAETHSEL AND NIETZSCHKE'S PHILOSOPHIE.

DR. SYLVESTER PRIMER.*

The nineteenth century solved problems, which, at its beginning, seemed insoluble. Not only the surprising theoretical progress in the real knowledge of nature, but also its astonishingly fruitful and practical application in technique, industry, commerce, etc., have completely changed our whole modern culture and given it a new cast. Therefore, the literature, which reflects actual life, has made corresponding changes both in its methods of presenting life and in the views it takes of the same. For since Charles Darwin, in his epoch-making books, opened up nature and nature's mysteries to the investigator as no other before him had done, old thoughts, old beliefs have yielded to new ones. All this demands and has produced a new literature to reflect the new ideas of life.

Not all mysteries of nature, however, have been cleared up. Enough enigmas still remain to keep the investigator occupied for ages to come. The uninitiated sit in the midst of innumerable world-enigmas and turn appealingly to scientists for their explanation. Progressive science is making rapid progress towards their solution, and already monistic philosophy claims that only one single, all-comprehensive world-problem is left, viz., the problem of matter, or substance.

At the beginning of the century not much had been done along the lines of investigation which proved so successful in the latter half. The microscope and the telescope enlarged the horizon of our knowledge and finally lead to a more perfect understanding of the cell-theory, which first established the true relations of the physical, chemical and psychological processes of life, those subtle phenomena which had hitherto remained a profound mystery. The unity of natural forces in the whole universe has now been proved. The most important discovery, however, is the theory of development, due to the efforts of Charles Darwin, in his Descent of Man (1857) Origin of the Species, etc., which Jean Larmarck had already outlined in 1809 in his Philosophie Zoologique, and whose fundamental idea the great poet, Goethe, in 1799 had prophetically conceived in his "Gott und Welt," "Prometheus," "Faust," but more especially in his "Metamorphose der Pflanzen."

The remarkable progress made in the knowledge of nature's laws

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in the practical application of these discoveries in all the relations of life; the telegraph, the telephone, ocean steamers, wireless telegraphy, airships, is due to the technical progress in the knowledge of physics, especially in the application of steam and electricity. Chemistry has so perfected photography that we can easily take the pictures of every object, planetary or spiritual (?), and has made wonderful changes in agriculture and medicine.

In social life, however, in the State, the school and the church, there has not been, according to Haeckel, any perceptible advance. The older systems still keep their hold upon us, and the little progress actually made is hardly noticeable. And yet the careful observer will discover a gradual remodelling of the older systems into newer, more rational ones, that are founded upon the clearer knowledge of the relations of man to man. Society itself is fast absorbing the latest results of scientific research and soon the gradual revolution of thoughts and feelings will demand and receive the best possible systems for the full and complete development of man.

The following propositions may be considered settled by the investigations that have been carried on for a century or more: 1. The universe is eternal, infinite and unlimited. 2. The substance (matter) of the same, with its two attributes (matter, energy), fills the infinite space, and these attributes are in constant motion. 3. This motion turns out to be, in infinite time, a uniform development, with periodic changes from birth to death, from progressive to regressive formation. 4. The innumerable bodies of the universe, which are distributed in space-filling aether, are subject to the laws of substance (matter); while in one part of the universe the rotating bodies are approaching slowly their regressive formation and their end, new formations and developments arise in another part of the universe. 5. Our sun is one of these numerous (?) perishable bodies, and our earth is one of the perishable planets which encircle it. 6. Our earth passed through a long process of cooling before water, and, because dependent upon this, the preeminent condition of organic life, could exist. 7. The long develpoment and transformation of innumerable organic forms took millions of years. 8. The vertebrates excelled all others in their development. 9. The mammals stand first here. 10. Among these the primates are first. 11. Man is the youngest of these. 12. The history of the world is a very short period when compared with the other unwritten history.

As to the unsettled world-problems, perhaps Emil du Bois-Reymond, in his address before the Leipzig session of the Berlin Academy in 1880, comes nearer the truth, when he propounds the following seven: 1. The Essence of Matter and force or Energy; 2, The Origin of Motion; 3, The Source of Life; 4, The (apparently intellectual) efficient, systematic Arrangement of Nature; 5, The Source of the Simple Sensations (Emotions, Feelings) and the Source of Consciousness; 6, The Faculty of Reasoning (Thinking) and the Origin of Language so closely connected with it; 7, The Question of Free Will.

Du Bois-Reymond pronounces three of these insoluble (1st, 2nd and 5th). Three others he considers soluble, though with great difficulty (3rd, 4th and 6th). The 7th and last he is undecided about. It is, however, the most important of all. Dr. Ernest Haeckel, the German zoologist, solves the first set (1st, 2nd and 3rd) by his peculiar conception or explanation of substance and matter. Admitting his definition of matter, his proof seems irresistable. The other three difficult, but yet soluble, problems (3rd 4th and 6th) have been finally solved by the modern doctrine of development. The 7th, Free Will, is not really an object of critical, scientific explanation, inasmuch as it, as a pure dogma, depends only on delusion or illusion, says Haeckel, for there would hardly be *will* if the world is mechanical.

In solving these riddles philosophy and science, i. e., speculation and empirics, are most helpful as equal and mutually complementary methods of acquiring knowledge. The greatest triumphs of modern research, the cell-theory and the theory of heat, the theory of development, and the law of matter and substance, are philosophical acts, but not the result of pure speculation; they are rather the result of previous excellent and thorough empiricism.

Philosophy affords two different ways of explaining world riddles, the dualistic and the monistic. Dualism divides the universe into two substances, the material world and the immaterial God, who, as creator, preserver and ruler, presides over it. Monism recognizes in the universe only one substance which is at the same time God and nature. The first theory leads to theism, the second to pantheism. Monism is not materialism pure and simple. For Goethe's conviction that matter never exists and becomes effective without spirit (energy) and that spirit (energy) never exists or becomes effective without matter is probably true. Spinoza's monism is, according to Haeckel, correct, for he looks upon matter as infinitely expanded substance, and spirit (energy) as the sensitive or thinking substance, both of which are fundamental properties of the comprehensive, divine, universal essence, of universal substance.

The whole trend of scientific investigations during the nineteenth century has been an endeavor to explain the origin of the universe and of animate and inanimate nature with their development from their primitive beginnings to their present state. In order to show the influence these investigations have exerted upon literature, it will be necessary to review briefly the results at least of those investigations and touch upon the theories advanced to explain world-riddles. No opinion as to their value will be given, inasmuch as the influence of said theories will be about the same whether they themselves be true or false. (As this is only an abstract, this part will be omitted here, and will appear in the full article to be published later.)

Thus the enigmas, according to Haeckel, are reduced to one, but a most important one, the problem of matter. What is nature or universe which the ideal philosopher calls matter or cosmos, and the pious believer, creator or God? Is the problem solved by science, or have we only moved a step nearer its solution? We (Haeckel et al.) concede that we stand today just as uninitiated into the mysteries of the innermost essence of nature, just as ignorant as Anaximander and Empedocles 2400 years ago, as Spinoza and Newton 200 years ago, as Kant and Goethe 100 years ago. We may even confess that the real essence of substance becomes even more wonderful and enigmatical the deeper we penetrate into its attributes, matter and energy, the more profoundly we become acquainted with its innumerable phenomenal forms and their development. What the thing per se hidden behind the known phenomena is we do not even know today. The fact that matter is subject everywhere to a perpetual motion and transformation makes it a universal law of development. This leads to the universal unity of nature and to the eternal force of nature's law. From the dark problem of matter the clear law of matter has been evolved.

Thus concludes Haeckel and the problem of life, of soul, of the world, of God is still a problem to science. Faith alone has solved it in God, soul, immortality, which arise from no emotional needs of the religiously inclined, but from the rational need of the scientific man. For God as an idea belongs not in the sphere of religion, but of science. But since science has failed to satisfy our longings for a solution of these enigmas, let us turn to philosophy for hope and consolation. For it has worked hand in hand with science in its efforts to solve these world-enigmas and its contributions have not been at all insignificant. We have already mentioned Spinoza and Kant and will, therefore, only give a short summary of the various philosophers down to Nietzsche, referring to the fuller article for a more extended account.

We find two tendencies in modern philosophy which appear as competitors, viz., the metaphysical idealism and cold critism, or the doctrine of the knowable and the unknowable, sometimes called the theoretical recognition-criticism. The old, dogmatic philosophy which created of empty ideas a real metaphysics, a speculative knowledge of the intelligible world, is practically dead. Critical philosophy is the complement of knowledge limited to the field of phenomena by the ideals of reason. The idea of God, freedom, immortality, become practically significant for necessary and comprehensible ideas. That is, man must necessarily consider reality through ideas.

The speculative tendency, or our first tendency, starts with Plato (sometimes called Platonic idealism) and is developed in the scholastic philosophy of earlier times. Leibnitz and Wolff retained it and it reached its highest development in Hegel. The second, or critical tendency, is the Kantian philosophy which maintains that all speculation is inadmissible in founding religious faith, making it independent of metaphyscs. Belief is of quite a different nature and origin than scientific knowledge, whether we may think we establish it, or whether we may shake it to the very foundations. Faith depends upon the will and feelings (i. e., the emotional elements of our nature) and is not touched by any change in speculation about it. All practical idealism is in its nature religious, resting on faith in that which we do not see. Philosophy should reconcile knowledge and faith.

The great cultural value of the age of enlightenment consisted in the constant assurance with which a free and unprejudiced universal public opinion, arising from scientific lines of thought, gradually permeated all Europe with its convincing power and saturated all literature with these results of philosophy which considered life in all its aspects. The most intimate relations exist between thought and literary production, especially in Germany. This was a characteristic feature of the period. Therefore literature reflects the beliefs of the age, and shows a clear and understanding insight into the emotional feelings, the index of the free and natural development of human life in poetry and philosophy. Rationalism, it is true, had permeated the world and acknowledged nothing as true which it could not prove; it restlessly reformed and remodeled life, but admitted nothing into it that reason could not grasp. The feelings, the emotional part of man, revolted against rationalism with all the irrationality of individual reality. This contrast of rationality and irrationality reaches back to the leading spirits of the Englisth enlightenment, Locke and Shaftesbury. It speaks with trumpet blast in the two great writers of the French enlightenment, in Voltaire and Rousseau. It is seen in Germany in the relation of the so-called school and popular philosophy to the emotional philosophy and passes into the literary contrast between the conventional and the unconventional writers. Note the writers of the storm and stress period and those of the early romantic period.

Kant was the man to carry out the rational feature of the leading thinkers of the age of enlightenment to their logical conclusions, to raise life from its stupid indifference to conscious clearness and significance, but the deep earnestness and great fidelity of his character showed him the boundaries between rational and irrational reality. Thus his life work was critical philosophy. He settled the boundaries of the rational value in the world and life, of the rational and irrational. He established the critical laws of the transcendental method and made reasoning a mathematical problem.

His critique left no basis for a scientific establishment of religion. The moral consciousness was not sufficient to solve this problem scientifically. Kant was quite conscious that the religious life possessed a transcendental element which surpassed all reality of the theoretical reasoning and of the practical, rational life. The essence of religious conviction consists in observing the moral law. The consciousness of the individual forms the basis of the Kantian critique, the mature consciousness of a highly developed culture.

Upon this relation rests the central position of Kant in the history of modern philosophy. In his contemplation, which was just as broad and comprehensive as it was profound and impressive, appear the features of the unusually rich, intellectual movements of the eighteenth century, which unite to form a completely modern philosophy, the so-called critical philosophy, and the sum of which we call German idealism.

The age of enlightenment had proclaimed the self-glorification of the individual and Fichte found in the spread of modern poetry and philosophy the beginning of rationalism. He was and remained really the leader of the intellectual movement, who with full consciousness, as Schiller from the aesthetic side, expected from science and poetry the introduction to a higher and better condition of society. This principle was energetically developed among the poets and the aesthetic life produced the richest fruit of reason. The most worthy part of the romantic movement was that it showed the intimate relationship of poetry and actual life, the deep conviction which sought in the depths of reality the pulse-beat of the popular heart. The education of the individual was the foremost thought of the leaders of the day. A rich and mature personal life was wrought with full consciousness out of the intellectual community-life of man, and, instead of a rule of dry reason, instead of a sentimentality centered in a narrow sphere, we now have a universal culture. Schelling and Hegel completed the philosophical system of the romantic movement, the former by giving a comprehensive form to nature-poetry and the religious features of the romantic thought, the latter by turning the historical feature of the new intellectual movement into a powerful, into a universal view.

Schopenhauer owes his principal doctrine of the will as absolute to Kant, Fichte and Schelling, his theory of ideas to Plato, and his pessimism and his doctrine of the negation of the will so gloriously represented in his "Die Welt als Wille and Vorstellung" to Buddha. According to Schopenhauer, there is no virtue worthy of the name, except pity or sympathy, the principle of the Buddhistic morality. All other virtues are founded on the will-to-live and will-to-enjoy. Life is the goal, and life is necessary, irremedial suffering, positive happiness is an eternal Utopia. The negation of the will is the common essence of the gospel and of Buddhism. His philosophy is realistic, because of the extreme concessions it makes to materialism; it is idealistic and critical, in that it denies the absolute reality of the phenomenal world and makes it depend entirely on our intellectual organism; its extreme pessimism rests on an imperfect knowledge of human nature.

The real dangers of these speculations, if danger lay in them, was not so much in naturalism, for that is self-correcting, and would soon throw off the slag and retain only the purified metal. It lay rather in the logical conclusions to be drawn from the various theories, both of the scientists and the philosophers. These led consequently and conclusively to a revaluation of old values, as Nietzsche puts it, and a complete revolution of society, of thoughts and ideas. Now, only the personal characteristics are demanded in the drama and novel; the idea is a matter of indifference. The abstract thought is replaced by the concrete, individual acts of man. It is the period of individualism. We see it in the alembic of Tolstoi's socialistic and religious evolutions, in which the conventional life of his day is finely portrayed. We see it in Zola, where the individual is subject to the laws of heredity and bound by the social environment in which he is born. We see it in Ibsen, where the individual is fighting against tradition, in which the issue is an open question. The individual is not anarchical enough to cross the Rubicon of society life and declare his complete independence, hence its problematic nature. The philosophy of the day sets problems, but does not solve them. The more important, weightier problems of the ethical value of life, since Kant assigned to the intellect a secondary place and put in its stead the practical reason, the will, have become the burning questions of the day. Whether the problem of life's values is answered optimistically or pessimistically, the real value of life has become a problem, and will remain so as long as the individual is to determine what the real value shall be. The same changes take place in the religious life of the times. God, life, soul, immortality, have become probelmatical, eternal enigmas awaiting their solution; the undividual exists only as a social being, becomes a decadent, who will not recognize the normal, nor see the sunlight, nor live a healthful life. Individualism is the great problem of the day.

The influence of Hegel was felt in the decades following his death and extended its power over the general literature and over the special sciences. The contrasts of the political and religious life proceeded peacefully together for a while. Through the romantic movement a new, inner, religious life was awakened, but its connection with the political restoration soon drew it over to the old ecclesiastical party, which divided the Hegelian school into two parties on the question of a personal God and immortality of soul. One party maintained a personal God, immortality of the soul and the doctrine of the trinity, while the other adopted the theory of pantheism, as in the case of the scientists. This contrast to the logical idealism of Kant and his followers is best seen in Strauss's ''Life of Jesus'' in 1835. The fight of these two parties was bitter and eagerly engaged in by the youth. The most conspicuous personage of this contest was Ludwig Andreas Feuerbach, who, in 1830, published anonymously his celebrated article, ''Thoughts On Death and Immortality,'' in which he advocated pantheism, according to Spinoza and Hegel. Instead of logical idealism, we now have sensual materialism, which possesses a corresponding theory of terrestrial happiness, a feature which took rapidly with the public and found its expression in David Friedrich Strauss's ''The Old and New Belief.'' With comprehensive consequence the Darwinian theory was developed. The soul-life was centered in the sensual ''this side.'' Hegelianism again gave rise to the socialism of Marx and Engel, which makes the moral, judicial, scientific, artistic and religious life the result of economic processes. Metaphysical materialism now united with anthropological materialism, a natural conclusion of essentially naturalistic scientific views of the world, and, in this form, with this claim, materialism appeared in the middle of the nineteenth century to inherit the idealistic systems which had lost their power over the spirits of men. Natural philosophy now appeared to be fanatstic, antiquated. Mechanical explanations, not only of all corporeal, but also of al psychical processes gained credence. The mechanical-chemical explanation of life and soul activities obtained. Monism prevailed in philosophy as in science. Lotze and Hartmann tried to stem the tide and turn philosophy back to idealism again, but failed.

