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TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES ARTS AND LETTERS

VOL XIV, PART I

1902

WITH THIRTY-THREE PLATES

EDITED BY THE SECRETARY

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TABLE OF CONTENTS.

VOL. XIV, PART I. *

LIST OF PLATES.

RECENT CRITICISM OF AMERICAN SCHOLARSHIP.

Address of the Retiring President, Charles S. Slichter.

"In spite of much notable achievement, America's position in the world of Science is inferior." This quotation from an article by Carl Snyder in a recent number of the North American Review, may be taken as a concise statement of the main tenet of that paper, as well as the final conclusion from the great flood of denial, explanation and further criticism which the original article has called forth in American and European periodicals. A professional critic can always be distinguished by the simple open-or-shut test which he applies to any proposition which comes under his critical eye. There is to him no mean ground, no qualifying circumstance. His finely balanced judgment is like the litmus paper of the chemist; if it be applied to one proposition and turn red, that means one conclusion; if it turn blue, that means the opposite conclusion. In the rainbow of the true critic there are no colors but red and blue. So in the paper referred to, we need not be surprised if we fail to find a careful analysis of the subject under discussion. A blue or red test is more to Mr. Snyder's liking. He adopts, therefore, the simple device of establishing his proposition by a series of comparisons between American and Continental achievement in selected lines of research, with no attempt at explanation, or discussion of causes or present tendencies. Our attention is first directed to Pasteur's memorable discovery of forty years ago, that the process of fermentation is due to the action of micro-organisms. The culmination of Pasteur's researches in the germ theory of disease, and the great army of workers in European states that took up and extended Pasteur's work is contrasted with the claim that in all the brilliant list of discoveries and applications, not one

American name is to be found. There is not only no Lord Lister, no Behring, no Koch, among the Americans, but no name of even secondary importance.

Mr. Snyder's second arraignment of American science has the physicists as the culprits. The theoretical works of Clerk Maxwell and the experimental work of Hertz on electrical waves, called out an army of investigators abroad, including such names as Branly of Paris, Righi of Italy, Slaby, Count Arco, and Braun of Germany, Preece and Lodge of Great Britain, but not a single American.

Our critic next takes up a recent continental work on metallurgy. He finds it to be almost a dictionary of names of Belgians, Hollanders, Germans, Englishmen, Frenchmen, and Russians. Two Americans appear in such a host, Professor Gibbs and Professor Howe, and yet, the critic remarks, America is the land of the steel industry and the home of the great trust.

Considering research on the phenomena of ultra-matter and the aether, the writer finds no American worthy of note among the disciples of Crooks, Roentgen, and J. J. Thompson.

Mr. Snyder next directs our attention to the work of the past quarter century which has been expended in the attempt to unravel the mystery of the mechanism of the human brain. A whole library could be filled with the monographs, memoirs and treatises on this subject from Spain, Italy, Germany, Belgium, Switzerland and Austria, but in all of the many shelves and stacks of this brain library there is not even a pamphlet or reprint from America.

The critic, having gained enthusiasm with the sweeping character of this last conclusion, now takes up a much larger subject, that of chemistry. Obscure lands, he says, like Sweden, Norway, Russia have often been to the fore, yet the history of this wonderful science could be written in full detail without mention of perhaps more than a single American name, which according to our critic would be that of Professor Wolcott Gibbs. In physical chemistry, or "electro chemistry" as our critic calls it, the case is not much better. Not only has America no name to place with Van't Hoff, Arrhenius, Ostwald, and Raoult, but a list which should include the names of even the lesser builders of this imposing fabric, would hardly contain a single American.

The critic says that it is easy to multiply examples, but cares to note but a single additional case; namely, the theory of the aether. Wise men from many lands have come offering gifts at this issue of a happy union of experiment and imagination, but in the long line from Kelvin and Helmholtz to Lorenz and Poincaré, you discover no faces out of the "desert of the western continent." The "desert of the western continent" is Mr. Snyder's name for that part of the map of the scientific world occupied by the United States.

The above are the principal claims set forth in the article. The impression made by the criticisms, as a whole, is distinctly that of unfairness. In some cases, as, for example, that of chemistry, the references are decidedly unjust to the rapidly expanding work and reputation of American scientists. It is not our purpose, however, to set up in rebuttal an opposite claim as to America's position in the scientific world. It is more profitable to consider the possible causes which have made the situation what it is; to note the character of present tendencies, and to see what hope can be found for the near future.

First, let us consider the situation in a field of activity very close to that of pure science. It is certain that no one need apologize for America in the field of invention and technical science. The steamboat, the telegraph, the telephone, are enough of the fundamental inventions for any nation to contribute in a single century. Even if one find credit for others than Morse and Bell in the last named inventions, one must remember that after all, the honors in technical science and invention belong not so much to the one who makes a discovery, as is the case in pure science, as to the one who makes a discovery and renders it a commercial success. On this basis America can take a large share of honor in many lines of endeavor. The vastness and novelty of the problems in a new country have contributed to our success. The great rivers to be spanned by bridges, the great mountain ranges to be crossed by highways, the great canals to be built with high priced labor have all resulted in great engineering advance and have placed the rest of the world in the position of pupil to America. But

America has not only advanced engineering science in bridge design, in railway construction and in canal digging, but has extended engineering science to entirely new fields. A familiar example is the complex development of the municipal rapid transit systems of the American cities. Another example is the American steel frame sky-scraper, with the difficult associated problems of heating and sanitation. A less well known example, but, nevertheless, one in which the economic results have been of international importance, is the application of engineering science to the design of machine tools—such as the lathes, boring-machines, shapers, planers, etc., used in machine shops to give form to the metal parts of a machine. Such tools have not only been made highly versatile and highly automatic, but the theory of their design has been enormously elaborated. The introduction of improved tool steel and scientifically designed cutting tools, permitting deeper cuts and higher speed, has increased immensely the earning power of all machine tools. Likewise the introduction of standard designs and dimensions in cutting tools and other parts and the use of graduated indices have converted the machine tool into an instrument of precision—a quantitative and not merely a qualitative instrument. The further development of the design so as to produce the maximum product in the minimum time has made the cost of unit output nearly independent of the operative and the rate of his daily wage. These achievements are of the kind that has enabled this country to enter successfully into international competition, notwithstanding the much higher cost of labor.

It is unnecessary to multiply examples of American contribution to technical science, or to enumerate further additions which American necessity has added to the recognized domain of engineering practice. I use these facts to indicate that American leadership in pure science is not hopeless, if in the future there can be provided for the scientist an environment as favorable as the past has allotted to the inventor and the engineer. One must be blind if he can not see such indications in the present situation. It is obvious that it is not the first concern of the pioneer to cultivate science and scholarship.

Speculation about the unknown must give way for a time to attention to the more immediate necessities. The savage must be driven back, the soil must be reclaimed, shelter must be provided. Next, roads, canals, and means of communication must be established, cities built, churches and schools erected. Then business, commerce, and manufacturing must be fostered before profits and surplus can accumulate wherewith to provide for leisure and to sustain the arts and sciences. I take it that it is the coming of age of commercialism in this country that has brought technical science to its present commanding place; unless things go quite wrong, the natural evolution of events should next culminate in a like development of pure science.

The coming change is foreshadowed in the modified character of technical science. In former days engineering technology was founded chiefly upon current practice rather than upon established principles; it was more closely allied to the crafts than to science. Not only is that day past, but it is no longer the case that technical science looks entirely to pure science for its fundamental material. It has so grown that it is investigating for itself and, in greater and greater measure, developing basal principles for its many needs. There are very few American treatises in pure science which will compare in scientific thoroughness with several treatises which have lately issued from the engineering press. This is a very hopeful sign in the growth of knowledge—to see applied science and pure science approaching each other at numerous points, so that it is increasingly difficult to distinguish any line of demarcation between them. In this change, science is not sacrificing any of its strength nor compromising its ideals. It is technology that is changing—that is becoming less empirical, less conservative, more systematic, more quantitative, more exact, more scientific.

The technical schools are planning their own departments for research and higher work. The Massachusetts Institute of Technology has organized such a department during the current year, while one of the plans dearest to the heart of the late Dean Johnson was an endowment fund for technical research at Wisconsin.

There are two results which naturally follow from the situation as I have described it. First, applied science, by its expansion into new fields, by its rapid approximation to a sounder scientific basis, as well as by its great vitality and energy, offers a most favorable opportunity for the rapid development of pure science, if other conditions are favorable. Secondly, unless the forces which are at present working against the highest development of pure science in America are discovered and removed, the greater share of productive energy will flow in technical channels, to the detriment of the best interests of both pure and applied science.

Let us now consider some of the facts in the present situation which are unfavorable to the highest and best work in science. The most fundamental defect, I believe, is to be found in the peculiarities of our American educational system. The great majority of scholars must always rely for their support upon the colleges and universities. The advancement of knowledge is as much a function of a university as is the propagation of learning. In fact, so many departments of scholarship in this country have no home outside our educational institutions, that it is highly important for the growth of knowledge that conditions should be as favorable as possible in these higher institutions. We find that the colleges instead of providing a distinctly favorable environment, adhere to substantially the same methods of education that are suited to elementary schools. The American college and university system is largely a system of text book and recitation. Tasks are assigned in small allotments and quizzes held, substantially as in the lower schools. Even the lectures of Junior and Senior grade lack the vitalizing principle appropriate to university or college work. We may explain away this fact as much as we please, we may draw as bright contrasts between the higher college work and the work of the elementary schools as we can, yet it is a fact that from the time the grade pupil begins his work in spelling, arithmetic and geography until as university student he does his language, history, and science, he is kept constantly at a grind of chores, doing tasks for a taskmaster. The taskmaster must consume much of his time in holding the student to account, in seeing that things are done at a specified time and in specified amounts. It results that the work is emaciated and lifeless, both for instructor and student. The lecturer gives in two or three lectures what should be given in one, and the student has twelve to eighteen of these periods per week instead of half as many—numerous lunches instead of half as many substantial meals. Such a system I believe to be disastrous to the best scholarship. No one working under such a plan can give or receive the highest inspiration. There is too much detail in instruction and too much detail in administration. The system has not produced scholars, and we may doubt if it has adequately succeeded as an educational scheme. Instruction of the higher undergraduates, as well as of the graduate students, must depend, I am convinced, upon inspiration rather than upon watchfulness. It must hope to reflect culture upon the students from the fire of higher investigative scholarship, rather than expect to force it upon them by the pressure of an educational system.

It is idle to expect any surrender of educational purpose in our colleges and universities. They must exist for the education of youth quite as much in the future as in the past. The change will come when it becomes apparent that this very work can be better done by a different and no more expensive system. Associated with such change will come a broadening of American scholarship. Instructional positions in American colleges and universities will become more attractive to ambitious scholars, and our position in science materially advanced.

American scholarship seems to be content with the filling in of details within boundaries outlined by continental masters. Men from other countries have mapped out the new regions and noted the chief features; American work has consisted in supplying particulars. This is a corollary to what we have said about our peculiar educational system. The scientific work of young men, of graduate students, is amply encouraged by scholarships and fellowships and the like. Their theses, written in this country or abroad, are too often the best pieces of work that they ever do, for our encouragement stops when one of them begins instructional work. At the time of life when the scientist should be producing his best work, say from 30 to 50 years of age, he is held down to mere instructional routine by the American quality of his college or university professorship. To take the lead in science our scholarship must become catholic; we must contribute to knowledge a due share of the great generalizations, of the fundamental principles. This requires that all professors in all institutions should be engaged in productive work, so that in the multitude the genius may be discovered and advanced to greater opportunity.

Let us attempt to name, as others have, the great scientific truths which the 19th century added to the sum of knowledge.* The list is about as follows:—

1. The principle of evolution.
2. The atomic structure of matter.
3. The existence of the aether and the undulatory theory of light and electricity.
4. The principles of electro-magnetic induction.
5. The principles of electrolytic action.
6. The discovery of micro-organisms and the germ theory of contagious disease.
7. The principle of conservation of energy.

The question for us to raise is:—How much would the discovery of these truths have been retarded if America had not existed? What would be the loss to science and humanity if the American contributions to these great principles could be removed from the libraries of the world? The answer must be that America has not materially affected the general result. Such is likely to be the case in the future if the position of the scholar in the educational system is to remain as it is at present.

Nearly every college and university instructor in the land needs wider opportunity for productive scholarship than our system permits. It is in the multitude of scientific workers that there is hope. The man of genius is a rare bird, and we must have a numerous class from which to produce him. A few institutions with high ideals cannot raise America from

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***I have added 5 and 6 to the list of Sir William Preece.**

her present position, if the instructors in other institutions must remain mere teachers, and view from afar the scientific work of others. Matthew Arnold once said that the smallest German university contributed more to human knowledge than Oxford and Cambridge with all of their wealth. College trustees and presidents in this country could well afford to ponder over the significance of this criticism.

A very good indication that America's inferior position in science is due in large part to her higher educational system is seen when we consider those branches of pure science in which America stands highest. I suppose that all will agree that the United States is in the very front rank in astronomy, geology, and meteorology. But these are the very branches which are freest from the influence of the American teaching system. Astronomy has thrived in the National Observatory, in the great university observatories, and in a few private or independent observatories, like the Lick. In all of these cases, instructional requirements are either absent altogether or are at a minimum. Likewise geology has been fostered by the great government bureau, and the best geologists in the universities have had opportunity to work under its auspices, with consequent curtailment of university instruction. Three past presidents of the Wisconsin Academy, Chamberlin, Irving, and Van Hise, have won international fame in this line of work. This was not due to a helpful situation at Beloit or Madison, but to the opportunity which the national survey afforded them. In meteorology the sole patron has been the general government, and the service has honored American science with a long list of names of international currency,—Espy, Redfield, Loomis, Ferrel, Abbé. Likewise, a few purely investigative institutions, like Wood's Holl, The Museum of Comparative Zoology, The Missouri Botanical Gardens, etc., all bring to bear their share of proof that it is not lack of brains or scientific capacity that has kept higher scholarship out of our colleges and universities.

Among the many discussions of the present subject which fill the reviews of the current year, there is one in a French periodical, *La Revue*, written by Jean Jussieu. Tihs writer will not admit that America is too young to have attained distinction in science and art. He has no doubt that the cause of America's scientific inferiority is the too great triumph of democracy. He says: "The idea of the moral equality of citizens brings about in most minds the idea of intellectual equality, which is of course a profound error. The result is the *"bourgeoisisme"* not only of a class, as in France, but of the whole nation. Democracy assures the triumph of utilitarianism. The formula of both is the greatest good for the greatest number. Now the value of a principle depends upon the person who adopts it. In the mouth of the majority this principle has come to mean:—'So long as I do not interfere with another, there is no reason why I should honor him rather than myself.' It is easy to see what this means in the mouth of one of average intelligence; it is the end of all spirit of disinterestedness, not only in science, but in art and in morality. Men who will not sacrifice themselves for another man will hardly do so for an idea, a precept. Worldly success, the money making ideal, has fettered and will continue to fetter American science. . . . . . In the United States, it may be said, the school governs science, the masters govern the school, the parents govern the masters, the children govern the parents,—therefore the children govern science."

"Again there is too much attention paid to athletics. A director of football at an American university gets $6,000.00 a year; a coach, $1,500.00 for ten or twelve weeks' service, with board and lodging. Sports occupy a proportional amount of space in American newspapers."

"The true scientific spirit, according to Herbert Spencer, is the synthetic spirit, which sees likenesses where the common mind only sees divergencies." It is this which M. Jussieu considers is almost lacking in America. Here scientific writings are almost always merely analytical—statistics, compilations, observations, etc., requiring altogether a lower order of intelligence.

The criticisms of M. Jussieu cannot be ignored or lightly dismissed. It is hard, or impossible, for an American to admit that science and democracy cannot both triumph on American soil. We are too prejudiced to accept such a proposition even if proved. Nevertheless, may we not agree that, after all, some of our ideals have been fallacious? Have we not gone too much on the principle that every one must receive a higher education, whether he will or not? If in preparation for such an education it is too difficult or too inconvenient to master Greek and Latin, have we not accepted too eagerly such things as civics and literary readings as equivalents? Is it not true that American colleges and universities have cared too much for numbers and for athletic success? It is not too much democracy that makes it relatively easy for colleges to get buildings and so hard to get income, both from individuals and from the state? Is it not true that too much is made of newspaper publicity and too little of scholarly reputation?

Answers to these questions show that Jussieu's criticisms are not without some force. Yet it seems to me that there is no indication that democracy is necessarily plebeian. The experience of Greece and even of our own country seems to show that democracy admits of sufficient refinement and that the evils that the critic notes are not to be considered as essential but merely incidental to certain phases of development. There are also a number of facts of a contrary character to those sought out by Jussieu. It is encouraging to know that the people of Wisconsin have erected as their noblest public building the Historical Library, a home for advanced scholarship and research. It also is significant that as a class the state universities, founded and endowed directly by the people, have advanced more in investigative scholarship during the past decade than in any other line of their growth.

There are some things inherent in democracy which should naturally tend to foster the higher interests of science. There are supposed to be, in republican institutions, no artificial restraints to hold down and keep obscure the exceptional man, the man of genius, no matter how obscure his origin. As Professor Simon Newcomb has well said: "The whole history of modern progress, whether in science or industry, is a history of the efforts of exceptional men." . . . . "The leader in science, the divinely inspired explorer of nature—

whom no university has made what he is, who has learned for himself how knowledge can be advanced, whose main outfit is the original genius with which nature has endowed him, whose paramount motive is a native impulse," should have the fairest show in a democracy. But Professor Newcomb complains that in our failure to estimate and honor the individual scientific investigator we stand far behind all other enlightened nations. Such honor as England showed to Lord Kelvin and Sir George Gabriel Stokes in the impressive jubilees held in recent years, the noble tribute paid by all Germany to the venerable Helmholtz upon his seventieth birthday and the recent tribute of France to Berthelot, seem quite impossible in America. Such honor, suggests Professor Newcomb, is not needed so that each investigator may say "See what may be done for me if I am successful" but so that all may say "See what a high value my countrymen set upon the best kind of intellectual work."

The most favorable classification of the rank of modern nations in productive scholarship that I have seen places America in the fourth place. This classification attempts to divide the countries into groups of approximately equal population, and is as follows:

1. Germany and Austria.
2. Great Britain and Colonies.
3. France and Belgium.
4. The United States.
5. Italy.
6. Scandinavia, Holland, and a miscellaneous group of states.
7. Spain and Spanish Colonies.

One cannot be satisfied with the position of America in this scheme, but it seems impossible to challenge its truth. Yet it is true that the difference between class 2, Great Britain and Colonies, and class 3, France and Belgium, is exceedingly slight: many would probably prefer to put France and Belgium in second place, so that America occupies a sort of third place, the second position being nearly evenly divided. But after all, it is not so much our actual grade that need concern us, as the character of present tendencies and our rate of development. And in this aspect there is much encouragement. The American scholar is now wide awake, both to his actual position in the world and to the vast opportunities before him. His ambition is kindled and he is beginning to insist upon opportunity for work and for proper recognition for what is attained.

It is the hope of every American that the new Carnegie Institution will have a marked influence upon the advance of science in this country. This munificent foundation was offered to America at a most opportune time. The whole range of American scholarship had just entered upon a season of promising growth. No stimulus of greater power to vitalize science can be imagined than the fortunate creation of this new corporation for the fostering of research. It is amazing to note, however, the lack of perspective, the inadequacy of ideals among American scientists which have been disclosed by the founding of this institution. The numerous discussions concerning the proper use of the Carnegie gift which have taken up so much space in the weekly issues of "Science" during the past autumn make one ashamed of the poverty of ambition and smallness of scientific scope which many of the scientific men of this country have displayed. If the advisory committees of the Carnegie Institution do not act on higher ideals than those presented by a majority of the suggestions printed in Science, then all the new establishment can hope to accomplish is to add to American science more of the same material that is being abundantly accumulated at the present time.

The Carnegie Institution should take its chief warning from the unfortunate history of the Smithsonian Institution, which at one time promised so much for American science. This institution instead of becoming the one place in the United States where the highest science could always find a home, has become very largely a routine institution. It spends its money for salaries and administration in true American fashion and has a minimum to show for its more than fifty years of existence. At the present time about four-fifths of its income goes for salaries and expense of administration. The American is a great man for stipends, and stenographers, and card catalogs. Fortunate would it have been if a Helmholtz had had charge of this institution. He would have been so absorbed in his science that he would have forgotten about his clerks and type-writers, but his suggestions and plans, given to his scientific workers, would have made at Washington an institution conspicuous "for the increase and diffusion of knowledge among men." It is one of the good signs of the times that scientific journals have come to recognize the deficiences in the work of the Smithsonian Institution and are loudly calling for a change of policy.

A question of much interest to us is: What part shall Wisconsin take in the new revival of learning which seems to be upon us? It has often seemed to me that Wisconsin was destined to become a sort of Scotland to the other states of the Mississippi Valley, to be the home of a sturdy people, with high intellectual and moral ideals, even if it could not excel neighboring states in commerce and wealth. Wisconsin is a state of rolling hills and partly drained valleys, marked out by nature for dairying and diversified farming rather than for grain and corn raising as it is found on the flat prairies of Illinois and Iowa. Wisconsin has no great beds of coal beneath her soil, and her manufacturing, instead of being of the cruder and grosser sort, must in large part develop the more highly finished products suitable to a more expensive cost of fuel. But these very facts have a compensating advantage. There will be little attraction in Wisconsin for the lower grade of immigrants which are brought in by the coal mines and the less finished manufactures. Instead of much wealth in the hands of a few, there is hope that Wisconsin may enjoy a more equal division of the good things of life, more contentment, and immeasurably greater refinement and learning than will be the lot of her more populous neighbors. Wisconsin will be satisfied if she can share in a large way in the intellectual life of the nation and furnish her country with scholars and statesmen. It must be the ambition of every scholar in the state to do his part in building up the intellectual reputation of Wisconsin, and, more than all, for each one to do all he can to bring about an elevation of ideals in all institutions of learning within our borders, so that her scientific men may enjoy wider opportunities for productive work. Our ambition must extend beyond our individual work, and must especially include the advancement of the best interests of the state Academy of Sciences, Arts and Letters. It should be the inspiration of every scholar in the state to have within our borders a better Academy than is found in any neighboring state. Our printed Transactions appear upon the shelves of practically every library in the learned world. No publication within our state has so wide a circulation, the original of a citation from an Academy paper being instantly accessible in almost any seat of learning in the world. It should be our pride, therefore, that this society, which is the intellectual ambassador of the state of Wisconsin to the learned world, should be maintained in the highest possible position; that its dignity should be commensurate with the honor of science as well as with the honor of a great commonwealth. With such a purpose in his mind, let every member of this Academy renew his allegiance and his activity. Let all the productive intellectual forces of the state be united in this society as an instrument for the advancement of investigation and the spread of knowledge.

ORIGIN AND MEANING OF WISCONSIN PLACE-NAMES; WITH SPECIAL REFERENCE TO INDIAN NOMENCLATURE.

HENRY E. LEGLER.

In the names of water-ways and other geographical features may be traced the history of colonization. Sometimes the study is hindered by reason of complex transformations from the primary simple form, rendering the origin and significance of terms doubtful; sometimes the meaning is so obscure as to lead to unsatisfactory controversy; but despite incongruities and etymological guesswork, the study of the geographical nomenclature of any country or political division is susceptible of valuable result to the student of philology and of history. This is especially true of the Western continent, where the local names preserve, though often hidden by successive corruption of the original terms, the migratory history and legendary lore of Indian tribes.[1]

The study of local names in America is attended, as in Europe, with the difficulties that naturally arise from dialectic changes. The Frenchmen, Dutch, Englishmen and Spaniards altered the forms to make the meanings applicable to themselves or to render the sound familiar to their own ears. The yellowed maps of the early cartographers become invaluable in this connection, as the names there recorded indicate in chronological sequence the displacement of the aborigines by races from the continent of Europe, who in turn gave way to each

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[1] "Local names—whether they belong to provinces, cities and villages, or are the designations of rivers and mountains,—are never mere arbitrary sounds, devoid of meaning. They may always be regarded as records of the past, inviting and rewarding a careful historical interpretation." Rev. Isaac Taylor's *Words and Places*, London and Cambridge, 1865.

other. In this century, Frenchmen, Spaniards, Dutchmen and Norsemen, who three hundred years ago collectively claimed all of the North American continent except a few colonies struggling for a foothold in the thin tide-water strip between the Atlantic and the Alleghenies, are left without an acre of their vast domains; the story of their explorations, their forest fortresses, their attempts to establish feudal empires, remains recorded in the names that still dot the modern map from ocean to ocean.[2]

As a rule (which, however, has notable exceptions) it will be found that the streams and lakes and mountains preserve the names given them by the red men, or their equivalents in European tongues; the cities and villages bear the names transplanted from European soil. Thus may be found scattered over this continent, in juxtaposition to names of undoubted Indian origin, a nomenclature whereby the immigrant exiles sought to preserve in the wilderness the associations endeared to them in youth.

Some striking feature in the landscape suggested to the imaginative savage mind a term descriptive of it. The analogous mind of the trappers and pioneers who pushed the frontier ever westward applied names on the same principle. Big Bone Lick, Bad Axe, Hickory Flats, etc., may be cited in illustration. It is to be regretted that the apt Indian names were not permitted to remain in all cases, or that the builders of commonwealths and cities did not confine their selections for christening to such old-world names as would suggest historical significance. For instance, "the name of Louisiana reminds us that, in the days of the Grand Monarque, France was the rival of England in the colonization of the Western World; the names of Virginia, of the Carolinas and of Georgia give us the dates of the first foundation of England's colonial empire."

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[2] "How rapidly such a stratification of names can be effected is shown in the case of North America, where we find a layer of Indian names, like Massachusetts, Niagara, Canada, Quebec, Erie, or Ontario, overlaid by Franco-Indian terms like Huron or Illinois, or pure French names such as Vermont, lake Superior or Montreal, by Dutch names like Brooklyn or Hoboken, with a Spanish stratum such as Florida, Colorado, Montana or Rio Grande, and the whole overlaid by such pure English names as Westpoint, Maryland, or Springfield—Taylor's *Names and Their Histories*, p. 3.

The liberal use of names derived from Greek and Roman mythology, or the history of countries which have not even a remote connection with the peopling of the New World, is certainly out of place. Such names, for example, as Palmyra in Wisconsin, Utica, Troy and Rome in New York, Athens in Georgia, Cairo in Illinois, Memphis in Tennessee, etc., are utterly inappropriate and have been deservedly criticised.[3] Even Thomas Jefferson, when he proposed to divide the Old Northwest Territory into states, suggested such utterly inappropriate names as Chersonesus, Assenisipia, Polypotamia and Metropotamia.[4]

Of the forty-five United States, none possesses a nomenclature more suggestive or historically significant than Wisconsin. The leading phases of its history are indexed by the names that appear on successive issues of its map: the French regime, the establishment of mining camps in the lead region of Southwestern Wisconsin, the planting of pioneer settlements by hardy frontiersmen from New York and New England, the subsequent waves of immigration comprising the nationalities that have made of Wisconsin a polyglot state. More than in most states, too, the Indian names have been retained, as is meet in a state where picturesque streams and lakes and rock formations abound in generous profusion.

The derivation of the names from so many different sources renders the study of their origin and significance especially difficult, despite the fact that the period of Wisconsin's settlement is so recent. Especially is this true of the Indian names, for Wisconsin was the meeting place of the two greatest ethnological divisions of red men located east of the Rocky Mountains—Dakotan or Siouan, and Algic or Algonquin. The tribal dialectic differences add to the difficulties that beset the student of Wisconsin's Indian nomenclature and in a measure excuse

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[3] "The incongruity between the names and the appearance of these places is amusing. Thus Corinth consists of a wooden grogshop and three log shanties; the Acropolis is represented by a grocery store. All that can be seen of the city of Troy is a timber house, three log huts, a saw mill and twenty negroes."—Russell, *Diary North and South*, vol ii, pp. 45, 46.