On the whole, German philosophy was in a deplorable condition during the last decade of the nineteenth century, and was incapable of new combinations. The special direction which any new movement should take was conditioned by the moods and the needs of the time in which the Germans were experiencing powerful metamorphoses in their political condition, which affected their intellectual life. There was a felt need of a philosopher who should construct and reconcile clashing theories and establish a new modus vivendi. Friedrich Nietzsche attempted to solve the philosophic problem. Born in the first half of the nineteenth century and dying on the boundary between the nineteenth and twentieth centuries (1844-1900) he became the dazzling light of the German literature at that epoch. He declared in his philosophy the principles which had been assumed by science and philosophy as fundamental, and carried them to their logical conclusions. All the contrasts of contemporary consciousness appear in the spirit of Nietzsche. It would certainly lead us too far to follow out in all its details the development of this remarkable man. For it would be a history of the various factors of modern civilization which he advocated. We can summarize his principal activities under the following seven heads: 1, anti-morality; 2, anti-socialism; 3, anti-democracy; 4, anti-feminism; 5, anti-intellectualism; 6, anti-pessimism; 7, anti-religion.

Nietzsche tore down the barriers to all authority and preached a new, hard doctrine, the evangel of force, power, strength, the "Survival of the Fittest;" hence his success. The moral and legal barriers come for him, not from nature, but from statutes; laws are only made by the weak, the vicious, the many for their own protection against the strong. Nature, however, desires the rule of the strong, who, from natural right, oppress the weak. This anti-moral principle declares all legal and moral laws unnatural chains which the strong man tears off. In all probability Fichte, in his *ego*-doctrine, is mostly responsible for these ultra ideas and yet the real source of Nietzche's theories of life, of his revaluation of old values, is to be found in Schopenhaur and Darwin. In the first period of Nietzsche's development Schopenhauer was his favorite philosopher. The great musician, Wagner (see Geburt der Trogoedie, 1871,) also exerted a powerful influence upon the rising young philosopher, though the primary influence came from Schopenhauer's Willenmetaphysik (Metaphyisics of the Will) and his (Schopenhauer's) pessimism.

Nietzsche considered the world as will and image (Bild). The never-satisfied will is for him also the source of all torment. Only the tragic man is the true teacher of men, therefore, Schopenhauer is the best teacher (see Schopernhauer als Ezieher). Only the tragic artist furnishes really comforting art, therefore, Wagner is the best artist. But Nietzsche was a classic scholar, and Wagner a national German, hence, they soon parted company. Darwin interested him with his ''Survival of the Fittest,'' and his ''Natural Selection'' theory, while Schopenhauer's ''Wille zum Leben'' became ''Nietzsche's Wille zur Macht. The conflict of powers and wills is to Nietzche the struggle for life. This is the Schopenhauerian Willenslehre under the influence of Darwin's ''Survival of the Fittest.'' In this conflict Nietzsche overcame the Schopenhauerian pessimism in his own nature and drove it from its stronghold in the nation. The fundamental principle of Nietzsche is, therefore, the positive application of Schopenhauer's doctrine of the *Will* under the influence of Darwin, which accounts for his anti-pessimism in his second period. From the same source come his anti-religious views. Schopenhauer was not so unfriendly to religion, nor were the other philosophers. Nietzsche considered the religion of Christ a curse to mankind. Its pessimism, its compassion for the weak, its protection to the weak, its sentimentality, its fetters for the strong, he considered a hindrance to the free development of man. Hence comes his Herren-moral and Sklaven-moral or morality for the strong and morality for the weak. Hence his revaluation of *Good* and *Bad*. *Good* is whatever the strong man does, and *Bad* is whatever the weak man does. The strong man can never be bad and the weak man can never be good. Of course, with such views he was anti-democratic. The weak have no rights, the strong are always right. Darwin, again in his ''Survival of the Fittest,'' Aristocrat vs. Democrat. This includes the view that woman, as the weaker vessel, is subject to man, and has no rights. He subordinates intellect to will, as Hegel. The weaker shall not be cared for. Let nature kill them. Death to the weak. A hard doctrine, but the logical result of theories advanced by others.

He takes his Uebermensch from Goethe, who had it from Herder, and uses it in two senses: 1. The representative of superior men in the past, Alexander, Caesar, Augustus, Charlemagne, Cesare Borgia, Napoleon. 2. The modern Uebermensch, whom selection and heredity shall produce, according to the Darwinian theory of selection. He himself is one, J. J. Rousseau another, and we add Goethe, Byron, Roosevelt.

According to this view, the masess can never attain to new valuation; that is only for the individual. If we are ever to have a revaluation of old values, it will be when the great thinker creates them, when he makes himself the law-giver of the life-values of mankind. This new law will be laid in the contrast of the individual with the masses. It will be superior to the conventional, will be beyond good and evil. It confers on the strong individual the right and duty of making his will supreme. For him nothing shall be true which does not further him in his self-aggrandisement. He can do anything that this self-realization demands. Only this unerring, joyous assertion of life is able to bring about a higher and more fortunate race. The superior manhood is not felt by Nietzsche as the ideal of genial personality in aristocratic contrast with the masses weighted down as they are by the entire load of tradition, but in him it is changed into a picture of a higher type of the human species. This charming, poetically beautiful presentation of the subject dissolves into a nebulous vapor of the different cultural theories since Rousseau. But just because in this contradictory play of colors all contemporary motives found their brilliant expression, because the unsolved contradictions, especially between the values of the intellectual culture and the passionate striving for development of power made up the fundamental tone of this prophetic poetry, he has been able to appear with his program of the revaluation of all values as the thinker of his day. Not the creator nor lawgiver of values is to be the philosopher, but the seeker and originator of values. It is not a matter of power values of the individual, but of the culture values determining the historic development and foundation on a high intellectual plane. Observing this feature and this need of the time the recent philosophy of Germany has begun to appreciate once more the real significance of idealism. Already in the conception of Kant the agnostic theory of recognition (knowable and unknowable) had been relegated to the background. In the same sense the great idealistic systems of Fichte, Schelling and Hegel have found a new dignity. The outer wonders of the dialectic construction have been cast off and the real matter appears all the more powerful. This new idealism, which appears in the most varied literary products of the last century, is still active. It now appears rather as a return to Fichte, now rather as a return to Schelling, and now as a return to Hegel.

These ideas spread like wildfire. Soon the whole country was full of a literature written in the spirit and for the purpose of making propaganda for Nietzscheanism. When they were denied the use of the regular stage and the regular periodicals, his adherents built theaters and established periodicals for the promulgation of their views. His theories captured the lower and middle classes and penetrated into the castle as well, and seemed destined to hold the citadel against the combined attacks of the conventional school. But they had forgotten reverence and culture, conventionalism and even self-respect; hence their day is now fast passing away; more rational views obtain.

Turning to the literature we find that the reaction against the good, old orthodox conventional literature set in about the middle of the eighteenth century, somewhat before science began its fruitful investigations, which led to such excellent results. But it is only when we turn to the modern period that we find the greatest influence of science and Nietzscheanism. The theory of a physical and mechanical world, the theory of the descent of man, the theory of the so-called scientific monism had brought thought, feeling and will under the sway of matter. The whole man was subject to mechanical development, the intellectual as well as the physical man. Heredity, environment, milieu, modified and limited, but did not free him from the natural or inherited impulses and views of life, hence his irresponsibility, from the moral point of view; the only thing that had kept the standard of morality at its best, religion, had been swept away. Morality was stranded. Nietzscheanism sits enthroned in its place, and the individual becomes lord by right of might. He develops only self, lives for self alone in the world, and there is no other world. In the struggle for life pity has no place. Selfishness, the value of man alone, obtain. The revolution is complete. Ibsen proclaims this revolutionizing of the human intellect to be the chief task of modern literature, and it certainly has served in this capacity. For two principle thoughts have swayed it: Emphasis of the Darwinian theory of man's descent, and the idea that might makes right, or, to put it more mildly, the struggle of life.

Naturalism is probably the first outgrowth of this revolutionary movement. It is a significant fact that the appearance of Flaubert's ''Madame Bovary,'' the first French novel of Naturalism, and Ibsen's ''Comedy of Love,'' in which the Norwegian individualist proclaims his doctrine of individual rights, are only five years apart, and that in these five years Darwin's chief work saw the light of day. Naturalism took deep root in French soil, and Flaubert was succeeded by the man whose name is the symbol of pure naturalism, Emile Zola. In his great novels the characters are the mere types of the different kinds of Naturalism, subject to the same ruling passion of love, selfishness, revenge, hate and greed, the lowest passions of man. Herein the author demonstrates his belief in the animal nature of the race.

The ideal, the ennobling qualities of man find no place in his works. For his vision is confined to the earth and the earthy. There is no vision of a higher life. The hero in "L'Assomoir," the unfortunate slater, is a hereditary drunkard, who in times of enforced idleness, falls a victim to the slumbering demon within, in spite of his utmost efforts at resistance. The family Rougon-Macquart is kept together by common fate, to which all their members are predestined by their forefathers. It is the iron law of a fate that makes one what he is. In Germinal it is the greed of ever making more money. Zola's only poetic passion is his accusation of the actual conditions. He showed an especial affection for the ugly, the brutal, the common; the dark side of life illumines all in the coarsest colors of murder, incendiarism and animal desires. Zola's novels correspond so completely to the psychical condition of the literary revolutionists in Germany in the eighties and nineties that all the examples which were to ally the discord of the young generation were taken from the series of Rougon-Macquart (heredity).

Zola produced his effects by large, carefully executed pen-pictures of customs; Ibsen, the representative of the recently resurrected Norwegian literature, sought to inspire the people by special tactics in the struggle. He proclaimed in his "Comedy of Love" the commandment of living one's life in one's own way, regardless of others, and remained true to it all his life, for it appears in his last piece, "When We Dead Awake." All his plays have a purpose. He is above all things a pioneer of the modern views of life. His later works have a pathological vein. He is the problem-poet, but he never solves his own problems. The individuality, the ego, goes forth like Nora from her "Doll's House" to find the higher life, the right to educate herself for life; it opposes, as in "Public Enemy," trusting to the victory of its freedom and truth, a whole city full of lies and dependence; it struggles in Brand with the religious forces of the past and of his own heart; it is the great discord of the age which, in Ibsen, has found its most eloquent, most profound interpreter. This is Ibsen's greatness, but at the same time his limitation; viz, that he has looked deepest into modern life and discovered in it the problems which disclose the conflict between the individual and society, problems that will probably never be solved. Thus modern literature leaves the conventional, the objective, and proceeds to the problematical, subjective; it leaves the sublime and proceeds to the seemingly ridiculous, the minute description of life's details, to an estimate of the apparently trivial.

In Tolstoi, as in Ibsen, are found conscience and love and truth, but perverted in each case. This powerful Russian was a simple believer; he had his Christianity, like Schopenhauer, but with all his Christianity and his strict morals he remained a simple nature, and became a religious mystic. He was also a social reformer of no small moment. Hardly any literary representative of our time has striven in such fierce encounters for the palm of that higher harmony of nature and the fixed idea. Hardly any writer unites in the same measure those qualities which are called realism on the one hand and idealism on the other. All that Tolstoi describes is nature, true, unadulterated nature, but not all is idealistically portrayed.

In Germany the influence of these three great authors is felt in every great work. The disintegration of moral and social forces began with the appearance of Nietzsche's Zarathustra. In lyric poetry men like Dehmel vie with one another in songs to Venus, in which the animal nature is exploited and described. The looser and more unrestrained the verses were the more esteemed the poet was as a genial individualist. In the short story and novel, Maupassant became the model, soon, however, surpassed in his own special line. Savage brutality seemed to have seized the reins and to be leading German literature a sorry race until some wiser heads succeeded in checking the headlong pace, and the storm is now apparently abating, nay, even dying out altogether. Of the innumreable writers of this period, the names of Hauptmann and Sudermann have gained the greatest fame, and will remain longest in the world of literature. They, too, were swept away by the whirlpool which had engulfed morality, religion, civil government and conventional life under the battle cry of revaluation of all values, called forth by the advanced investigations on the field of science and philosophy. Hauptmann became the color sergeant of realism by exposing the ugly shades of life under the bright footlights. Pieces like "Vor Sonnenaufgang," "Die Weber," "Fuhrmann Henschel," etc., all show realism and naturalism in their naked form. The first is a story of a noble heroine in a drunken village, in a drunken family, all reeking in alcohol, with only one ray of hope for escaping her environment and breathing the pure air of heaven again. But this hope is founded on a lover, who has manhood, ability, intelligence, and apparently love. He finds out, however, that the heroine's family are all drunkards, and, being a scientist, and knowing the law of heredity, he packs his grip and leaves the girl to her fate, on the plea that he does not wish to be the father of drunkards. Only one thing now remains for her, death at her own hands. Cold, stern, unrelenting, soulless science takes the place of feeling, emotion, sentiment. The others are about the same. Even "Hanele's Himmelfahrt" makes no exception. For we have only a series of visions of a poorhouse girl, where Hauptmann's socialism, as in "Die Weber," again appears. The only owrk that bears the stamp of greatness is "Die Versunkene Glocke." Here we breathe a purer atmosphere, and portions of the play are full of beauty and poetry, but the leading thought again shows Nietzsche. The Bell-founder Henry will never become an ideal figure for his fellowmen, for he is the incipient Nietzschean Uebermensch. He sacrifices wife and children to his ambition, or selfishness, seeks his fortune with the waternymphe, Rautendelein, who probably represents nature, and nature-worship, or pantheism. He makes the mistake of representing something which the Uebermensch never does. Henry curses Rautendelein, goes to his former home, is stoned from there and dies in despair. Neither Nietzsche nor science would have tolerated such an ending. They would have had him complete on the mountain the temple begun to pantheism and proclaim from thence the pantheistic gospel to his followers. The play would then have been a well-rounded drama, and Henry would have been Nietzsche's Uebermensch, instead of the pitiful figure he now is. And yet Hauptmann's admirers place him beside Goethe!

Sudermann portrays the ethical conditions of his times, a wise choice, but it takes a masterhand to do it, a task that Sudermann is not equal to. He takes Zola as model, rather than Ibsen, though the latter has also influenced him. Marriage, love, domestic life are his favorite themes, and he handles these well from the view-point of naturalism. "Sodom's Ende," "Die Heimat," etc., are genuine French pieces; even "Johannes," the Biblical story of John the Baptist, is not free from this feature, as we see in the character of Salome and the dance scene. His dependence on Nietzsche, however, is best seen in his "Die drei Reiherfedern," written to counteract the wonderful effect of Haptmann's "Die Versunkene Glocke." It is allegorical from beginning to end. "Prinz Witte" is another attempt at Nietzsche's Uebermensch, but a failure. He is too vacillating, too thoroughly naturalistic, too modern, or rather too much like the modern German period, too lifeless, has no initiative, no object in life, is too problematical. His esquire, "Lorbass," comes nearer being the hero, the Uebermensch. He represents Nietzsche's Herrenmensch, or the might makes right principle of the "Struggle for Life" theory and "Selection of the Fittest" proposition.

Enough has been said to show the trend of the paper and the influence of science and philosophy on literature. The scientific and philosophical parts are based on the study of specialists in each field, and their thoughts have been used freely. Credit will be given in the full article.

LIFE, CHARACTER AND WORKS OF PROFESSOR J. W. M'LAUGHLIN, M. D.

H. L. Hilgartner, M. D.*

Mr. President, Members of the Texas Academy of Science, Ladies and Gentlemen:

By the untimely death of Dr. J. W. McLaughlin on November 13, 1909, under circumstances of peculiar sadness, and at a comparatively early age, we lost, I am sure we will all agree, the foremost physician in the State.

It has been said that "the history of an epoch is the history of its leading men. They are the center and source of intellectual energy. In them the ever-widening waves of mental progress have their origin, and it is under their vivifying influence that science and learning grow and spread." We, therefore, do well, from time to time, to gauge our gains by contemplating the life work of men who have largely contributed to them, and have thus left behind the imprint of their power and individuality. It is considerations such as these that induce the Texas Academy of Science to see in these occasions, brought to our notice by the stern act of death, opportunities, not only for showing our esteem and admiration for those who have wrought faithfully and well, but also for dwelling for a too brief moment upon their life history and estimating albeit imperfectly the worth of their labors and their lives.

As a friend of nearly twenty years, who enjoyed a rarely privileged intimacy for more than half that time, I have charged myself with the sad, but cherished, duty of pronouncing a few words in honor of the memory of my friend. That my effort will prove but feeble, I know only too well. It would require a man of broad learning and real power, a gifted orator and a master of our English speech, to do justice to the life work of J. W. McLaughlin.

Born near Springfield, Ohio, the 7th day of September, 1840, on the death of his father, C. D. McLaughlin, the subject of this sketch, to use his own words, "engaged in the study of medicine with his uncle, A. C. McLaughlin, with whom he lived until the breaking ou of the war between the States in April, 1861. Being an earnest and ardent supporter of States' rights, the Wide-Awakes soon convinced young McLaughlin that south of the Mason and Dixon line was his only safe domicile, and, this move being in perfect harmony with the political views of the young man, he quietly disappeared from his

*Austin, Texas.

home early in April, 1861, between sunup and sundown. Reaching Louisville, Ky., he enlisted in Company D, First Kentucky Infantry, and at Harper's Ferry was sworn into the Confederate Army to serve for twelve months. He remained in service, however, until army surrendered in 1865, serving at various times under Johnston, Jackson, Morgan and Forrest.

"Being still rebelllious and unreconstructed, McLaughlin and A. H. Cross, an army comrade, started for South America. But on reaching Texas, McLaughlin met Miss Tabitha Bird Moore, who later became his wife, and decided to take up medicine as a profession. He at once entered into its practice with Dr. Sam D. McLeary, near Columbus, Texas. Working diligently, the following spring, (1867), after completing the prescribed course of study, he graduated from Medical Department of the University of Louisiana.

"His marriage was solemnized in September of the same year, and with his devoted wife he located in Fayette county for the practice of his profession, where he remained until 1869, when he removed to Austin."

Dr. McLaughlin practiced in Austin thirty-two years, when he was called to the chair of Medicine in the Medical Department of the University of Texas. This chair he filled with distinction eight years, when he resigned and returned to Austin. Dr. McLaughlin was President of the Texas State Medical Association in 1894, a regent of the University of Texas from 1907 until his death, and President of the Texas Academy of Science at the time of his death.

As a mature man the greater part of Dr. McLaughlin's energies was devoted to the practice of his profession. Of that I shall speak later, but the attraction of the scientific side was very strong, and soon led him to devote much time and thought to the scientific work he liked best. Very early in the medical career his thoughts were directed toward an explanation of drug action. This led to investigations which resulted in his well-known wave-interference theory of catalysis, and catalytic theory of immunization, which he worked upon to his last days. His views on the different problems constitute in the judgment of the competent, a noteworthy contribution to scientific theory.

Possibly even more valuable was the work he did during the epidemic of dengue in 1885, which resulted in his discovery of the bacillus of that fever. When we remember that this work was done, not in a laboratory equipped with all modern appliances, which do so much to ease the work of the student, and so little to develop his resourcefulness, but in a room at his residence, surrounded by the most meager appliances, we begin to appreciate his remarkable skill and ability as well as the exceptional strength of his devotion to the cause of science.

In 1887 he published an article entitled "The Etiology of Acute Infectious Diseases" in Daniel's Texas Medical Journal, and in 1890 he read a paper at the Texas State Medical Association entitled "An Explanation of the Phenomena of Immunity and Contagion, Based Upon the Action of Physical and Biological Laws."

In connection with the latter paper he said: "I found it impossible to intelligently and fully include a subject so complex and noved within the compass of a society essay, consequently the paper was seriously crippled by its brevity. Notwithstanding this defect, it received from some of the leading medical journals of this country very favorable notices, and the complete article was translated into a foreign language and published in a foreign medical journal.

"The encouragement I received from such favorable notice induced me to be more fully elaborate, and again publish an article on this subject. This I did during the last year in serial numbers of the Texas Sanitarium." These articles, corrected and enriched with new matter bearing upon this subject, compose the volume entitled "Fermentation, Infection and Immunity," published in 1892.

In addition to the above, I beg to mention several of his most important minor publications, as follows:

"The Advantage and Use of the Microscope to the General Practioner in Diagnosis and Therapy." Read before the State Medical Association, April, 1904.

"Gastro-Intestinal Condition in Epilepsy." Reprinted from the Medical News, (New York), April 15, 1905.

"The Modern Diagnostic Method in Cancer of the Stomach." Read before the State Medical Association, April 1906.

"Personal Observations in Latent Malaria." Read before the Twelfth District Medical Society, January, 1908.

"A Catalytic Theory of Infection and Immunity." Reprinted from the Medical Record, May 1, 1909.

"Critical Remarks on Ehrlich's Side Chain Theory of Immunity." Presidential address of the Texas Academy of Science, October, 1909.

It may be of special interest to this company who knew J. W. Mclaughlin personally, if I digress at this point to read from a letter written upon his death bed, probably the last manuscript he ever published.

There had been some correspondence between him and Arthur Lefevre upon certain points in his catalytic theory of immunization.

Lefevre at length pointed out that it would furnish definite corroboration both of the identification of catalysis with the free energy of surfaces and of the catalytic theory of immunizations, if both concurred to explain why, when the specific substrate for a pathegen was destroyed, that particular isomer of albumin did not form again in the blood serum.

The Doctor's answer comprises a succinct restatement of the salient point of both theories and gives the desired explanation, causing all to appear as a consistent and strongly warranted hypothesis for a rational comprehension of the processes of nutrition and pathogenic reactions:

"It is taught that all forms of kinetic energy of matter are developed from the heat energy of its molecules. This view has failed to explain the nature of chemical energy, of catalytic energy, of therapeutic energy, of the energy of pathogens, enzymes, and toxins. My theory takes a different view of the source and nature of kinetic energy. I claim to show that the energy of a molecule is an exact representation of its chemical and physical structure. This is the pivotal point of argument. What follows are corollaries, legitimate, if not inevitable conclusions deduced from this predicate. Taking up the text book description of molecular structure, i. e., its contained atoms, spatially placed, and moving in periods which characterize each kind of atom, I go further and assume that the moving atoms in the molecule produce intermolecular waves in the ether, which accurately correspond to the atomic motions. These waves are necessarily discordant, but under the operation of the law of interference, they become adjusted, so that crests and troughs correspond. I think it quite reasonable to assume that waves of this kind, falling millions of times a second, are waves of energy. Now the factors which produce such molecular waves are the number and kind of atoms a molecule contains, and the spatial arrangement of the atoms (Stereo-Chemical Configuration of the molecule) and since the chemical and physical structure of molecules are very different, the forms of energy they possess differ correspondingly. Such molcules have necessarily specific affinities, since they will re-act with other molecules, but only those whose waves they can influence, increase, retard, or destroy.

"In chemical reactions the atoms of the dissociated molecule recombine under atomic or chemical forces into other molecules, these combine into a mass according to molecular affinities; the crest of molecular waves of one side correspond to wave trough of the other side, the union which occurs will be in stable equilibrium, as the wave energies are mutually equalized. But the condition of the molecules of the surface of the mass is quite different from those of the interior, since their waves are not equalized, but remain free and active. I call this free energy of surfaces, catalytic energy. Its intensity is in direct proportion to the surface of the mass and in indirect proportion to mass itself. Colloids, colloidal platinum, etc., enzymes, pathogens, toxins, and albumins, all belong to the colloidal class and possess catalytic energy.

"Emil Fischer, in his experimental work with sugars, has clearly shown that the action of an enzyme is specific. Enzyme and substrate must bear a definite relation one to the other. Susceptibility of a substance to a ferment required not only a definite chemical structure, but a definite stereo-chemical configuration of molecules. Now, bearing in mind this specific relation, it may be seen that the non-immune organism must contain many substrates; and that these are either different tissues or one composed of many isomers. I have assumed that the albumins of the blood serum and tissue juices are made up of groups of homologous molecules that are isomers, that is, they are alike in chemical structure, but differ one group from the other in the spatial arrangement of their contained atoms. It is made clear by the behavior of a ferment—maltose toward the A. and B. series of glucosides that this feature of molecular structure changes the vulnerability of the substrate to organic catalyzer —say a pathogen. Each group of albumins in the blood serum will furnish a specific substrate which differs from others in vulnerability to microbic action. There is no absolute proof of the truth of this concept, but it is supported by the following evidence: There are important differences between immune and non-immune blood serum, the nature of which is not known—the blood serum of different species is not the same. This fact is used in medico-legal cases to determine the origin of blood—whether from a man or beast. The nature of these differences in sera is not known, but it is known that the serum of one species may be immunized against that of an alien species by small frequent inoculations. Just as it may be against a pathogen of toxin; the reaction brought about in the blood of the non-immune animal is definitely specific.

"The blood serum and other tissue juices furnish the pabulum from which all the tissues of the body receive nourishment for repair of waste and functional action, and it is inconceivable how tissues of such a heterogeneous character can each receive particular nourgishment from a homogenous pabulum, but when we regard metabolism as catalytic, the tissues being organic catalysts, and the blood serum as containing many isomers of albumin, a bright light is shed upon the obscure process of nutrition.

"You ask whether a substrate totally destroyed may be regenerated. I do not believe it can, since the destruction would involve the patterns or moulds by means of which new molecules are manufactured from the furnished products of food digested. Besides, recent investigations show that the substrate of an enzymic reaction is never totally destroyed; that the reacta are arrested by the end products (specific antibodies) before all the subtrate is hydrolized. This matter was not discussed in the paper you read, but is gone into a more recent paper (my address as President of the Texas Academy of Science). I there offer evidence in proof that the end products of an enzymic reaction, which arrests the process before it is completed, also changes the remaining substrate into isomers, and thus destroy its vulnerability to the pathogen. This process is called the 'convertability of enzymic reactions,' and I think it satisfactorily explains the cause of lasting immunity. I must refer to my address for details with regard to the effect on the organism that may result from total destruction of one of the many groups of Albumin isomers of the serum, I do not believe it would be serious, but don't know. As a matter of fact there appear to be many individuals and some races who are naturally immune to certain infections. Now, according to my hypothesis, natural immunity is largely due to absence of susceptible groups of substrates."

One of the most fruitful periods of Dr. McLaughlin's life was passed during the time he was Professor of the Practice of Medicine in the Medical Department of the University of Texas. I have received a long and appreciative letter from Dr. John T. Moore, who was his assistant during a large portion of that time, and from it I take the liberty of quoting freely, paraphrasing some parts of the letter in order not unduly to extend the time of this address.

On assuming the duties of the chair, Dr. McLaughlin saw at once the necessity of bringing the laboratory work of the students into closer connection with the teaching in the hospital wards. Previously the laboratory had been in a building at a distance from the hospital. Towards this great improvement in methods he labored earnestly and enthusiastically, but with his usual unselfish and modest methods. For a time he and his assistant fitted up a room in the basement of the hospital, with simple apparatus, at their own expense, and it was only after bearing this burden for some years that the Regents of the University were able to provide funds for the equipment of a satisfactory laboratory. Dr. McLaughlin's method of securing this appropriation was characteristic of the man. He induced the Regents, during one of their meetings at Galveston, to visit his little laboratory, which seemed little more than a small room with a few inconspicuous instruments. After their entrance, the doctor began to explain the advantages of a modern laboratory, but soon one of the Regents interrupted him and asked to be shown this laboratory. Then the doctor, in his gentle way, said: "Gentlemen, you are now in the clinical laboratory of the University, and you behold all of our splendid equipment." The appropriation was forthcoming at once.

Dr. McLaughlin probably deserved the credit of having introduced the recitation method in the teaching of the medical department of the University of Texas. This is the method in operation at Harvard, Johns Hopkins and some other of the larger schools. He was very successful in employing it, and was regarded as one of the most inspiring teachers by his students, and by them was greatly beloved. Many of the best young doctors in Texas today look back with gratitude to J. W. McLaughlin for his helpful and inspiring teaching and for his sympathy, kindness and help as a man.

He was also distinguished for the consideration shown his patients who served as subjects for clinical instruction in the hospital under his charge. Though they were entirely at his disposal, his treatment of them was so kind and generous that they failed to realize that they were being used merely as instruments for helping others without consideration of their own unfortunate state.

Dr. McLaughlin was a fine example of the professor of the old school, thoroughly in love with his subject, anxious to teach it by the best methods, full of kindly interest in his students and of a broad, gentle consideration for those with whom he came in contact in his work.

As a practicing physician, J. W. McLaughlin's specialty was diagnostics. No field could have been better suited to his genius. His vivid conception of the vital organism as a whole and in all its functions, his acute and balanced judgment and his wonderful intuitive grasp of a situation, both in its entirety and its complex relations, placed him as a diagnostician in the class of Osler and Janeway. I believe that all brother practitioners who have called him in consultation will agree in this estimate of McLaughlin's pre-eminent ability as a diagnostician. But it was in his general practice as a family physician that the full greatness of the man best appeared. Although a modern of moderns in scientific progress, in his professional attitude, he was a doctor of the best old style, who not only diagnosed and prescribed remedial agencies for members of the families under his care, but who inevitably became the confidential adviser of the family in all its vitally important affairs. Hundreds of families today mourn him as their lost guide, counsellor and friend, whose great-hearted sympathy and ripe wisdom were ever at their service, not only for cure of bodily sickness, but for their protection and help in all the issues of life.

I am now brought to the last and highest point of view in considering the place and worth of any man. I have spoken of J. W. McLaughlin as a soldier, as a scientist and as a doctor; it remains to speak of him as a man. But at this point, especially do I feel not merely my own oratorical weakness, but the absolute inadequacy of the words to describe a truly magnanimous man.

Personal affection and bereavement also here tongue-tie me. I can only bear witness that J. W. McLaughlin was a true man, perfect in all the "weightier matters" of character, justice, mercy and truth. One of the sincerest, truest and most modest of men, he was free from every tinge of vanity or other petty feeling. I never saw a man who thought so little about himself or his own concerns. His temper was imperturbably good, with the most winning and courteous manners; yet as I have seen, he could be aroused by any bad action to the warmest indignation and prompt measures. No one could be admitted to intimacy with him without enlarging ideals of courage and generosity—of all that we mean by manhood. Never did he show more nobly than as I saw him day by day through the last months when relentless disease had prostrated even his enormous strength. Physical pain and weakness, however, could not impair his thoughtfulness for others and perfect courtesy, or abate his interest in the scientific problems upon which his thoughts and conversation dwelt to the very end:

"For he preserved from chance control
The fortress of his 'stablished soul,
In all things sought to see the whole,
  Brooked no disguise,
And set his heart upon the goal,
  Not on the prize."

His diligence and patient zeal in the search for the truth could not be more touchingly illustrated than by an episode of the last week of his sickness. We had a mutual friend well qualified to discuss the scientific questions in which Dr. McLaughlin was most interested. Several letters dealing with certain points of such discussion had passed between them. Finally about six weeks before his death, McLaughlin penciled with his own hand, as he lay on his bed of suffering, fourteen closely written pages, which he gave me to mail to our friend. (The Doctor's letter I have already read to you.)

I take the liberty of quoting the concluding paragraph of the letter to Dr. McLaughlin, sent in response to that paper. After highly appreciative remarks upon the Doctor's statements from a scientific point of view, the writer said:

"But, dear Dr. McLaughlin, it is the fact that you should have taken the trouble to write and send the exposition to me which moves me to an admiration of your generosity, and to a warmth of response to the friendship with which you honor me that could not be described in words. It is with especially poignant sorrow, therefore, that I have heard of the severity of your sickness. I hope it is only a passing attack; but in any case there is naught to say to a man of your magnanimity except the unvoiced meaning of a hand-clasp offered by one who loves and honors you. Our intercourse has been limited, but I have always had the sense to recognize a great mind and noble heart whenever the commanding vision of that rare existence has been vouchsafed me. You are one of a very few men whom to have known in the noble mystery of friendship's election I count the best element in my own being, and the ground for an otherwise dubious hope of some worthiness in myself."

As through those long days of sickness, I had no way of expressing my sorrow for our approaching separation and my admiration for his great mind and noble heart, except by the "unvoiced meaning of a hand clasp," so now it seems to me that for those who knew him words are superfluous, and for those who knew him not, it is too late.

On the other hand, there is a truth in the poet's exclamation:

> "The living do not rule this world. Ah, no!
> It is the dead—the dead."

For the good and great do leave an abiding influence, if those who saw and knew pass the vision onward.

So I have stood here before you, not to stammer an eulogy in empty words, but to pay my tribute of loyalty to a great man and to his ideals, for

> "There are deeds that should not pass away,
> And names that must not wither."