[4] Doubtless these names were inspired by the desire for classic learning which obtained about this period. In speech, as in writing, allusion to mythology and classic literature was regarded as the stamp of learning.

the different conclusions reached in many instances by authorities of equal standing. Even the meaning of the name Wisconsin, which is an Englished version of the French rendering of an Indian word, is in doubt.

But scant information concerning the etymology of Indian place-names is to be gleaned from the printed narratives of early day travelers. The records left by these keen pioneers of forest commerce tell us much of the customs of the aborigines, of their manners, their implements, their social relations, their religions.[5] Such attention as was paid to their language was limited to the compilation of vocabularies that would serve the most practical purposes. Of these there are many, almost every tribal dialect employed in Wisconsin being represented. Some of the vocabularies are remarkably full and well attain to the dignity of dictionaries.[6] A study of these, however, gives few clues to the derivation of place-names. Fancied resemblances are more apt to mislead than to guide the searcher who wishes to trace the geographical nomenclature derived from Indian sources.

The names of this state, of the great river that borders it on one side and the great fresh-water sea that adjoins it on the opposite side, of the largest stream that flows within and almost bisects it, of the largest lake wholly within its territory, of the principal range, and the chief of its bustling city communities, are all of undoubted Indian origin. It is interesting to compare the synonyms that appear on the early maps. In the collection of Parkman maps in the Massachusetts Historical Society is an undated manuscript map, which he says shows "the earliest representation of the upper Mississippi, based perhaps on the reports of the Indians," supposedly the work of the Jesuits. The following names appear thereon:

Baye des Puans.
Lac des Illinois.
Lac Tracy ou Supérieur.
Riviere Colbert.

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[5] The *Jesuit Relations and Allied Documents*, 73 vols., edited by Reuben Gold Thwaites, are a veritable encyclopedia covering every phase of Indian life.

[6] Some of the most creditable work remains in manuscript in the Wisconsin Historical Society and in the Bureau of Ethnology.

Another map, supposed to be the work of the engineer Franquelin (1681) calls Wisconsin "Miskous." So does Joliet in his Carte Generale, where he defines the Riviere de Messissipi. Joliet's smaller map (in the Archives Marine, Paris) bears the same nomenclature. Another anonymous map in the Parkman collection designates Lake Mitchiganong ou des Illinois. Lake Winnebago is designated as Lake Kitchigamenqué, ou Lac St. Francois.

Joliet's map of 1673–74, which is the earliest that includes the Mississippi from actual knowledge, bears these terms: Lac Supérieur. Baye des Puans. Lac des Illinois ou Missihiganin. Riviere Miskonsing. Riviere de Buade. (Lake Winnebago is not designated.)

Marquette's map: R. de la Conception. Lac des Illinois. Lac Superieur ou DeTracy. (No name is given the Wisconsin and none Lake Winnebago.) There is a map given in Thevenot as Marquettes's, but it is spurious.

Franquelin's map, 1688: Fleuve Messisipi. R. Ouisconsing.

Coronelli map, 1688: Ouisconsing. Lac des Illinois, ou Michigami, ou Lac Dauphin.

Hennepin, 1683: Lac de Condé. Lac Dauphin, ou Illinois. R. le Outonagamis (Fox river). R. de Ouisconsins. R. Colbert.

Hennepin, 1697: Le Grand Fleuve Meschasipi. R. Ouisconsing. R. Verte (Fox river).

Hennepin, 1697 (engraved for the English editions of his book): Riviere Ouisconsing.

La Hontan, 1709: Lac des Ilinois. R. des Puants (Fox river). R. d. Ouriconsing. Grand Fleuve de Missisipi.

La Hontan, 1703 (English edition): Upper Lake. Illinese Lake. Ouisconsink.

The first time the name Mississippi appeared in print was in a Jesuit Relation. Claude Allouez had heard from Indians sojourning at his Chequamegon chapel of bark of a great stream which they termed Me-sipi. The Iroquois Indians, whose habitations were in what is now New York, called this river Gastacha. In Friar Hennepin's narrative, this river is called

Mechasipi. Joliet, when his canoe came from the Wisconsin river to the junction with the great river at the place where later rose the city of Prairie du Chien, christened the stream Buade river, in honor of the family name of Count Frontenac. His companion, Marquette, less worldly-minded, called the river Conception, because it was on the day known by that name in the calendar of his faith that he had received permission to accompany Joliet. Eleven years later the Sieur de La Salle gave to the noble river, which he descended to its mouth, the name Colbert, in honor of the great minister of France whose friendship he enjoyed. A century and a half before the Spaniard De Soto had given to the river the name Rio Grande del Espiritu Santo.

The name the Spaniard gave, the many names given by the Frenchmen, are to be found only on maps yellow with age; on the modern map there survives, as is meet, the name given by the aborigines. The orthography has been most varied, for geographers who sought to convey in modern spelling the pronunciation of the old Algonquin word rarely agreed. Thus the old maps, and the old chronicles of travelers, have included these forms of the word Mississippi: Mechisipi, Messasipi, Miscissipy, Misasipi, Mischasippi, Missessipie, Mississippy.

The definition usually given of the word Mississippi is, "father of waters." This is far from a literal translation of the word derived from the Algonquin language, one of the original tongues of the continent. The historian, Shea, who made a study of aboriginal philology, says that the word Mississippi is a compound of the word Missi, signifying "great," and Sepe, "a river." The former is variously pronounced Missil, or Michil, as in Michilimackinac; Michi, as in Michigan; Missu, as in Missouri, and Missi, as in Mississippi. The word Sipi may be considered as the English pronunciation of Sepe, derived through the medium of the French, and "affords an instance of an Indian term of much melody being corrupted by Europeans into one that has a harsh and hissing sound."

An interesting, but apparently unauthentic version of the meaning of the word Mississippi is given in *The Magazine of American History,* Vol. I. The writer quotes a tradition given in Heckewelder's Indian Nations, according to which two large tribes emigrated several centuries ago from west of the Mississippi, giving to that stream the name of Nawoesi Sipu, or River of Fish, whence the present name is derived.

Lake Michigan was the last of the five great inland seas of the continent concerning which the early cartographers derived knowledge. The old maps call it Lake Illinois (Ilinovik, Ilinois etc.), after the tribe of Indians that dwelt on its southern border; and Lake Dauphin, after the heir to the throne of France. Lake Mitchiganons is the term used in the old Jesuit Relation (1670–71), and a Paris map of 1688 labels it Lake Michigami. Most of the early French maps give preference to the word Illinois and its variants.

This Indian word, which has outlived the European names, is variously interpreted to mean "fish weir," and "great lake." Some authorities maintain that the word is derived from Mitchaw, "great," and Sagiegan, "lake." This seems to be the most plausible explanation. The assumption that the meaning is weir, or fish-trap, is based on the shape of the lake.

As with other geographical names derived from Indian sources, the real meaning of the word Wisconsin (Chippewa origin) is so obscure as to be in dispute. The popular translation is "wild, rushing channel," a definition that accords well with the nature of the stream, but which nevertheless is of doubtful authenticity. Another rendering, "the gathering of the waters," is pronounced absurd by students of the Algonquin tongue. Mrs. Charlotte Ouisconsin Van Cleve, in her *Three Score Years and Ten* says that the Indians termed the stream Nee-na-hoo-na-ninka (beautiful little river).

It is claimed by Consul W. Butterfield that the name is derived from the physical features of its lower course, where are observable the high lands or river hills. "Some of these hills present high and precipitous faces towards the water. Others terminate in knobs The name is supposed to have been taken from this feature, the word being derived from Missi, 'great,' and Os-sin, 'a stone, or rock.' "

The word Wisconsin is the result of considerable change from the first rendering. On Marquette's genuine map, where the stream is indicated for the first time, no name is put down. Joliet's map gives it as Miskonsing. Friar Hennepin wrote it Onisconsin and again Misconsin, and the French traveler Charlevoix, who visited this country early in the eighteenth century, gave his preference to this form: Ouisconsing. It was not long before the final letter was dropped, and this form was retained until the present English spelling superseded that of the French.

From its source in Lake Vieux Desert, on the northern boundary line, the stream flows through this state for four hundred and fifty miles. Its descent from the lake to where, at Prairie du Chien, it debouches into the Mississippi, is about a thousand feet. From the famous portage that has played such an important part in Western history, where the Wisconsin turns to the southwest, the current is exceedingly rapid, and the distance to the mouth a hundred and eighteen miles.

The Indian name for Lake Superior was Kitchi-Gami, or, as Longfellow has rendered it, Gitchee-Gumee. The name is derived from the Ojibwa tongue, its English equivalent being "big water." Lac de Tracy was a French appellation given in honor of Gen. Tracy, but it was not sufficiently popular to take firm root. On some of the old maps of the seventeenth century this great fresh-water sea is given the name of Grand Lac des Nadouessis. The latter word was the appellation by which the French usually designated the Sioux Indians. It was at the western end of the lake that the Sioux were wont to come in war parties for sudden raids on the villages of their old-time foes, the Ojibwas.

Lake Superior is the only one of the five great lakes that has retained the name Frenchmen gave it, Supérieur, or Upper Lake. This is the more remarkable in that legendary lore is associated with every island in this lake, and headland and bay on its shores. The Indian fairies known as pukwudjinees had their fabled home along the southern shore of Lake Superior, among the great sand dunes. This pigmy folk is happily described in Longfellow's "Hiawatha."

Early travelers on Lake Superior ascribe the origin of the legend of the pukwudjinees to the mirage, a phenomenon that can be observed frequently on this lake on summer days.[7]

It seems singular that of all the great lakes, the one most closely identified with Indian tradition and legend alone bears a name of European origin.

The name Milwaukee is regarded as of Pottawatomie origin. As many meanings have been ascribed to the word as there are modes of spelling—and these have been many. Mr. Henry W. Bleyer has compiled the following list:

Melleoki—Father Hennepin, 1679.
Millioki—Father Zenobe Membre, 1679.
Meleki—Old French map of 1684.
Milwarik—John Buisson de St. Cosme, Oct. 7, 1699.
Milwacky—Lieut. James Gorrell, September, 1761.
Milwakie—Col. Arent S. DePeyster, July 4, 1779.
Millewackie—Samuel A. Storrow, September 29, 1817.
Milwahkie—Dr. Jedediah Morse, in summer of 1820.
Milwalky—Maj. Irwin to Col. McKenney, October 6, 1821.
Milwaukie—In headline of *The Sentinel* to Nov. 30, 1844.
Milwaukee—Nov. 30, 1844, to present time.

The most generally accepted version of the meaning of Milwaukee is, that the original Indian word signified council place, and that here was neutral ground. Old residents say that it is a fact that the Indians regarded the east side of the river as a sort of gathering place, the chosen spot for their councils being the hill that used to occupy the place where the St. Charles hotel now stands.

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[7] The German traveler Kohl saw a tall, bluish island, with which the mirage played in an infinity of ways. At times it "rose in the air to a spectral height, then sank and faded away; again, islands appeared hovering over one another in the air; islands appeared, turned upside down; and the white surf of the beach, translated aloft, seemed like the smoke of artillery blazing away from a fort."

Another traveler in *Western Woods and Waters* describes imagery so clearly defined as to be seeming reality. "It occurred just as the sun was setting. The sky was overcast with such a thick haze as precedes a storm; and the inverted images of twelve vessels—with the full outlines of the rigging, as well as the sails and other parts—were most distinctly visible on the darkened background." Again, "a blue coast stretched along the horizon in front of us. Surprised, I referred to Bayfield's accurate chart, and found, as I expected, no land so near in that direction. The pilot told me it was a mirage."

In the reminiscences of Augustine Grignon, a grandson of Charles de Langlade, Wisconsin's first permanent settler, occurs the following explanation of the word Milwaukee: "I was once told by an old Indian that its name was derived from a valuable aromatic root used by the natives for medicinal purposes. The name of this root was 'manwau,' hence Man-a-waukee, the land or place of the man-wau. The Indians represented that it grew nowhere else, to their knowledge, and it was regarded as very valuable among them. The Chippewas on Lake Superior would give a beaver skin for a piece as large as a man's finger. It was not used as a medicine, but was for its fine aroma put into all their medicine taken internally. I have also understood, though without placing so much confidence in it as in the other definition, that Milwaukee meant simply 'good land.' "[8]

Grignon's explanation would be a good one, but for the fact that the aromatic root concerning which he speaks in his memoirs seems to have existed largely in imagination. If it ever existed, it must have become extinct, for Dr. Lapham and others found no trace of it, and certainly none of it is to be found in this vicinity now.

Most of the Indian names that dot the map of Wisconsin are of Ojibwa or Winnebago origin, with scattering additions attributable to the Pottawatomies, Sauks and Menomonees. In the following list of Wisconsin place-names and their meanings, the initials in parentheses are given for convenience of reference to authorities cited in the bibliography which follows:

Ableman's—In honor of Col. S. V. R. Ableman, who settled there in 1851. (History of Sauk Co., p. 631.)

Ahnapee (Ah-nup-pee)—When or at what time. (W)

Altoona—Platted as East Eau Claire in 1881; changed to Altoona. (Chip. Valley, p. 184.)

Aniwa—Corruption of Aniwi, "those." (Hist. Colls., v. 12, p. 390.)

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[8] Mr. Benjamin Sulte, of Ottawa, Can., writes me concerning a curious coincidence: "If I remember well what an Algonquin told me one day, the word Milwaukee means good land, bonneterre, or Terrebonne. Solomon Juneau was a native of Terrebonne seigneurie, in the province of Quebec."

Antigo—Evergreen.

Arcadia—Named by Mrs. David Bishop in 1856. The valley was an unbroken field of flowers when she first saw the place.

Ashland—Indian name, Zhamawamik, meaning long-stretched beaver.

Augusta—First called Bridge Creek; platted in '57. (Randall's Chippewa Valley.)

Aztalan—According to Humboldt this is the ancient name of the country from which the people of Mexico, called Aztecs, emigrated; and this is described as lying far to the north. Hence a little fancy only is necessary to locate this country in Wisconsin. (L)

Bangor—John Whelan gave the name on account of the Welsh settlers there. (History LaCrosse Co., p. 723.)

Barron—After Henry D. Barron, of St. Croix Falls, judge of the Eighth Judicial Circuit. (Chippewa Valley, p. 311.)

Bayfield—Named in honor of Captain Bayfield, of the British Royal Engineers.

Belmont—From three mounds called by early French Belle Monte. (History Lafayette Co., p. 612.)

Boscobel—Named in 1855 by Mrs. John Mortimore as the Spanish synonym for "beautiful grove."

Buttes des Morts—Hill of the Dead. (L) The story of this battlefield is given in Legler's "Leading Events of Wisconsin History."

Cassville—Named after Gov. Lewis Cass.

Chequamegon (Sha-gu-wa-mick-koong)—Place of shoal water. (W)

—— Shaguamikon means literally "something gnawed on all sides." (W W)

—— A long narrow strip of land running into a body of water. (V)

Chetek (Zha-da)—Pelican. (W)

Chilton—John Marygold wished the town called Chillington after his English home. The county clerk omitted the second syllable in recording it.

Chippewa (Ojibway)—To roast till puckered up. (W)

—— Indian name, Chenondac. (M)

Crocodile River—A stream flowing into Lake Winnebago from its southeastern side. So called by Capt. Jonathan Carver from a story that prevailed among the neighboring Indians, of their having destroyed an animal in its waters, which, from their description, he supposed to be a crocodile or alligator.

Darlington—Named after Joshua Darlington, of Warsaw, N. Y.

Delavan—In honor of E. C. Delavan, temperance advocate of Albany, N. Y. (Walworth Co. History, p. 657.)

De Pere—Called Rapids des Peres, "rapids of the Fathers." Claude Allouez established a mission here.

Dodgeville—In honor of Henry Dodge, first territorial governor.

Eau Claire (Wahyawconuttaguayaw)—Clear water, now known as Eau Claire.

Edgerton—Named after H. B. Edgerton of Milwaukee.

Fort Atkinson—In honor of Gen. Henry Atkinson. (Wis. Hist. Proc., '98.)

Fox Lake—Indians called it Hosh-a-rac-ah-tah, meaning fox. (Dodge Co. History, p. 465.)

Gogebic (Gu-gwa-gee-bing)—The place of diving; probably referred to the jumping out of water of schools of small fish. (W)

——— A body of water hanging on high.

Green Bay—Derives its name from a fancied deeper green colors of its waters than usual. (L)

——— Marquette called it Bay of the Fetid; Hennepin and Membre did the same. Marquette says the Indians called it Salt Bay; St. Cosme called it Bay of Puants; on de L'Isle's maps (1700, 1718) it appears Bay des Puans; sometimes it was called Le Grand Baie; Mr. Burnett, 1798, called it Le Bay. (Hurlbut's Chicago Antiquities, p. 441.)

——— A corruption of La Grande Baie. (U)

Hazel Green—First called Hardscrabble. Renamed in '38 by Capt. Chas. McCoy. (Grant Co. History, p. 735.)

Horicon—Clear or pure water. So called from the original name, Lake George. (Dodge Co. History, p. 479.)

Hudson—Called Buena Vista, Willow River, and finally Hudson (Hall's Hudson.)

Janesville—In honor of Henry Janes, first postmaster. (Janesville Illustrated, p. 5.)

Kaukauna (Oh-ga-ka-ning)—The place of pike. (W)

—— At the place where pickerel are caught. (K)

—— Kawkawnin, literally "Can't get up," in Menominee tongue. Called Cocolo by Canadians voyageurs "who ruin every Indian word they meet with." (Featherstonhaugh, Vol. 1, p. 162.)

Kegonsa (Gee-go-sug)—Little fishes. (W)

Kenosha (Gin-no-zha)—Pickerel. (W)

—— Pickerel or pike. (V)

—— Keinauche. Algonquin name for the fish known as pike; applied to a clan of Ottawas having that fish as its totem. From this is derived the name of Kenosha. (J. R., v. 54.)

Kewaskum—(Gee-way-skum)—His tracks are homeward. (W)

—— Named after an old chief who died there. (History of Washington and Ozaukee Counties, p. 436.)

—— The road is crooked. (V)

Kewaunee—Prairie hen (formerly known as Wood's River). (H)

—— I cross a point of land by boat. (V)

Kishwake—Cottonwood. (Long)

Koshkonong—The lake we live on. Black Hawk's lurking place in 1832. (H)

Lac Court Oreille—Short ears, from a band of Ottawas, who cut off the rims of their ears. (A B.)

La Crosse—Etymology doubtful. It is said that when the pioneer Nathan Myrick ran his flat-boat ashore at the point now known as the foot of Main street he found a cross fastened to a pine stump—doubtless an emblem planted there by some wandering Catholic priest. Thus the name Le Croix was given the spot, afterwards anglicized into La Crosse. The Winnebago Indians knew the city only as the "Woman's Bosom," because east of the city two cone-shaped points rear their heights from the bluffs, and can be seen many miles from several directions.

Lac Flambeau—Torch lake, a collection of five small lakes; they abound in fish which were formerly taken by torch light. (A B)

Lake Geneva—Named by John Brink, because the lake reminded him of Seneca Lake, near Geneva, N. Y. (Simmons, Annals, p. 11.)

Lake Vieu Desert—See Jesuit Relations, Vol. 16, note. Lapham's Wisconsin, p. 95.

—— Katakittekon (Lake)—Called by the French Lac Vieux Desert, from the fact that on an island in this lake there was an old deserted planting ground of the Indians. (L)

La Point—Monungwanacaning is the name applied to La Point on Lake Superior, and signifies yellow woodpecker. (C)

Manawa—Chippewa word, he has no tobacco. (Wis. Coll. 12, p. 392.)

Manitowoc—Spawn of spirits. Pagan Indians imagined that spirits spawn like fish. (V)

—— Devil's den, from a tradition. (H)

—— Manitouwauk—The home or place of the spirits. (Louis Moran.)

—— (Mun-nido-walk)—Spirit woods. (W)

—— Manitouwaukee, River of bad spirits. (Dr. Jed. Morse)

—— River of spirits. (L)

—— Manitowokie, from Manito, a spirit; auk, a standing or hollow tree that is under a mysterious influence. (S)

Marinette—From a Chippewa Indian, whose father was French. (Marinette Eagle, July 15, 1876.)

Mattawan—On the sand. (W)

Mazomanie—Moose berries. (V)

Medford—Named after Medford, Mass., by projectors of the Wisconsin Central who lived there.

Menomonee—(Oh-mun-no-min-eeg)—Rice people. (W)

Menong—Place of blue berries.

Mequon—A feather. (V)

Michigami (Mich-chi-gum-mih)—Great body of water or lake. (W)

Michigan—Mitchaw, great; sagiegan, lake. (Blois, Michigan, p. 177.)

—— Great lake or the weir, or fish-trap, from its shape. (B)

—— Probably a corrupt form of Michigami, meaning a large body of water or great lake. The Ottawas and Pottawattomies who lived along the shores of Lake M. may have given it that name instead of the Chippewa word Kitchigami (pronounced Kee-chee-gau-mee) whereby the latter designated Lake Superior or any other large body of water. (W)

Michipicoton—Big sandy bay. (S)

Milwaukee—A rich or beautiful land; pronounced by the Indians Me-ne-aw-kee. (Louis Moran.)

—— (Min-no-u-ki)—Good land. (W)

—— The name of Milwaukie exhibits an instance of which there are many others, in which the French have substituted the sound of the letter l in place of n, in Indian words. Min in the Algonquin languages signifies good. Waukie is a derivation from aukie, earth or land, the fertility of the soil along the banks of that stream being the characteristic trait which is described in the Indian compound. (S)

—— Mr. Gurnoe of Court des Oreilles derives the word from Minewaki (pronounced Mee-na-wau-kee), a high promontory such as may be found on both sides of the city now within the city limits. (W)

—— Minnoaki—Good land. (W) Min-no-a-ki. (See Introduction.)

Mineral Point—In the early days of lead mining, the plateaus that abound in this region were called "points."

Minocqua—Good woman.

Mississippi—The father of waters. (B)

—— (Mihchi-zee-bih)—Big river. (W)

—— The Indians never speak of the Mississippi as the Father of Waters—that is rather fanciful, but invariably refer to it as the Big River. The Winnebagoes called it Ne-koonts-Ha-ta-kah—Ne-koonts meaning "river," ha-ta-kah "large." The Sioux called it Wat-pa-ton-ga—watpa, "river," and tonga, "large." Sauks designated it as Mecha-Sapo; Menomonees, Mecha-Sepua; Kickapoos, Meche-Sepe; Chippewas, Meze-Zebe; Ottawas, Mis-sis-se-pi, all variations of the same. (Traditions and Recollections of Prairie du Chien, by B. W. Brisbois, Wis. Hist. Coll., Vol. 9.)

—— The name of the Mississippi River is derived from the Algonquin language, through the medium of the French. The term appears first in the early missionary letters from the west end of Lake Superior, about 1660. Sippi, agreeably to the early French annotation of the word, signifies a river. The prefixed word Missi is an adjective denoting all, and, when applied to various waters, means the collected or assembled mass of them. The compound term is then, properly speaking, an adverb. Thus, Missi-gago means all things; Missi-gago-gigjetod, He who has made all things—the Creator. It is a superlative expression, of which great river simply would be a most lean, impracticable and inadequate expression. It is only symbolically that it can be called the father of American waters, unless such sense occurs in the other Indian tongues. (Schoolcraft's Narrative, p. 140.)

Montello—Spanish for "the hill by the water." Named by a Mexican war veteran.

Mont Trempe-l'eau—The mountain that stands in the water. (AB)

Mosinee (Mo-zin-eeg)—As given. (W)

—— From Mosinig, Moose. (Hist. Coll., vol. 12, p. 394.)

Mukwonago—A ladle. (A)

—— (Mauk-wau-wau-nan- gong)—The place where the bear constellation is. (W)

Muscoda (Mush-koh-da)—Prairie. (W)

—— Prairie. (C)

Mushkoda—Prairie (rapids) now known as Jenny Bull. (C)

Muskego—Corrupt form of Mush-kee-gong, meaning at or from a swamp. (W)

—— Cranberry. (H)

Namekagon—Place of the sturgeons. (V)

Nashota (neesh-zho-da)—One of a pair; a twin. (W)

Necedah—Let there be three of us. (V) (Hist. Coll., Vol. 12, p. 394.)

—— Corruption of nissida, "let there be three of us."

—— Yellow. (Wis. Hist. Coll., Vol. 8, p. 396.)

Neenah—Water. (Cunningham's Necedah, p. 45.)

—— "Once Gov. Doty was walking with an Indian, and pointing to Fox River, asked its native name. Supposing the governor meant the element, and not its particular geographical name, the Indian responded 'Nee-nah,' water. Gov. Doty at once applied the name."

—— Col. Petterol, an engineer sent by the Secretary of War during Van Buren's administration, gave the name Neenah in his report. (Morgan L. Martin in a letter to Lyman C. Draper.)

Oconomowoc—Oh-kon-nim is a beaver dam. Oh-kun-nim-muh-gag is the region of the beaver dams. Oh-kun-nim-muh-walk, the beaver dam woods. (W)

—— Beaver Dam. (V)

Oconto—Black bass.

Odanah—Town. (W)

Onalaska—Bright water.

Oshkosh—A hoof. (Louis Moran.)

—— Named after Chief Oshkosh. The original word, which in the Menomonee signifies brave, was pronounced without the h in the first syllable, and was accented on the last: "Os-kosh." The naming of the place was done at a meeting for the purpose held at the house of George Wright in 1840. The names proposed were Athens, Fairview, Osceola, Stanford and Oshkosh. Robert Grignon and a number of half-breeds from up the river at Butte des Morts were the strong party and formed a majority in favor of the name Oshkosh.

Ottawa (O-daugh-waog)—The traders. (W)

Outagamie (A-dow-wi-ga-meeg)—Contracted to O-duh-ga-meeg, on either side of the river dwellers. (W)

Ozaukee (Uh-za-geeg)—People of the mouth of the river. (W)

Packwaukee—Forest opening. (V)

—— (Bug-wau-keeng)—Thin land, oak openings. (W)

Pahjetakakening—The water that falls over rocks, now known as Little Bull Falls. (C)

Penokee (O-pin-uh-keeng)—Land or country of potatoes. (W)

Pewaubic (Bee-wa-bick)—Iron. (W)

Pewaukee—The flinty place; pronounced by the Indians Pee-wau-naw-kee. (Louis Moran.)

—— (Pewaukee-wee-ning)—Lake of shells or snails. (L)

Pishtaka—Fox. (L)

Plover—Indian name is Aupuhkirakanewe, River of Flags. (C)

Plymouth—First called Springfield; renamed after Plymouth, Conn. (Plymouth Reporter, Dec. 10, 1872.)

Port Washington—First called Wisconsin City, then Washington City, in 1844 Port Washington.

Prairie du Chien—Dog's prairie, from the name of a Sauk chief. (A B)

—— Prairie des Chiens—Near the mouth of the Ouisconsin; signifies dog plains. (Jonathan Carver.)

Puckaway—Perhaps a contraction of Bo-kuhn-za-wa, an unclean disease. Indian names frequently betray shameless uncleanness. (W)

Racine—From the French equivalent for root. The river was called Root River.

—— St. Cosme called the Root River at Racine Kipikwi and Kipikuskwi; it has also been called Chippecotton or Schipicoten as Mrs. Storrow termed in it 1817, the signification of which we have heard was "maskalonge." We have seen it called in print "Masquedon." (Hurlbut's Chicago Antiquities, p. 441.)

Wisconsin—Gov. Doty, one of the territorial governors, used to insist on the name being written Wiskonsan, but the mode was unpopular, and the legislature irrevocably established the form of its orthography as Wisconsin. (Hurlbut's Chicago Antiquities, p. 441.) (See Introduction.)

Shawano—In the South. (V)

—— (Zha-wun-no)—The southerner. (W)

Sheboygan—Any perforated object, as a pipe stem. (V)

—— Expresses a tradition that a great noise, coming underground from the region of Lake Superior, was heard at this river. (H)

—— (Zhee-bo-i-gun)—That which one perforates or pierces through; hence zha-bun-ni-gun, a needle. Another meaning possible is Zee-bwa-gun, a cane, like corn-cane, etc. (W)

—— A hollow bone. (Louis Moran.)