PROCEEDINGS

OF

THE TEXAS ACADEMY OF SCIENCE

FOR

1908-09 and 1909-10.

THE TEXAS ACADEMY OF SCIENCE.

Organized January 9, 1892.

OFFICERS FOR 1908-1909.

PRESIDENT, DR. EUGENE P. SCHOCH, Austin
VICE-PRESIDENT, DR. GEORGE S. FRAPS, College Station.
TREASURER, MR. R. A. THOMPSON, Austin.
SECRETARY, DR. FREDERIC W. SIMONDS, Austin.
LIBRARIAN, MR. P. L. WINDSOR, Austin.

Other Members of the Council.

HON. A. E. WILKINSON, Austin.
DR. HOMER HILL, Austin.
PROFESSOR O. C. CHARLTON, Bryan.

Past Presidents.

DR. EDGAR EVERHART, Atlanta, Ga.
MR. E. T. DUMBLE, Houston.
DR. GEORGE BRUCE HALSTEAD, Greeley, Colo.
PROF. T. U. TAYLOR, Austin.
DR. FREDERIC W. SIMONDS, Austin.
DR. HENRY WINSTON HARPER, Austin.
PROFESSOR J. C. NAGLE, College Station.
MR. ROBERT A. THOMPSON, Wichita Falls.
DR. EDMUND MONTGOMERY, Hempstead.
DR. M. B. PORTER, Austin.
DR. THOMAS MONTGOMERY, JR., Philadelphia, Pa.
DR. S. E. MEZES, Austin.
DR. JAMES E. THOMPSON, Galveston.

Publication Committee.

DR. E. P. SCHOCH. MR. R. A. THOMPSON. DR. F. W. SIMONDS.

PAPERS PRESENTED AT THE REGULAR MEETINGS.

January 24, 1908.

"Landscape Architecture and Civic Improvement," an illustrated lecture, Mr. Howard E. Weed, Chicago, Ill.

February 21, 1909.

"Lord Monbodda, a Precursor of Darwin," Miss May Jarvis, B. A., Tutor in Zoology, University of Texas, Austin.

"Notes on City Surveying," Dean T. U. Taylor, Department of Engineering, University of Texas.

"Lord Kelvin," Dr. William T. Mather, Professor of Physics, University of Texas.

March 13, 1908.

"A New Theory of Ferments and Their Action," Dr. J. W. McLaughlin, former Professor of Medicine, University of Texas, Austin.

April 11, 1908.

"Soil, Fertility and Phosphoric Acid, Dr. George S. Fraps, State Chemist, College Station.

May 8, 1908.

"The Law of the Fall of Rivers and the Value of the Deduced Curve in River Improvements," Mr. F. Oppikofer, U. S. Engineer, Tarpon.

"On Apioidal Stars," a lecture, Dr. H. Y. Benedict, Professor of Applied Mathematics, University of Texas.

June 8, 1908—Formal Meeting.

"Some Figures on the Cost of Freight and Passenger Train Service" (by title), Mr. R. A. Thompson, Chief Engineer, State Railroad Commission, Austin.

November 13, 1908.

"The Problem of the Rusting of Iron and Its Economic Prevention,'' Inaugural Address by the President, Dr. Eugene P. Schoch, University of Texas, Austin.

December 12, 1908.

''Plantae Lindheimerianae, Part III,'' a review, Harlan H. York, M. A., Instructor in Botany, University of Texas.

''The Electrostatic Effect of a Changing Magnetic Field,'' J. M. Kuehne, M. S., Instructor in Physics, University of Texas.

''An Experimental Study of the Grey Squirrel,'' Dr. C. S. Yoakum, Instructor in Philosophy, University of Texas.

THE TEXAS ACADEMY OF SCIENCE.

Organized January 9, 1892.

OFFICERS FOR 1909-1910.

President, Dr. James W. McLaughlin, Sr.,* Austin.
Vice-President, Dr. James R. Bailey,** Austin.
Treasurer, Professor Edwin C. H. Bantel, Austin.
Secretary, Dr. Frederic W. Simonds, Austin.
Librarian, Mr. P. L. Windsor,*** Austin.

Other Members of the Council.

Dr. Homer B. Hill, Austin.
Dr. W. T. Mather, Austin.
Dr. H. H. Newman, Austin.

Past Presidents.

Dr. Edgar Everhart, Atlanta, Ga.
Mr. E. T. Dumble, Houston.
Dr. George Bruce Halstead, Greeley, Colo.
Professor T. U. Taylor, Austin.
Dr. Frederic W. Simonds, Austin.
Dr. Henry Winston Harper, Austin.
Professor J. C. Nagle, College Station.
Mr. Robert A. Thompson, Wichita Falls.
Dr. Edmund Montgomery, Hempstead.
Dr. M. B. Porter, Austin.
Dr. Thomas Montgomery, Jr., Philadelphia, Pa.
Dr. S. E. Mezes, Austin.
Dr. James E. Thompson, Galveston.
Dr. Eugene P. Schoch, Austin.

Publication Committee.

Dr. E. P. Schoch, Prof. E. C. H. Bantel, Dr. F. W. Simonds.

*Died November 12, 1909. Succeeded by Dr. W. S. Sutton.
**Resigned. Succeeded by Dr. O. M. Ball, College Station.
***Removed from Austin. Succeeded by Mr. N. L. Goodrich, Austin.

The Fellows and Members of the Texas Academy of Science desire to place on record the regret they feel at the death of their beloved President, the late Dr. J. W. McLaughlin, and their deep sense of the value of his service to the Academy, to Science and to his fellow men.

As a man he was the embodiment of all that was pure, noble and true; as a soldier he was intrepid, courageous and patriotic; as a husband and father he was indulgent, kind and loving; as a physician he was profound in the knowledge of medicine, gifted as a diagnostician, able, thorough and successful in practice; as an investigator he was earnest, patient and persistent; as a teacher he was inspiring; and as a friend he was loyal to the end. Great is our loss, and sincere is our grief.

H. W. HARPER.
E. P. SCHOCH.
H. L. HILGARTNER.

PAPERS PRESENTED AT REGULAR MEETINGS.

January 8, 1909.

"A Striking Example of the Struggle for Existence," and "Verification of the So-Called 'Fossil Rain Marks'," Dr. Frederic W. Simonds, Professor of Geology in the University of Texas.

"The Organization of the Railroad Commission of Texas, and Its Fight for Existence," Charles S. Potts, Adjunct Professor of Law and Government in the University of Texas.

January 29, 1909.

"The Problem of an International Language," Professor B. Mackenzen, San Antonio, Texas.

February 19, 1909.

"The Distribution and Origin of the Salt and Saline Waters in the Costal Plain Sediment of Texas," Alexander Deussen, M. S., Instructor in Geology in the University of Texas and Member of the U. S. Geological Survey.

March 19, 1909.

"The Catalytic Theory of Infection and Immunity, Dr. James W. McLaughlin, Sr., Austin.

April 16, 1909.

"Notes on the Structure and Relationship of the Devil's Cigar (*Urnula geaster*)," Dr. Frederick D. Heald, Professor of Botany, and Mr. Frederick A. Wolf, Tutor in Botany, University of Texas.

"The Process of Heredity as Exhibited in Fish Hybrids," Dr. H. H. Newman, Professor of Zoology, University of Texas.

April 30, 1909.

"Symptoms of Disease in Plants," Dr. Frederick D. Heald, Professor of Botany, University of Texas.

May 28, 1909.

"The Influence of Science on German Literature," Dr. Sylvester

Primer, Associate Professor of Germanic Languages, University of Texas.

June 7, 1909.—Formal Meeting.

Counting of ballots and announcement of officers elected for the year 1909-1910.

October 28, 1910.

"Critical Remarks on Ehrlich's Side-Chain Theory of Immunity," Inaugural Address by the President, Dr. James W. McLaughlin, Sr.,* read by Dr. H. L. Hilgartner, Austin.

December 22, 1910.—Meeting of the Council.

At a meeting of the Council held this day, William S. Sutton, LL. D., Dean of the Department of Education, University of Texas, was elected President, to fill the unexpired term of the late Dr. J. W. McLaughlin, Sr. The resignation of Dr. James R. Bailey, as Vice-President, having been accepted, Professor O. M. Ball, of the Agricultural and Mechanical College, was elected his successor. At this meeting the resignation of Mr. P. L. Windsor, Librarian, was also accepted, and Mr. N. L. Goodrich, Librarian of the University, elected to fill the vacancy.

*Dr. McLaughlin was unable to attend this meeting owing to serious illness, which terminated fatally, November 13.

REPORT OF LIBRARIAN.

The Library of the Academy, given to the University of Texas Library on certain conditions, has been cared for as well as lack of proper space and time would permit. The exchanges received have been filed, and bound whenever the binding of the set had been already begun. The following sets have been taken from the files and bound, and efforts made to complete them when necessary:

American Philosophical Society, Proceedings, Vols. 30-45.

Royal Society of Edinburgh, Proceedings, Vols. 18-28.

Cambridge Philosophical Society, Proceedings, 4 Vols.

Circolo Matematico di Palermo, Rendiconti, Vols. 1-26.

In addition, 115 volumes of United States Government publications were bound, mainly the bulletins and circulars of the various bureaus of the Department of Agriculture. These were made up by combining the unbound files belonging to the Academy and the University Library.

Requests for numbers of the Transactions to complete the files of other institutions have been met as far as possible. The Librarian will be glad to obtain early numbers of the Transactions, particularly volume 1, in order that complete files may be sent to new exchanges.

A list of the institutions entertaining exchange relations with the Academy is appended to this report.

Respectfully submitted,

N. L. Goodrich, Librarian.

INSTITUTIONS TO WHICH THE TRANSACTIONS ARE SENT IN EXCHANGE.

EUROPE.

AUSTRIA.

Wien—Kaiserl. Akademie der Wissenschaften; K. K. Geologische Reichsanstalt.

BELGIUM.

Bruxelles—Academie Royale des Sciences, des Lettres et des Beaux-Arts.
Liege—Societe Royale des Sciences.
Uccle—Observatoire Royal de Belgique.

BOHEMIA.

Prague—Kon, Böhm. Gesellschaft der Wissenchaften.

ENGLAND.

Cambridge—Cambridge Philosophoical Society.
London—British Museum Library; The Royal Society; Royal Geographical Society; South London Entomological and Natural History Society.
Manchester—Manchester Literary and Philosophical Society.

FRANCE.

Marseille.—La Faculte des Sciences de Marseille.
Paris.—Bibliotheque Nationale; Bibliotheque du Museum d'Histoire Naturelle.
Toulouse.—Academe des Science, Inscription et Belles-lettres; Université de Toulouse, Biblothêque.

GERMANY.

Berlin.—Berliner Anthropologische Gesellschaft; Zeit. f. Wiss. Insektenbiologie.
Giessen.—Oberhessische Gesellschaft fur Natur- und Heilkunde.
Halle.—Naturforschende Gesellschaft.
Kiel.—Der Naturwissenschaftliche Verin.
Leipzig.—Die Naturforschende Gesellschaft.
Rostock.—Verein dêr Freunde der Naturgeschichte in Mecklenburg.

HUNGARY.

Budapest.—Magyar Tudomânyos Akadēmia.

IRELAND.

Belfast.—Natural History and Philosophical Society.
Dublin.—Royal Dublin Society; Royal Irish Academy.

ITALY.

Livorno.—L'Associatione "Mathesis."
Palermo.—Circola Matematico.
Pisa.—Società Toscana di Scienze Naturali.
Portici.—R. Scuola Superiore d'Agricoltura. (Laboratorio di zool. generale e agraria).
Torino.—Reale accademia delle scienze; Rivista di Matematica.

NETHERLANDS.

Haarlem.—La Société Hollandaise des Sciences.

PORTUGAL.

Lisbon.—Academia Real Sciencias; Real Observatorio de Lisboa.
Porto.—Academia Polytechnica do Porto.

RUSSIA.

Helsingfors.—Finskoie Uchonoie Obshchestvo.
Kazan.—Physico-Mathematical Society.
St. Petersburg.—Imper. Akademia Nauk.

SCOTLAND.

Edinburgh.—Royal Society.
Glasgow.—The Philosophical Society of Glasgow.

SWEDEN.

Göteborg.—Kongliga Vetenskaps och Vitterhets Samhälle.
Stockholm.—Kongliga Svenska Vetenskaps Adamemien.
Upsala.—Universitet Mineralogisk-Geologisk Institutionen.

SWITZERLAND.

Bern.—Naturforschende Gesellschaft.
Zurich.—Naturforschende Gessellschaft.

ASIA.

JAPAN.

Sapporo.—Sapporo Natural History Society.
Tokyo.—Tokyo Mathematico-Physical Society; Zoological Society of Tokio.

INDIA.

Calcutta.—Indian Museum.

AFRICA.

CAPE COLONY.

Cape Town.—South African Philosophical Society.

NORTH AMERICA.

CANADA.

Halifax.—The Nova Scotia Institute of Science.
Montreal.—The Natural History Society.
St. Johns.—The Natural History Society of New Brunswick.
Toronto.—The Canadian Institute; The University of Toronto, Library.

MEXICO.

Mexico City.—Comission de Parasitologia; Institute Geologico de Mexico; Sociedad Mexicana de Geografia y Estadistica; Societe Scientifique, "Antonio Alzate."
Tacubaya.—Comision Geodesica Mejicana; Observatorio Astronomico Nacional.

UNITED STATES.

CALIFORNIA.

Berkeley.—University of California Library. Exchange Dept.
Los Angeles.—Los Angeles Public Library.
San Francisco.—California Academy of Science.

COLORADO.

Colorado Springs.—Colorado College Scientific Society.
Denver.—Colorado Scientific Society.

CONNECTICUT.

New Haven.—Yale University Library.

DISTRICT OF COLUMBIA.

Washington.—Library of Congress; Smithsonian Institution; U. S. Dept- of Agriculture Library; U. S. Geological Survey Library; Washington Academy of Sciences.

ILLINOIS.

Chicago.—Chicago Academy of Sciences; Field Columbian Museum; John Crerar Library.
Urbana.—Illinois State Laboratory of Natural History.

INDIANA.

Indianapolis.—Indiana Academy of Science; Indiana Department of Geology and Natural Resources.

IOWA.

Davenport.—Davenport Academy of Sciences.
Des Monies.—Iowa Academy of Science.

KANSAS.

Lawrence.—Kansas University Library.
Topeka.—Kansas Academy of Science.

MAINE.

Portland.—Portland Society of Natural History.

MARYLAND.

Baltimore.—Johns Hopkins Hospital; Johns Hopkins University Library.

MASSACHUSETTS.

Boston.—American Academy of Arts and Sciences; Boston Public Library; Boston Society of Natural History.
Cambridge.—Harvard University Library.
Salem.—Essex Institute.
Melrose.—Boston Mycological Club.

MICHIGAN.

Ann Arbor.—Michigan University Library.

MINNESOTA.

Minneapolis.—Minnesota Academy of Natural Science; Minnesota Geological Survey.

MISSOURI.

Jefferson City.—Missouri State Geological Survey.
St. Louis.—Missouri Botanical Garden; St. Louis Academy of Science.

NEBRASKA.

Lincoln. Nebraska Academy of Sciences.

NEW YORK.

Brooklyn.—Brooklyn Conchological Club; N. Y. Entomological Society.
Buffalo.—Buffalo Society of Natural History.
Ithaca.—Cornell University Library.
New York City.—American Museum of Natural History; Columbia University Library; New York Academy of Sciences; New York Botanical Garden; New York Entomological Society.
Rochester.—Rochester Academy of Science.

OHIO.

Cincinnati.—Lloyd Library of Botany, etc.
Oberlin.—Oberlin College Library.
Granville.—Denison Scientific Association.

PENNSYLVANIA.

Philadelphia.—American Philosophical Society; Franklin Institute; Pennsylvania University. Exchange Bureau.
Pittsburg.—Carnegie Library; Carnegie Museum.

TENNESSEE.

Nashville.—Tennessee University Library.

TEXAS.

Austin.—Texas State Historical Association; Texas State Library.
Brownwood.—Carnegie Library.
Cleburne.—Carnegie Library.
College Station.—A. and M. College, Library; Agricultural Experiment Station.
Corsicana.—Carnegie Library.
Dallas.—Carnegie Library.
Denton.—College of Industrial Arts, Library.
El Paso.—Carnegie Library.
Fort Worth.—Carnegie Library; Texas Christian University.
Galveston.—Rosenberg Library.
Georgetown.—Southwestern University Library.
Houston.—Carnegie Library.
Lockhart.—Clark Library.
San Antonio.—Carnegie Library; Scientific Society of San Antonio.
Temple.—Carnegie Library.
Terrell.—Carnegie Library.
Tyler.—Carnegie Library.
Waco.—Baylor University Library; Carnegie Library.
Waxahachie.—Sims Library.

VIRGINIA.

Charlottsville.—Virginia University Library.

WISCONSIN.

Madison.—Wisconsin Academy of Sciences, Arts and Letters; Wisconsin Geological and Natural History Survey; Wisconsin University Library.
Milwaukee.—Public Museum of the City of Milwaukee; Wisconsin Natural History Society.

SOUTH AMERICA.

ARGENTINA.

Buenos Aires.—Deutsche Akademische vereinigung; Museo nacional de historia Natural.
La Plata.—Universidad Nacional, Biblioteca.

BRAZIL.

Rio de Janeiro.—Museu Nacional de Rio de Janeiro.

CHILE.

Santiago.—Biblioteca Nacional.

URUGUAY.

Montevideo.—Museo Nacional.

AUSTRALIA.

QUEENSLAND.

Brisbane.—Royal Society of Queensland.

VICTORIA.

Melbourne.—Royal Society of Victoria.

REPORT OF TREASURER, 1908-1909.

Receipts.

June 9, 1908—To Balance on hand June 9, 1909..........	$ 109.14
Dec. 31, 1908—Fees and Dues June 9 to Dec. 31, 1909....	102.45
Oct. 9, 1908—From F. Oppikofer, 100 reprints Vol. X....	.55
Nov. 3, 1908—From R. A. Thompson, 150 reprints Vol. X..	6.05
Nov. 6, 1908—From Dr. G. S. Fraps, 150 reprints Vol. X..	4.25
Nov. 21, 1908—From Dr. J. E. Thompson, 150 reprints, Vol. X	12.20

Disbursements.

June 13, 1908—To stamps for Treasurer................$	1.00	
Aug. 24, 1908—Express on Thompson and Udden Plates..	.60	
Aug. 24, 1908—Stamps for President Schoch............	2.00	
Sept. 8, 1908—Express, return of plates................	1.00	
Sept. 9, 1908—Barnes Crosby Co., for plates............	15.90	
Oct. 31, 1908—Austin Printing Co. for ballots..........	6.75	
Nov. 4, 1908—Stamps for mailing Transactions by Secy..	4.00	
Nov. 10, 1908—Von Boeckmann-Jones Co., part payment on account, printing Vol. X.........................	100.00	
Nov. 12th, 1908—Stamps for Treasurer.................	4.00	
Dec. 26, 1908—500 envelopes for Treasurer............	1.75	
Dec. 26, 1908—Von Boeckmann-Jones Co., bal. acct. Vol.X	47.00	
Dec. 31, 1908—Express on books, by Dr. Simonds........	1.25	
Dec. 31, 1908—Cash balance on hand...................	49.39	
	$ 234.64	$ 234.64

(Signed) R. A. THOMPSON, Treasurer.
Resigned Dec. 31, 1908.

Receipts.

Jan. 1, 1909—Received of R. A. Thompson.............	$ 49.39
Mar. 27, 1909—From Miss May Jarvis for 30 reprints Vol. X	3.30
June 8, 1909—From fees and dues, Jan. 1 to June 8....	88.00

Disbursements.

Feb. 2, 1909—To E. P. Schoch, President, for stamps....$	2.00	
Feb. 6, 1909—To stamps for Treasurer................	2.00	
Feb. 16, 1909—To Austin Printing Co., cards and programs	5.50	
Mar. 15, 1909—To President E. P. Schoch, stamps and letters	1.50	
Apr. 9, 1909—To Austin Printing Co., invitations.......	3.00	
Apr. 9, 1909—To President E. P. Schoch, stamps.......	3.00	
May 10, 1909—To C. M. Miller, for cloth sign..........	1.50	
June 7, 1909—To President E. P. Schoch, stamps......	2.00	
June 8, 1909—Cash balance on hand..................	120.19	
	$ 140.69	$ 140.69

(Signed) E. C. H. BANTEL, Treasurer.

REPORT OF TREASURER, 1909-1910.

Receipts.

June 8, 1909—Cash balance on hand..................		$ 120.19
June 14, 1910—By fees and dues for session 1909-1910..		96.00

Disbursements.

Oct. 25, 1909—To E. P. Schoch for stamps..............	$ 3.50	
Nov. 22, 1909—To express on books for Academy's Library, by Dr. Simonds............................	1.00	
Jan. 8, 1910—To C. M. Miller, for cloth sign...........	.75	
Jan. 8, 1910—To Austin Printing Co., printing.........	11.05	
Jan. 8, 1910—To stamps for Treasurer.................	4.00	
Jan. 10, 1910—Express on books from Wisconsin Academy of Science..................................	.70	
Apr. 1, 1910—To Von Boeckmann-Jones Co., Printing postals	3.30	
May 17, 1910—To Von Boeckmann-Jones Co., for printing	7.80	
June 14, 1910—To cash balance on hand...............	184.09	
	$ 216.19	$ 216.19

(Signed) E. C. H. BANTEL, Treasurer.

CONSTITUTION OF THE TEXAS ACADEMY OF SCIENCE (AS AMENDED JUNE 12, 1899, JUNE 10, 1901, AND DECEMBER 27, 1901).

ARTICLE I.—NAME.

SECTION 1. This Association shall be called "THE TEXAS ACADEMY OF SCIENCE."

ARTICLE II.—OBJECTS.

SECTION 1. The objects of the Academy are: To advance the natural and exact sciences, both by research and discussion; to promote intercourse between those who are cultivating science in different parts of the State; and especially to investigate and report on any subject of science or industrial art, when called upon by any department of the State government.

ARTICLE III.—MEMBERSHIP.

SECTION 1. The Academy shall consist of Members, Fellows and Patrons.

SEC. 2. In order to become a member, the applicant must be recommended in writing by two Members or Fellows, approved by the Council, and elected by ballot of the Society. In order to be elected, two-thirds of the ballots must be affirmative.

SEC. 3. Fellows shall be elected by the Council from such of the Members as are professionally engaged in science, or have in any way advanced or promoted science.

SEC. 4. Anyone who contributes to the funds of the Academy the sum of five hundred dollars shall be classed as a Patron.

ARTICLE IV.—OFFICERS.

SECTION 1. The officers of the Academy shall consist of a President, a Vice-President, an Honorary Secretary, a Treasurer, and a Librarian. They shall be elected from the Fellows by a ballot of the Academy at the June meeting of each year.

SEC. 2. The officers of the Academy, together with the Past Presidents and three Fellows, to be elected by the Academy at the June session in each year, shall constitute a Council for the transaction of such business as may be assigned to them by the Constitution and By-Laws of the Academy.

SEC. 3. The President of the Academy, or, in case of his absence, the Vice-President, shall preside at the meetings of the Academy and of the Council; shall nominate all committees except such as are otherwise specially provided for; shall refer investigations required by the State government to members especially conversant with the subject, and report to the Academy at its next formal meeting; and, with the Council, shall direct the general business of the Academy.

SEC. 4. The Honorary Secretary shall conduct the correspondence, advise with the President and Council in cases of doubt, and make a report at the formal meeting in June of each year.

It shall be the duty of the Secretary to give notice to the members of the place and time of all meetings, of all nominations for membership, and of all proposed amendments to the Constitution.

The minutes of each meeting shall be duly engrossed before the next meeting, under the direction of the Secretary.

SEC. 5. The Treasurer shall attend to all receipts and disbursements of the Academy, giving such bond and furnishing such vouchers as the Council may require. He shall collect all dues from the members, and keep a set of books showing a full account of receipts and disbursements. He shall present a general report at the June session of each year.

ARTICLE V.—MEETINGS.

SECTION 1. There shall be two formal meetings of the Academy each year, one of which shall be held in June, at Austin, and the other within Christmas week, at any place selected by the Council.

SEC. 2. The ordinary meetings of the Academy shall be at Austin during the months of October, November, January, February, March, April, and May, the place and dates to be fixed by the Council.

SEC. 3. The meetings of the Local Sections may be provided for in the "rules for their government."

ARTICLE VI.—PAPERS.

SECTION 1. Intimation of the business of each meeting shall be given to each member by means of a printed card.

SEC. 2. No title of a paper can appear on the card before the paper itself, or an abstract of it, has been approved by the Council or the Secretary.

SEC. 3. The Academy may provide for the publication, under the direction of the Council, of proceedings, memoirs, and reports.

SEC. 4. The advice of the Academy shall be at all times at the disposal of the State government upon any matter of science or art within its scope.

ARTICLE VII.—ASSESSMENTS.

SECTION 1. The admission fee for a Member shall be two dollars, and the admission fee for a Fellow five dollars, or an additional three dollars on promotion to Fellowship.

SEC. 2. The annual assessment shall be one dollar.

ARTICLE VIII.—ALTERATION OF THE CONSTITUTION.

SECTION 1. No part of this Constitution shall be amended or annulled, except after notice given at a formal meeting, and approval by two-thirds of those voting at the succeeding formal meeting.

ARTICLE IX.—LOCAL SECTIONS.

SECTION 1. Local Sections of the Academy may be established by the Council on receipt of a request to do so signed by ten members of the Academy in good standing residing in the territory within which the Local Section is desired.

SEC. 2. Such Sections shall appoint their own officers and committees, and may make any rules for their government not inconsistent with the Constitution and by-Laws of the Academy.

SEC. 3. The place of headquarters and definite territory selected by each Local section within which its membership must reside will be subject to the approval of the Council.

SEC. 4. Any Local Section may be dissolved by the Council for good and sufficient cause.

BY-LAWS.

CHAPTER 1.—MEMBERSHIP.

1. No person shall be accepted as a Member or Fellow unless he pays his initiation fee and the dues for the year within three months after notification of his election.

2. An arrearage in payment of annual dues shall deprive a Member or Fellow of taking part in the management of the Society and of receiving the publications of the Society. An arrearage for one year shall be construed as a notification of withdrawal.

CHAPTER 2.—ELECTION OF MEMBERS.

1. Nominations for membership may be made at any time in due form to the Honorary Secretary.

2. The form of the nomination of Members shall be as follows:

In accordance with his desire, we respectfully nominate for membership in the Texas Academy of Science—

Full name: ....

Address: ....

Degrees, if any: ....

Occupation: ....

Branch of science engaged in, work already done, and publications, if any:

....

Signed by two Members, or Fellows.

The Honorary Secretary will bring the nominations before the Council at its first meeting thereafter, and the Council will signify its approval or disapproval of each nomination.

The Honorary Secretary shall have lists or cards printed and sent to each Member, giving name of each nominee and such information as may be necssary for intelligent voting.

The Members and Fellows receiving the list will signify their approval or disapproval of each nominee, and return list to the Honorary Secretary. At the next meeting of the Council, the Honorary Secretary will present the lists and the Council will canvass the returns and declare the results at the next succeeding meeting of the Academy.

CHAPTER 3.—COMMITTEE ON PUBLICATION.

The Council shall appoint a Committee on Publication, consisting of three members, of which the Honorary Secretary shall be chairman ex officio, who shall decide upon the value of articles submitted to them for publication, and in case of doubt be authorized to call upon any member of the Society who is specially familiar with the branch of science treated of for assistance in such determination.

If the paper is accepted, the author must deposit with the Honoary Secretary a sufficient sum to defray publication charges, at a rate not exceeding $2.00 per octavo page, and pay for all cuts or illustrations.

(At present the Academy bears a part of the expenses of publication.)

CHAPTER 4.—ORDER OF BUSINESS.

1. Call to order by Presiding Officer.
2. Statements by President.
3. Report of Council.
4. Report of Treasurer.
5. Election of Officers.
6. Declaration of results of election of Officers.
7. Reports of Committees.
8. Announcements.
9. Unfinished Business.
10. New Business.

At the monthly meetings the order of business shall be:

1. Call to order by the President.
2. Statements by the President.
3. Presentation of memoirs, and discussion.
4. Report of Council.
5. Announcements.

CHAPTER 5.—ELECTION OF OFFICERS AND OTHER MEMBERS OF THE COUNCIL.

(Added April 12, 1895.)

The Honorary Secretary shall send to each member a circular letter including a list of the Fellows, with a request to send in a ballot nominating each officer and other members of the Council. The ballot must be received by the Honorary Secretary by May 15. The Council will select two from the three nominees receiving the highest number of nominations for each position, and prepare a ballot to be sent to each member of the Academy, in time to permit his vote being received previous to the June meeting, at which time the votes will be counted.

CHAPTER 6.—PERMANENT MEMBERS.

(Added January 11, 1896.)

Any Member of the Academy may become a "Permanent Member" on payment of fifty dollars; all "Permanent Members" to be free from all subsequent assessments.

The money received from this source shall be invested as a permanent fund, the interest of which may be used towards paying for the printing of the transactions of the Academy or for such other purposes as the Council may determine.

CHAPTER 7.—PROXIES.

(Added October 3, 1899.)

A proxy may be used at a meeting of the Council only when necessary to constitute a quorum, and such proxy may be held only by a duly elected member of the Council.

LIST OF PATRONS, FELLOWS AND MEMBERS.

PATRONS.

Brackenridge, Geo. W., Member Board of Regents, University of Texas, San Antonio.

Halsted, Mrs. Geo. Bruce, Greeley, Colorado.

Total, 2.

FELLOWS.

Askew, H. G., Expert Statistician for Texas Railroads, Austin.

Bailey, Dr. Jas. R., Associate Professor of Chemistry, University of Texas, Austin.

Ball, Dr. O. M., Professor of Botany and Mycology, Agricultural and Mechanical College, College Station.

Bantel, Edw. C. H., Adjunct Professor of Civil Engineering, University of Texas, Austin.

Battle, Dr. W. J., Dean College of Arts and Professor of Greek, University of Texas, Austin.

Benedict, Dr. H. Y., Professor of Applied Mathematics, University of Texas, Austin.

Brown, Prof. J. S., Professor of Mathmatics, Southwest Texas Normal School, San Marcos.

Bruce, Dr. W. H., Principal North Texas State Normal School, Denton.

Callaway, Dr. Morgan, Jr., Professor of English, University of Texas, Austin.

Carter, Dr. W. S., Dean of Department of Medicine and Professor of Physiology, University of Texas, Galveston.

Charlton, Prof. O. C., Dallas High School, Dallas.

Curtis, Geo. W., Manager Oklahoma City Mill and Elevator Company, Oklahoma City, Okla.

Deussen, Alex., Instructor in Geology and Minerology, University of Texas, Austin.

Dohmen, Dr. Franz J., 7 Holland St., Cambridge, Mass.

Dumble, E. T., Consulting Geologist, Southern Pacific Company, Houston.

Ellis, Dr. A. Caswell, Professor of the Philosophy of Education, University of Texas, Austin.

Fraps, Dr. Geo. S., State Chemist, Agricultural and Mechanical College, College Station.

*Garrison, Dr. Geo. P., Professor of American History, University of Texas, Austin.

Halley, Prof. R. B., Professor of Science, Sam Houston Normal Institute, Huntsville.

Halsted, Dr. Geo. Bruce, Professor Mathematics, State Normal School, Greeley, Colorado.

Harper, Dr. W. H., Professor of Chemistry, University of Texas, Austin.

Harrington, Dr. H. H., Director Agricultural Experiment Stations, College Station.

Hartman, Carl, Professor Sam Houston Normal Institute, Huntsville.

Heald, Dr. F. D., Professor of Botany University of Texas, Austin.

Herff, Dr. Ferdinand, San Antonio.

Heusinger, E. W., San Antonio Scientific Society, San Antonio.