Sheshgemaweschecan—Soft maple, now known as Eau Pleine, or Full Water. (C)

Shiocton—Force of wind. (V)

—— Doubtful derivation. A back tide or current induced by wind is spelled u-zha-ya-tun. (W)

—— It floats up stream.

Shullsburg—Named after John W. Shull.

Stevens Point—Kahkagewincheminitegong, Hemlock island, a name applied to Stevens Point, on account of an island in the Wisconsin River opposite, covered with hemlock, a rare growth in that region. (C)

Stoughton—Named by Luke Stoughton, who purchased the site from Daniel Webster in 1847.

Suamico—Yellow beaver. (V)

—— (O-sa-wa-mick-kong)—The yellow residence place. (W)

Tomah—Named in honor of a famous Menomonee chief.

Waubesa—Swan lake. (V)

—— (Wau-bih-sa)—A white bird flies along. (W)

Waukesha (Wau-gosh-i-kag)—The place of foxes; barely possible that as a totem designation it was shortened to Waugosh-shag; may be a corruption of the plural form of wau-gosh-shug, foxes. (W)

—— Joshua Hathaway inscribed the name upon an old tree. Waukesha had been known as Prairieville. "I was engaged in subdividing the townships now comprising Racine county, and from some Indian boys lodged near my encampments I made additions to my Indian vocabulary. With the medium of my fox-skin collar I obtained this name, understanding it to be Pottawattomie for fox, which is a favorite name with the natives for all crooked rivers whose course resembles the eccentric trail of that animal. By giving the middle syllable a thin, prolonged, decided accent, and leaving the last syllable but half aspirated, you have the original as given to me—Wau-kee-shaw." (H)

—— Foxes. (V)

—— The little fox; pronounced by the Indians Waw-goosh-sha. (Louis Moran.)

Waupaca (Wau-pug-ga)—White sand bottom. (W)

Waupaca—Tomorrow. Named in connection with Weyauwega, which means "here we rest." Ascending the slack waters of the Wolf and Waupaca rivers to the former place, the red men were wont to encamp there for the night and on the morrow would resume their journey. Hence the terms "resting-place" and "tomorrow" bestowed by them on these places.

—— (Wau-bun)—Dawn. (W)

—— East. (V)

Wausau (Wau-suh)—Far away. (W)

Wausaukee (au-wuss-sa-kih)—Beyond the hill. (W)

Wauwatosa (Wah-wah-ta-sih)—Lightning bug. Wah-wah-to-say, he shines as he walks. (W)

Weyauwega—Here we rest. (See Waupaca.)

—— He makes it his body; probably derived from a legend. (V)

Winnebago—Fetid water.

—— (Ween-nih-beeg-gog)—Dwellers by dirty water. (W)

—— The meaning is placid, or beautiful. (*Historical Magazine*, Vol. 1, p. 317.)

—— Dirty water. (V)

—— Original name was Winibi (dirty water). Winipeg is a Cree word of the same meaning.

Winneconne—Doubtful derivation Kan-ing, a place where something is obtained or produced; possibly derived from the ween, meaning marrow, and kan-ing The marrow of deer bones is a great delicacy with Indians, and above place may have been a feasting place. (W)

Winnibigoshish (wee-nih-beeg-gohn-shish)—The miserable little lake. (W)

Wisconsin—Muskrat house; no two Indians agree as to the meaning of the word. (V) (See Introduction.)

—— The Winnebagoes referred to the river as the Neekoonts-Sa-ra or Gathering river; hence a river having many tributaries. (Wis. Hist. Colls., V. 9.)

Wonewoc (Wa-wo-nowug)—They howl, probably of Winnebago origin. (W)

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THE VOCABULARY OF SHAKESPEARE.

JAMES DAVIE BUTLER.

No depreciator of Shakespeare has denied that "the fool had planted in his memory an army of good words." It is interesting to ascertain, and even to inquire, where he recruited those soldiers.

We know that he more or less borrowed all his structural plots except one from preceding writers, and he would naturally borrow language also. That he did so borrow has been asserted by most writers, and their statements led Boswell Stone in his edition of those chronicles of Holinshed from which Shakespeare learned the facts concerning his English historical plays, with every word Shakespeare had in fact copied from them printed in Italics. The words thus italicized proved to be surprisingly far between. An extreme instance will hardly make us overrate their fewness.

A man imprisoned in the Tower of London being found dead the next morning was thought by some to have been *strangled.* Strangled in the chronicle is the only word italicized of all those in these following lines, and more after them:

> But see, his face is black and full of blood,
> His eyeballs further out than when he lived,
> Staring full ghastly like a *strangled* man,
> His hair upreared, his nostrils stretched with struggling,
> His hands abroad displayed, &c.

Again, Sidney Lee declares that in the classical plays our dramatist adhered to the translated text of Plutarch "with the utmost literalness." But there is a reprint of North's translation of 1587—the edition which Shakespeare must have used, which points out every line from which any word was actually adopted and those lines are fewer than the pages. In support of his statement Lee quotes the following passages: Plutarch's words are: "I am Caius Marcius who hath done to thee particularly and to all the Volces generally, great hurt and mischief, which I cannot deny for the surname of Coriolanus which I bear." In Shakespeare's lines we read:

> My name is Caius Marcius, who hath done
> To thee particularly and to all the Volces
> Great hurt and mischief; thereto witness may
> My sur-name Coriolanus. 4. 5. 71.

Ten words identical in scarcely four lines! What of that? No matter how great the verbal similarities are in these citations, for I can prove that the borrower had already used every single word that is here quoted except "particularly." He had no need to borrow words for his diction was already better than Plutarch or his translator could supply. New terms were to him no temptation.

No book was kept before our youthful dramatist more than the Bible. Translations were then numerous and widely circulated. There may have been a copy in his birth-house for his kindred were not without Puritan leanings. At all events the Scriptures were before him in church and in school where attendance was alike obligatory. His "small Latin" was largely learned from the Testament in Latin. The Great Bible of 1539 was set up in the church of his baptism, and that wide open and where the way-faring man could read. Scriptural quotations are so numerous that a bishop has written a volume about them. In fact no two books of the time had so many words in common as Shakespeare and the Bible. Yet for the most part neither borrowed from the other while both in common took up the words of common life. Hence quotations from Holy Writ were not so literal as has been often believed. They were adapted to Shakespearian purposes by Shakespearian words. In the locution, "He that doth the ravens feed yea providently caters for the sparrow," two most expressive words are not Biblical, namely, providently and caters. Neither of them had been before used by Shakespeare nor were they again, and so they belong to his *ἀπαξ λεγόμενα.* The Oxfordians have also discovered that cater as a verb is a Shakesperian creation, for no writer had used it before,—and there is reason to think they will find that providently too was of Shakespearian birth. Of course neither of these terms occurs in any verse of the Bible. Biblical doctrine it would seem meets us in the dramatist much oftener than biblical diction.

In regard to dictionaries as word-sources it is clear that our play-maker owed them very little. The most popular contemporary works of that class were Palsgrave and Florio—the one a teacher of French and the other of Italian. Florio's work entitled "A World of Words," must have made some new ones known to Shakespeare. In 1611, however, when Florio registered the term a-bee-cee-booke he could not have read King John in which Shakespeare had sixteen years before called the same thing by its folk-name an absey-booke, (I. 1. 196) speaking of "answer following question as in an absey-book," that is a-b-c book. Not without reason do we find Florio's peculiar follies held up to ridicule under the name of Holofernes in Love's Labor Lost. On the whole, one is more and more forced to the conclusion that the historical or bookish sources of Shakespeare's vocables were a beggarly account of empty boxes, —and can only be contrasted with the treasures which his own writings display. A brief digression seems here more excusable than may at first be thought.

For the last half century a dictionary of English has been in making in England. It is printed in instalments each no larger than a single number in a leading magazine. It abounds in illustrative citations which demonstrate the preeminence of Shakespeare's vocabulary as it was impossible to see it before. It will point out every word which he was first to use, and every writer who used any word of his sooner than he. This work which it is hoped will be half finished during the present year, is called on its title pages, "A New English Dictionary on Historical Principles." This title being too long for every-day use has been abridged in more ways than I can mention, and has at last dwindled to a monosyllable—that is either H-E-D or N-E-D—H-E-D being made up of the initials of Historical English Dictionary,—and N-E-D of those beginning the words New English Dictionary. N-E-D is preferred by Dr. Murray who has been the chief editor from the outset,—and accordingly N-E-D is the name I shall use in the present writing, and it is because I must iterate and reiterate that word so often that this prefatory note was necessary. Murray insists on the word *New* because he claims that his work is absolutely new—old things are passed away and all things are made new.

An idea, or it may be a phantasy possesses me that Shakespeare who has so inimitably portrayed characters, began from a child to distinguish them, and soon became aware that he could see through his fellows while their eyes only beheld his outer man. He was a clairvoyant of souls while Röntgen rays are content to pierce bodies and that darkly. His inward light, however, could not shine forth unless set free by outward auxiliaries. It was hemmed in like Ariel pegged in the knotty entrails of the oak. Words, or something like them, were helpful to his own character-studies, and they were indispensable whenever he would make known what he knew. Messengers vocal or written must tell others what his mind's eye, his only, could detect. The speech of each speaker was this speaker's counterpart or double and so that each seemed made for the other. Words held a character as a carpenter's vise holds a block of wood while the youngling player surveyed and fashioned it at his pleasure.

Noting characteristic utterances only for the satisfaction of his own thought—no further harm,—would grow into a childish indulgence and custom. Then when among his fellows, little boys and girls, he was called on for a story that "storied" individual who was made by the teller to paint himself most deftly in his own natural terms was sure to be the favorite. This and that turn of his syllables was declared to be just like him. The more he abounded in such clear-cut portraits the more, like Walter Scott, was he the ringleader of juveniles who did converse and waste their time together. Nor did future metropolitan homage steal over him with such a peace above all dignities as had been his lullaby after the juvenile overflow of clamors and kisses on their idol.

The genius of the wonder-child had full play in choosing out of a crowd the words befitting the diversified natures he had detected before he could read. His skill became as sagacious as the hunter's who distinguishes dogs—the swift, the slow, the subtle, every one according to the gift which bounteous nature hath in him closed. In discernment of diction he must have been of an instinct as unerring as Falstaff claimed that his was when he recognized the royal heir-apparent in the dark and where his last thought was of meeting him. Perhaps his instincts ought to be called those which teach bees from among flowers which are poisonous and bitter to select and fasten upon only the honey-bearing for bringing home to their tent-royal.

The child is father of the man. The infantile word-needer and word-seeker became the greatest of word-masters, chiefly in those very lines where he had ferreted out his characters,—trees as it were which he pulled up with every rootlet and not a little of the surrounding soil. In the world of language and the corresponding world of human lineaments he was alike original for he knit them into a preestablished harmony. His unique companionships had afforded him better materials than any university could furnish, and his genius could so mould them dramatically that parts into parts reciprocally shot—

> "They keep in one consent,
> Congreeing in a full and natural close
> Like music."

But Shakespeare's words, equally multitudinous and matchless, where did he get them? The first and chiefest foundation of his vocabulary was English undefiled,—pure from outside adulterations,—his mother tongue and preeminently his mother's tongue. While still mewling in his mother's arms some of her love-inspired lullabies may have been so imprinted on his heart that in the fulness of time they relived in his own songs. Among such warblings N-E-D finds that *ding-a-ding* is an onomatope which has been caught up by no one before Shakespeare in 1600, who was also foremost to register Hamlets buz, buz! and he will find that there were others as Juliet's repeated "Hist!," but whether *Tu-whit Tu-who* of the staring owl, and *suum su* of the cold wind were among those infantile impressions the words stand too far down in the criss-cross-row for N-E-D to see as yet.

Half the words which are ever mastered by most people are acquired unawares before the end of the first seven year climacteric. He who gave us the phrase "parlous boy" was one himself—and perhaps by heredity gained the gift of the gab from both parents. Even if Mary Arden was not talkative she must have been a good listener when babbling gossips came from far and near, came together for a long afternoon—bringing their work—that by making nether-stocks or mending them—no reproach might fall on their idle hands. Then surely tongues were not idle. Men, women and things were discussed with a zest which is only possible when cronies after long isolation have free course in an exchange and interchange of confidences. Not one was languageless like a fish on land. All shared in the sweet enlargement.

But little pitchers have great ears. The curious child with open mouth, or certainly ears, among strange faces, devoured the chit chats which N-E-D shows that he was perhaps the first to call "vain bibble-babble" in 1601. Whether he would or not, he let no word fall to the ground. See such a couplet as this:

> Yet that which seems a wound to kill
> Doth turn oh! oh! to ha! ha! he!
>
> (Troi. 3 1. 132.)

The Ardens were of higher social standing than the Shakespeares and the bride had raised the standard of speech, or at all events diversified it in the circle of her bridegroom. Among her associates too there were members of decadent families who had seen better days, and the most long-lived relics of gentility may be detected in language. Many linguistic peculiarities or idioms were represented. The receptive urchin was not slow to divine the true inwardness of what in default of a better term may be styled *inarticulatives.* That urchin is proved by N-E-D to have brought some of those interjectional words which are no words, before all other writers into the light of language. For instance he first wrote down "Hum" in three senses; the hum of either army that stilly sounded, the hum of the cloudy messenger—no where before called cloudy—whose hum was as if he would say, you'll rue your answer: (Mac. 3. 6. 41.) and the hum and ha—the petty bransd that calumny with a shrug doth use.[1] Another example which possibly should come under the post-nursery period is afforded by the root of the word "Hurry." Hurry both as a noun and a verb, like hundreds of other words was created by Shakespeare. It is not found either in the Bible or in any other book before him.[2] How did he make it? N-E-D's answer is that he either contracted and twisted it out of the more ancient hurly-burly, or that he or some one of the gossips at his mother's hearth expanded it out of *hurr,* or whir an onomatope or mouthing which is naturally used in many unconnected languages to mean "rapidity in vibration and in the consequent motion." Analogous word-building every mother sees in her four year old hopefuls. One outcome from such *seances* of tattling cronies was that the licensed eavesdropper came out of them like the porcupine who in a vineyard rolling over and over on windfalls carried off a grape on the point of every quill. But the parlous boy's grapes were words, often words which his own quill was foremost to write.

My conviction is firm that our greatest master of words secured his vast aggregations on the line I have now sketched by observant watch, conscious and as often unconscious—of what he heard, and not largely from reading of any kind. Two books and no more have been made much of being believed to show his name written by his own hand. But these autographs are of doubtful genuineness. His best biographers tell us that at his death he was owner of scarcely a single volume—for otherwise his will would have mentioned such possessions. Nor can I ascertain that there existed in his contemporary London any such Library within his reach or I may add without it as the commentators would persuade us that he studied and

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[1] Again, the little pitcher heard toadies defined as "pickthanks," a local word he was one day to explain to Londoners by the line,—"Smiling pickthanks and (as epexegetical) base newsmongers." I Hen. iv, 3. 2. 25.

[2] Venus and Adonis, line 904, 1592:

> A second fear,
> Which madly hurries her she knows not whither.

conned. No such oasis as yet in that Sahara. All the more was his word-harvest rather from folks than from books.

No sooner did he step out of the nursery into his father's slaughter-house—or butchery as it was named in common parlance—than he saw the fat of a beeve rolled up in a lump and covered with its own caul—and was told that the mass was called a "Keech,"—Without a thought of any use of the vocable he kept it in hand—used it as a name for a butcher's wife—but reached its highest use only in his latest play and that in envenoming the keenest sarcasm on Wolsey who was both corpulent and the son of a butcher. The sarcasm was:

> I wonder,
> That such a keech can with his very bulk
> Take up the rays of the beneficial sun (the king)
> And keep it from the earth.
> (H. VIII. I. I. 55)

Keech! What a soul of wit in the brevity of a syllable! But his plays abound in vocables which were unknown in dictionaries till derived from his writings—and which often testify their origin to have been from the streets and not from the schools Thus his words are: "gillivors which some call nature's bastards." "Long purples which maids call dead men's fingers, and shepherds give a grosser name." "The fearful spout which *shipmen* do the hurricano call." This last word hurricano without dropping the Spanish termination and first brought out the year after the Armada. Such locutions betoken a vocabulary gained more through ears than eyes, more through hearing than through reading.

As in the sitting-room of the birth-house and in business stands near it, the unfledged poet was elsewhere a word-finder even where he was by no means a word-seeker. Among his unsought findings in the free-school were vocables which nobody before him had gathered up either there or anywhere. One of these utterances seems to have been the expression Honorificabilitudinitatibus—his longest word, the longest too in English or indeed in any tongue outside of Greek which distances all competition in the Aristophanic mammoth—biggest born of earth (Love's Labor Lost, V. I, 44.)

More than half a century ago living next door to a Quakeress who was a nonagenarian or near it, I chanced to ask her about the dame-school she had attended in the prerevolutionary era. The last function every day she said was that the children all stood up and intoned in chorus, two syllables by two, —Hono-rifi-cabil-itu-dini-tati-busque. This voicing from one equally innocent of both Shakespeare and of Latin was rather startling. Nor could I persuade the Quakeress to bate the final syllable *-que* which seemed to me superfluous. She insisted that the terminal *busque* was intoned with more gladsome emphasis than any other couplet because it rang out the breaking up of school. In truth her polysyllable,—though she did not know it, was a fitting daily valedictory to both teacher and school-mates. It seems to mean, "and with all highest compliments." It is like *Wohl bekommt'es ihnen!* at the close of German schools. Can we believe that the long word came into a Puritan school directly from Shakespeare? It seems more likely that it had descended by a sort of apostolical succession from the school in which Shakespeare had been taught —or from one formed on the same model—and that it had been imported into the curriculum there from the founding of the establishment, for on the continent the term is traceable in earlier centuries. N-E-D cannot ferret out this greeting in any English book prior to Shakespeare who, however, while introducing the monster assumes that it must be well-known to every school master. Various other school words N-E-D tells us are found in no author earlier than Shakespeare. Among these are "Accidence" meaning grammar, and exclamation denoting a mark of punctuation, and "caret" showing that something is wanting. "Hic jacet" learned either in school or from tombstones on the way thither, N-E-D says has been read in no English writing before All's well that ends well, of 1601. iii, 6, 66. "Exit," Latin for "he goes out" which the young school-boy had learned in a drilled dull lesson he at first employed, following others, in the Latin sense, and afterward originated the noun "exits" and at the same time its companion word entrances. N-E-D shows that both words—originating with the same player are both compounds of the same Latin verb,—one *exeo* and the other *ineo,* the divergent form of "entrance" resulting from its coming through French, while exit was borrowed directly and bodily from Latin with no change of a letter. But both in English had the same father. That father since neither of his parents could read, probably learned the word "catechism" in school, but N-E-D sets him down as before any one else making it to signify "a course of question and answer, in 1596, when Falstaff says "and so ends my catechism." Such are specimens of school words known to all scholars alike but noted by N-E-D as first treasured up and made literary words by the parlous boy. One crumb more is *Ignis fatuus* which in my judgment was first picked up in the school though it had been written before he was born in one scientific book, Fulke on *Meteors,* a work which we cannot believe to have been within Shakespeare's reach in 1596 when he used it. (Hen. iv, iii, iii, 38.)

A word seems called for regarding a host of bookish Shakesperian words which could not have been picked up among early companions of Shakespeare—or indeed among those he was at any time associated with. N-E-D makes it very probable that this host were for the most part original creations. Many have been sought in vain by a thousand eyes in any pre-Shakespearian writer—and others when found were traced out in writers he could not have read—or they were used in senses either unknown to him or unregarded. Instances crowd upon me but my limits exclude mentioning even one. In N-E-D's hundred past issues he has never come empty-handed of words never found before in Shakespeare, and in the hundred to come his harvest will be as great. Whence came they? is a question which volumes cannot answer.

Whenever I have noted a word in N-E-D set down as found in no book earlier than in Shakespeare I credit him with enriching our printed speech with that word—catching it up from every day speech around him—or forming it as a variant of older forms,—or elements—or coining it outright—or bringing it in from some foreign tongue—I could not do otherwise without holding that he discovered, in the few books within his reach, vocables which have lain hid after a half century of search from N-E-D's legion of experts.

It has been fancied that N-E-D has too hastily decided usages to be earliest,—and no doubt he has sometimes erred in this way. It is, however, an error he has watched against from the beginning with perpetual vigilance. With this view he has drawn up lists of his earliest usages so far as discovered by his readers, and begged from every one who knew of instances yet earlier the charity of making them known to him. Such lists —and often single words—have for five decades appeared among the queries in the London Weekly *Notes and Queries.* They have also been sent to every subscriber of N-E-D's between the leaves of sections as they have been mailed all over the world.

One of these lists—a specimen of the series in which it is No. 12, contains 412 words, all between deacon and demonstrative, with the earliest date at which each one has been detected in use, and an earnest appeal to all persons who should fall in with earlier dates that they would forward those dates by letter or book-post to Oxford.

This painstaking to ferret out earliest usage makes it very unlikely that words credited to Shakespeare as the first user can be espied in any author before him.

It were easy to fill many pages in showing Shakespearian coinages of vocables which not only out-lived their author's time but must for the most part pass current as long as our language lasts. The world has need of them and knows its need. But at present I must content myself with a word about a single formation.

Many words with the suffix *ment* were made by Shakespeare. The list may well be headed with allayment which has been brought to light by N-E-D neither in any author before nor yet after Shakespeare's own two uses of that coinage. The same may be said of cloyment. None of his predecessors had said abodement or bodement or annexment or engrossment. He created bewitchment and blastment—which no one caught from him before 1800. Cerement which he made in 1602 was not picked up by Scott till 1820, definement a birth of the same 1602 first reappeared in 1867. Shakespeare's "enfranchisement" of 1595 was adopted by Francis Bacon thirty-one years afterward.

It is amazing that the word amazing is itself found nowhere back of Shakespeare nor is amazement in three of its four senses. It was used in a fourth sense, now obsolete, by Spenser, six years before the word occurs in Hamlet.

But in this and hundreds of other cases where Shakespeare was not first to use a word it is easy to show that he was no borrower—but added a new and better sense of his own to an old form—or knew nothing of any such old form. Congealment, definement, hardiment, and interchangement are cases of this nature.

In one instance I chance to notice that Shakespeare was first to use a word which has eluded the argus-eyes of N-E-D. Hist! Romeo, hist! cried Juliet. (2. 2. 159.) This was in 1591, while the earliest citation in N-E-D was twenty-six years later, and that from a dictionary.

Among Shakesperian words of which I find no coiner but him with the prefix *en* are endart, enfetter, enhearse, enmesh, enrank, enrapt, enround, ennoble, ensconce, ensear, ensky, entame, enthrone, enthrall, entreasure, enwheel, enguard, enjail, etc.

But Shakespeare's verbal creations demand a treatise which cannot be begun till N-E-D has dragged its slow length along to the very end of its appendix. May its "finis" hasten on!

The school-day words he saved are presented in evidence that the incipient or growing play-wright before entering his teens was already whether wittingly or unwillingly a snapper up of trifles close at hand—and so became a word-monger—a word-gatherer—a word-treasurer. His conceptions demanded constant kodak catches of words. It were easy to multiply illustrations all pointing the same way and along many lines. Many which I cannot mention have been shown me by N-E-D.

In 1569 strolling players had obtained permission from Shakespeare's father then High Bailiff to perform before him seated in the place of honor with his five year old son standing between his knees. In 1572 Queen Bess was a guest in Charlecote and three years after was fêted at Kenilworth—and the festivities in both places were so near that the stripling might have reached them both on foot. Not long afterward it is supposed that his holiday excursion to see a play in Coventry gave birth to his phrase "out-herod Herod."[3] No such glimpse of high life would fail to enrich the word-hoarder or gleaner with happy expressions—and more of them than were dreamed of by other observers who hearing heard not and seeing saw not.

Verbal augmentations there must have been out of schoolhours in village gardens and rural walks, most of all when school-years were over. What a gap between his last flogging for playing truant and the flight to London. Deer stealing was the crowning escapade of Bohemianism during much of the seven years before it. How many a dramatic word betrays its

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[3] In connection with "out-herod" the section of N. E. D. issued in April, 1903, shows such pervasive divergencies between the vocabulary of Shakespeare and that of Bacon as will not let us believe that both names can belong to the same man. It shows numerous verbs formed with the prefix "out," and cites illustrations from Shakespeare of fifty-four of this number. For thirty-eight of these Shakespeare is the earliest and for nine of them he is the only authority which has been discovered. On the other hand in only one or at most two instances has Bacon been found first to use any of these terms. It seems probable that the more we study N. E. D. the contrasts between the diction of these two writers will make it very clear that the words of the one were copied from books—while the other's were original being brought into books from speech that had not been before written—and often not even coined from its primitive elements.

This remarkable series of verbs was furnished in advance of entire publication to the *Nation*, as follows: Those in italic occur first in Shakespeare; those in small capitals first and alone in him; outbed, outbrag, outbrave (first in special sense) *outbreath*, *outburn*, OUTCRAFTY, *outdare*, outdo, OUTDWELL, outface, outfly, OUTFROWN, outgo, *outgrow*, OUT-HEROD, OUTJEST, outlaw, outlive, *outlook*, outlustre, OUTNIGHT, OUTPARAMOUR, OUTPEER, *outpray*, *outprize*, outride, *outroar*, outrun, *outscold*, OUTSCORN, *outsell*, *outshine*, outsleep, outspeak, OUTSPORT, outstand, *outstare*, *outsay*, outstretch, outstrike, outstrip, OUTSWEETEN, *outweigh*, *outswear*, outswell, *outtalk*, *out-tongue*, OUTVENOM, outvie, OUTVILLIAN, *outvoice*, outwear, outwork, OUTWORTH. Bacon's list is at most only outcompass and outshoot.

writer as a youthful and unhandled colt, stung by the hot condition of his blood, like his own prince Hal when he put off the prince and put on the natural man. We see him up to every thing and down about as low, a hail-fellow-well-met among vagabonds more or less fools, tavernhaunters, priests of the old and the new faith, sham soldiers, star-gazers, conjurers, witches, minions of the moon. Though sharp to read the mind in the face, yes, because he was thus sharp, he says to all, "Speak, that I may know you!" and was such a sponge that there was not a word which fell from their tongues which he had not made his own. His maxim was, "Not a shop, church, court-session, hanging, but yields a careful man work," and words to boot. Wearied and footsore on the tramp to London—fearing each bush an officer, and skulking in by-ways—his pedestrian talk was with more divergent types than we encounter among Chaucer's wayfarers to Canterbury or Bunyan's pilgrims, and he drank deep from wells which if not pure and undefiled became for his genius the dramatic water of life. His vocabulary was thus like Lincoln's from first to last, a natural growth compounded of many simples, extracted from many objects, and its expansion was greater year by year like that of a tree in which the present year's increment overlaps all the past. It was to be an unknown tongue to no variety of auditors for it had come from many minds and many hearts but above all from heterogeneous humors, for it is in humor that Shakespeare is first and the rest nowhere,—humor of which he snatched so much that he left very little for Milton and other immortals. Had the pre-London years been spent among stainless associates content to dwell in decencies forever, they would have yielded no word harvest either tragic or comic of the real world, out of joint and full of knaves and fools who make it more so. In fact, his walks and conversations while he was tried and tutored in the world were all a repertory of dramatic speech. Something of his wordage he found, more of it found him.

In judging the youngster by the moral law, we may be misled through ignorance, as Prince Hal's father was regarding him. Phillipps, who more than any other man has wiped aspersions from his bard's good name, declares "there was nothing discreditable in the circumstances of his marriage," and that "even the bequest of his second-best bed was a token of affection, not of indifference." Stratford holds fast to his traditionary song on Ann Hathaway:

> She hath a way so to controll
> To rapture the imprisoned soul
> And sweetest heaven on earth display
> That to be heaven she hath a way
> To be heaven's self she hath a way.

Few can walk through the Shakespearian gallery of true lovers without assurance that so consummate a painter must have been at some time himself imparadised in that purest of passions. There may be a cryptic spelling of his name in Doricles who speaks out to Perdita the heart of every true lover, as no other words can, and whether she speak, or sing or dance, so crowns what she's doing in the present deed that all her acts are queens,—and that, too, queens created of every creature's best.

As the growing dramatist learned language from living voices in childhood and upward, it was natural for him to push on in the same linguistic training to the end. His persistence in this self-educaton was favored by the new and cosmopolitan companionships in London, by his annual pedestrian visits to his birthplace for so many years, and yet more by the itinerary of his theatrical troupe in a score of provincial centers, which Phillipps was first to discover.

The ample interchange of sweet discourse in all varieties of many-colored life which thus became inevitable, may best account for the ultimate perfection in style of his latest dramas in comparison with his earliest. This consummation is an advancement so marvelous that critics call it "another morn risen on mid-noon." But this life-long linguistic progress, Time, who stands still for no man, now forbids me to speak of at all.

Entrance into London was epoch-making for the fugitive. It taught him that, while having nothing, he was possessing all things. From a child his genius had been a discerner of spirits and unlocked character with a master-key. But so long as it lacked interpreting words, his genius—yes, his tongue, was itself enjailed. It must have remained mute and inglorious forever but for his vocabulary. It makes no difference whether he early realized that no genius can say to words any more than a sculptor to marble: "I have no need of you." His whole course of action had been as if he had so realized, and that he must work for words by wit,—and not by witchcraft—and that wit depends on dilatory time. Thus his wit had free course and was glorified along the highway of words.

In London he soon saw that his vocabulary was capital enough. No matter how low the first labors of his hands. Thanks to his words, he must have been almost at once lifted up. Some hack playwriter who had well-nigh ended a task would be too drunk or too lazy to give it his last hand, and the country lad was laid hold of as Jack-at-a-pinch.. Thrown into water, he proved in a moment that he could swim. In the first retouching or bringing to a finish, his acceptable words and honeyed sentences which no man could mend assured his success, his indispensability. He never thereafter ceased to be encored. Springing up and up, high, higher, highest, as assistant, co-worker, rival, and master of his masters, and even of all masters in his art, he demonstrated that five words befitting any one of his countless characters would outweigh and outlive and outshine ten thousand words in a tongue unknown and therefore dead to the common folk.

Such in genesis may have been Shakespeare's vocabulary.

A STUDY IN LONGEVITY.

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Two years ago I presented to the Academy a few facts relating to the topic which I now offer for consideration, and it may be desirable at this time to make a brief restatement of the line of thought.

There can be no doubt of the great advance which the passing years have brought in the prevention and treatment of disease in all civilized communities, with a resultant lengthening of the mean period of human life. But apparently there has been very little, if any, gain in respect to the proportion of deaths among young children, a paradox which perhaps may be explained by the recognition of an increase in the perils to infant life due to an increasing proportion of urban population sufficient to balance all pathological advance. On the other hand, census statistics seem to assure us that the median age is advancing, a fact which can be reconciled with the one previously stated only by assuming a decrease of deaths in youth and early manhood. This consideration offers place for the pessimistic view that the boasted advance in overcoming the power of disease is by no means a blessing, since many who by the beneficent working of the law of the survival of the fittest would have been removed at a comparatively early age are now unduly preserved to become the progenitors of a race sadly deficient in physical vigor: a condition which is asserted to be shown by a marked decrease in the proportion of people attaining old age, despite the increased mean age at death.

It is claimed that a comparison of the vital statistics of successive periods of time sustains this assertion. But such comparisons, as they are usually made, give opportunity for a very considerable error which has been avoided in the investigation of which the results are here presented.

Obviously the records of recently organized communities are not available for such comparisons, since they cover an insufficient period of time; and therefore in American investigations it has seemed necessary to confine attention to the records of those sections of the country which were settled at the earlier dates. But from these regions there has been a constant drain of the most vigorous elements for the settlement of new communities, with a resulting difference in the physical vigor of the two sections sufficiently evidenced by the greater proportion of the eastern volunteers in the days of the civil war who were rejected by the examining surgeons than of those who were thus found physically defective among their western comrades. A marked deterioration in physique could hardly have been avoided in the regions whence there had been a steady flow of vigorous life.

My former paper presented the results of an examination of the successive generations of three New England families having their membership scattered throughout the country, an examination evidently offering no place for the error which has been mentioned. The results were such as suggested a serious doubt of the correctness of the theory of decreasing vigor; but the work did not cover a sufficiently extensive field to justify anything more than a suggestion that the conclusion based upon the statistics of successive periods taken from the same region had a serious probability of error.

My present paper is based upon a careful examination of the records of eight families extending back to the beginning of the seventeenth century, and containing more than one hundred thousand names, although of course only a rather small fraction of the entire number could rightly be used in the computation, not merely because in all genealogical records there are numerous failures to give date of either birth or death, but also because of the later, and of course much the larger, generations, there are yet living members. Attention will be given to the effect of the first of these conditions later in the paper, and concerning the generations with record yet incomplete it may be said that, as far as that record has yet been made in the case of any family, it generally has a striking resemblance to the completed records of earlier generations of the same family.

An objection to the reliability of the conclusion drawn from such records perhaps may be based upon an assumption that histories are printed of only such families as occupy the more prominent positions, and that therefore these records do not present a just picture of the complete facts in question. But a little consideration of the facility of intercourse beween the different strata of the American people and of the frequency of social ascents and descents will suggest the fallacy in such an objection. In fact, in all the families whose records have been examined, with possibly two exceptions, the close admixture of social strata is marked. It is not impossible that the historian of one of these two families exercised what he believed to be a judicious selection in omitting the less reputable lines of descent from the common ancestor; and the record of the other family extended only through three generations from the immigrant, who was a rather influential man of colonial times, as were many of his descendants in their own generations. Those two families, designated in the accompanying table by the letters B and S, present the lowest mean ages of the eight families examined. But they are the two smallest families of the number, together comprising only three per cent. of the entire number of lives considered, and can therefore cause but a very trifling modification of the result. They were included on account of the exceptional care which seemed to have been exercised in the preparation of the histories.

The largest of the eight families is that of the two presidents, John and John Quincy Adams. But in this family, designated by the letter A, there are branches which make it a typical American family. The Loomis family is the second in size, and its record was selected on account of the extreme care exercised by its compiler, Prof. Elias Loomis, and also because it includes to a very unusual extent the descendants of female members of the family. The four remaining families seem to be of fairly representative character, containing a few well known names, but largely composed of the hard-working average citizens of our country.

For the purpose of facilitating the comparison and union of the records, the successive generations are arranged in the accompanying table opposite seven dates separated by intervals of a third of a century and extending from 1600 to 1800, each date being approximately the mean date of birth of the members of the generation to which it is affixed. In the successive columns of the tabular record of each family are given the percentage of deaths in each period of ten years, while the last column gives the mean age of death in each generation. The last table presents the same statistics for the members of the eight families together. Of course the term "mean age" has no real place in the first line of each table, since the age in the final column is that of the single common ancestor. And the corresponding age in the second line has little weight on the question under consideration, since in several of the families we are led to the conclusion that no mention is made of those of the immigrant's children who died young. And in a careful examination of most early records it is difficult to avoid the belief that certain conditions indicate no small number of brief lives which left no record, and that on this account the recorded percentage of deaths in the first decade is very considerably too small, and that the mean age of the early generations is made larger than the facts would justify.

It should also be stated that, although it was thought advisable to include in the tables of the greater part of the families the generation having the mean birth date 1800, yet at the times of writing the different histories which were examined that generation was not entirely extinct, and it is evident that even a small number of survivors would make a very appreciable change in the percentage of deaths in the last two decades. This is especially obvious in the case of family F, the record of which was published twenty-three years ago, while the fraction yet living of the generation of 1800 must have been

Table showing Family Longevity.

Family.	Date.	Under 10.	10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	Over 90.	Mean.
A	1600	......	......	......	......	......	......	......	......	......	......	?
	1633	......	......	......	......	......	......	25	50	25	......	74
	1667	38	......	4	4	6	7	9	16	9	7	40
	1700	27	1	4	11	7	7	13	13	13	4	45
	1733	26	3	8	5	6	7	9	16	13	7	46
	1767	19	4	7	5	6	8	12	18	16	5	51
	1800	16	4	9	8	8	8	13	17	13	4	49
	Total..	19	3	8	7	7	8	12	17	15	4	49
L	1600	......	......	......	......	......	......	......	......	......	......	68
	1633	......	......	......	......	......	16⅔	66⅔	16⅔	......	......	62
	1667	18	6	11	5	10	8	13	11	15	3	45
	1700	20	3	6	3	7	10	15	17	14	5	50
	1733	20	5	7	7	9	8	13	13	13	5	48
	1767	19	4	7	6	7	8	14	18	14	3	50
	Total .	19	4	7	6	7	9	14	17	14	3	49
D	1633	......	......	......	......	......	......	......	......	......	......	56
	1667	......	......	......	......	......	33⅓	16⅔	16⅔	33⅓	......	69
	1700	10	5	5	5	5	10	10	20	20	10	59
	1733	16	4	10	7	10	7	14	15	12	5	47
	1767	7	1	4	4	10	16	12	24	19	3	60
	1800	13	3	7	8	8	8	16	20	15	2	52
	Total..	11	3	6	7	9	10	15	20	16	3	54
W	1600	......	......	......	......	......	......	......	......	......	......	34
	1633	......	......	......	......	......	......	66⅔	......	33⅓	......	71
	1667	20	3	8	5	5	8	16	16	14	5	50
	1700	21	7	11	5	7	10	11	15	13	......	44
	1733	24	4	9	5	7	6	10	20	13	2	45
	1767	16	5	8	6	10	10	15	16	12	2	48
	Total..	19	5	8	6	8	9	13	17	13	2	47
F	1600	......	......	......	......	......	......	......	......	......	......	85
	1633	......	......	......	33⅓	......	33⅓	33⅓	......	......	......	52
	1667	......	......	20	......	......	20	20	......	40	......	64
	1700	13	......	4	......	4	9	31	22	13	4	58
	1733	17	3	11	8	8	5	14	6	14	14	51
	1767	16	6	9	5	7	8	11	20	13	5	50
	1800	18	4	10	10	8	13	15	14	6	2	45
	Total..	17	4	10	8	7	10	14	16	10	4	55

Table showing Family Longevity—continued.

Family.	Date.	Under 10.	10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	Over 90.	Mean.
R	1633	......	......	......	......	......	......	......	......	......	......	80
	1667	25	......	......	......	......	......	25	......	50	......	61
	1700	......	17	17	......	17	33	......	16	......	......	49
	1733	22	......	11	......	......	......	11	11	34	11	60
	1767	3	6	9	15	6	3	23	17	9	9	56
	1800	3	6	19	6	5	13	12	25	10	1	52
	Total	5	6	15	7	5	10	14	22	13	3	54
S	1600	......	......	......	......	......	......	......	......	......	......	71
	1633	12	6	6	18	6	17	23	6	6	......	47
	1667	18	7	7	9	7	16	16	11	7	2	44
	1700	22	5	9	9	13	7	9	9	13	4	43
	Total..	30	6	7	10	10	11	13	10	10	3	44
B	1633	......	......	......	......	......	......	......	......	......	......	69
	1667	29	......	29	......	14	14	14	......	......	......	30
	1700	70	......	......	......	12	......	12	......	6	......	18
	1733	33	15	4	12	7	11	7	4	7	......	31
	1767	6	12	24	12	6	......	17	6	17	......	44
	1800	19	5	16	24	9	12	5	5	5	......	45
	Total..	29	7	13	13	9	8	10	4	7	......	33
All	1600	......	......	......	25	......	......	25	25	25	......	65
	1633	5	2	3	10	3	13	36	15	13	......	60
	1667	23	3	11	5	7	10	13	12	12	4	44
	1700	22	4	7	6	8	9	13	14	13	4	43
	1733	21	4	7	5	12	7	11	15	13	5	47
	1767	12	5	8	3	8	10	14	20	16	4	55
	1800	15	4	9	8	8	10	14	17	12	3	52
	Total..	15	4	8	5	8	10	14	18	14	4	51½

very considerable. The small number recorded in family W as having died when nonogenarians is explained by the publication of the family history in 1883.

But despite these two conditions tending to make the statistics give support to the theory of deterioration in successive generations, the investigation now presented makes no such response. We look in vain for evidence of a decreasing percentage of octogenarians, or even those whose lives have extended into the succeeding decade. The slight tendency in that direction shown in the 1800 line of the general table including all the families is no larger than may be easily explained by the reference to the surviving members of the latest generation.

The percentage of deaths in each decade, as given for each generation of each family and of the families taken as a whole, has also been computed for the combined generations, and the results are shown in the lowest lines of the separate family tables and also that of the families combined. The near approach to identity between those lines of figures and the lines immediately above them to which attention has just been called, is very striking, the most marked deviation from agreement being in the three smallest families, B, S, and R. The close agreement in the two largest families, A and L, and in the closing table including all the families suggests the probable result of a more extended investigation, and gives no countenance to the theory that the American is not living to be as old as of yore on account of the wiser care which is taken lest he die early in life.

NUCLEAR DIVISIONS AND NUCLEAR FUSION IN COLEOSPORIUM SONCHI-ARVENSIS, LEV.

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The study of the nuclear phenomena in the rusts has led to some very interesting and unexpected results. Sappin-Trouffy (1) has shown that the mycelial cells are regularly binucleated through a large portion of the life history of the fungus. He investigated some ten genera of *Uredineae* and his results on this point cannot be questioned. Dangeard and Sappin-Trouffy (2) have shown that these pairs of nuclei lie side by side in division and in such a fashion that the daughter nuclei, for each new cell formed, are not sister nuclei, but maintain a separate and distinct line of descent through the vegetative growth of the fungus, including the formation of uredospores and aecidiospores. This method of division has been called conjugate division by Poirault and Raciborski (3).

As far back as 1880 Schmitz (11) observed that the vegetative cells and the uredospores of the *Uredineae* were binucleated. He regarded the binucleated condition of these spores as analogous to that of the pollen grains of phanerogams.

Rosen (12) in 1892 found that the binucleated condition extended to the other spores. The "basidium" which bears the aecidiospores he describes as uninucleated. The nuclar phenomena connected with the formation of the aecidiospores as he observed them are as follows. The nucleus of the "basidium" divides and the daughter nuclei separate in the direction of the long axis of the cell. The upper of the daughter nuclei, thus produced, then divides again. The spore is cut off by a wall separating the upper portion of the "basidium," containing the two nuclei, from the lower portion, which is uninucleated.

From the lower portion of the spore, thus formed, a sterile cell is cut off containing two nuclei. He does not give details of this division but from what he does say and from his figures it is evident that he had seen something of the so called conjugate division but had failed to understand what he saw. In the same way he describes the young teleutospore of *Puccinia* as containing two nuclei. It then becomes two celled by the formation of a wall between these two nuclei. Each of these cells is thus at first uninucleated. This nucleus then divides. There is then a two celled teleutospore, each cell containing two nuclei. He regards it as probable that these two nuclei in each cell fuse, as they were later found close together.

Dangeard and Sappin-Trouffy (4) observed that these two nuclei which are found in the young teleutospore and which, as a result of the conditions just described, are widely separated in their nuclear parentage, fuse to form a single nucleus. They interpret this as a sexual fusion and consider that the ripe teleutospore cell is a fertilized egg. Sappin-Trouffy pointed out the mistake of Rosen by showing that the two nuclei in the teleutospore are not formed by the division of a single nucleus. Poirault and Raciborski attempt to show that these two nuclei, dividing side by side, form a single spindle and therefore at the time of division behave as a single nucleus.

These authors describe quite fully the formation of the spores of *Coleosporium.* Poirault and Raciborski (3) described the aecidiospore of *Peridermium Pini-acicolum* and Sappin-Trouffy (1) describes the uredospore of *Coleosporium senecionis.* In *Coloesporium* it seems probable that the so called uredospore is really an aecidiospore (Fig. 2). The mycelium which is to produce aecidiospores sends up perpendicular hyphal branches just beneath the epidermis. The apical cells of these branches contain two nuclei, which usually lie side by side in the long axis of the cell. These nuclei then take an oblique position and finally a transverse position. They next divide, going simultaneously through the phases of division. Then the cell divides, two nuclei going to each cell. In these daughter cells the two nuclei come one from each of the mother nuclei of the mother cell so that the nuclei in each cell are not sister nuclei. The upper of the two cells then repeats the process of division, but this time the cell divides unequally. The lower cell is much smaller and is cut off obliquely. The upper cell, resulting from this latter division, is destined to be an aecidiospore, while the lower is sterile and ultimately disappears. The lower cell, resulting from the first division, continues to cut off cells above. Each of these cells, in turn, cuts off a sterile cell. There is thus formed a row of cells, the alternate members of which are sterile. The disappearance of the sterile cells leaves a row of fertile cells, the aecidiospores, each containing two nuclei. Ultimately the epidermis is ruptured and the spores are free for dispersion. Sappin-Trouffy (1) and Poirault and Raciborski (3) have described the formation of the teleutospore and its germination to the promycelium in *Coleosporium*. The two accounts agree in general The teleutospore is cut off from the mycelium in a manner similar to that of the first cell in the aecidiospore series. It thus contains from the start two nuclei, which soon place themselves close together and fuse (Fig. 1). The teleutospore then increases in size to about four times its former dimensions and thus becomes a promycelium. Nuclear and cell division follow, resulting in a row of four uninucleated cells. From each of these cells a sterigma grows out toward the surface of the sorus. When the tube emerges on the surface of the sorus, its end expands and the nucleus and cytoplasm flow into the enlarged part, which is set free as a sporidium.

The process of conjugate division as described by Poirault and Raciborski involves some very unusual features when compared with the nuclear divisions in other fungi and must certainly be further investigated before the results of these authors can be accepted.

The most normal division they have observed is in the teleutospore. In one instance they found an anaphase with four centrosomes and finely striated protoplasm in the equatorial region. The division of the fusion nucleus in the promycelium of *Coleosporium Euphrasiae* is described as follows. The nucleus is provided with a network of thickset fibers and a single nucleole with a large central vacoule. This stage lasts for a considerable time, after which the membrane and the nucleole disappear. The network contracts and collects into two very long and irregular chromosomes, which, they think, split longitudinally, though they have not seen the process very fully. The two halves of the chromosomes immediately separate and in passing to the poles become shortened and very irregularly thickened. The daughter nuclei are then constructed at the poles. As will be seen, the figures described further on differ widely from those given by these authors.

Poirault and Raciborski (3) do not regard the fusion of nuclei in the teleutospore as directly comparable to the fusion of differentiated male and female nuclei. Later Raciborski (5) has suggested that it is similar to the delayed fusion in the zygospore of *Basidiobolus ranarum* and proposes the term *zeugite* for all such cells in which occurs a fusion of nuclei belonging to the same cytoplasmic mass.

Juel (6) has more recently studied the division of the fusion nucleus of *Coleosporium campanulae.* His figures of the nuclear division differ widely from those of Poirault and Raciborski and Sappin-Trouffy. The figures which he shows are very much like those in other fungi and algae. Instead of the axis of colorless substance of Sappin-Trouffy he finds a red staining spindle. At each pole he finds a small rounded red or violet stained mass which sends out into the surrounding cytoplasm delicate thread like processes, so that there is here formed a characteristic polar aster. The chromatin lies in the equatorial region as a finely granular or fire thready mass. Individual chromosomes could not be distinguished. Later the spindle body becomes drawn out and thinner in the middle. The chromatin mass becomes constricted in the middle and then separates and passes to the poles. The structure about the poles remains unchanged.

The exceptional character of the karyokinetic figures as represented by Poirault and Raciborski, as well as by Sappin-Trouffy, suggests the necessity for further investigation of nuclear division in the rusts, and we have undertaken a more detailed study of a single form as promising the best results. A cursory examination of some seventeen species of *Puccinia,* *Melampsora, Gymnosporangium, Coleosporium, Uromyces, Aecidium* and *Phragmidium* has lead to the conclusion that *Coleosporium sonchi-arvensis* is exceptionally favorable for a more detailed study of the nuclear phenomena. As will be seen from the figures, the karyokinetic division is far less aberrant in type even than might be expected from Juel's figures. The material was for the most part collected during the summer and autumn of 1899. The material was fixed by placing it for twenty-four hours in Flemming's stronger solution. It was then washed in running water for four hours and hardened in alcohol in the usual manner. Where the material was to remain some time before being imbedded, it was transferred through seventy per cent alcohol to a mixture of equal parts of glycerin, alcohol and water. It was later imbedded and sectioned in the ordinary manner. The sections were bleached on the slide for four hours in a three per cent solution of hydrogen peroxide. The triple stain with safranin, gentian violet and orange was used almost exclusively. The fungus was found on the host plants, *Solidago Canadensis* and *ulmifolia, Aster sagittifolius* and *Callisteplus sp.* There seems to be little or no difference in the rust from these different host plants. It was perhaps a little more vigorous on the *Callistephus.* On this plant only small patches of the leaves were affected, but the hyphae of the rust seemed to be a trifle larger. The first uredospores were found on July third, but then in such abundance that it was evident that they had been on the host plant for some time. The uredospore material was abundant throughout the remainder of the summer and was found as late as the middle of November. Teleutospores were not abundant and were found only in the middle of the season. In autumn plants bearing uredospores were placed in the greenhouse. Here they continued to produce uredospores throughout the winter. But if left undisturbed the plants soon rid themselves of the rust by the natural dying off of the leaves infected by it. The rust seemed unable to spread from one leaf to another under the conditions in the greenhouse. The entire plant was at times covered with a mildew, *Erysiphe cichoracearum.* In the early part of the winter the rust was easily spread by artificial infection. Later it was only with the greatest care that new leaves could be infected. Infection was more often secured by clamping together with a light spring the undersides of two leaves, one of which contained ripe spores and then covering the plant with a bell jar.

Our observations on the process of spore formation agree in general with those of the authors cited. Rosen (12) says that the wedge-shaped sterile cells in the aecidiospore rows are cut off alternately on the opposite sides. In our material they seem to be cut off quite irregularly. Cases were also observed in which apparently no sterigmata were formed. The divisions of the promycelium simply rounded themselves off and became spores as frequently happens in *Gymnosporangium.*

Our preparations of the nuclear phenomena in the development of the uredospore agree with those of Poirault and Raciborski (3). It is perfectly certain that the nuclei lie at first in the long axis of the cell and that later they lie side by side in the transverse axis where they divide simultaneously. The cell division always results in the cutting off in the daughter cells of a pair of nuclei, each member of which is formed from one of the pair in the mother cell. From this it is seen that the pair of nuclei in the daughter cell are never sister nuclei. By reference to Fig. 21, it will be seen that the two masses which are to form the two nuclei in each new cell are still connected, *not* with each other, but with the corresponding mass in what is to be the other daughter cell. As to whether a single spindle is formed for the two nuclei as claimed by Poirault and Raciborski, it is very difficult to say. However, their figures do not seem to be conclusive on this point. Also as to the number chromosomes the evidence given by Poirault and Raciborski and Sappin-Trouffy seems hardly conclusive. Our figures show the chromatin as solid masses in all stages of division, but it is quite likely that these appearances are due to poor fixation and are not to be trusted as showing details either as to the number of chromosomes or the spindle. Indeed for reasons which will be given later it seems highly probable that there are more than two chromosomes in each division figure. It is perfectly clear that the nuclei lie side by side to divide and that the daughter nuclei are distributed as indicated above. More than this is not shown by the figures.

While it was impossible to study the details of the process of cell division, it is clear that there is no formation of a cell plate and that the cell divides by constriction (Fig. 22). The division is, in general, of the type described by Strasburger (13) for *Cladophora.* There is nothing whatever in the cytoplasm to indicate the direction in which the cleavage furrow is to proceed and in this the process differs from that described by Mottier for *Dictyota* (9).

In the teleutospore we find the conditions much more favorable for the study of the nuclear phenomena. The young teleutospore is a single cell and contains two nuclei formed by the division of a pair of nuclei in the mother cell as described above. Shortly after the young teleutospore is cut off from the mycelium by a cross wall, the nuclei increase rapidly and considerably in size. In a majority of cases they probably at least double their volume. They may lie in any position whatever with reference to the axis of the cell (Fig. 3). This condition is in marked contrast to that which we find when the nuclei are about to divide when, as noted, they always lie side by side in the transverse axis of the cell. The nuclei after increasing in size approach each other till they touch (Fig. 11). At this stage they have lost the appearance, which is characteristic of the conjugate nuclei. They are much less dense and seem to contain more of the so called nuclear sap. The threads of chromatin, quite uniform in size, have become evenly distributed so that there is no longer a clear space about the nucleoli (Fig. 11). The first step in actual fusion is the disappearance of the definite outline of the individual nuclei at their point of contact. This is caused by the disappearance of the nuclear membrane. By the loss of the membrane at this point of contact the contents of the two nuclei come together and mingle so that no line of demarcation between them can be discovered. The nuclei continue to crowd closer together. The area of contact is thus increased and as fast as contact is made the membrane disappears. This process continues till we have a single oval nuclear mass. At every other point except the region of contact the membrane remains intact. In Fig. 12 the fusion nucleus has not yet reached the oval shape. The chromatin threads still maintain a quite uniform size. They seem to assume no particular direction but are somewhat massed along the zone of contact of the nuclei (Fig. 12). In this zone the threads seem to be slightly finer than those which are found in the other parts of the nucleus. It seems that the chromatin threads are also withdrawing from certain irregular areas of the nuclear cavities. Some of the threads appear much coarser than before, but they vary in diameter in different parts and are connected with each other and the nuclear membrane by still finer threads. The coarser threads are doubtless chromatin and the finer ones may represent the linin network. Uu to this time there is no apparent change in the nucleoli, either in their structure of position. In the next later stage which I found there is a single nucleolus. It seems entirely probable that the two nucleoles fuse. At a later stage the nucleus appears still more swollen and less completely filled with the chromatin thread. The threads tend also to be more massed together. Frequently the masses are so dense that the filaments are not recognizable as such. This stage (Fig. 14) is probably one of fairly long duration and may correspond to the so called synapsis stage in the nuclei of the higher plants. At this stage no matter how deeply the surrounding cytoplasm may be stained the nuclear sap is perfectly transparent. While these nuclear changes have been going on the teleutospore has been increasing in size and this growth continues till the promycelium is fully formed. The size of the teleutospore varies considerably and Fig. 3 represents one which is rather larger than the average. The resting fusion nucleus is nearly spherical and occupies a quite constant position near the center of the cell. The nucleolus in this and the following stages occupies a position near the periphery of the nucleus. The next change, which the fusion nucleus undergoes, consists in the loosening up of the denser chromatin masses. The threads become definite in outline and are more readily traced (Fig. 15). They increase in thickness and sharpness of outline. The increase in thickness is probably due to shortening and this in turn reduces the number of coils or loops, (Fig. 16). As the threads become thicker they stain more deeply, while the nucleoli at this stage stain less deeply and no longer preserve a smooth plump outline but show minute irregularities. At a later stage the nucleoli show still further changes of the same sort. They are less deeply stained and instead of being irregularly oval, may show any irregular shape and the smaller irregularities in the surface become more prominent, (Fig. 17). At a little later stage the nucleolus disappears entirely and it seems probable that it has been gradually broken up and dissolved. In the later spirem stages the nuclear membrane disappears entirely and the chromatin thread lies in a finely granular material, not sharply distinguished from the surrounding cytoplasm, (Figs. 16 and 17). The thread is seen now to have been split longitudinally, (Fig. 17). In some portions the halves are still in contact while in others they are quite widely separated. That a longitudinal splitting occurs thus in the prophases in this fungus nucleus, is of considerable interest as establishing another point of agreement between thallophyte nuclei and those of the higher plants. The later separation of the daughter chromosomes on the spindle is merely a distribution of the split halves of the original chromatin thread. It is very noticeable in preparations of this stage that the spirem thread is not continuous. This is plainly shown in Figs. 16 and 17, and it is quite probable that this condition indicates a segmentation into chromosomes. The stages in the formation of the spindle have not been found. The equatorial plate stage on the other hand, here as in most other cases, is relatively easy to find. It is an interesting and characteristic figure and differs entirely from that given by Poirault and Raciborski for *Coleosporium Euphrasiae* and also but in a somewhat less degree from that given by Juel for *Coleosporium campanulae*. The figures in our preparations are extremely sharp and clear and agree much more nearly with those of other mitoses than do those of the authors named. The characteristic structural features of this stage in fungi and algae generally are all present. Polar radiations, central bodies, spindles and chromosomes are all very sharply differentiated. The central bodies are conspicuous but apparently somewhat variable in size. Occasionally they appear saucer shaped with the concave side toward the spindle. It is noticeable that the spindle fibers seem thicker and more deeply stained toward the poles. The polar radiations are short and rather few in number, but are sharply differentiated. Among the bases of the polar rays, the protoplasm is denser, forming thus an oval mass, which lies beyond rather than around the central body. The chromosomes are quite irregular in shape and grouping. There appears to be no stage in which they are aggregated in a flat plate. They seem always more or less strung out along the length of the spindle (Figs. 18 and 19). Frequently two or more chromosomes overlap each other and lie so close together that they cannot be clearly differentiated. It is hence impossible to determine their number with certainty. However there can be no doubt that the number is greater than two as described by Poirault and Raciborski for *Coleosporium Euphrasiae* and the rusts generally. The evidence drawn from our preparations indicates that their number is somewhere between six and ten. When the chromatin masses withdraw to the poles, which they do quite irregularly, the axis of the spindle lengthens somewhat. At this stage the polar radiations seem somewhat longer than before and do not form so regular an aster. The daughter nuclei are reconstructed in the usual manner and the promycelial cell now divides so that the two nuclei are separated and we have a two celled stage as shown in Fig. 5. After the cell division is complete the daughter nuclei divide almost immediately. The division of the two is nearly simultaneous though not entirely so (Fig. 23). These nuclei are very much smaller than the original parent nucleus. Their mitotic figures are also much smaller and consequently less favorable for study. Still it can be seen that the stages of division are essentially the same as in the division of the fusion nucleus. The chromosomes are so massed that it is impossible to distinguish their individual outlines. The central bodies and polar asters are however very sharply differentiated. The rays of the latter are long, reaching in some cases almost to the periphery of the cell and in some cases curiously curved at their tips (Fig 23, the lower of the two nuclei). The upper of the two nuclei in Fig. 23 is in a late prophase stage. The polar asters are present but the outline of the nucleus between them is still intact. After the second division of the nuclei cell division follows immediately and we have the four celled promycelium.