Hilgartner, Dr. H. L., Austin.
Hill, Dr. Homer B., Austin.
Hill, Dr. Robert T., Consulting Geologist, 25 Broad Street, New York City.
Houston, Dr. David F., Chancellor Washington University, St. Louis, Mo.
Howard, Dr. Wm. R., Professor of Medicine, Fort Worth University, Fort worth.
Jarvis, Miss May M., Tutor in Zoology, University of Texas, Austin.
Keasbey, Dr. L. M., Professor of Institutional History, University of Texas. Austin.
Keiller, Dr. Wm., Professor of Anatomy, University of Texas, Galveston.
Kuehne, Dr. J. M., Adjunct Professor of Physics, University of Texas, Austin.
Lefevre, Hon. Arthur, Superintendent of Public Schools, Dallas.
McClendon, Dr. J. F., Cornell University Medical School, New York City.
McDaniel, Dr. A. C., 119 Alamo Plaza, San Antonio.
McFarlane, Dr. Alexander, 307 Victoria Avenue, Chatham, Ontario, Canada.
Mackensen, Prof. B., Professor of Science, San Antonio High School, San Antonio.
Marshall, Miss Margaret E., 4423 Live Oak St., Dallas.
Mather, Dr. Wm. T., Professor of Physics, University of Texas, Austin.
*McLaughlin, Dr. J. W., Austin.
Mezes, Dr. Sidney E., President University of Texas, Austin.
Mitchell, J. D., Victoria.
Montgomery, Dr. Edmund, Hempstead.
Montgomery, Dr. Thos. H., Professor of Zoology, University of Pennsylvania, Philadelphia, Pennsylvania.
Nagle, Prof. Jas. C., Professor of Civil Engineering, Agricultural and Mechanical College, College Station.
Newman, Dr. H. H. Professor of Zoology, University of Texas, Austin.
**Paine, Dr. J. F. Y., Professor of Obstetrics and Genecology, University of Texas, Galveston.
Patterson, Dr. J. T., Instructor in Zoology, University of Texas, Austin.
Pearce, Prof. Jas. E., Principal High School, Austin.
Porter, Dr. Milton B., Professor of Mathematics, University of Texas, Austin.
Potts, C. S., Adjunct Professor of Government and Law, University of Texas, Austin.
Prather, Jno. K., Mining Engineer, El Paso (permanent address, Waco).
Primer, Dr. Sylvester, Associate Professor Germanic Languages, University of Texas, Austin.
Puryear, Prof. Chas., Professor of Mathematics, Agricultural and Mechanical College, College Station.
Rall, Dr. E. E., Instructor in Science and Art of Education, University of Texas, Austin.
Reichman, Dr. Fritz, Superintendent of Weights and Measures, State of New York. (Permanent, care W. and L. E. Gurley, Troy, New York.)
Rice, Prof. C. D., Adjunct Professor in Mathematics, University of Texas, Austin.
Romberg, A., University of Texas, Austin.
Rucker, Miss Augusta, Medical Department, Johns Hopkins University, Baltimore, Maryland.
Schoch, Dr. E. P., Associate Professor of Chemistry, University of Texas, Austin.

Simonds, Dr. F. W., Professor of Geology, University of Texas, Austin.
Smith, Dr. A. J. Professor of Pathology, University of Pennsylvania, Philadelphia, Pennsylvania.
Sutton, Dr. W. S., Professor of Science and Art of Education, University of Texas, Austin.
Taylor, Prof. Thos. U., Dean of Department and Professor of Civil Engineering, University of Texas, Austin.
Thompson, Dr. Jas. E., Professor of Surgery, University of Texas, Galveston.
Thompson, R. A., Chief Engineer Wichita Falls Lines, Wichita Falls.
Udden, Dr. J. A., Professor of Geology, Augustina College, Rock Island, Ill.
Wilkinson, Judge A. E., Reporter of Supreme Court of Texas, Austin.
Yoakum, Dr. Clarence S., Instructor in Philosophy, University of Texas, Austin.
York, H. H., Instructor in Botany, University of Texas, Austin.

Total, 73.

MEMBERS.

Anderson, A. E., Instructor in Chemistry, University of Chicago, Chicago, Ill.
Baker, Burke, Austin.
Baker, R. H., President Texas Central Railroad, Austin.
Bennett, Dr. T. J., Austin.
Birge, Miss Willie, University of Texas, Austin.
Blake, Prof. J. C., Professor of Chemistry, Agricultural and Mechanical College, College Station.
Bliem, Dr. M. J., San Antonio.
Breihan, E. W., Professor of Physical Sciences, High School, Austin.
Brooks, R. C., Engineer, Stone & Webster Properties, El Paso.
*Brown, R. L., Attorney at Law, Austin.
Calhoun, J. W., Instructor in Pure mathematics, University of Texas, Austin.
*Clark, Jas. B., Proctor and Secretary Board of Regents, University of Texas, Austin.
Clement, Prof. W. W., Principal Temple High School, Temple.
Cline, Dr. J. L., U. S., Weather Bureau Service, Corpus Christi.
Connerly, R. H., Clerk Court of Civil Appeals, Austin.
Corrigan, C. S., Asst. Engineer, G. C. & S. F., Galveston.
Decherd, Dr. Geo. M., Austin.
Decherd, Miss Mary E., Instructor in Mathematics, University of Texas, Austin.
Dodd, Dr. E. L., Instructor in Pure Mathematics, University of Texas, Austin.
Duggan, Dr. Malone, San Antonio.
Estill, Miss A. Julia, Teacher of Science, High School, Fredericksburg.
Evans, Major Ira H., Austin.
Giesecke, Prof. F. E., Professor of Drawing, Agricutlural and Mechanical College, College Station.
Glasscock, B. L., Chemist, American Carbon Company, Cleveland, Ohio.
Goeth, A. C., Austin.
Graham, J. W., Austin.
Graves, Dr. M. L. Professor of Medicine, University of Texas, Galveston.
Gregory, T. W., Attorney at Law, Austin.
Harper, Dr. W. A., Austin.

Hexter, J. K., Victoria.
Hill Clyde W., University of Texas, Austin.
Holliday, Dr. Margaret R., Physician; Lecturer on Education, University of Texas, Austin.
House, Col. E. M., Austin.
Houston, H. B., University of Texas, Austin.
Howard, E. E., Assistant Engineer, Waddell & Harrington, Bridge Engineers, Kansas City, Missouri.
Howe. J. M., Civil Engineer, Houston.
Hubbard, Prof. L. H., Principal Belton High School, Belton.
Hudson, Dr. S. E., Austin.
Hunnicutt, W. H. P., Draughtsman State General Land Office, Austin.
Jones, W. Goodrich, Temple.
Kahn, Samuel, Union Heat and Power Company, Fargo, N. D.
Koenig, A. G., University of Texas, Austin.
Leisewitz, Mrs. J. M., Matron Grace Hall, Austin.
Lemmon, Mark, Assistant in Geology, University of Texas, Austin.
Lewis, Dr. I. M., Instructor in Botany, University of Texas, Austin.
Lombardi, C., Vice President Dallas News, Dallas.
Lowber, Rev. Dr. J. W., Author and Lecturer, Austin.
Maxey, Jno. W., Civil Engineer, Houston.
McCallum, Prof. N. A., Superintendent Austin Public Schools, Austin.
McLaughlin, Dr. J. W., Jr., Austin.
McVea, J. C., Assistant Engineer, Houston & Texas Central Railroad Co., Ennis.
Metzenthin, W. E., Adjunct Professor of German, University of Texas, Austin.
Miller, Dr. E. T., Instructor in Economics, University of Texas, Austin.
Moore, Dr. Jno. T., Scanlon Building, Houston.
Morgan, Prof. J., Dallas.
Munson, Miss Eloise, Sherman.
Neville, W. R., Jr., Austin.
Oppikofer, F., U. S. Engineer, Department of Texas, Tarpon.
Ostrander, F. C., Instructor Romance Languages, University of Texas, Austin.
Pantermuehl, R. C., Teacher of Physics, Dallas High School, Dallas.
Reedy, J. H., Professor of Natural Science, Southwestern University, Georgetown.
Rosenberg, Louis, Assistant Engineer, S. W. Tel. & Tel. Co., Dallas.
Seltzer,, H. K., Engineer, Union Bridge and Construction Co., Kansas City, Missouri.
Smith, R. F., Associate Professor of Mathematics, Agricultural and Mechanical College, College Station, Texas.
Stanfield, S. W., Professor of Science, Southwest Texas Normal School, San Marcos.
Sykes, Miss Ethel, Galveston.
Thompson, Will C., University of Texas, Austin.
Warfield, Dr. Clarence, 602 Carordelet St., Los Angeles, California.
Wells, Dr. E. H., Professor of Natural Science, Baylor Female College, Belton.
Whitis, Miss Mary, Principal Whitis Preparatory School, Austin.

Whitten, Miss Harriet V., Teacher of Science, College of Industrial Arts, Denton.

Williams, Mason, Attorney at Law, San Antonio.

Wilmot, Dr. E. P., President Austin National Bank, Austin.

Winkler, E. W., Librarian, State Library, Austin.

Wipprecht, Walter, Bryan.

Wolf, Frederick A., Cornell University, Ithaca, N. Y.

Worrell, S. H., Chief of Testing Laboratory, University of Texas, Austin.

Wright, Dr. W. K., University of Chicago, Chicago, Illinois.

Yothers, W. W., Box 165, Orlando, Florida; Bureau of Entomology, Washington, D. C.

Total, 79.

Grand Total, 154.

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*Deceased.
**Resigned.

Transactions

of the

TEXAS ACADEMY *of* SCIENCE

for 1910 to 1912

PART I

Together with the Proceedings for the same time

Volume XII

Austin, Texas, U. S. A.
Published by the Academy
1913

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PREFACE

Volume XII is made available through the thoughtful care of Dr. F. W. Simonds, who preserved a few undistributed copies of Part II and the plates for Part I.

Part I was published as a University bulletin and in that form delivered to the members of the Academy. Because of the demand made for Volume XII by libraries and individuals Part I has been reprinted. The illustrations are from the original plates. In so far as is known the present volume contains all that was in the original.

H. B. PARKS, Secy.-Treas.

June, 1931.

FAUNA

OF

THE BUDA LIMESTONE

BY

FRANCIS LUTHER WHITNEY

INSTRUCTOR IN GEOLOGY AND PALEONTOLOGY IN THE UNIVERSITY OF TEXAS

Presented before the Texas Academy of Science
Issued as Bulletin No. 184, Scientific Series No. 18

REPRINT, 1931

CONTENTS

ILLUSTRATIONS

BIBLIOGRAPHY

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FAUNA OF THE BUDA LIMESTONE

By F. L. Whitney

PREFATORY NOTE

The species described in this paper were first figured and described in a thesis presented to the faculty of Cornell University for the A. M. degree.

A close examination of material collected since the completion of the above thesis has made necessary a few slight changes. Some species have been withheld from publication for further study with more satisfactory material, and a few forms have been added.

I am deeply indebted to Dr. F. W. Simonds and Prof. G. D. Harris for many helpful suggestions and to my wife, who, by careful collection and presentation of specimens, has added greatly to the number of species which I hope to figure and describe in the near future.

DESCRIPTION OF SPECIES

MOLLUSCA

PELECYPODA.

ARCIDAE

Genus BARBATIA Gray.

BARBATIA SIMONDSI n. sp.

Pl. I, fig. 6.

Dimensions.—Length, 55mm.; breadth, 32mm.

Description.—Shell medium, elongate, inequilateral; beaks near anterior end, inflated, directed forward; anterior margin short, rounded; ventral margin nearly straight; posterior margin rounded, slightly truncate above; dorsal margin subparallel to the ventral; side of valve with a depression extending from the beak obliquely backward and downward to the ventral margin; surface marked with concentric lines of growth crossed by fine, well pronounced, radiating striæ, which cover the entire surface of the shell.

This shell resembles *Arca galliennei* d'Orbigny, but it is slightly different in form, and the striæ do not alternate in size. It also resembles *Barbatia micronema* Meek and *Arca galliennei var. tramitensis* Cragin, but comparison with Cragin's type, the equivalent of Meek's species, shows that the form and markings are somewhat different.

Localities.—Barton Creek and Shoal Creek, Austin, Texas.

PINNIDAE

Genus PINNA Linnæus.

PINNA sp.

Pl. I, fig. 3.

Description.—There are, at hand, two specimens of this species, but both are too fragmentary for description. The specimen figured was found near the contact of the Buda with the Del Rio.

Localities.—Shoal Creek and Bouldin Creek, Austin, Texas.

PERNIDAE

Genus INOCERAMOUS Sowerby.

INOCERAMOUS sp.

Pl. I, fig. 5.

Dimensions.—Length, 50mm.; breadth, 35mm.

Description.—Shell subovate, ventricose, inequilateral; hinge oblique to long axis; umbo narrow, prominent, incurved. Shell ornamented externally and internally with rounded, concentric plications, separated by grooves of similar width. The plications are very fine at the beak, but gradually increase in size toward the base.

There is only one specimen of this species in this collection, and it is too fragmentary for determination. The outlines shown in the figure may not be accurate, but are the result of following down the parts of shell and cast while removing the rock covering them.

Locality.—Barton Creek, Austin, Texas.

OSTREIDAE

Genus ALECTRYONIA Fischer.

ALECTRONIA CARINATA Lamarck.

Pl. I, figs. 1, 2.

Ostrea carinata Roemer, 1849, Texas, p. 304.

Ostrea carinata Roemer, 1852, Die Kreide. von Texas, p. 75, Taf. 9, fig. 5.

Ostrea carinata Conrad, 1857, Rept. U. S. and Mex. Bound. Surv., Vol. I, Pt. 2, p. 156, Pl. 10, fig. 6.

Ostrea carinata White, 1884, Fourth Ann. Rept. U. S. Geol. Surv., p. 293, Pl. 43, figs. 1-4.

Ostrea carinata Hill, 1889, Texas Geol. Surv., Bull. No. 4, p. 6.

Alectryonia carinata Hill, 1898, U. S. Geol. Surv., Bull. No. 151, p. 26.

Dimensions.—Length, 42mm.; breadth, 10mm.

Description.—Shell narrow, curved, moderately auriculate; beaks depressed, slightly twisted; surface ornamented with twelve or more strong, narrow, sharp ribs, which, in some specimens, are ornamented with two or three rows of tubercles; ribs more elevated on the convex side of the shell; ventral margin strongly dentate.

The specimens collect d from the Buda have not attained such vigorous development as those from the Georgetown.

Locality.—Shoal Creek, Austin, Texas.

PECTINIDAE

Genus PECTEN Mueller.

PECTEN WRIGHTII (Shumard).

Pl. I, fig. 4.

Janira wrightii Shumard, 1860, Trans. Acad. Sci., St. Louis, Vol. I, 1856-1860, p. 607.

Vola (Janira) wrightii Hill, 1889, Geol. Surv. Texas, Bull. No. 4, p. 8.

Vola wrightii Cragin, 1892, Fourth Ann. Rept. Geol. Surv. Texas, p. 217, Pl. 32, figs. 2, 3.

Dimensions.—Length, 22mm.; height, 28mm.

Original description—Shell ovate, subtrigonal, longest diameter from beak to base; superior valve flat or slightly concave, marked with three strong, rounded, plications, which are prolonged at the base into prominent angles; inferior valve strongly convex; anterior and posterior slopes abrupt, margins straight and diverging from the beak at an angle of about 40°; surface ornamented with four very prominent, simple radiating ribs or folds on the body of the shell, and one much less developed within the margin on either side. Both valves are also elegantly marked with crowded, strongly waved concentric, filiform striæ; beaks elongated, slender, incurved; wings unknown.

Locality.—Shoal Creek, Austin, Texas.

SPONDYLIDAE

Genus SPONDYLUS Linnæus.

SPONDYLUS, CRAGINI n. sp.

Pl. II, figs. 7, 8.

Dimensions.—Greatest length, 35mm.; greatest breadth, 27mm.

Description.—Shell variable, inequilateral, inequivalve, oblique. Inferior valve the larger, ventricose, produced, ornamented exteriorly with faint costæ and thin lamellæ; interior with fine, flat, wavy, radiating costæ, separated by grooves of equal width. Superior valve convex, ornamented with many, irregular, wavy, radiating costæ, eight of which are stronger than the others, and separated by three strong costæ, often supplemented by weaker ones. The strong ribs sometimes bear lamellar spines, which, in the adult, are confined to the umbonal region. In the young specimens, all the ribs are spine bearing, and the spines extend throughout the length of the shell. Ears transversely ribbed.

This species resembles S. *hystrix* Goldf., both in young and adult stages. However, there are eight heavy costæ on this species, whereas S. *hystrix* has only six.

Locality.—Shoal Creek, Austin, Texas.

SPONDYLUS TEXANUS n. sp.

Pl. II, figs. 1, 2, 3.

Dimensions.—Length, 25mm.; breadth, 23mm.

Description.—Shell small, subtrigonal, inequilateral, auriculate; anterior straight; posterior slightly produced; base regularly rounded; surface marked by fifty or more fine, uneven, irregular, sometimes dichotomous costæ, about equal in width to the grooves separating them. Ears ornamented with fine, oblique, pronounced striæ; interior marked with costæ, corresponding to those on the outside, strongest at base of shell, thereby giving it a crenulate-serrate appearance; muscle impression with a raised border in thickened portion of shell. Right valve unknown.