If we compare now figures, 18, 19, and 20, with those of Sappin-Trouffy and Poirault and Raciborski, it becomes evident that the contention of these authors that but two chromosomes are present at this stage in the development of the rusts is not supported by the facts as found in *Coleosporium sonchi-arvensis.* The curiously abnormal mitotic figure of *Coleosporium Euphrasiae* as given by Poirault and Raciborski, consisting of only two long irregularly lobed threads, bears scarcely the faintest resemblance to the corresponding stages as we find them in *Coleosporium sonchi-arrensis.* That such extreme differences can exist in such closely related forms is hardly to be believed and as the figures in our own preparations correspond so much more nearly with those in other fungi and algae it seems probable that the preparations of Poirault and Raciborski were distorted in fixation. As noted above it is not possible to give the number of chromosomes in *Coleosporium sonchi-arvensis* with exactness but it is plain that there are many more than two, and in view of the unusual appearance of the figures given by Poirault and Raciborski, it is very questionable whether they have determined the number correctly for *Coleosporium Euphrasiae.*

The haustoria of *C. sonchi-arvensis* are normally binucueated, while the portion of the cell of which the haustorium is a part but which is outside of the cell of the host plant, usually contains no nucleus (Fig. 26). Rosen and later Sappin-Trouffy have maintained that the haustoria apparently seek out the nuclei of the host plant and apply themselves to its surface. There is little evidence of this in *Coleosporium sonchi-arvensis.* A host cell may contain several haustoria but they all seem indifferent to the host cell nucleus. The haustorium is always the end of a hyphal cell, a large portion of which is outside the host cell. As a rule the haustoria of *Coleosporium sonchi-arvensis* are oval in form (Figs. 25 and 26). The haustoria always present a turgid appearance even in old host cells, which have become nearly empty. The protoplasm of the haustorium proper usually seems quite dense, while that of the rest of the cell of which it is a part, particularly the more distant portion outside of the host cell, has a much looser structure. The nuclei of the haustoria are at the usual short distance from each other which is characteristic for the conjugate nuclei. The nuclei are regularly of greater diameter than the neck of the haustorium through which they must have passed to reach their characteristic position inside the host cell. But there is no question that they are plastic enough to be elongated and narrowed in order to pass through such a small opening. It is noticeable that the opening in the wall of the host cell is uniformly much larger than the neck of the haustorium. This condition is in sharp contrast with that in the *Erysipheae* as figured by Smith (7) and others. Fig. 25 shows a case of a young haustorium into which one of the two nuclei has not yet penetrated.

Fig. 7 shows the formation of a sterigma from one of the cells of a promycelium. The sterigma is rather thick and irregular and the nucleus is already well advanced toward its tip. The sporidium soon becomes binucleated by the division of its primary nucleus. The germination of the sporidium we have not been able to trace.

If we summarize now the life history of the *Coleosporium* rust, we shall find that at certain stages the cell contains two and at other stages but one nucleus. The uredospore is a binucleated cell. When the uredospore germinates it gives rise to a mycelium whose cells also contain two nuclei, which divide by conjugate division. If this mycelium produces teleutospores, they will be binucleated, and will get their nuclei from the mycelium by the process of conjugate division. This will be the last binucleated cell of this series. In the teleutospore the conjugate nuclei fuse to produce an enlarged single nucleus. After fusion the teleutospore is stimulated to growth at once instead of after a resting stage as in *Puccinia* and forms the promycelium. The fusion nucleus next divides and the elongated teleutospore or promycelium divides, each daughter cell receiving one of the daughter nuclei. The division of the daughter nuclei is followed by further cell division. The teleutospore has grown into a four celled promycelium, each cell of which contains a single nucleus. From each of these divisions a sterigma arises on the end of which is produced a sporidium and a promycelial nucleus passes out into each sporidium. The sporidium is then unincleated but its nucleus divides. This nuclear division is not followed by cell division and there is thus constituted a binucleated sporidium. This is the first binucleated cell of the new generation. Starting with the sporidium there is developed a mycelium of binucleated cells, which divide by conjugate division. From the teleutospore to the sporidium we find uninucleated cells. From the sporidium to the teleutospore we have binucleated cells.

The regular presence of two and only two nuclei in the mycelial cells of the rusts presents a very unique condition among plants. Coenocytic cells contain numerous nuclei but there is much evidence that the nuclei of the binucleated cells of the rust bear a very different relation to each other than do the nuclei of multinucleated cells. Strasburger (8) has described nuclear and cell division in such typical coenocytic cells as those of Cladophora. The nuclei in these cells may amount to a hundred or more in number. Nuclear division takes place by the ordinary karyokinetic process. The division of the nuclei is not necessarily simultaneous. Nuclei in various phases of division as well as even resting nuclei occur in the same cell at the same time. There seems to be no close time relation between the division of one nucleus and that of its neighbor. Later the cell divides. There seems to be no direct and constant relation between nuclear division and cell division. With the conjugate nuclei the division is always simultaneous and conjugate nuclear division is always followed by cell division. The fusion of the conjugate nuclei in the teleutospore is then something different than a fusion between any two nuclei of a coenocyte. Whether it is to be interpreted as equivalent to a typical sexual fusion is a very interesting question.

As we have seen the two nuclei which fuse in the teleutospore can be traced back in separate series through binuclated cells to the point where they originate by the division of a single nucleus in the germination of the sporidium accordng to the authors cited. The two nuclei which fuse maintain a separate existence throughout almost the entire life cycle of the rust. There can be no question as to the long continued separate existence of the fusing nuclei nor as to the fusion itself. This fusion results in *Coleosporium* in a renewed tendency to growth on the part of the cell containing the fusion nucleus.

In *Closterium* Klebahn (10) found that in the zygote the pronuclei remained separate for some time. In *Cosmarium* he found a similar condition. Häcker (13) has shown that in *Cyclops* the two sexual nuclei maintain a relatively independent existence at least through the early stages of the cleavage of the egg. There is some evidence that the chromosomes in the division of the fusion nucleus of the rust are collected into groups on the spindle (Figs. 18, 19 and 20). It is quite possible that these two groups of chromosomes are respectively the chromosomes of male and female nuclei not yet combined.

Raciborski (5), in view of the fact that a longer or shorter period of development exists between the fusion of the cytoplasm and the fusion of the nuclei in the cases mentioned above and also even more notably in the case of *Basidiobolus,* holds that the entire life cycle of the rust from the germination of the sporidium to the fusion of the nuclei in the teleutospore is to be interpreted as an intercalation between cell fusion and nuclear fusion in a single sexual act. The division of the nuclei without cell division in the young mycelium represents for him a cell fusion, the nuclear fusion occurring long after in the teleutospore. The evidence cannot be regarded as sufficient to establish this view. It is not yet established for a sufficient number of forms at what stage the binucleated cells with conjugate nuclei first appear in the life cycle.

There is as yet no evidence of any proper cell fusion in the rusts though the fusion of the nuclei in the teleutospore has the essential characteristics of a sexual fertilization in the origin of the nuclei and in the behavior of the teleutospore after fusion as described above. The existence of nuclei in the mycelial cells, maintaining independent lines of descent for indefinite periods, has perhaps made cell fusion unnecessary.

Sexual reproduction in the rusts may possibly dispense with cell fusion, while retaining the more essential feature of the union of nuclei more or less widely separated in origin. In view of the abundant evidence in both plants and animals that the fusion of the pronuclei is the more essential element in all sexual reproductions, this condition in the rusts is seen to be by no means out of harmony with our conceptions of sexual reproduction in other groups. Certainly the fusing nuclei of *Vaucheria* or *Cystopus* may be less distantly separated in their origin than the fusing nuclei of the rusts and the sexual differentiation of the former is unquestioned. The fusing nuclei in the zygospores of *Spirogyra* may be much more closely related than those in the rusts. That the fusion of nuclei contained in the same mass of cytoplasm for a long series of nuclear generations, hay have the same effect for the cell in which they are contained, as results from ordinary fertilization is, however, a distinctly new idea and must modify our conceptions correspondingly. As pointed out above, it emphasizes still further the doctrine that nuclear rather than cytoplasmic fusion is the essential process of fertilization.

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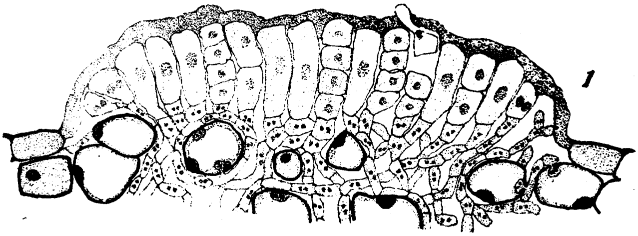
EXPLANATION OF PLATE I.

All figures were drawn with the aid of the camera lucida.

Fig. 1. × 196. Teleutospore sorus of *Coleosporium sonchi-arvensis.* The mycelium and haustoria are shown binucleated. At the extreme left are shown two teleutospores in which nuclear fusion has not yet occurred. At the right is another teleutospore. In most of the cells nuclear fusion has occurred and the teleutospore has developed into a promycelium. In two instances the promycelium has become two celled. In other cases it has become four celled. In one case one of these divisions has already formed a sterigma and passed through the epidermal sorus cover and the second division is in the act of passing.

PLATE I.

Fig. 2.	×606.	Portion of an uredospore sorus. The four large cells at the bottom are the growing cells from which cells are cut off above. The second of these cells from the right is in normal growing condition with the nuclei lying longitudinally in the axis of of the cell. The cell on the left has the nuclei revolved to a horizontal position and is ready for conjugate nuclear division. In the cell on the right, nuclear division has taken place and is about to be followed by cell division. In the second cell from the left nuclear and cell division are complete and nuclear division has again occurred in the upper cell and a sterile cell is about to be cut off from the lower part of this upper cell. Beneath the top row of cells the sterile cells have disappeared.
Fig. 3.	×340.	Teleutospore.
Fig. 4.	×340.	Promycelium.
Fig. 5.	×340.	Two celled stage of the promycelium.
Fig. 6.	×340.	Four celled stage of the promycelium.
Fig. 7.	×340.	One of the divisions of the four celled stage forming a sterigma.
Fig. 8.	×685.	A uninucleated sporidium.
Fig. 9.	×685.	A binucleated sporidium. Nuclei close together.
Fig. 10.	×480.	A normal binucleated sporidium.
Fig. 11.	×1525.	Teleutospore nuclei ready for fusion. The dark extra nuclear body is uniformly present at this stage.
Fig. 12.	×1175.	Early stage of fusion.
Fig. 13.	×2285.	Later stage of fusion.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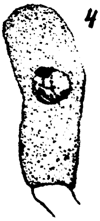
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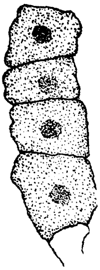
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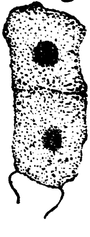
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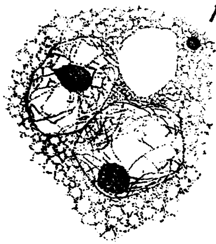
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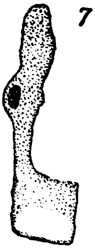
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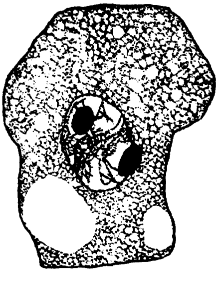
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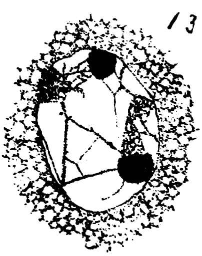
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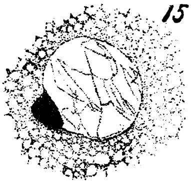
PLATE II.

EXPLANATION OF PLATE II.

Fig. 14.	×1525.	Resting fusion nucleus.
Fig. 15.	×1525.	Early prophase of division.
Fig. 16.	×2285.	Later prophase.
Fig. 17.	×2285.	Later prophase showing the splitting of the chromosomes. The nucleolus has lost its rounded contour.
Fig. 18.	×1525.	Equatorial plate stage showing central bodies, chromosomes, spindle and polar radiations.
Fig. 19.	×1525.	Equatorial plate stage showing central bodies, chromosomes, spindle and polar radiations.
Fig. 20.	×1525.	Anaphase showing chromosomes grouped about the poles. Polar radiations are present.
Fig. 21.	×1525.	Conjugate division showing the dumbbell shaped chromosome masses and the nucleoli occupying positions at the sides.
Fig. 22.	×1525.	Conjugate division. Nuclear division is complete and cell division is taking place by constriction.
Fig. 23.	×1525.	The second division in the promycelium. Centrosomes and polar radiations are present.
Fig. 24.	×685.	An apical mycelial cell showing the binucleated condition.
Fig. 25.	×2285.	Haustorium in cell of host plant. One nucleus only has entered the haustorium.
Fig. 26.	×1525.	Cell of host plant showing binucleated haustorium, nucleus of host plant and chlorophyll bodies.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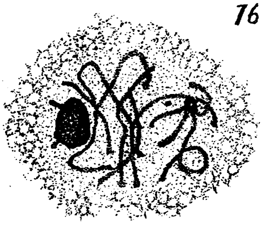
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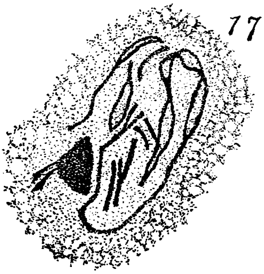
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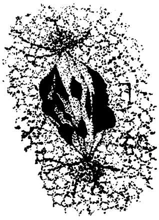
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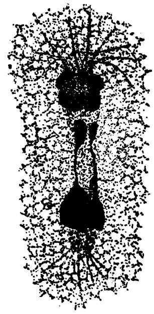
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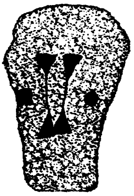
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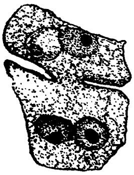
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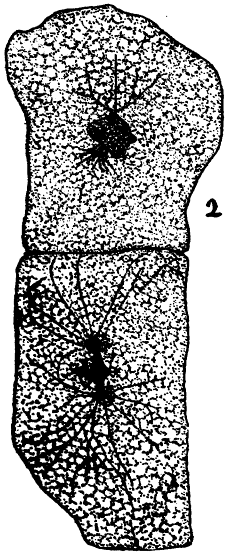
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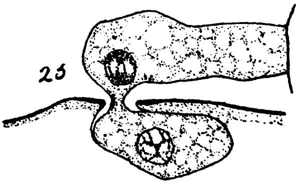
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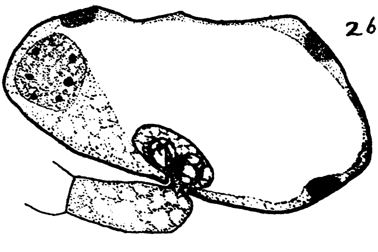
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THIRD SUPPLEMENTARY LIST OF PARASITIC FUNGI OF WISCONSIN.

J. J. DAVIS.

In 1882 Dr. William Trelease, at that time occupying the chair of Botany in the University of Wisconsin, prepared a Preliminary List of the Parasitic Fungi of Wisconsin, enumerating 268 species. In 1893 the writer compiled a Supplementary List, and in 1897 a Second Supplementary List, carrying the number to 567. These lists were published in the Transactions of the Wisconsin Academy of Sciences, Arts and Letters, in Vols. VI, IX, and XI, respectively. The present enumeration is a record of those species not included in the previous lists that have come under my notice. With a few exceptions noted, it is founded on specimens in my herbarium. They are enumerated under serial numbers continuous with those of the preceding lists. This is preceded by a list of hosts bearing fungi that were not recorded as growing upon them in the previous lists. The numbers attached to these are those under which the fungi were enumerated. The name of the collector is given except in those cases in which the writer is also the collector.

The collections that have furnished the basis for this list have mostly been derived from two sources: the vicinity of Racine and several vacation trips of a few days each in the northern part of the state. As the first mentioned territory had already been gleaned for the two preceding lists, it may be assumed that the species from that locality are rare or scarce or that they are only occasionally, or at most locally abundant. The fluctuations of the fungus flora are striking and it will doubtless be an interesting field for the ecologist. The observations in northern Wisconsin are too limited to allow much comment on the distribution or the abundance of the species.

In addition to those whose assistance has been acknowledged in the previous supplementary lists, I wish to thank Dr. J. C. Arthur of Lafayette, Indiana, for the determination of some of the *Uredineae*. Renewed thanks are due the veteran mycologist, Mr. J. B. Ellis, of Newfield, New Jersey.

The writer hopes to assist in the further extension of the recorded parsitic fungus flora of Wisconsin, and would be glad to have the aid of collectors.

J. J. Davis.

Racine, Wisconsin, January, 1903.

ADDITIONAL HOSTS.

Fungi occurring on hosts other than those upon which they were reported in the previous lists.

10. Plasmopara halstedii, (Farl.) Berl. and De Toni.
On *Erechtites hieracifolia*, Raf. Wind Lake.
On *Helianthus* sp. Racine and Kenosha county. On the sunflowers it sometimes appears as early as the latter part of May and does considerable damage to the host plants.

15. Bremia lactucae, Regel.
On *Lactuca leucophaea*, Gray. Racine.

17. Peronospora potentillae, DBy.
On *Geum macrophyllum*, Willd. Wind Lake.

20. Peronospora effusa, (Grev.) Rabh.
On *Chenopodium hybridum*, L. Racine.

22. Peronospora calotheca, DBy.
On *Galium lanceolatum*, Torr. Genoa Junction.

40. MICROSPHAERA ALNI, (Wallr.) Winter.

(M. nemopanthis, Peck.) On *Nemopanthes fascicularis,* Raf. Three Lakes.

On *Lonicera tatarica,* L. (cult.) Racine. Although the latter host bears in Europe the var. *lonicerae* (DC.) the Racine material shows, when mature, the well developed recurved appendage tips of the type.

43. PODOSPHAERA OXYACANTHAE, (DC.) DBy.

On *Spiraea salicifolia,* L. Racine. Rather scarce on this host.

45. SPHAEROTHECA HUMULI, var. FULIGINEA, (Schlect.) Salmon. (*Sphaerotheca castagnei,* Lev. Prelim. List.)

On *Lophanthus scrophulariaefolius,* Benth. and *Veronica serpyllifolia,* L. Racine. On the latter host the cells of the perithecial walls are small as in *S. humuli,* (DC.) Burr. but Prof. F. S. Earle of the New York Botanical Garden, to whom a specimen was sent, refers it to the variety because of "the small size of the perithecia and a certain softness of texture."

In the Supplementary List *Lactuca Floridana,* Gaert., is given as a host of *Sphaerotheca castagnei,* Lev., but examination of the specimen in my herbarium shows only an *Erysiphe.*

49. ERYSIPHE POLYGONI, DC.

(*Erysiphe communis,* (Wallr.) Fr. Prelim. List.)

On *Parnassia Caroliniana,* Michx. Madison. (Professors Tracy and Halsted.) This is *Erysiphopsis parnassiae,* Halsted. Salmon (A Monograph of the *Erysiphaceae*) refers it to this species.

64. EPICHLOE TYPHINA, (Pers.) Tul.

On *Calamagrostis Canadensis,* Beauv. Genoa Junction.

74. RHYTISMA ILICIS-CANADENSIS, Schw. (?)

On *Nemopanthes fascicularis,* Raf. Vilas county. Collected in July and therefore immature.

78. DIDYMARIA UNGERI, Corda.

On *Ranunculus acris,* L. Racine.

83. RAMULARIA MACROSPORA, Fres. var. SENECIONIS, Sacc.

On *Aster cordifolius,* L. and A. *diffusus,* Ait.? Somers.

145. SEPTORIA POLYGONORUM, Desm.

On *Polygonum Convolvulus,* L. Three Lakes; *Polygonum cilinode,* Michx., Vilas county.

147. UROMYCES BREVIPES, (B. & Rav.)

(*U. terebinthi,* (DC.) Prelim. List.) According to Dietel, the uredospores are quite distinct from those of *U. terebinthi,* (DC.) (Botanical Gazette, *24*-1-24, 1897.)

154. UROMYCES JUNCI, (Desm.) Tul.

On *Eleocharis palustris,* R. Br. Racine. In spite of the morphological resemblance I refer this here with some doubt. If correctly placed, then similarity of habit and structure of the hosts count for more in this case than biological similarity through kinship.

157. UROMYCES CALADII, (Schw.)

Aecidium and Uredo on *Arisaema Dracontium.* Schott. Kenosha county.

169. PUCCINIA IRREGULARIS, Ellis & Tracy.

(*Puccinia solidaginis,* Pk. Prelim. List.) "An examination of the material in the herbaria of the Missouri Botanical Garden and of the Iowa State College leads to the belief that this is undoubtedly the species referred to *P. solidaginis,* Pk., by Dr. Trelease, No. 169, *Preliminary list of parasitic fungi of Wisconsin.*" H. Harold Hume, Botanical Gazette, *28*-6-420, 1899.

178. PUCCINIA POLYGONI-AMPHIBII, Pers.

Uredo and teleutospores abundant on *Polygonum Convolvulus,* L. Racine and Genoa Junction. Uredo on *Polygonum hydropiperoides,* Michx. Racine.

179. PUCCINIA PRUNI, Pers.

On *Prunus Pennsylvanica,* L. f. Three Lakes.

190. PUCCINIA GALII, (Pers.) Wint.

The Aecidium has been rather sparingly found on *Galium trifidum,* L. var. *latifolium,* Torr., at Racine. The teleutospores have not been found here on that host but are rather abundant on *Galium concinnum,* Torr. & Gray.

218. PUCCINIA PECKIANA, Howe.

(*Caeoma nitens,* Schw. Prelim. List.) (*Puccinia interstitialis,* (Schl.) Transchel.) The teleutospores were collected in small quantity on *Rubus villosus,* Ait., in Vilas county.

222. PUCCINIA CARICIS—OENOTHERAE, n. comb.

(*Aecidium oenotherae,* Pk. Preliminary List. *Aecidium peckii,* De Toni. *Puccinia peckii,* (De Toni) Kellerm.) Dr. Kellerman established the relationship between the cluster cups on *Oenothera biennis,* L. and the teleutospores on *Carex trichocarpa,* Muhl. Dr. Arthur repeated the experiment with teleutospores on *Carex trichocarpa* collected at Racine. With reference to the name used see No. 242.

225. AECIDIUM PEDATATUM, (Schw.) Arthur.

(*Ae. petersii.* B. & C. Prelim. List. *Ae. mariae wilsoni,* Pk. Suppl. List.) On *Viola pedata,* L. Racine.

227. AECIDIUM GROSSULARIAE, DC.

In the Journal of Mycology, VIII, June, 1902, p. 53, Dr. Arthur described *Puccinia albiperidia* having its aecidial stage on *Ribes cynosbati* L. and teleutospores on *Carex pubescens,* Muhl. During the spring of 1903 Dr. Arthur produced a similar aecidium on *Ribes gracile,* Michx, using teleutospores from *Carex gracillima,* Schw., collected at Racine. I have not seen the pallid cluster cups in the field and suspect that their peculiar appearance is due to the conditions under which they grew and that the ordinary *Aecdium grossulariae* has its rust stage on *Carex.* For the reason stated under No. 242 I should prefer the name *Puccinia caricis-grossulariae* if that proves to be the case.

233. PUCCINIA FRAXINATA (Lk.) Arth.

(*Aecidium fraxini,* Schw. Prelim. List; *Puccinia peridermiospora* (Ell. & Tracy) Arthur.) Teleutospores on *Spartina cynosuroides,* Willd. Racine. I have collected this rust but once. It is probably more abundant in the western part of the state where the Aecidium occurs on the ash.

234. AECIDIUM RANUNCULACEARUM, DC.

On *Anemone nemorosa,* L. Pelican Lake. Locally abundant.

242. AECIDIUM COMPOSITARUM, Mart.

On *Bidens frondosa,* L. Racine. On the cotyledons and first leaves in early spring.

Aecidia on *Aster* and *Erigeron* have been produced by Dr. Arthur from teleutospores on *Carex foenea,* Wild., and *Carex festucacea,* Wild., respectively, and the species designated as *Puccinia caricis-asteris,* Arthur, and *P. caricis-erigerontis,* Arthur. He has also shown that aecidia on *Solidago* are produced from teleutospores on *Carex* and given the name *Puccinia caricis-solidaginis.* As it is becoming evident that there are a number of species of rusts on *Carices* this method of forming specific names from the generic names of both æcidial and rust hosts would, if carried out, be of much assistance in understanding them. This is merely using the prior name with a prefix. No cultures have been made, to my knowledge, with Wisconsin material.

255. USTILAGO STRIAEFORMIS, (West.) Niessl.

(*Tillitia striaeformis*, West. (?) Preliminary List.) On *Poa pratensis*, L. Racine. *Poa debilis*, Torr. Somers. Fresh spores gathered in May germinated readily in water.

256. ENTYLOMA COMPOSITARUM, Farl.

On *Erigeron Philadelphicus*, L. Racine.

268. EXOBASIDIUM VACCINI, (Fckl.) Wor.

On *Arctostaphylos Uva-ursi*, Spreng, and *Cassandra calyculata*, Don. Three Lakes.

270. SYNCHYTRIUM PLURIANNULATUM, (B. & C.) Farlow.

Sanicula gregaria, Bicknell seems to be the host of this species about Racine.

272. PERONOSPORA FICARIAE, Tul.

On *Ranunculus Pennsylvanicus*, L. f. Genoa Junction and Vilas county.

On *Ranunculus septentrionalis*, Poir. Somers.

282. SPHAEROTHECA MORS-UVAE, (Schw.) (B. & C.)

On *Ribes cynosbati*, L. Tabor.

301. CERCOSPORA GALII, Ellis & Holway.

On *Galium Aparine*, L. Vilas county.

314. CERCOSPORA SAGITTARIAE, Ellis & Kell.

On *Sagittaria heterophylla*, Pursh. Racine. Develops rarely and scantily on this host when abundant on *S. variabilis*. Engelm, growing in the same place.

330. FUSARIUM UREDINUM, E. & E.

On *Salix longifolia*, Muhl. Racine. The statement in the Supplementary List that the willow is the host of this fungus is probably not warranted although it occurs upon leaves upon which no sori of the *Melampsora* are to be seen.

341. UREDINOPSIS SCOLOPENDRII, (Fckl.) Diet. (*Gloeosporium phegopteridis,* Frank, Second Suppl. List.)

On *Osmunda regalis,* L., *O. Claytoniana,* L., *O. cinnamomea,* L., and *Phegopteris Dryopteris,* Fee. Vilas county. Abundant.

392. SCOLECOTRICHUM GRAMINIS, Fckl.

On *Poa compressa,* L. and *Asprella Hystrix,* Willd. Racine. On *Muhlenbergia sylvatica,* Torr. & Gr. Kenosha county.

413. SEPTORIA CUCURBITACEARUM, Sacc.

On leaves of watermelon, *Citrullus vulgaris,* Schrad. (cult.) Racine.

421. SEPTORIA LACTUCAE, Pass.

On *Lactuca sativa,* L. (cult.) Racine.

444. SEPTORIA SCUTELLARIAE, Thum.

On *Scutellaria versicolor,* Nutt. Racine.

450. SEPTORIA SOLIDAGINICOLA, Pk.

On *Aster umbellatus,* Mill. Wind Lake.

462. UROMYCES sp.

(*Puccinia caricis strictae,* Dietel, Supplementary List.)

Dr. Arthur informs me that this is not the rust described as *Uromyces caricis* by Peck and referred to *Puccinia* by Dietel, but a true *Uromyces* not yet described.

463. PUCCINIA CYPERI, Arthur.

Uredo and teleutospores on *Cyperus filiculmis,* Vahl. Madison.

(Prof. R. A. Harper and J. J. Davis.)

469. PUCCINIA HEUCHERAE, (Schr.) Diet.

(*Puccinia spreta,* Pk. Supplementary List.)

On *Mitella nuda,* L. Pelican Lake.

470. PUCCINIA MARYLANDICA, Lindr.

(*Puccinia saniculae,* Grev., Supplementary List.)

This has been separated under the above name. I have not seen it about Racine since 1886. The host is probably not *Sanicula Marylandica,* L., as that species is limited by Bicknell, but more likely *S. gregaria,* Bicknell.

473. PUCCINIA VERONICARUM, DC.

Erroneously referred to *Puccinia veronicae,* Schroet. in the Supplementary List.

519. CYLINDROSPORIUM LEPTOSPERMUM, Pk.

On *Aralia hispida,* Vent. Vilas county. Apparently rare on this species. This is hardly a good *Cylindrosporium.* Material collected at Wind Lake on *Aralia nudicaulis,* L., shows immature superficial perithecia bearing the conidia.

523. MARSONIA BRUNNEA, Ell. & Evht.

On *Populus tremuloides,* Michx. Racine and Genoa Junction. On *Populus balsamifera* var. *candicans,* Gray, (cult.). Racine.

531. PHYLLOSTICTA DECIDUA, Ell. & Kell.

On *Nepeta Glechoma,* Benth., *Veronica Virginica* L., and *Lactuca Canadensis,* L. Racine. On *Bidens frondosa,* L. Kenosha county. This fungus appears to attack young and tender leaves of various species of plants on many of which it seldom develops spores.

559. USTILAGO LONGISSIMA. (Sow.) Tul.

On *Glyceria grandis,* Watson. The ordinary form of the species with spores mostly 5–6 microns in diameter.

563. SCLEROTIUM. (*Doassansia obscura,* Setchell, Second Supplementary List.) *Doassansia obscura,* Setchell, was described as occurring in the petioles of *Sagittaria variabilis,* Engelm, and characterized by large globular sori, the central portion of which consisted of hyphae. In searching for it, I found at Racine and also at Kenosha what I took to be the sori of that species especially as when crushed on a slide it was to be seen that the central portion was composed of hyphae. It was therefore noted with reference to the then forthcoming Second Supplementary List, with the expectation that it would be examined in section before the list went

to print. That expectation was not fulfilled, however, and the sections were not made until after the list was printed. It then developed that the supposed sori were composed entirely of closely interwoven hpyhae with an outer layer of rind cells. A white fleshy fungus growth in the crown of *Sagittaria* is perhaps connected with these sclerotia. I have not seen it in a spore bearing stage and cannot say what it is. I have seen similar sclerotia in the culms of *Scirpus lacustris,* L., *Zizania aquatica*, L., and *Glyceria fluitans,* R. Br.

565. DOASSANSIA SAGITTARIAE, (West.) Fisch.

There has been collected near Genoa Junction and in small quantity near Racine a *Doassansia* on *Sagittaria heterophylla,* Pursh., which differs from the ordinary form of this species in the rather large sori which are frequently confluent. At both of these stations the host grew in the midst of *Sagittaria variabilis,* Engelm., which was much the most abundant but in neither place was I able to find the fungus on the latter host. It seems probable, therefore, that it is confined to *Sagittaria heterophylla.* In that case the question will arise as to whether it is to be considered a biological race or a distinct species. Following the practice which has obtained, this would be considered of specific importance among the smuts while the treatment of the question is different when the rusts are considered. For the present, I label it *forma confluens.*

566. BURRILLIA GLOBULIFERA, Davis.

I have been unable to again secure the growth described as due to the germination of the spores. I suspect that it was adventitious—a contamination. The character and relationships of this fungus are therefore to be considered as unknown at present.

Since this was written, Prof. G. P. Clinton, in *North American Ustilagineae,* has referred to this and *Doassansia zizaniae,* also a Wisconsin fungus, as follows: "*Doassansia zizaniae* on old stems of *Zizania aquatica* and *Burrillia globulifera* occurring on similar parts of *Glyceria fluitans* . . . do not seem to be true *Ustillagineae* but are more probably sclerotial stages of *Ascomycetes.*" (*Journal of Mycology, 8*–63–130.) Both of these species I think are parasitic although the material distribution would give a contrary impression. The latter sometimes is found in leaves alone in which case the affected leaves only suffer. When, however, the culm is attacked, it seems to cause the death of the plant before the sclerotia (?) are formed.

ADDITIONAL SPECIES—NOT RECORDED IN THE PREVIOUS LISTS.

568. SYNCHYTRIUM ASARI, Arthur & Holway.

On *Asarum reflexum,* Bicknell. Somers. A single station where it was fairly abundant in 1897 and again in 1901. As far as I know, it has not been reported since the original collection at Vermillion lake, Minnesota.

569. PERONOSPORA ALSINEARUM, Caspary.

Conidia and oöspores on *Cerastium nutans,* Raf. Racine.

570. PERONOSPORA GRISEA, Ung.

On *Veronica Anagallis,* L. Racine.

571. PERONOSPORA RUMICIS, Corda.

On *Polygonum dumetorum,* L. var *scandens,* Gray. Kenosha county.

572. PERONOSPORA RUBI, Rabh.

On *Rubus villosus,* Ait. Vilas county, July.

573. PLASMOPARA RIBICOLA, Schroeter.

On *Ribes rubrum,* L., var. *subglandulosum,* Maxim. *Ribes prostratum,* L'Her. and *Ribes oxyacanthoides,* L. In alder thickets along creeks. Vilas county. Sometimes abundant.

574. PODOSPHAERA LEUCOTRICHA, (E. & E.) Salmon.

(*Sphaerotheca mali,* Burrill.) I have seen no specimens of this but it is credited to Wisconsin in Salmon's Monograph of the *Erysiphaceae.* Its host is the apple, *Pyrus Malus,* L. (cult.)

575. DIMEROSPORIUM CONGLOBATUM (B. & C.), E. & E.

On *Arctostaphylos Uva-ursi,* Spreng. Collected in small quantity near Three Lakes on the lower surface of spots bearing an immature *Phyllosticta* (?)

576. VENTURIA DICKIEI, (B. & Br.) Ces. & De Not.

On *Linnaea borealis,* Gron. Pelican Lake.

577. DALDINIA VERNICOSA, (Schw.) Ces. & De Not.

On trunk of living *Carpinus Caroliniana,* Walt. Somers.

578. PSEUDOPEZIZA SINGULARIA, Peck *in litt.* (*Peziza singularia,* Peck.)

On *Ranunculus Pennsylvanicus,* L. Vilas county.

578a. FABRAEA ROUSSEAUANA, Sacc. & B.

On *Caltha palustris,* L. Vilas county. I am indebted to Dr. E. J. Durand of Cornell University for the determination.

579. ASCOCHYTA ALISMATIS, (Oud.) Trail.

On *Alisma Plantago,* L. Racine and Kenosha county.

580. ASCOCHYTA CORONARIA, Ell. & Davis, *n. sp.*

Spots small, irregular, definite, subangular, partly limited by the veinlets, first reddish brown, then dark brown, finally pallid, 1–3 *mm.* in diameter. Perithecia epiphyllous, globose, black, pierced above, 150–200 microns. Sporules of two elliptical or oblong biguttulate cells placed at various angles to each other; each cell 9–15 × 5–8 microns.

On living leaves of *Pyrus coronaria,* Racine, Wisconsin, September. *Ascochyta pyricola,* Sacc., has sporules only 10 × 2 microns.

580a. ASCOCHYTA LOPHANTHI, n. sp.

On *Lophanthus scrophulariifolius,* Benth. Racine and Kenosha county. Spots dark brown, definite, round to oval, margin repand, 5–20 *mm.* diameter. Perithecia globose, usually innate but sometimes formed just beneath the epidermis and forming minute papillae, 50–150 microns in diameter. Sporules short-cylindrical with rounded extremities, constricted at the septum, 20–30 × 10–12 microns. August and September.

581. ASCOCHYTA RHEI, E. & E.

On *Rheum Rhaponticum,* L. (cult.). Racine. (Dr. Erwin F. Smith.)

582. CERCOSPORA ACALYPHAE, Peck.

On *Acalypha Virginica,* L. Racine. Conidia amphigenous but most abundant on the lower surface of the spots. Hyphae about as long as the conidia which sometimes attain a length of 150 microns.

583. CERCOSPORA ALISMATIS, Ellis & Holway.

On *Alisma Plantago,* L. Racine. Collected but once.

584. CERCOSPORA BOEHMERIAE, Peck.

On *Boehmeria cylindrica,* Willd., var. *scabra,* Porter. Genoa Junction.

585. CERCOSPORA CALLAE, Pk. & Cl.

On *Calla palustris,* L. Vilas county. In these specimens the spots are often 5 or 6 *cm* in length and the leaf is usually split through the spot. The conidia are about 6 microns in diameter and sometimes 100 microns in length.

586. Cercospora caricina, Ell. & Dearn.

On *Carex rosea,* Schkuhr. Racine. *Carex arctata,* Boott. Vilas county. Rather abundant over a small area at each of these stations.

587. Cercospora comari, Pk.

On *Potentilla palustris,* Scop. Vilas county.

588. Cercospora desmodii, Ell. & Kell.

On *Desmodium acuminatum,* DC. Somers.

589. Cercospora diffusa, Ell. & Evht.

On *Physalis* sp. on the prairie near Racine.

590. Cercospora gerardiae, Ell. & Dearness.

On *Gerardia grandiflora,* Somers. This has been referred to *Cercospora clavata* (Gerard) Pk.; which it much resembles. It appears, however, to be confined to *Dasystoma.*

591. Cercospora gnaphaleacea, Cke. (?).

On *Gnaphalium polycephalum,* Michx. Racine. I have followed Earle (Bull. Torr. Bot. Club, *25,* 366. 1898.), in the disposition of this species.

592. Cercospora heterospora, Ell. & Evht., *ined.*

On *Euphorbia corollata,* L. Racine.

593. Cercospora lippiae, Ell. & Evht.

Mr. S. C. Wadmond called my attention to this fungus on herbarium specimens of *Lippia lanceolata,* Michx., collected by him at Racine.

594. Cercospora lythri, (West.) Niessl.

On *Lythrum alatum,* Pursh. Racine.

595. Cercospora majanthemi, Fckl.

On *Maianthemum Canadense,* Desf., Pelican Lake. Differs from the type in its smaller size,—about one-half. More typical specimens have since been collected in Vilas county.

596. CERCOSPORA NYMPHAEACEA, Cke. & Ellis.

On *Nymphaea.* Madison. (Prof. R. A. Harper and J. J. Davis.

596a. CERCOSPORA PUSTULA, Cke.

On *Ampelopsis quinquefolia,* Michx. Racine.

597. CERCOSPORA RHAMNI, Fckl.

On *Rhamnus cathartica,* L. Racine. *Rhamnus alnifolia,* L'Her. Wind Lake.

598. CERCOSPORA ROSAECOLA, Pass.

On *Rosa Carolina,* L. Wind Lake. Hyphae sometimes exceeding 100 microns in length.

599. CERCOSPORA SYMPLOCARPI, Peck.

On *Symplocarpos foetidus,* Salisb. Kenosha county.

600. CERCOSPORA UMBRATA, Ell. & Holway.

On *Bidens connata,* Muhl. Racine.

601. CERCOSPORA VICIAE, Ell. & Holway.

On *Vicia Caroliniana,* Walt. Somers.

602. CYLINDROSPORIUM ERYNGII, Ell. & Kell.

On *Eryngium yuccaefolium,* Michx. Racine. Sometimes locally abundant.

603. GLOEOSPORIUM CARYAE, Ell. & Dearn.

On *Carya alba,* Nutt. Racine. Very abundant

604. GLOMERULARIA CORNI, Peck.

On *Cornus Canadensis,* L. Three Lakes. On *Lonicera ciliata,* Muhl. Vilas county.

605. MARSONIA DELASTREI, (De Lacroix) Sacc.

On *Silene stellata,* Ait. Racine.

606. MARSONIA FRAXINI, Ell. & Davis *n. sp.*

On leaves of *Fraxinus sambucifolia,* Lam. Vilas county. (J. J. Davis, 028, July, 1902.) Acervuli buried in the substance of the leaf on small, pale, indefinite spots or scattered singly over the entire lower surface of the leaf, the fusoid-cylindrical, nearly straight conidia, 17–33 (mostly 24–27) × 2–3 microns, erumpent in pale, slightly flesh-colored cirrhi on the lower surface of the leaf, which is but slightly changed in appearance. This comes near *Septogloeum fraxini*, Hark., but that is epiphyllous with larger acervuli and broader conidia 2–5 septate and curved. The conidia in *Marsonia fraxini* are, as far as observed, only one septate.

607. MASTIGOSPORIUM ALBUM, *Riess,* var. CALVUM, Ell. & Davis, *n. var.*

On *Calamagrostis Canadensis,* Beauv. Vilas county. (J. J. Davis, 0220.)

"It is *Mastigosporium* all but the three bristles arising from the upper septum, so that it is either a variety or a new species." J. B. Ellis *in litt.*

608. OVULARIA MONILIODES, Ell. & Martin.

On *Myrica asplenifolia,* Endl., and *Myrica Gale,* L. Vilas county.

609. PASSALORA FASCICULATA, (C. & E.) Earle.

On *Euphorbia corollata,* L. Racine. The synonymy of this species is fully given by Earle in *Torreya, 2,* 10–159.

610. PHLEOSPORA RETICULATA, Ell. & Evht.

On *Lathyrus venosus,* Muhl. Racine.

611. PHYLLOSTICTA LAPPAE, Sacc.

On *Arctium Lappa,* L. Somers.

612. PHYLLOSTICTA SIMILISPORA, Ell. & Davis.

On *Solidago rigida,* L. Racine.

613. PHYLLOSTICTA SPERMOIDES, Pk.

On *Vitis riparia,* Michx. Madison. (Prof. R. A. Harper.)

614. RAMULARIS EFFUSA, Peck.

On *Vaccinium Canadense,* Kalm. Vilas county. Apparently scarce.

615. RAMULARIA MITELLAE, Peck.

On *Mitella diphylla,* L. Racine.

616. Ramularia sambucina, Peck.
On *Sambucus racemosa,* L. Pelican Lake.

617. Ramularia subrufa, Ell. & Holway.
On *Smilax ecirrhata,* Watson. Racine.

618. Ramularia virgaureae, Thum.
On *Solidago latifolia,* L. Somers.

619. Ramularia waldsteiniae, Ell. & Davis, n. sp.
On leaves of *Waldsteinia fragarioides,* Tratt. Vilas county. (July, 1902, Davis 0218.) Hyphae hypophyllous in white punctiform tufts on brown subindefinite spots straight or slightly curved, sometimes abruptly bent above, 25–35 x 2–3 microns. Conidia straight, cylindrical, continuous, 20–30 x 3 microns. The brown spots are visible on the upper side of the leaf and the leaf turns yellow around them.

620. Septocylindrium concomitans, (Ell. & Hol.) Halsted.
On *Bidens frondosa,* L. Genoa Junction.

621. Septogloeum apocyni, Peck.
On *Apocynum androsaemifolium,* L. Somers. Abundant.

622. Septogloeum potentillae, Allesch.
On *Potentilla palustris,* Scop. Vilas county.

623. Septoria alnifolia, Ell. & Evht.
On *Alnus viridis,* DC. Vilas county.

624. Septoria brevispora, Ell. & Davis, n. sp.
On leaves of *Bromus ciliatus,* L. Racine. (J. J. Davis 025, July, 1902.) Spots elongated-elliptical, brown, 1–2 cm x 2–5 mm, finally confluent, the whole leaf becoming dead and dry. Perithecia not confined to the spots, light colored, 120–150 u in diameter, pierced above. Sporules clavate-cylindrical, 15–18 x 2½–3 microns, quadri-nucleate, straight. Differs from *Septoria bromi,* Sacc., in its much shorter sporules.

625. Septoria campanulae, (Lev.) Sacc.

On *Campanula Americana,* L. Racine. Very abundant at one station in 1900.

626. Septoria cephalanthi, Ell. & Kell.

On *Cephalanthus occidentalis,* L. Kenosha county. In these specimens the perithecia are frequently hypophyllous. The sporules are 1½–2 microns thick.

627. Septoria corydalis, Ell. & Davis.

On *Corydalis glauca,* Pursh. Vilas county. Hardly a good *Septoria.*

628. Septoria erigerontis, B. & C., var. boltoniae, Webber.

On *Boltonia asteroides,* L'Her. Kenosha county. I am indebted to Prof. F. E. Clements for the comparison of this with Nebraska specimens. Although *Septoria erigerontis,* B. & C., is recorded in the Preliminary List, I have thought it best to give this variety a separate number.

629. Septoria gei, Rob. & Desm.

On *Geum macrophyllum,* Willd. Wind Lake.

630. Septoria halstedii, Ell. & Evht., *in herb.* (*Septoria chrysanthemi,* Halsted.)

On *Chrysanthemum Leucanthemum,* L. Racine.

631. Septoria liatridis, Ell. & Davis.

On *Liatris scariosa,* Willd, and *Liatris spicata,* Willd. Racine. I have observed this species for a number of years but never in any abundance.

632. Septoria menyanthis, Desm.

On *Menyanthes trifoliata,* L. Madison and Vilas county.

633. Septoria saccharina, Ell. & Evht.

On *Acer saccharinum,* Wang. Vilas county. In the specimen examined the sporules are shorter, about 30 microns.

634. PANOEOLUS EPIMYCES, Pk.

On *Coprinus atramentarius,* Fr. Madison. (Prof. R. A. Harper.)

635. UROMYCES HALSTEDII, De Toni.

On *Leersia Virginica,* Willd. Dells of the Wisconsin river. (Dr. J. C. Arthur.)

635*a*. UROMYCES MINOR, Schroet.

Aecidium on *Trifolium repens,* L. La Crosse. (Prof. L. H. Pammel.)

I am indebted to Dr. Arthur for the specimen, which I presume was referred to under No. 152, *U. trifolii* (A. & S.) of the Preliminary List.

636. PUCCINIA ASPARAGI, DC.

On *Asparagus officinalis,* L. Racine.

637. PUCCINIA BOLLEYANA, Sacc.

I am indebted to Dr. J. C. Arthur for the detection of this rust on an unidentified host (Carex ?) collected in Kenosha county. This was collected again in 1902 on sterile plants that were apparently the same as the *Carex trichocarpa,* Muhl. that was abundant in the vicinity. Dr. Arthur has, by means of cultures, established the fact that *Aecidium sambuci,* Schw. (No. 232) is the æcidial stage of this rust and has accordingly changed the name to *Puccinia sambuci,* (Schw.) Arthur. I should prefer to write it *P. caricis-sambuci.*

637a. PUCCINIA BULLATA, (Pers.) Wint.

Uredo and teleutospores on *Pimpinella integerrima,* Benth. & Hook. Kenosha county.

A single station of quite limited extent.

638. PUCCINIA CYPRIPEDII, Arthur & Holway.

Uredo and teleutospores on *Cypripedium pubescens,* Willd. Somers.

639. PUCCINIA HALENIAE, Arthur & Holway.

On *Halenia deflexa,* Griseb. Banks of the St. Louis river. (Prof. L. S. Cheney.)

640. PUCCINIA HYDROPHYLLI, Pk. & Clint.

On *Hydrophyllum Virginicum*, L. I have seen this but once and then in small quantity in Kenosha county.

641. PUCCINIA NARDOSMII, Ell. & Evht.

On *Petasites palmata*, Gray. Bark Bay, Bayfield county. (Prof. L. S. Cheney.) Mouth of the Brule river, Douglas county. (Prof. L. S. Cheney.)

642. PUCCINIA PANICI, Dietel.

Teleutospores on *Panicum virgatum*, L. Racine.

643. PUCCINIA POARUM, Niels.

Uredo on *Poa pratensis*, L. Madison (Seymour). Racine. Referred to in Suppl. List under No. 199.

644. PUCCINIA SEYMOURIANA, Arthur.

Teleutospores on *Spartina cynosuroides*, Willd. Racine.

645. PUCCINIA SIMILLIMA, Arthur.

On *Phragmites communis*, Trin., accompanying *Puccinia phragmitis* (Schum.), Koern. This is the rust that has been referred to *Puccinia magnusiana*, Koern., in this country.

646. PUCCINIA WALDSTEINIAE, M. A. Curtis.

On *Waldsteinia fragarioides*, Tratt. Adanale (Prof. L. S. Cheney.) Forest and Vilas counties. Locally abundant.

647. CHRYSOMYXA ALBIDA, Kuhn.

On *Rubus strigosus*, Michx. Vilas county. Reported from Wisconsin on *Rubus occidentalis*, L., by Tracy & Galloway. (Jour. of Mycol., 4-7-62.)

648. MELAMPSORA LINI, (Pers.) Desm.

Uredo on *Linum sulcatum*, Riddell. Sauk City. (Mr. H. F. Lueders.)

649. MELAMPSORA VACCINIORUM, (Lk.) Schroet. (*Thecopsora vacciniorum*, (Lk.) Karst.)

Uredo on *Vaccinium Canadense*, Kalm, and *Vaccinium Pennsylvanicum*, Lam. Three Lakes.

650. AECIDIUM EPILOBII, DC.

On *Oenothera biennis,* L. Pelican Lake.

651. PERIDERMIUM DECOLORANS, Peck.

On *Picea nigra,* Lk. Oneida county. (Prof. L. S. Cheney.) Vilas county. This is considered a variety of *Peridermium abietinum,* (A. & S.) by some botanists.

652. DOASSANSIA INTERMEDIA, Setchell.

On *Sagittaria variabilis,* Engelm. Vilas county. Through the courtesy of Dr. Setchell, I have been able to examine authentic material of this species, the description of which appeared in the *Botanical Gazette, 19,* 185–86, 1894. *Doassansia affinis,* Ell. & Dearn., which I consider a synonym, was published in the *Bulletin of the Torrey Botanical Club, 22,* 364, 1895, consequently the name used has priority and it is not invalidated by *Doassansia intermedia,* Morot (on *Alisma*), *Journal Botanique,* 1895. Since this was written Prof. G. P. Clinton has announced the same conclusion. *Journal of Mycology, 8,* 63, 129. This appears to have a northern range: Shelburn, N. H., *Farlow;* London, Canada, *Dearness;* northern Wisconsin; Port Arthur, Minn., *Dewart, fide* Setchell, and Decorah, Iowa, *Holway.*

653. DOASSANSIA ZIZANAE, Davis, occurring on *Zizania aquatica,* L., at Racine, Kenosha and Madison, is considered by Prof. G. P. Clinton to be probably a *Sclerotium, loc. cit,* 130. See note to No. 566.

654. ENTYLOMA POLYSPORUM, (Pk.) Farl.

On *Ambrosia artemisiaefolia,* L. Racine. Sometimes abundant.

655. SCHIZONELLA MELANOGRAMMA, (DC.) Schroet.

On *Carex.* Madison. (Dr. R. H. True.) Racine. (Dr. F. L. Stevens.) My thanks are due to Dr. Stevens for calling my atention to the omission of this species from the previous lists. It sometimes occurs in considerable abundance on *Carex Pennsylvanica.*

656. TRACYA LEMNAE, (Setch.) Sydow.

(*Cornuella lemnae,* Setch.) On *Spirodela polyrrhiza,* Scheid. Genoa Junction. This occurred on the inner margin of the "lagoon" at Powers lake but I failed to find it at any other point around the lake. A search for it the following year was fruitless.

657. USTILAGO OLIVACEA, (DC.) Tul.

On *Carex utriculata,* Boott, Vilas county. I have not compared this with authentic specimens. In my copy of Sydow's *Ustilagineen* the specimen so labeled is *Cintractia caricis,* (Pers.) Magnus. Prof. Clinton has since authenticated a Wisconsin specimen.

658. USTILAGO PERENNANS, Rostr.

On *Arrhenatherum avenaceum,* Beauv. Abundant in a field of *Bromus inermis* with the seed of which the host and smut had apparently been introduced.

659. USTILAGO UTRICULOSA, (Nees.) Tul.

On *Polygonum hydropiperoides,* Michx. Racine. This smut appears to be rare in Wisconsin.

659a. USTILAGO MACROSPORA, Desm. on *Agropyrum repens,* Beauv. and

659b. USTILAGO OXALDIS, Ell. & Tracy.

On *Oxalis corniculata,* L. var. *stricta,* Sav. Reported from Wisconsin in Clinton's list of *North American Ustilagineae.* (Journal of Mycology, 8-63.

660. CLADOCHYTRIUM MACULARE, (Wallr.) (*Physoderma maculare,* Wallr. *Cladochytrium alismatis,* Busgen.)

On *Alisma Plantago,* L. Kenosha county and Racine. In 1898 about forty leaves bearing this fungus were secured in a small button bush swamp in Kenosha county, but I have not been able to find it there since. Two or three leaves bearing the sori were subsequently found near Racine also growing under *Cephalanthus.* There is also in my herbarium a specimen (ex herb. Ellis) collected in the state of Washington. Prof. G. P. Clinton in his excellent account of the life history of this species adopts Busgen's name, but I have preferred to follow the custom prevailing at the present time.

661. CLADOCHYTRIUM MENIANTHIS, (DBy.)

On *Menyanthes trifoliata,* L. Genoa Junction and Vilas county.

INDEX TO HOSTS.

ARIZONA DIATOMITE.