Locality.—This and the above species were found in the chalky beds, about ten feet below the contact with the upper beds at Thirtieth Street, Shoal Creek, Austin, Texas.

ANOMIIDAE

Genus ANOMIA Müller.

ANOMIA GENICULATA n. sp.

Pl. II, figs. 4, 5.

Dimensions.—Length, 10mm.; breadth, 11mm.

Description.—Shell small, sub-ovate, acuminate; left valve convex, geniculate, ornamented with eight strong, radiating costæ, terminating in hollow, lamellar spines, at the geniculation. Below the geniculation, the surface is marked by heavy lines of growth, with only a trace of the costæ. Right valve ornamented with five or more radiating costæ extending to the margin and bearing four concentric rows of spines.

The hinge and interior were unknown when, in my thesis, I described this shell as *Plicatula geniculata* n. sp. Recently, however, material has been gathered, indicating that it should be referred to the genus Anomia.

Locality.—Shoal Creek, Austin, Texas.

MYTILIDAE

Genus MODIOLA Lamarck.

MODIOLA AUSTINENSIS n. sp.

Pl. II, fig. 6.

Dimensions.—Length, about 40mm.; breadth, 18mm.

Description.—Shell elongate, subcuneate, arcuate, inflated anteriorly, compressed posteriorly; beaks subterminal, twisted forward; umbonal ridge prominent, sloping abruptly to the anterior; surface ornamented with concentric lines of growth, crossed by numerous fine striæ radiating from the beak, and covering the entire shell.

Locality.—Shoal Creek, Austin, Texas.

PHOLODOMYACIDAE

Genus HOMOMYA Agassiz.

HOMOMYA BUDAENSIS n. sp.

Pl. III, figs. 1, 2. Pl. IV, figs. 1, 2.

Dimensions.—Length about 110mm.; breadth, 60mm.; thickness 61mm.

Description.—Shell large, globose, equivalved, inequilateral, greatly produced and broadened posteriorly; anterior margin short, curved; ventral margin deeply curved; posterior margin broadly rounded; dorsal margin curved, subparallel with ventral; umbos globose, approximate, elevated, curved inward and slightly forward, situated anteriorly; shell closed anteriorly, gaping posteriorly. Surface marked by lines of growth, which vary considerably in size.

This shell resembles v.ry closely, *H. vulgaris* Shattuck, but differs from it in the curve of the dorsal and ventral margins, the expansion of the posterior, the greater proportional thickness of the shell, and the ornamentation.

Locality.—Shoal Creek, Austin, Texas. From the top of the formation downward, about six feet.

PACHYMYIDAE

Genus PACHYMYA Sowerby.

PACHYMYA AUSTINENSIS VAR. BUDAENSIS n. var.

Pl. V; Pl. VI.

Pachymya austinensis Shumard, 1859, Trans. Acad. Sci. St. Louis, Vol. I, pp. 604-605.

Pachymya austinensis White, 1879, Eleventh Ann. Rept. U. S. Geol. and Geog. Surv. Terr., p. 298, Pl. 8, figs. 1, a, b; Pl. 5, figs. 7, a, b.

Pachymya austinensis Hill, 1889, Geol. Surv. Texas, Bull. No. 4, p. 15.

Pachymya austinensis Shattuck, 1902, U. S. Geol. Surv., Bull. 205, p. 26.

Dimensions.—Length, about 15cm.; breadth, about 9cm.; thickness, about 5.5cm.

Description.—Shell large, heavy, gibbose; beaks anterior, incurved, approximate; umbonal slope angulated from the beaks to the posterior extremity; anterior margin short, narrowly rounded; posterior margin truneate, narrowly rounded to angulate below; ventral margin concave in the middle, more rounded anteriorly than posteriorly; dorsal margin nearly straight, subparallel to the ventral; sides, with a depression extending from below the beaks, obliquely backward and downward to the ventral margin; surface ornamented with strong, concentric lines of growth, crossed by granulate line radiating from the beaks.

This shell is very closely related to *P. austinensis* Shum. and may be identical with it, but the Buda type is much higher posteriorly, and not so greatly angulated on the umbonal slope.

Locality.—Shoal Creek, Austin, Texas.

PLEUROPHORIDAE

Genus ARTICA Schumacher.
ARTICA COMPACTA (White).
Pl. VII, figs. 1, 2, 3.

Pachymya ? compacta White, 1880, Proc. U. S. Nat. Mus., Vol. II, p. 297, Pl. 6, figs. 3, 4, (Smithson. Misc. Coll., Vol 19.)

Pachymya ? compacta White, 1883, Twelfth Ann. Rept. U. S. Geol. and Geog. Surv. Terr., Pt. I, pp. 22, 23, Pl. 17, figs. 4a, b.

Dimensions.—Length, 30mm.; breadth, 19mm.; thickness, 16mm.

Original description.—Shell small, narrower posteriorly than anteriorly, slightly gaping behind; beaks depressed, approximate, incurved, directed forward, their position being very near the front; basal margin broadly convex; posterior margin narrowly rounded; postero-dorsal margin forming an oblique downward and backward truncation of that part of the shell; cardinal margin nearly straight, subparallel with the basal margin, much shorter than the full length of the shell; ligament short, its area depressed and sharply defined; front very short, depressed beneath the beaks and narrowly rounded below; umbonal ridges prominent and angular or subangular; the space above and behind them, moderately broad and flattened; the remainder of eah valve somewhat regularly convex. Hinge and interior markings unknown. Surface marked by the ordinary concentric lines of growth.

A study of the material found in the Buda, shows that this shell is not a Pachymya, but either a Trapezium (Cypricardia), as White suspected, or an Artica. The material that I have been able to study indicates, by its hinge structure, that it belongs to the latter genus.

Locality.—Shoal Creek, Austin, Texas.

CRASSATELLITIDAE

Genus STEARNSIA White.
STEARNSIA ROBINSI White.
Pl. VII, fig. 7.

Stearnsia robinsi White, 1887, Proc. Acad. Nat. Sci. Phila., Pt. 1, for 1887, pp. 33, 34, Pl. 2, figs. 7-9.

Astarta (*Stearnsia*) *robinsi* Hill, 1889, Texas Geol. Surv., Bull. No. 4, p. 11.

Dimensions.—Length, 22mm.; breadth, 16mm.

Original description—Shell much compressed, trihedral in marginal outline; lunule long and narrow, nearly straight from end to end, concave transversely; escutcheon similar in shape and character to the lunule, but longer; beaks small, appressed, angular; ligament slightly exposed, and it appears to have been divided into an outer and inner portion by a calcareous septum; umbonal furrows distinct, producing an emargination at the posterior part of the convex basal border and considerable prominence of the posterior extremity; hinge strong; the lateral teeth slender and extending the full length of the lunule and escutcheon respectively; surface marked by strong concentric furrows and ridges, which end abruptly at the margin of the lunule and escutcheon respectively; the surface of both lunule and escutcheon plain.

The material studied seems to be a little different from that figured by White, but a comparison with specimens from the Del Rio and a probable Georgetown rock, leads me to believe that the differences are not sufficient to be specific.

Locality.—Shoal Creek, Austin, Texas.

VENERIDAE

Genus MERETRIX Lamarck.

Meretrix leonensis ? (Conrad).

Pl. VII, fig. 4.

Cytherea leonensis Conrad, 1857, Rep. U. S. and Mex. Bound. Surv., Vol. I, Pt. 2, p. 153, Pl. 6, fig. 1.

Cytherea leonensis Hill, 1889, Texas Geol. Surv., Bull. No. 4, p. 14.

Dimensions.—Length, 35mm.; breadth, 44mm.

Description.—Shell medium, subovate, inequilateral, moderately ventricose; beaks, about one-fourth the length of the shell from the anterior end, small, excavated anteriorly, approximate. Anterior margin slightly curved, rounded below; ventral margin broadly rounded; posterior margin convex, rounded below. Surface ornamented with concentric lines of growth.

The material found in the Buda resembles *C. leonensis,* as figured in the Mexican Boundary Report. However, the anterior margin seems to be more gently curved in my specimens, while the posterior is more rounded. The proportions also agree closely with those of Conrad's figure. In my thesis, I referred to this as *Meretrix budaensis* n. sp. but the study of more material inclines me to refer it doubtfully to Conrad's species.

This species appears to be quite common in the upper layers of the Buda, but it is not well preserved.

Localities.—Shoal Creek, Barton Creek, and Bouldin Creek, Austin, Texas.

Genus TAPES Mergele von Muhlfeldt.

TAPES AUSTINENSIS n. sp.

Pl. VII, figs. 8, 9.

Dimensions.—Length, 25mm.; breadth, 17mm.

Description.—Shell small, ovate-elongate, narrowly rounded anteriorly and posteriorly; posterior broader than anterior; ventral margin broadly convex; dorsal margin convex, gently sloping downward from the beaks to the posterior margin; beaks approximate, situated about three-fifths the length of the shell from the posterior end. Surface marked by fine, unequal, concentric lines of growth.

Locality.—Shoal Creek, Austin, Texas.

GASTROCHAENIDAE

Genus FISTULANA Bruguiére.

FISTULANA RUPERTI n. sp.

Pl. VII, figs. 5, 6.

Dimensions.—Length, 23mm.; breadth, 12mm.

Description.—Shell elongate, suboval, broader anteriorly than posteriorly, substance thin; beaks nearly terminal; anterior margin broadly rounded; posterior margin narrowly rounded; dorsal and ventral margins convex and diverging from the posterior; beyond the middle the ventral margin turns abruptly to meet the anterior; ventral side gaping for a considerable part of its length; surface smooth, marked by fine lines of growth.

Tube clavate and generally vertical in the rock.

This species is very common in some beds of the Buda, and seems to range from near the base to the top. The material is quite well preserved, but difficult to remove.

Locality.—Shoal Creek, Austin, Texas.

GASTEROPODA.

NATICIDAE

Genus TYLOSTOMA Sharpe.

TYLOSTOMA HILLI n. sp.

Pl. VIII, figs. 1, 2. Pl. IX.

Dimensions.—Height about 100mm.; maximum breadth, 77mm.; minimum breadth, 52mm.

Description.—Shell large, globose, solid, greatly compressed; spire elevated; whorls five and one-half, convex; body whorl much larger than the others, inflated, about two-thirds the height of the shell; surface smooth; varices well developed and strong on the spire of the adult; aperture elongate; lip unknown.

Locality.—Barton Creek, Shoal Creek, Austin, Texas.

TYLOSTOMA HARRISI n. sp.

Pl. X, figs. 12, 13, 14.

Dimensions.—Height, 39mm.; breadth, 24mm.

Description.—Spire elevated, conical, whorls five, convex; suture somewhat canaliculate; lip thin, slightly reflected; inner lip callous; aperture acute posteriorly, rounded, produced anteriorly. Surface smooth, marked by fine lines of growth. The varices are not prominent on the exterior of the type specimen. They are, however, more pronounced on some individuals of this species. They are well developed on casts.

Locality.—Shoal Creek, Barton Creek, Austin, Texas.

CERITHIIDAE

Genus CERITHIUM Adanson.

CERITHIUM STANTONI n. sp.

Pl. X, figs. 1, 2.

Dimensions.—Height, 32mm.; breadth, 8mm.

Description.—Spire elevated, angle 16°; whorls twenty-seven or more; aperture rounded; canal short, twisted. Decorations consist of two spiral rows of tubercles to the whorl, situated at its edges; posterior tubercles much larger than anterior of same whorl. As the shell grows larger, the tubercles become more separated.

Figure 1, Pl. X, shows an adult form; figure 2, a younger form.

Locality.—Shoal Creek, Austin, Texas.

Cerithium shumardi n. sp.

Pl. X, fig. 3.

Dimensions.—Height, 55mm.; breadth, 30mm.

Description.—Shell turreted; whorls six or more, moderately convex; spire straight, angle about 31°; sutures well defined; aperture subquadrate; acute anteriorly-posteriorly; columella simple; lip unknown; surface ornamented with fourteen transverse costæ. These costæ and the intervening spaces are traversed by five to seven heavy, prominent, rounded, revolving lines, separated by spaces about equally as wide, and ornamented with five to seven fine, variable, prominent, rounded lines. This ornamentation extends over about one-half the body whorl, the lower portion lacking the transverse costæ but ornamented with the same revolving lines, the heavy ones being somewhat tuberculate. This species is very similar to *C. aguilerae* Böse, but the lines are all single, whereas in that species some are paired. It has the single lines similar to *C. debile* Zekeli, but the transverse costæ are more numerous. These three species appear to be closely related.

Locality.—Shoal Creek, Barton Creek, Austin, Texas.

Cerithium hilli n. sp.

Pl. X, fig. 4.

Description.—Shell turreted; spiral angle about 19°; number of whorls unknown; surface ornamented with twenty-four transverse ribs set end to end, giving the shell a fluted appearance, broken only by the suture lines. On the poorly preserved specimen at hand, there is no evidence of revolving lines.

This species appears to be quite rare, only one specimen having been obtained. It reminds one of *C. haidingeri* Zekeli, but differs from that species in the angle of the spire and the character of the transverse costæ.

Locality.—Shoal Creek, Austin, Texas.

FUSIDAE

Genus FUSUS Lamarck.

FUSUS SIMONDSI n. sp.

Pl. XI, fig. 2.

Dimensions.—Length, 100mm.; breadth, about 30mm.

Description.—Shell elevated, turreted; whorls nine, rounded; sutures well defined; spire straight, conical, equalling about one-half the height of the shell; angle 25°; anterior canal long, straight, deep; lip and aperture unknown; surface of whorls ornamented with eight to ten transverse costæ, which, with the intervening spaces, are crossed by four to six prominent, rounded, revolving lines. The costæ are prominent on the upper part of the body whorl, but disappear below, leaving only the revolving lines.

This species resembles *F. texanus* Shattuck, but the spire and body whorl are nearly equal, and the angle of the spire is much less.

Locality.—Shoal Creek, Austin, Texas.

VOLUTIDAE

Genus VOLUTILITHES Swainson.

VOLUTILITHES AUSTINENSIS n. sp.

Pl. XI, fig. 1.

Description.—Shell small, fusiform; spire elevated, sutures well defined; body whorl large, constituting the greater part of the shell, shoulder rounded; aperture narrow, elongate; canal long, straight, open and deep; columella with three strong, oblique plaits near the middle of the aperture; lip thin. Surface ornamented with about eighteen prominent, transverse costæ crossed by numerous, fine rounded, revolving lines.

Locality.—Shoal Creek, Austin, Texas.

ACTEONIDAE

Genus CYLINDRITES Lycett.

Cylindrites whitei n. sp.

Pl. X, fig. 8.

Dimensions.—Height, 4.7mm.; breadth, 2.5mm.

Description.—Shell small; surface marked by prominent lines of growth; whorls four; spire depressed, canaliculate; aperture narrow, extending posteriorly to the end of the body whorl, anteriorly extended below the body whorl and narrowly rounded; columella with one fold.

There is, in this collection, only one specimen of this species, but it is quite unlike any other that has come to my notice.

Locality.—Shoal Creek, Austin, Texas.

RINGICULIDAE

Genus CINULIA Gray.

Cinulia conradi n. sp.

Pl. X, figs. 5, 6, 7.

Dimensions.—Height, 9mm.; greatest breadth, 7mm.

Description.—Shell small, imperforate, subglobose; whorls three, spire short, about one-eighth of the height of the shell; aperture elongate, acute posteriorly, rounded anteriorly; outer lip thickened, smooth, reflected; inner lip callous, with three plaits, two of which are well up on the shell; surface of body whorl ornamented with fourteen rather broad, spiral costella, separated by narrow grooves developed by a series of spirally arranged puncta. The lip is somewhat broken in the specimen studied, but it appears to have been ornamented with two or more vertical lines.

Locality.—Shoal Creek, Austin, Texas.

Cinulia pelleti n. sp.

Pl. X, figs. 9, 10, 11.

Dimensions.—Height, 18mm.; maximum breadth, 13mm.

Description.—Shell small, solid, subglobose; whorls about three, rounded; spire about one-sixth of the height of the shell;

aperture slightly oblique rounded anteriorly, acute posteriorly; outer lip thickened, reflected, smooth within; inner lip callous, with three plaits, the upper one slightly above the middle of the aperture, the others well down. Surface marked with about twenty-seven revolving, well defined costella, separated by grooves equally as wide, and crossed by numerous fine, transverse lines.

Locality.—Batron Creek, Austin, Texas.

CEPHALOPODA.