BY WILLIAM P. BLAKE, F.G.S.,

Professor of Geology, University of Arizona.

In a recent paper[1] descriptive of the occurrence, composition and uses of the extensive beds of diatom-earth in the valley of the San Pedro,[2] Arizona, the paleontology of the deposits was necessarily omitted. In this communication I attempt to supply that deficiency and to illustrate some of the more important and novel forms by micro-photography.

The fossils occur in thick beds many square miles in area, in horizontal layers cut through by ravines, and probably one hundred feet in thickness. These beds when freshly broken are snow-white and chalk-like in appearance, but are siliceous and not calcareous in composition. Under the microscope the diatoms are seen to be distributed through, or mingled with, nearly colorless vitreous particles, apparently a very finely divided volcanic ash or dust such as may have been wafted by the wind and deposited in a lake or estuary of quiet water. The siliceous shields or frustules are easily separated from this vitreous magma and form beautifully perfect objects in the field of a microscope of high power.

Full suites of samples were submitted to eminent specialists, who have expressed great interest in this discovery, and have

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[1] Diatom Earth in Arizona. W. P. Blake. *Trans. Am. Inst. Min. Engrs.* 1902.

[2] The Rio San Pedro of the early explorers and fathers is the Rio Quiburi of the aborigines. The valley was explored in 1697 by two Spanish parties, united for the purpose, and accompanied by 30 Indian auxiliaries. They marched down the river to the Gila, and thence to Casa Grande, returning up the Santa Cruz. (See *Bancroft's History*, vol. xvii., p. 355.)

noted several apparently new forms, or, at least, variations from types hitherto described.

I am indebted to Dr. D. B. Ward of Poughkeepsie, N. Y., for the following list of species or forms recognized by him and for the micro-photographs from which the illustrations have been made.

List of Species Recognized.—Actinocyclus Ralfsii, var. *Arizonae; Amphiprora pulchra* (fragments); *Amphora coffaeformis,* var. *protracta* (Pant. II, 5); *A. lineata; A. proteus* (abundant); *Denticula tenuis;* also, var. *Mesolepta* (Grun.); *Epithemia gibba;** also, var. *ventricosa;* E. gibberula;* E. incisa** (Pant.); *E. turgida;* Fragilaria virescens; Frustulia* (*navicula*) *interposita; Gomphonema subclavatum;* Hantzschia amphioxys,* var. *vivax; Haynaldella* (*antiqua*), var. *Arizonae; Hyalodiscus scoticus; Mastogloia Braunii; M. elliptica,* var. (A. S. At., 185, 8); *M. lanceolata; M. Smithii; Melosira Borrerii; M. nummuloides; Navicula Bohemica;* N. divergens* (f. minor A. S. ; *N. elliptica; N. interrupta; N. formosa; N. limosa;* N. Macraeana* (Pant.); *N. peregrina; N. Sculpta;* Nitzchia vitrea; N. sp.* ?, (*Hantzschia?*) *Stauroneis aspera* (very narrow var.); *Surirella striatula.*

Dr. Ward writes:

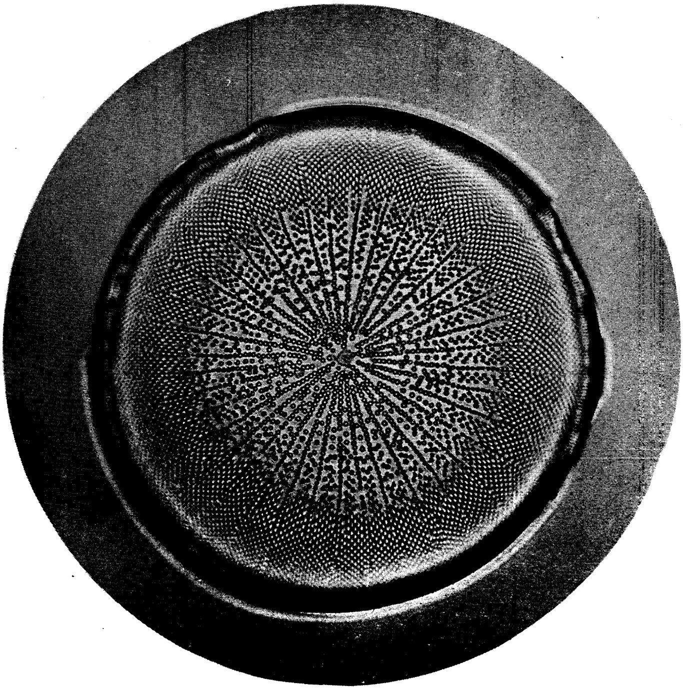
"I enclose a list of the forms as I identify them. The actinocyclus which I formerly called *A. Ralfsii* v. *Monicae* is not exactly that form, but pretty close to it. It might be called *A. Ralfsii* v. *Arizonae.*

"The *Haynaldella* differs slightly from Pantoesek's original in having heavier markings and wanting a clear space in the center. I have never seen this form in American material before. The small *Mastogloia* is found also in Utah fossil material, and is figured in Schmidt's atlas (Pl. 185–8) as a variety of *M. elliptica*—which I doubt.

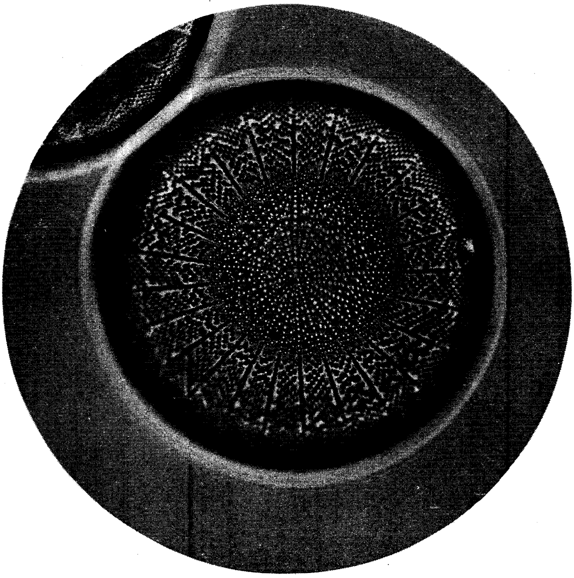
"There is a *Nitzschia,* or *Hantzschia,* which I cannot identify.

* * * * * * * *

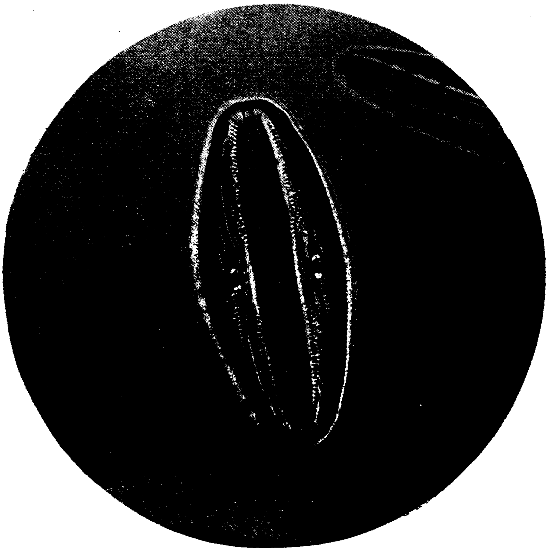
"You will find a good deal of variation in the *Actinocyclus;* but I believe it is all one species, as intermediate forms occur. This deposit is marine, although it contains a few fresh-water forms, which I have noted in the list by an asterisk."



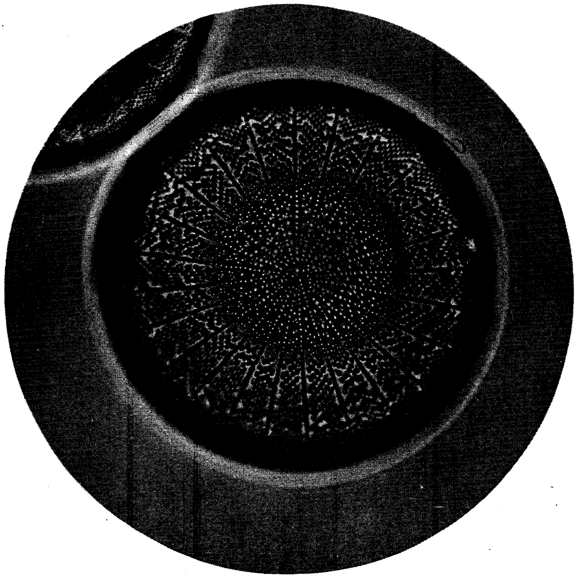
Actinocyclus (Ralfsii var.?) Arizonae.



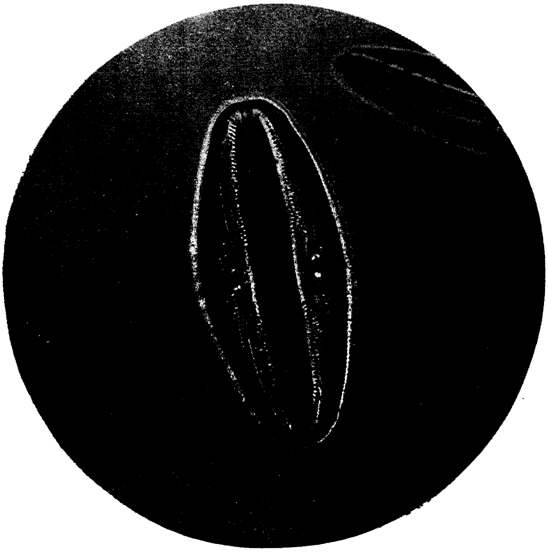
Actinocyclus (Ralfsii var.?) Arizonae.



Amphora proteus. Greg.



Actinocyclus (Ralfsii var.?) Arizonae.



Amphora proteus. Greg.

The following forms are illustrated:

1. *Actinicyclus* (Ralfsii var.?), *Arizonae.*
2. *Actinocyclus* (Ralfsii) *Arizonae.*
3. *Amphora proteus,* Greg.
4. *Denticula tenuis,* var. *mesolepta,* Grun.
5. *Frustulia interposita,* Lewis (*frustules*).
6. *Heynaldella antiqua,* Pant. var. *Arizonae.*
7. *Mastogloia elliptica,* var. front and side views.
8. *Mastogloia Braunii,* Grun.
9. *Mastogloia Smithii,* var,
10. *Nitzschia vitrea,* Norm.
11. *Navicula Macraeana,* Pant.

Dr. Arthur M. Edwards, F.L.S., of Newark, N. J., to whom I sent specimens reported:

"Examined miscroscopically, this earth is found to be made up of the following forms of *bacillaria:* The commonest is *Denticula protea* (P. A. C. N.). This is called *Denticula lauta* (J. W. B.), and is found in the celebrated Monterey earth of California, which is marine. It is also found in the earth of the Yellowstone Park, and likewise living there also. It is beautifully figured by A. Grunow in Van Heurck's *Synopsis des Diatomées de Belgique,* Atlas, 1880–1881, where, on Planche XLIX, it is given with various names, in just nine of them altogether, but they can all be referred to *Denticella protea,* P. A. C. N. There is also present (very common) a form that is extremely interesting to students of the *bacillaria.* This is a large disc, marked most beautifully with rays of small dots, so that it looks almost like a sun. At first, this seems to be a new form or 'species,' and was so ranked by me in my report on the diatomaceous earths of the Northwest Boundary Survey, published ten years ago. But it is not new, although it appears so. It is a *Cyclotella* or *Stephanodiscus,* and is published by A. Grunow as *S. carconensis,* from Carson City, Nevada, and Klamath Lake, Oregon. It is really *Cyclotella bevolinensis* (C. G. E.), and is published in the *Bericht* for 1845, and includes *Discoplea astrea* (C. G. E.) and *D. Eorcca,* C. G. E. They are the sporangia of Melosira granulata,

C. G. E., which is common—in fact, is the prevailing form of the Occidental Sea. See *American Journal of Science,* 1891.

"Mixed with these forms, although in small quantity, are the following: *Navicula appendiculata* (C. A. A.); *N. oblonga* (F. T. K.), and *Nitzschia scalaris* (C G. E.) This last is common in the brackish water of our coast. It is also seen in the Glacial period clay, which is fresh-water.

"There is also present a form which looks like *Mastogloia lanceolata* (C. K. T.).

"When we consider the origin of this 'diatom-earth,' there are present mostly fresh-water forms; but one form is decidedly marine, as *bacillaria* grow now, and has not as yet been detected living in fresh water. This is what has been called *Hyalodiscus Franklinii* (C. G. E.), and was orginally found in the waters of the frozen North, but is common now everywhere. It is also called *Hyalodiscus subtilis* (J. W. B.), and is proposed by Bailey to be used as a 'test' for microscopic objects. But it is also found in the mud of a brackish-water swamp at Melbourne, Australia, and perhaps was washed down from fresh-water, ages ago.

"The *Cyclotella bevolinensis* (C. G. E.) which I have described looks very much like an *Actinocyclus*—in fact, is very closely allied to *A. Ralfsii* (W. S.), and is figured by Van Heurck in his *Synopsis* (Planche CXXIII, Fig. 6). In fact, it is probably nearly allied to that form which is so common along all coasts, and in the celebrated guano of Ichaboe, *Apica.* It is also common, along with fresh-water forms, in the clay of Hatfield swamp, New Jersey. This clay, by the way, is Upper Pliocene.

"Epithemia *musculus* (F. T. K.) is present in small, or ordinary-sized, frustules, and large and unusual-sized ones."

The Monterey earth to which reference is made was discovered by me in 1853 and is described in my Report,[1] and in the Proceedings of the Academy of Sciences, Philadelphia.[2] It was partially examined by the late Professor J. W. Bailey.

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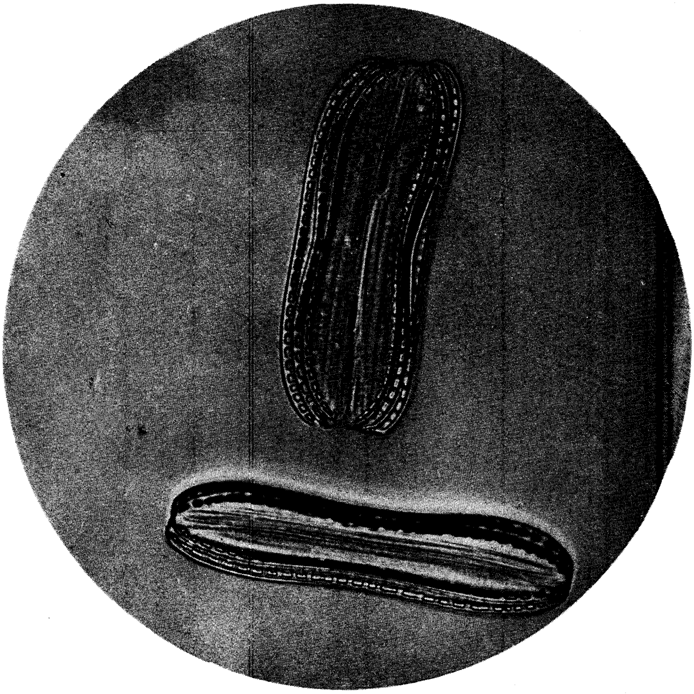
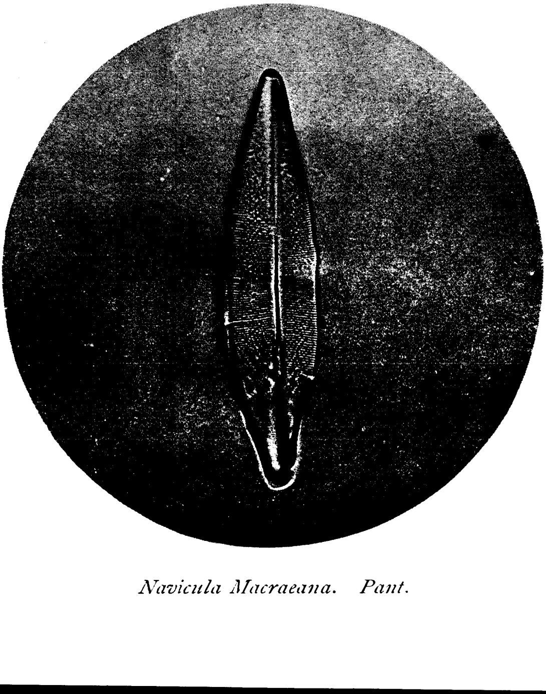
[1] Geological Reconnaissance in California, 4to. 1855, and also in volume V, Pacific R. R. Reports.

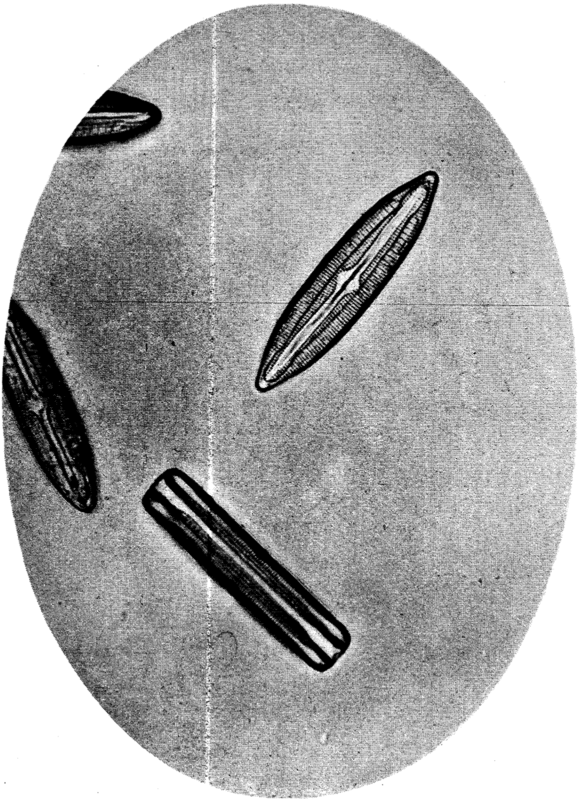
[2] Vol. vii, p. 328.



Nitzschia vitrea. Norm.

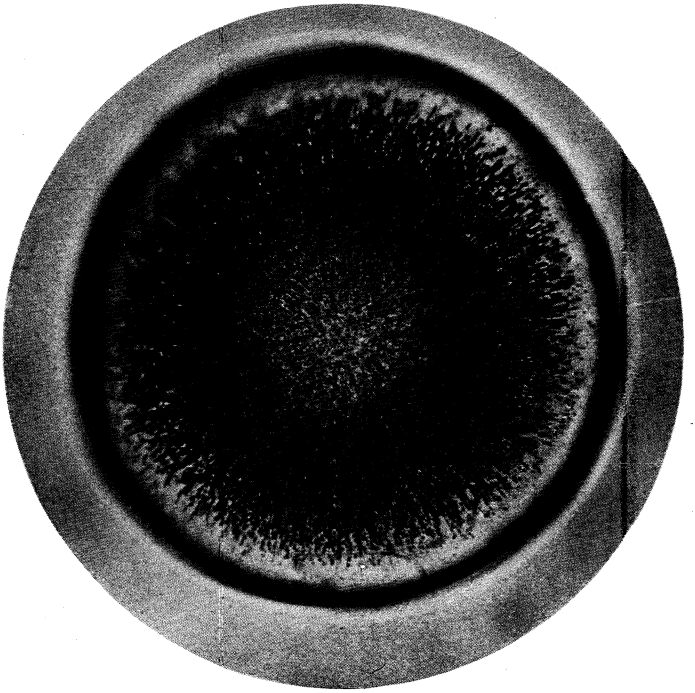


Navicula Macraeana. Pant.

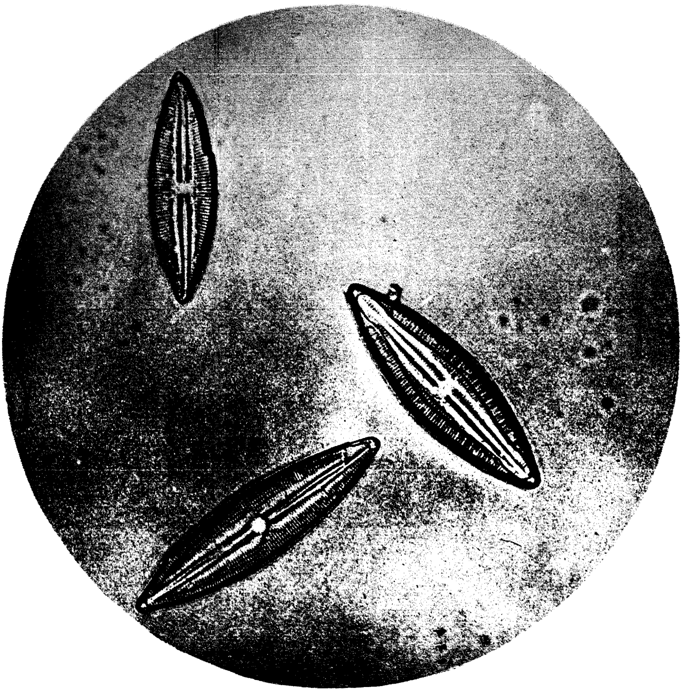


Mastogloia elliptica var., front and side views

Mastogloia Smithii var., frustules in different focus.



Heynaldella antiqua Pant, var. Arizonae.



Mastogloia Braunii. Grun.

Extensive deposits of this nature derive additional scientific interest of late from the suggested possible connection of these microscopic organisms with the genesis of petroleum. Some of the layers of compact silica in the Monterey series are highly bituminous. Dr. Phillips, the Director of the Texas Geological Survey, has observed globules of petroleum in diatoms from the marine ooze off the Sabine Pass.[1]

The lacustrine or marine estuarine origin of the Arizona deposits has been discussed by me in a recent paper on Lake Quiburis.[2]

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[1] "*Texas Petroleum,*" by Wm. Battle Phillips, Ph. D., Bull. No. 5 of the Univ. of Texas (1901), pp. 20–28.

[2] *Arizona University Monthly.* March, 1902.

ON A NEW SPECIES OF CANTHOCAMPTUS FROM IDAHO.

BY C. DWIGHT MARSH,

Professor of Biology, Ripon College.

Canthocamptus idahoensis sp. nov.

This *Canthocamptus* was found in some material collected by Professor B. W. Evermann in Alturas Inlet, Idaho.

There were only a few mature specimens of the form so that the description which follows is somewhat imperfect, but is sufficiently complete, perhaps, to characterize the species, which seems undoubtedly new.

Length of the male .7 mm. The abdominal segments are nearly as broad as those of the thorax, and both abdominal and thoracic segments are serrated on their posterior borders, and armed with fine setae. Two dentations, one on each side, are especially prominent on the abdominal segments.

The branches of the furca (Plate IX, fig. 4) are slender, the length being about four times the average width, and the apical extremity about half as wide as the base. At about half the distance from the base to the apex there is a somewhat sudden constriction in width, and at this point there is a group of rather small setae. The apex is armed with a long central seta, a short and weak external lateral seta, and a still shorter internal lateral seta.

The first antennae of the female (Plate IX, fig. 5) are eight jointed, and of the form typical for *Canthocamptus*. The first four segments are much larger than those which succeed, and are of approximately equal length. The relative lengths of the segments, commencing with the first, are as follows: 25, 23, 21, 24, 7, 15, 8, 20. The first three segments have circlets of small spines. The sensory seta of the fourth segment extends beyond the end of the eighth segment. The seventh and eighth segments are somewhat indistinctly separated. The first antenna of the male is composed of seven apparent segments, of which the first three are very much swollen.

In the female the endopodite of the first swimming foot is three jointed, and is longer than the exopodite. (Plate IX, fig. 6.) The endopodites of the second, third, and fourth feet are two-jointed. The apical segment of the endopodite of the second foot is armed with two lateral and two terminal setae, that of the third foot is armed with three laterals and two terminals, while that of the fourth is armed with three terminal setae. (Plate IX, figs. 7, 8, and 9.)

In the male the endopodites of the first and third feet are three-jointed, and the second and fourth two-jointed. The apical segment of the endopodite of the second foot is armed with three lateral and two terminal setae. (Plate IX, fig. 10.) The second segment of the endopodite of the third foot is armed with one long seta, and the apical segment with two terminal setae. (Plate IX, fig. 11.) The apical segment of the endopodite of the fourth foot is armed with two lateral and three terminal setae.

The fifth feet in both male and female are unusually elongated. In the male (Plate IX, fig. 12) the outer part consists of a slender segment armed on the exterior margin with two stout spines, a short and a long spine at the apex, and a slender seta about midway of the interior margin. The inner part of the foot is quadrangular, and armed at the apex with two stout spines of which the inner is twice as long as the outer.

The two parts of the fifth foot of the female (Plate IX, fig. 13) are nearly equal in length, and are long and slender, the length being about six times the width. The outer part is armed like that of the male, but the spines are weaker and the seta on the internal margin is on the apical portion of the segment. The inner part of the foot is armed with six setae, of which two are apical, one external, and three internal.

Habitat, Alturas Inlet.

The marked characters by which the species is easily distinguished are the slender furca and the remarkably slender fifth feet of both sexes. In fact, it is possible that the peculiar characters of the fifth feet should be considered of generic value.

PLATE IX.

EXPLANATION OF PLATE IX.

Fig. 1. *Canthocamptus idahoensis,* furca of female x 302.

Fig. 2. *Canthocamptus idahoensis,* antenna of female x 302.

Fig. 3. *Canthocamptus idahoensis,* first foot of female x 302.

Fig. 4. *Canthocamptus idahoensis,* endopodite of second foot of female x 423.

Fig. 5. *Canthocamptus idahoensis,* endopodite of third foot of female x 423.

Fig. 6. *Canthocamptus idahoensis,* endopodite of fourth foot of female x 423.

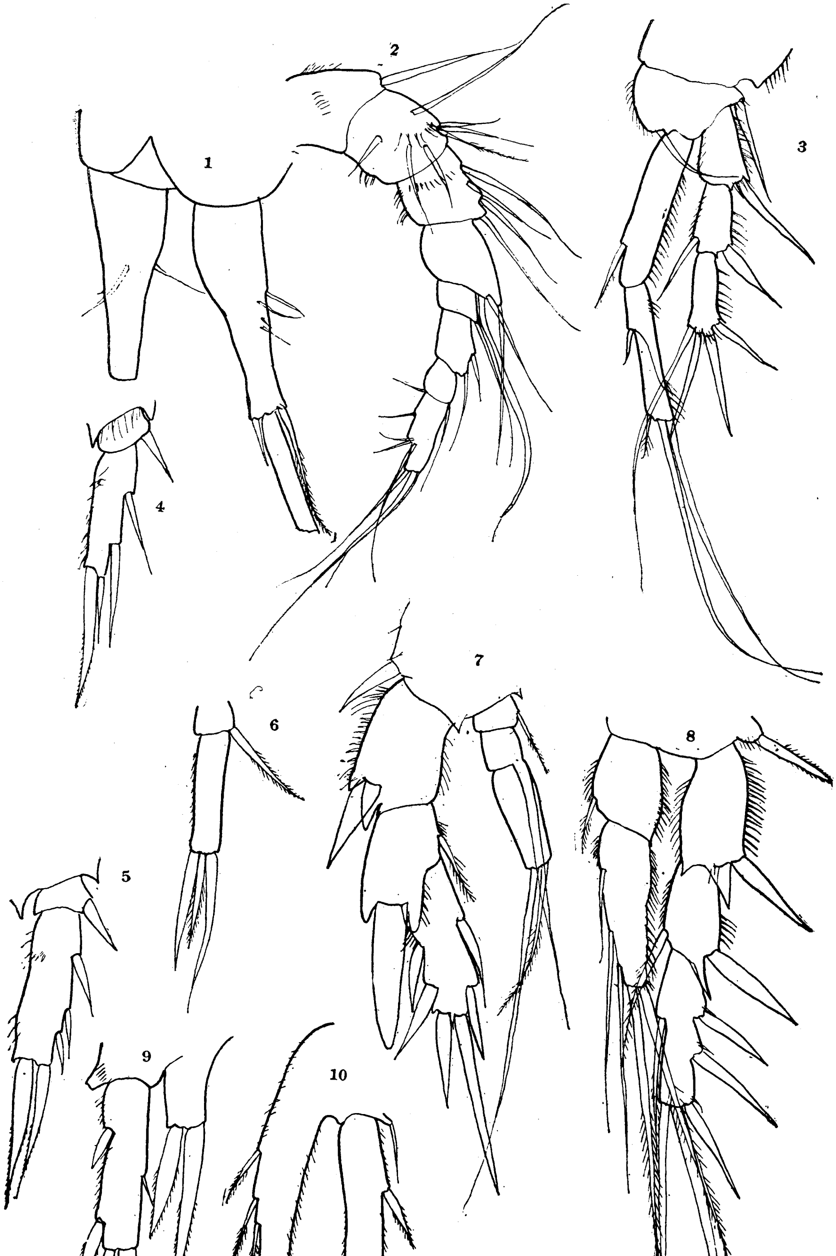
Fig. 7. *Canthocamptus idahoensis,* third foot of male x 375.