TURRILITIDAE

Genus TURRILITIES Lamarck.

TURRILITES BRAZOENSIS Roemer

Pl. XII, fig. 1.

Turrilites brazoensis Roemer, 1849, Texas, p. 415.

Turrilites brazoensis Roemer, 1852, Die Kreide. von Texas, p. 37, Taf. 3, fig. 2.

Turrilites brazoensis Hill, 1889, Texas Geol. Surv., Bull. No. 4, p. 23.

Original description—The shell large, sinistral, tuberculate; whorls almost quadrilateral, flat outside, ornamented with four rows of large tubercles; the tubercles of the uppermost row standing on the obtusely rounded margin between the broad scarcely arched lateral surface of the whorl and the narrow superior surface, and extending themselves into plain plaits covering the superior surface; both middle rows consist of large, pointed tubercles, standing on the margin of the inner surface of the whorls and covered by the following whorl. The inner surface, turned toward the axis of the conical spire, covered with perpendicular plain plaits, which correspond to the tubercles of the lowest row.

The specimens collected frcom the Buda are mere fragments. However, a fairly complete specimen from the Georgetown formation measures in height 20cm.; breadth, 9cm.

Locality.—Barton Creek, Shoal Creek, Austin, Texas.

TURRILITES ROEMERI n. sp.

Pl. XII, figs. 2, 3.

Dimensions.—Height, 36mm.; breadth, 30mm.

Description.—Shell turriculate, conical, sinistral; angle 49°; volutions angular in front, convex behind, overlapping; suture deep; surface ornamented with four rows of unequal tubercles; the anterior row with about thirty-two tubercles, placed on the sutural angle at the outer end of ribs which converge toward the umbilicus; a second row of narrow more elongate tubercles is placed parallel to and behind the first row. It has the same number of tubercles as the first. Below the second, is a third row of elongate tubercles, of the same number as those in the other rows. The fourth row consists of large, rounded tubercles placed in the middle of the volution, and numbering about eleven.

This species differs from *T. tuberculatus* Bosc, by the spiral angle and the shape of the tubercles; from *T. gravesianus* d'Orbiny, by the more elongate form of tubercle and the angle. In this species, the three rows of smaller tubercles are covered by the overlapping of the adjacent whorl, whereas in *T. tuberculatus* and *T. gravesianus* only one row is overlapped. It appears to be rare in the Buda, only one specimen having been found.

Locality.—Shoal Creek. Austin, Texas.

ARTHROPODA

CRUSTACEA.

BRACHYURA

Indeterminate Crustacean.

Pl. XIII, fig. 1.

There is, in my collection, a specimen of the great chela of a crustacean, possibly Paramithrax, but it is so poorly preserved that its determination is very doubtful.

Locality.—Shoal Creek, Austin, Texas.

Genus GRAPTOCARCINUS.

Graptocarcinus texanus Roemer.

Pl. XIII, figs. 2, 3.

Graptocarcinus texanus Roemer, 1887, Neues Jahrbuch f. Mineral. und Paleont. Band 1, Heft. 2, pp. 173-176, figs. *a* and *b*, text.

Dimensions.—Length, 28mm.; breadth, 36mm.

Description, original somewhat modified. — Cephalothorax transverse oval, rounded, five-sided in outline; enclosed by a fine, raised, sharp border separating the dorsal and ventral surfaces; dorsal surface moderately convex, flattened centrally; frontal bent downwards, ending in a broad, obtuse-angled, pointed rostrum, divided medially by a fine, longitudinal furrow; outer margin of rostrum raised; orbits deeply cut. Surface coarsely and thickly granulate; between the grains or tubercles are scattered separate smaller ones. Where the tubercles are not completely preserved and crumbled on the summits, they appear ring-like and deepened in the centre. On the central surface are two pairs of converging furrows. The furrows of the anterior pair are longer and stronger than those of the posterior. They are bent slightly inwards and converge at an angle of about 130°. They are deepest and broadest at their outer ends. At their inner ends, they are so weak that their junction is scarcely visible. The furrows of the posterior pair are at first parallel to the anterior pair, then bent abruptly backwards and weakened till scarcely traceable. No other sculpture is present on the dorsal surface. The surface of the sloping and inwardly bent ventral side is almost smooth. It is finely granulate only opposite and just behind the frontal. Opposite the front pair of furrows is a small notch, in the sharp margin separating the dorsal and ventral surfaces, from which a fine, line-like furrow passes forward in a moderate curve.

Localities.—Shoal Creek, Barton Creek, Austin, Texas.

PLATE I

PLATE I

		Page
Figs. 1, 2.	Alectryonia carinata (Lam.)	12
Fig. 3.	Pinna sp	11
Fig. 4.	Pecten wrightii Shum	13
Fig. 5.	Inoceramous sp	12
Fig. 6.	Barbatia simondsi n. sp	11

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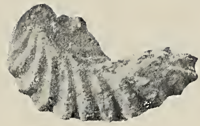

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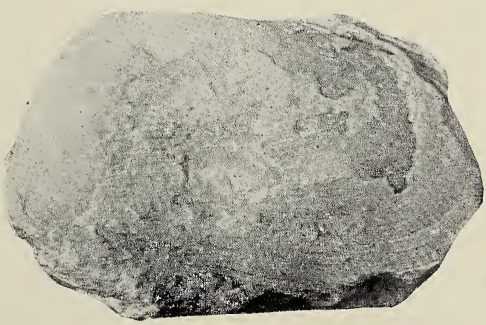

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PLATE II

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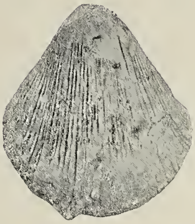

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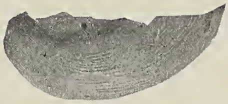

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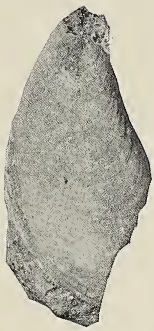

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PLATE III

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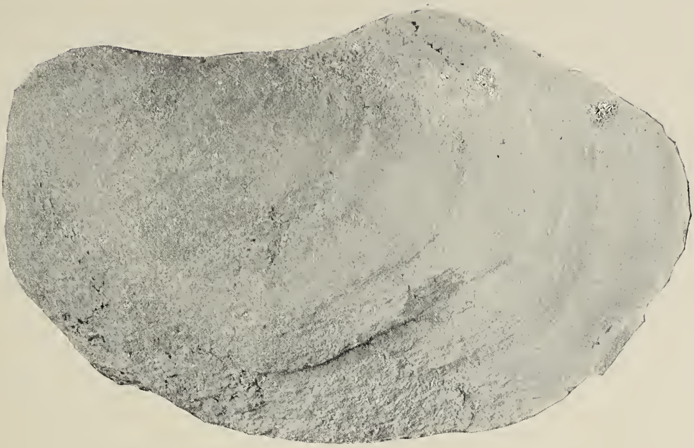

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2

PLATE IV

PLATE IV

	Page.
Figs. 1, 2. Homomya budaensis n. sp	15

1

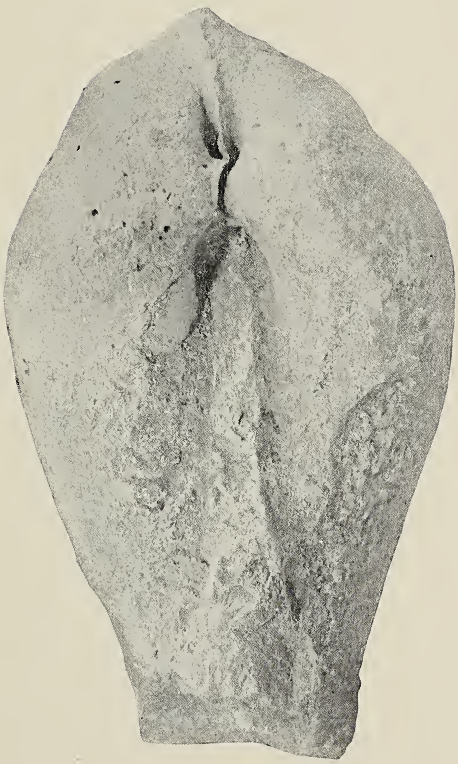

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PLATE V

PLATE V

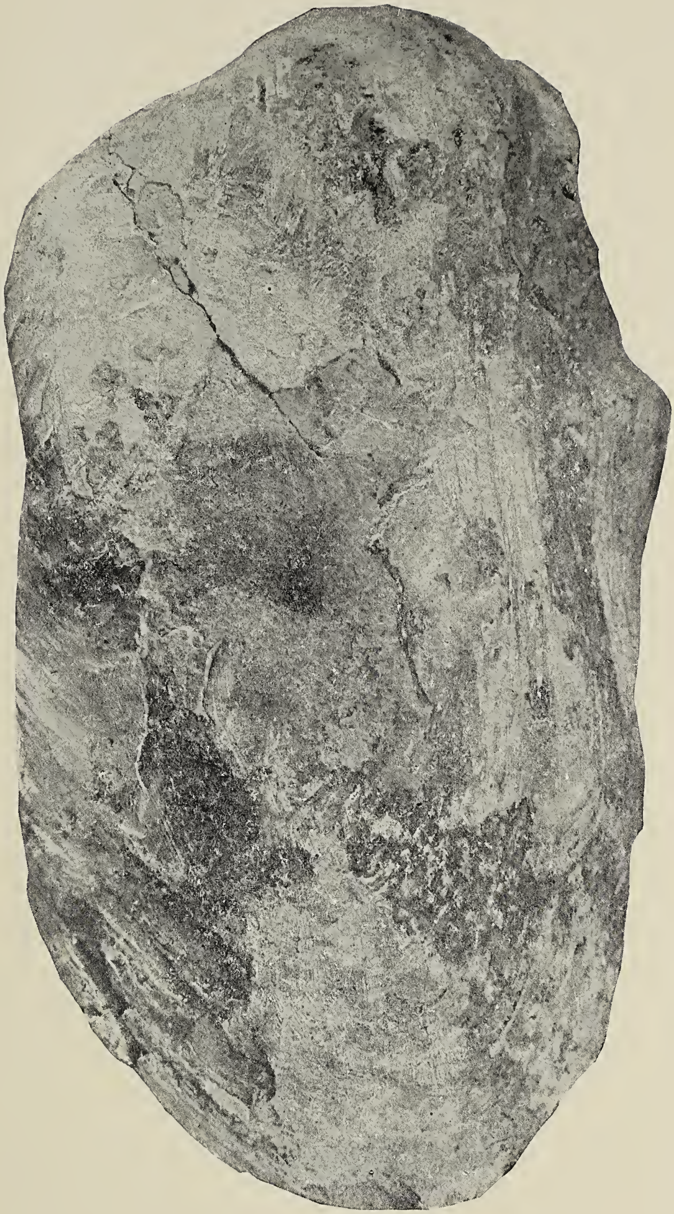

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PLATE VI

PLATE VI

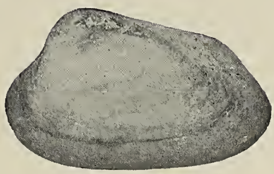
Page.

Pachymya austinensis var. budaensis n. var. x. 8 16
Showing surface ornamentation.

PLATE VII

PLATE VII

		Page.
Figs. 1-3.	Artica compacta (White)	17
Fig. 4.	Meretrix leonensis? (Con.)	18
Fig. 5.	Fistulana ruperti n. sp	19
Fig. 6.	Tubes of Fustulana ruperti	19
Fig. 7.	Stearnsia robinsi White	17
Figs. 8, 9.	Tapes austinensis n. sp	19



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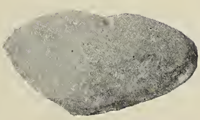

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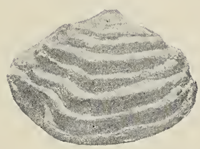

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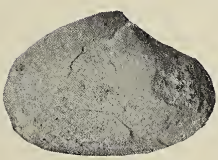


8

9

PLATE VIII

PLATE VIII

1

2

PLATE IX

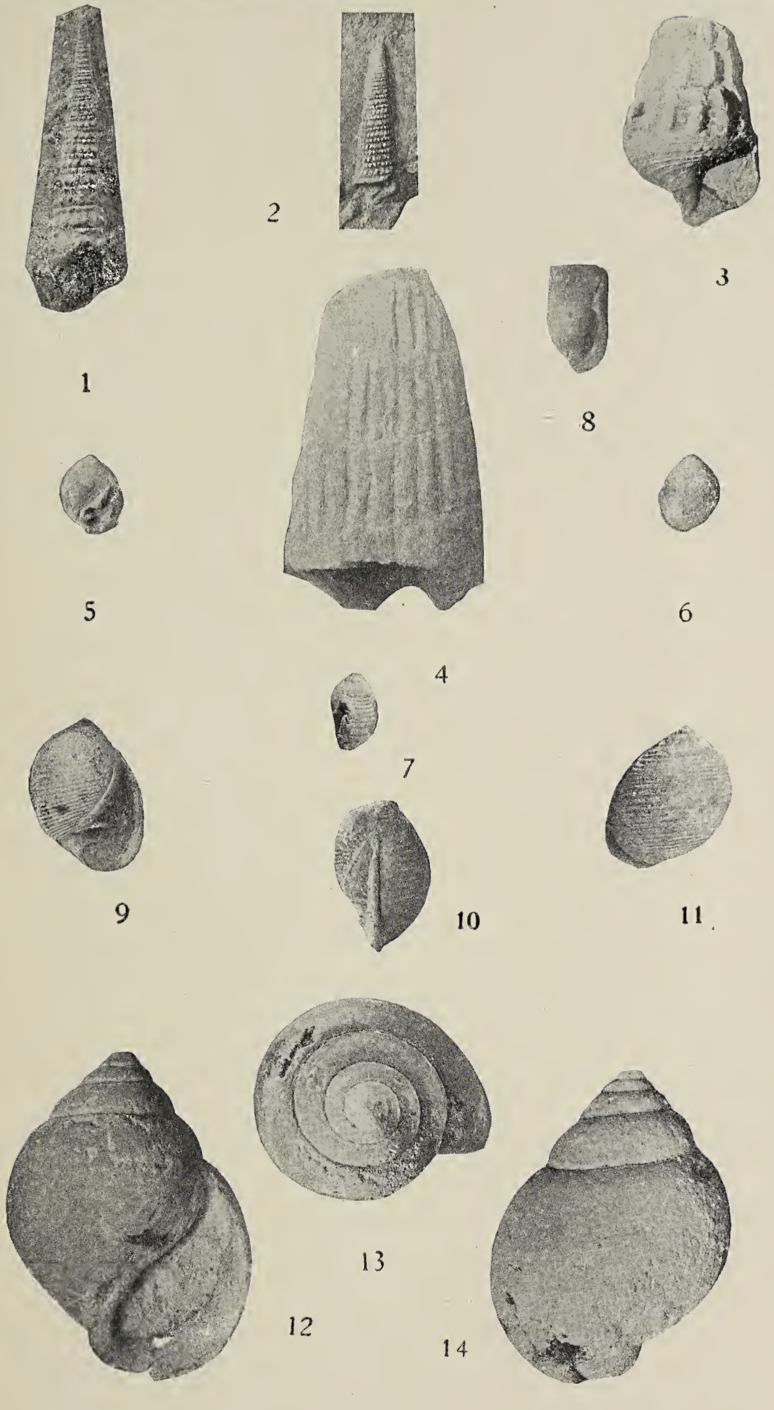
PLATE IX

1

PLATE X

PLATE X

		Page.
Figs. 1, 2.	Cerithium stantoni n. sp	20
Fig. 3.	Cerithium shumardi n. sp	21
Fig. 4.	Cerithium hilli n. sp	21
Figs. 5-7.	Cinulia conradi n. sp	23
Fig. 8.	Cylindrites whitei n. sp. x3	23
Figs. 9.-11.	Cinulia pelleti n. sp	23
Figs. 12-14.	Tylostoma harrisi n. sp	20


1
2
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7
8
9
10
11
12
13
14

PLATE XI

PLATE XI

1

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PLATE XII

PLATE XII

1

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3

PLATE XIII

PLATE XIII

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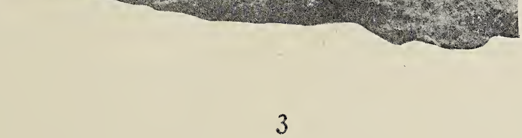
2



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INDEX

(Names in italic are synonyms; figures in black-face type are numbers of page on which detailed descriptions appear; figures in italic denote illustrations.)

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