Fig. 8. *Canthocamptus idahoensis,* second foot of male x 302.

Fig. 9. *Canthocamptus idahoensis,* fifth foot of male x 423.

Fig. 10. *Canthocamptus idahoensis,* fifth foot of female x 292.

Plate IX.



ENTOCYTHERE CAMBARIA (*nov. gen. et nov. spec.*), A PARASITIC OSTRACOD.

BY WM. S. MARSHALL,

Assistant Professor of Zoology, University of Wisconsin.

While examining a number of branchiae taken from recently killed crayfish, I noticed on one of them a small crustacean, which upon examination with a microscope, proved to be an Ostracod. The peculiarity of its habitat at once struck me as anomalous, and desiring to procure more specimens, I adopted the following method which I found very satisfactory. When any specimens of the Ostracod were wanted a crayfish was killed, the branchiae removed and placed in a large watch-glass partially filled with water. The contents of this glass being examined a few minutes later, the Ostracods, if present, were found near the edge of the water at the side farthest from the light, to which they appear very sensitive. As soon as the branchiae were placed in the water the parasites would leave them and reaching the glass would crawl along it until they came to the edge of the water, where they would remain as far from the source of light as possible.

The first crayfish (different species of *Cambarus*) examined were from the vicinity of Madison; of these, nearly half were infected. Other crayfish were obtained through a dealer and varied considerably in their infection; some localities yielding nearly as high a percentage as those near Madison, while crayfish from other localities appeared to be entirely free. The dealer obtained this material from different parts of Wisconsin, but I could get no definite locality other than Madison. At no season of the year were the parasites entirely absent although both eggs and young were present only during the warm weather, being most abundant early in summer.

The question of *Entocythere* being a parasite or a commensal is one that could not be answered from its habitat alone. Living in the branchial chamber and on the branchiae and branchial filaments of the crayfish it might have no further connection with its host than to obtain a sheltered abode. The number of other animals found living in the branchial chamber could supply it with sufficient food, but these, being principally nematodes and rotifiers, would leave traces of their identity in the stomach contents. An examination of all my specimens showed that in most of them the stomach was either empty or filled with a nearly homogeneous mass. While the mouth parts of *Entocythere* are not modified for a parasitic life, I believe that its food consists of the blood circulating in the branchiae of the host.

The method of infection appears difficult of elucidation. At no stage in its life-history has *Entocythere* the power of swimming, so that it is unable to go through the water from one host to another. During the copulation of the crayfish it could easily pass from one individual to another, or could reach the young as long as they remained attached to the swimmers of the mother. The latter view does not seem probable as I never found any of the very young crayfish infected, always finding the parasites most abundant in the largest individuals.

At one time I obtained from the same locality near Madison, over thirty crayfish which were all placed in a large sink. Fifteen of them, killed within two days, were found to be well infected, more than half containing parasites. The remainder of the lot were kept together for more than four weeks, and when finally killed, every one was found infected; the number of parasites being greater than in any other crayfish I ever examined. It seems improbable that the first lot of crayfish were any less infected than those not selected, but more likely that had they also been examined when first obtained, nearly half of them would also have been free from parasites. I do not see why in taking half of the lot I should have selected those in which the per cent of infected specimens was smallest, or in which the parasites were less numerous. The probable means of infection, other than during copulation, seems to me to be as follows. In the daytime crayfish are found quite abundantly under the stones and logs in the streams and near the shores of the lakes. They leave these retired places to feed and then return to the same or similar localities. Here the parasites could leave their hosts, the light being naturally excluded, and reach other crayfish which came under the same stone.

Lacking some of the larger systematic works, I have been unable to definitely determine the position of *Entocythere* in the family *Cytheridae* to which it belongs. Müller's (8) work gives but two genera of this family, to neither of which does our species belong. From *Linnicythere* it differs in having six terminal setae on the first antenna instead of two; in having the flabellum of the second antenna unsegmented, besides a marked difference in the structure of the maxilla. The maxilla is also quite different from that of the other genus, *Metacypris;* besides the number of terminal setae on the first antenna, and the segments of the mandibular palp not being the same.

In the key given in Bronn's (2) it is nearest to *Loxochonca,* differing, however, from a species of the same genus figured by Brady and Norman (1), in the form, both of the posterior part of the abdomen and of the maxilla. It is also very similar to *Sclerochilus contortus* Sars, as figured by Kaufman (7), but differs in the number of segments of both the second antenna and the mandibular palp, as well as in the general appearance of the maxilla.

A reference to the systematic table given in Bronn's (2) or to those given by Sars (13) or Kaufmann (7) shows that *Entocythere* comes nearest to *Loxochonca,* but is enough different to claim a new genus.

Methods: After their removal from the crayfish the specimens were killed in hot water, or in a mixture of equal parts of hot water and sublimate. Picro-sulphuric was also used but not considered as effective as either of the other methods. The specimens killed in hot water were either brought directly into alcohol, or, after their removal from the water were first allowed to remain for fifteen minutes in a nearly saturated solution of sublimate. The shells being chitinous, decalcification was unnecessary. Delafield's haematoxylin was found to be the most satisfactory stain; often following it with orange G.

Specimens which I wished to mount entire were killed in a dilute solution of Flemming, washed for several hours, and mounted in balsam. The strength of the Flemming and the time employed differed a great deal. Usually a solution of one part Flemming to five parts water was taken and the specimen allowed to remain in this for twenty to thirty minutes.

ENTOCYTHERE.

Shell sub-reniform, becoming, in old individuals, slightly pointed anteriorly. Chitinous, thin and delicate; lateral compression very great. Bristles few and short. Eyes fused.

First antenna six-segmented, slender, gradually tapering; the first segment twice as large as any of the others. Setae thin and many segmented. Second antenna four-segmented, ending in large claws. First segment much broader than the others. Flabellum unsegmented, long and slightly curved. Mandible strong, with masticatory teeth. Palp four-segmented having at its base a small branchial plate from which arise three filaments.

Maxilla four times as long as broad, palp unsegmented. Branchial plate on outer surface near base bearing thirteen setose filaments. Legs nearly similar increasing in length from first to last pair. First leg bears two bristles at knee, others but one; each ends in large, curved, divided claw. Abdominal rami short and thick.

Males abundant, general form and appendages similar to females. Length .6 m m.

The shell of *Entocythere* is smooth and fragile, being without any of the characteristic markings and outgrowths so common in the Ostracods. The few setae present are short and restricted to the margin of the shell. In general, the shell is closer in appearance to the figures of *Paradoxostoma* and *Machaerina* than any other forms I have seen. The shell is so transparent that living specimens show a number of the internal parts, and in specimens that have been cleaned and mounted, the removal of the shell aids but little in working out the internal organization.

There is a slight variation in the shell of different individuals, also between the different sexes. In Pl. XI, figs. 11 and 12 are figured three male and four female shells, all drawn to the same scale. It will be noticed that the youngest male shell is very similar to all three of the youngest females. When, however, the animals become older the anterior end shows a tendency to become pointed, a characteristic much more noticeable in the male than in the female. Again in the male the comparative height is not at any part so great, and it lacks the rounded edge present in the female.

In the shell duplicature, Pl. XII, fig. 19, very nearly the same structure is shown as figured by Claus. Taf. XII fig. 9, for *Pachycypris Leuckarti.* At either side the layer of hypodermal cells is present, those on the outer layer being larger than the inner ones. The nuclei are small and scattered regularly but not so close together as figured by Claus. Connecting the two sides were a number of supporting fibres differing in structure from the hypodermal cells. They stain readily but appear nearly homogeneous. The peculiar sub-hypodermal cells which appear so numerous in the figure already cited from Claus, are abundant in *Entocythere* only in the anterior part. They stain very darkly and are especially noticeable in the great number of vacuoles they contain.

First antenna:—The insertion of the first antenna is directly under the posterior margin of the eye. Its basal segment Pl. X, fig. 1, is much larger than any of the others, possessing two muscles which from their position, one dorsal and one ventral, appear to be used as extensor and flexor of the rest of the antenna. The proximal part of this segment is encircled by a chitinous ring-like band from which the muscles arise. The other five segments are very similar in shape, differing in the number of setae and in the size which decreases toward the distal end. The second segment has two small muscles which occupy in it the same positions that the muscles did in the first segment. In the four last segments nothing that could be distingushed as a muscle was seen, but in each segment two or three fine strands were present, these, however, might have been processes from the muscles of the first two segments or nerves passing out to the terminal setae. The setae of the antenna are all situated at the distal end of the segment on which they are borne. The first segment has two setae, one smaller, on the inner dorsal, and one larger on the inner ventral surface, while the following segment has but one near the middle line of the inner surface. The third segment has two setae which have the same relative position as those on the first. The five setae of the next segment are longer than any so far mentioned; four of them are borne on the inner and two on the outer surface. The fifth segment is without setae, but the last bears six terminal ones slightly longer than those on the fourth. All these are nearly similar in structure.

Second antenna:—S. Fischer (6) has called the second antennae the "Antennenfüsse," an exceedingly appropriate name when one considers their use. They are used entirely in crawling, their fitness for which is shown in the backwardly directed claws and the exit through the flabellum of the secretion of the adhesive gland.

Claus (3) mentions that the second antenna possesses a basal piece which corresponds to the protopodite and is formed by two small pieces, coxa and trochanter, fusing together. This basal piece is here not present as a separate segment, Pl. X, fig. 2, but is very likely represented by a large chitinous piece which is withdrawn entirely within the body, making the femur the basal or first segment. Five muscles have their origin within this segment, three on the dorsal wall, and two from the chitinous strands at its base. These latter two are inserted near each other at the base of the next segment. Of the other three the lowest is inserted at the base of the flabellum, the middle one passes on to the base of the third segment, while the upper one passes through the three following segments to be inserted at the base of the terminal claws. Near the boundary of the third and fourth segments this last muscle gives place to a strong tendon which just before its insertion runs through a chitinous pulley. This pulley makes possible the movement of the claw without the direction of the tendon being changed and also keeps it from pressing on the two setae over which it passes. Opposing this last muscle is one, the only other muscle in the antenna, which, arising at the base of the third segment is inserted above on the base of the claws; its insertion is also tendinous.

Of the three setae on this appendage two are nearly similar and are situated one at the distal end of the third, and the other near the middle of the fourth segment. Each of these consists of a large basal piece followed by numerous small segments; they resemble the setae of the first antenna in all respects except their greater thickness.

Differing, however, from all other setae is the one borne on the distal end of the first segment, the flabellum or urticating seta. It is curved, hollow, tapering and long; its length being equal to that of the antenna minus the terminal claws. At its base it receives the secretion from the adhesive gland; this passing through the seta exudes from the hollow end and is used to help give a firm support when the animal is crawling on smooth surfaces where the claws would not take hold. When examining living specimens under the microscope this use could easily be seen. Wherever the flabellum was raised from the slide or cover glass a small drop of a nearly transparent viscid matter could be seen marking the spot where the end of the flabellum had been, while often a fine thread would be distinguished connecting one drop with another. This secretion and its connection with the hollow flabellum has been figured a number of times, although the name used by Zenker (19), S. Fischer (6) and others, poison-gland, does not signify its use. There can be no doubt but that the secretion is used to enable the Ostracod to crawl on smooth surfaces where the claws would be of no use, and such being the case, a more significant name would be adhesive gland. At the end of the antenna are the three curved claws each armed with a number of stiff straight bristles. The middle claw is much smaller than the others. They all appear connected at their base with an irregular chitinous piece on which the tendons of both muscles are inserted. By this arrangement the three claws move in unison, making it possible that two muscles can move them all.

Mandible:—This appendage, Pl. X, fig. 3, is strong, the chitin of the basal part being very thick, especially along the dorsal and ventral walls. Dorsally the base projects backward forming a heavy blunt spur. The basal part (that back of the insertion of the palp) contains two muscles originating, one above and one below, at the proximal end and passing forward to be inserted, in the same relative position, on the base of the palp. Beyond the point of attachment of the palp, the mandible becomes much smaller, is slightly curved, and ends in six pairs of masticatory teeth. These are heavy, branched and in part hollow; all are slightly curved, the upper and lower pairs more so than the others. Between the teeth are small bristles not at all prominent and much smaller than any of those figured by Claus (3). Near the end of the mandible is a single seta, differing from all others in being unsegmented and terminating in a short rod. The palp is four segmented and bears setae at the distal end of the following segments; second, one seta; third and fourth, each two setae. These are all similar in structure to the setae of the antennae. The palp terminates in a claw which towards the end is abruptly curved. A large muscle passes from the base of the palp to the base of the terminal claw, and a second smaller muscle of doubtful origin is inserted dorsally on the proximal end of the last segment.

The branchial plate (reduced exopod, Claus) differs from all those figured by Claus (3) in being very small and short, and bearing but three filaments. Each filament consists of a large basal segment followed by numerous small ones.

Maxilla:—The elongated basal part of the maxilla, Pl. X, fig. 4 (protopodit) bears on its outer surface near the base, the gill-plate. Along the outer margin of this plate are thirteen branchial filaments of the usual form. Between the insertion of the gill-plate and of the palp the chitinous covering becomes very much thickened to form a supporting framework, the upper and lower parts of which are connected on either side by two oblique bands. At its tip the maxilla becomes much narrower ending in two slightly curved setae.

The palp arises just anterior to the two chitinous bands and extends a little beyond the end of the maxilla. It is unsegmented and bears at its end two claws the lower of which is sickle-shaped and nearly as long as the palp itself.

Upper lip:—The chitinous supporting rods in the upper lip, Pl. XII, fig. 12, have been described by Claus (3) in a number of species of Ostracods and both he and Turner (16) have worked out the other parts of both the upper and lower lips. In *Entocythere* the supporting strands are not well developed. Along the lower surface at the outer end are a number of small hollow inwardly directed setae. These at their base communicate with a row of enlarged hypodermal cells which are connected by filaments with the labial nerve. Both this and the sense organ which is directly under it in the lower lip have been described by Turner (16). Just behind this setigorous portion the lower wall of the lip bends slightly upward forming with an opposed bend in the lower lip, an enlarged space, the atrium, in which the masticatory teeth of the mandible meet. Back of the roof of the atrium the wall suddenly bends toward the lower lip and then after a short distance gradually upward again until the level of the rest of the lip is reached. This peculiar pushed out portion makes the beginning of the oesophagus very small. Just above this is the single labial gland a multi-nuclear mass in which the cell boundaries were not seen. This gland is figured by Claus (3) as paired, from each part of which a duct passes downward to open into the oesophagus. In *Endocythere* the gland is single, the duct which undoubtedly is present I was unable to find.

Lower lip:—The skeletal framework is much stronger and consists of more pieces than that of the upper lip. Pl. XII, figs. 12 and 13. Along the upper and lower margins are paired strands, the upper one along each edge is continued at its front end into a large upwardly projecting tooth, while those below connect with the tooth through oblique lateral pieces. From the base of each tooth small processes pass forward to connect each with a "reichenorgan," the end of which is projected beyond the margin of the lip. A row of hypodermal cells lies just within the lining of the lip. These at the tip are modified to form a sense organ which is situated just below the one in the upper lip, and shows clearly the connection through the labial nerve with the infra-oesophageal ganglion. Fig. 12h. The upper lip is single, the lower lip paired.

Legs:—The three pairs of legs, Pl. X, fig. 5, are so similar that a description of a single one will answer for all of them. The only difference noticeable in the three pairs, are: first, the terminal claws are largest in the first and smallest in the third pair; second, the first bears two large setae at the distal end of the femur, the second and third have but one each; third, a slight increase in length from the first to the third pair.

Each leg is firmly articulated to the internal skeletal framework and has inserted on its base two pairs of muscles. The narrow base of the femur is encircled by an irregular chitinous ring from which arises two muscles, an upper single, and a lower double one, which pass forward to be inserted at the base of the tibia; insertion tendinous. The long, slightly curved tibia is not more than half the thickness of the femur and contains no muscles except the proximal half of one which goes to the claw. The tarsus is two-segmented and contains three muscles; two arise dorsally on the proximal end of the first segment passing to the base of the claw, one above, and one below, while the third has its origin along the dorsal wall of the tibia a litte anterior to the center and is inserted above on the claw's base. This last muscle has a tendinous insertion which passes near its end through a pulley similar to the one in the second antenna. The femur, tibia and first segment of the tarsus each bears at its distal end a seta. The terminal claw is strongly curved, nearly at a right angle, and bears four teeth the comparative length of which varies somewhat in different individuals and on different legs.

The legs are supported by an internal chitinous framework, Pl. XI, fig. 8, consisting of two longitudinal strands and six vertical pieces arranged in three pairs. Each vertical strand is at its upper end articulated to one of the horizontal pieces, from which it passes downward to join the base of the nearest leg. The longitudinal pieces are laterally compressed, each dividing just posterior to the insertion of an upright into an upper and a lower part. The openings thus formed vary in size, the anterior being largest, the posterior smallest.

Anteriorly each longitudinal strand articulates with pieces which support the antennae and the mouth parts while posteriorly they are connected by a loop to which articulate the supporting pieces of the copulatory organ. This loop in females has the position as given in fig. 8, but in the males is more dorsally directed and has articulated to it the connecting pieces of the copulatory apparatus. In young specimens all the supporting strands are almost colorless and very fragile, becoming stronger with the growth of the individual.

Alimentary tract:—The opening of the alimentary tract is small being in part closed by the sensory setae projecting from the upper and lower lips, Pl. XI, fig. 9. The cavity soon enlarges to form the atrium in which the masticatory teeth of the mandibles meet. Following the atrium the passage, beginning of the oesophagus, becomes much smaller the decrease in size being due to a large outfolding of the dorsal wall. Back of this growth there is a gradual increase in the width of the oesophagus until it passes into the crop.

The crop projects into the stomach and shows in longitudinal section a marked difference between its dorsal and ventral walls. The dorsal wall is much the thicker and has on its surface a chitinous lining covered with short rods. It shows, from a depression seen on its anterior wall, that it is formed by an outfolding of the wall between the oesophagus and stomach. The wall of the ventral part is also lined with chitin which ends in a rod projecting back and beyond the cells. The ventral wall is without the bristles or rods described in many other Ostracods. Zenker (19). Claus (3).

The stomach, the largest part of the alimentary tract, has its two ends nearly similar, the anterior end being slightly broader due to the presence of the crop. The cellular structure of the crop and stomach is very similar, the cells of the former being somewhat smaller and not showing the cell boundaries distinctly The wall of the stomach is composed of a layer of cells, Pl. XII, figs. 15 and 16, which in some places appear cubical, in other parts the width is somewhat greater than the height. The tissue at the base of the cells is so thin that no differentiation could be distinguished, while their free ends were often very irregular. This irregularity is due to the free ends being cut off by a process of strangulation already described for the Ostracods by Claus (3). In *Entocythere* nearly every section of the stomach shows this process of strangulation, Pl. XII, fig. 15, the parts already cut off being easily seen. In many sections the cells here and there were very much flattened as if they had already thrown off a large part of themselves, and near them the lumen of the stomach contained a number of balls some of which showed a distinct outline while others had begun to disintegrate.

Posteriorly the stomach passes abruptly into the intestine, the decrease in size being very noticeable as is also a change in the structure of the wall. In the intestine the cell boundaries were not discernible, the cells being grouped together into villi-like clusters. The nuclei are grouped together, Pl. XII, fig. 14, being proportionately very much smaller than those in the cells of the stomach. I was unable to distinguish any cell boundaries. At its posterior end the walls of the intestine becomes thin and the lumen decreasing very much in size forms a long thin passage which ends in the anus.

Glands:—Like other *Cytheridae* no mid-gut diverticula, digestive gland, is present in *Entocythere.*

Shell-gland:—The upper part of the shell-gland is situated just in front of and on a level with the eye; extending from here forward and downward the lower edge being equidistant between the dorsal and ventral surfaces of the shell. A study of sagittal and transverse sections shows only four large cells on each side as belonging to the gland. Never more than two of these cells were shown in any transverse section and in only one sagittal section were all four present. Pl. XII, fig. 17. These large cells appear more like the cells of the racemose portion of the shell-gland in *Cypris muncronota* than any of the other figures of this gland given by Claus (3). The nucleus is irregular in outline containing one or two small nucleoli and a rather dense chromatic network scattered evenly through all its parts. In each cell, especially near the outer margin, are a number of vacuoles. The three cells which lie closest together, the fourth being more ventral than any of these, contain within their abutting sides, each, a spherical bladder-like cavity; these, in living specimens, are of a light yellow color, clear and refractive, in section appearing as colorless vacoules. They are connected with each other and in living specimens were seen to be in communication with a long narrow tube. The fourth and most ventrally placed cell contains, instead of the bladder-like portion, a wide, irregular duct which is nearly as long as the cell and in two slides was seen to open outside the body, Pl. XII, fig. 17′, the opening being on a level with the insertion of the second antenna.

Adhesive-gland:—Kaufmann (7) in his figures of *Sclerochilus contortus* (Plate XI, figs. 3 and 7) has shown a large gland which he calls the antennal, which arising near the centre of the body passes into the flabellum of the second antenna. The part shown by Kaufmann (7) is only the secretion of the gland which he did not figure. This is the "poison"-gland or "spinning"-gland of the *Cytheridae.* It is situated near the dorsal wall of the shell just back of the eye, the glands of the right and left sides nearly touching along their inner surfaces. Each, Pl. XII, fig. 18, is unicellular and laterally compressed; the nucleus is small with a large nucleolus. In stained specimens, or those killed in Flemming's solution, both the gland and its secretion were easily seen, the latter being readily followed to the tip of the flabellum. The secretion is collected in the lower part of the cell and passes through a long duct which, gradually decreasing in diameter opens at the tip of the flabellum, urticating seta, of the second antenna. The use of the secretion I have already explained in the description of the appendage containing its outlet.

Claus (3) has described for the Ostracods both labial and maxillary glands and Vavra (17) says that besides these, large glandular cells are found in the basal segments of the appendages. In *Entocythere* there are two pairs of distinct glands situated in front of the brain and extending into the antennae. Those of the first antennae lie directly in front of the fore-brain, while those of the second antennae are in front of the hind brain. Besides these and the gland of the upper lip similar structures are found below the second, third and fourth ventral ganglia; there are no doubt glands for the other appendages.

Nervous System:—My account is restricted to the brain and ventral cord; the nerves arising from these were so small that, while in some instances I could distinguish their origin, I was unable to follow them into the parts of the body they supplied. Most of the nerves have already been worked out by Zenker (19), Claus (3), Vavra (17), and Turner (16). The optic nerves, the only ones I could trace, arise from the anterior part of the dorsal surface of the fore-brain and pass directly upward to the eye. The distance between the brain and eye is very short and in only one section could I distinguish the optic nerve. From this section it was impossible for me to say whether one or three nerves went to the eye.

Brain:—Sagittal sections, both median and lateral, through the brain, supra-oesophageal ganglion, shows a difference between the anterior and the posterior surfaces, Pl. XIII, figs. 21 and 22. The anterior face is convex and entirely covered with nerve cells, the posterior concave face shows the nerve cells covering only the dorsal third of its surface. The axis of the brain is inclined so that dorsally it runs slightly forward. The upper end is rounded and continues into the optic ganglion (fore-brain, Vavra) which is slightly constricted off from that part of the brain lying directly underneath it. In these lateral views no other divisions of the brain are seen; the nerve cells on the anterior surface appear greatest in number just above the oesophagus, decreasing toward the optic ganglion.

In Pl. XIII, fig. 23 is shown a transverse section of the brain cut as represented by the line ab in fig. 21. Here the fore-brain is shown quite distinctly, the fibrillar substance indicating by its bi-lobed appearance its double origin; the third ganglion supposed to take part in its formation not being shown. Just ventrad to this, along the lateral surface, are two small groups of nerve cells which represent the antennulary ganglia; still more ventrad, near the oesophagus, the antennary ganglia can be seen. The short circum-oesophageal commissures converge towards each other as they pass around the oesophagus below which they unite to form the large infra-oesophageal ganglion. This ganglion consists of an upper fibrillar half and a lower part containing all of the nerve cells.

The ventral nerve cord, Pl. XIII, figs. 24 and 27 is composed of the infra-oesophageal and four other ganglia. The first and second ganglia are fused, the others being distinct and entirely separated from each other. In both longitudinal and transverse sections this separation is noticeable as is also the arrangement of the nerve cells. In the two nerves it is shown that the nerve cells are not abundant in the inter-ganglionic spaces but that, excepting the first ganglion, they are present along both the dorsal and the ventral surfacs. As already noticed the first ganglion differs from the others in having the nerve cells entirely absent from its dorsal surface. The other ganglia plainly show the nerve cells more abundant dorsally than ventrally, and it is in the dorsal masses that the separation of the ganglia from each other is most distinctly seen, Pl. XIII, figs. 25 and 27, as is also the division into a right and a left. The fibrillar part of the cord passes continuously from one end of the chain to the other, Pl. XIII, fig. 27. The nerve cells on the ventral wall are nearly continuous a few being found in transverse sections of the inter-ganglionic space, Pl. XIII, fig. 26.

Eye:—The eye is situated equally distant from the top of the brain and the dorsal surface of the shell: a plane, passed transversely through the body, which touched the posterior edge of the eye would pass through the middle of the fore-brain. The triune structure is readily seen in a dorsal view, Pl. XIII, fig. 29, the two lateral parts being slightly larger than the median one. The basal surface of each of the three parts of the eye is covered with a layer of pigment, Pl. XIII, fig. 28, composed of a number of dark brown and black spherical granules, which are in some places massed so that they touch each other, while in other parts they are more scattered. These cover the next layer, tapetum, fig. 28 t p (Claus, Exner) which is quite thick and composed of many minute lamellae so close together that seen under a low power, the layer appears light yellow and homogeneous. The lamellar structure is, however, easily made out under a high power and is most distinct at the edge. The remaining space, from the outer surface of the tapetum to the periphery is filled with a number of retinal cells, each one of which has a large nucleus. A lens was not seen.

REPRODUCTIVE ORGANS.

Female:—As characteristic for the *Cytheridae* the ovaries do not lie within the shell duplicature. They are found at either side of the intestine occupying nearly all the space between it and the shell but varying somewhat in that they may be either partially above or partially below it. Woltereck[18] separated the ovary of the Ostracod into four zones which he has distinguished as: 1. Keimzone; 2. Synapsiszone; 3. Differenzirungszone; 4. Wachthumszone. We find in *Entocythere* that the parts corresponding to these zones are present although from the shortening of the ovary and the massing of the cells together, the divisions between them are by no means distinct. Pl. XIII, fig. 30. The first zone does not show any cell boundaries, the nuclei are numerous, each containing several deeply stained granules arranged near the periphery. The change from the first to the second zone is so gradual that it is impossible to place any boundary between the two. The nuclei are slightly larger in the "Synapsiszone," containing the deeply stained granules, which are, however, more scattered. A number of division figures are seen here which are not present in any of the other zones. Cell boundaries are indistinctly seen. The cells of the third zone are separated from each other and are beginning to assume the elongated form which is characteristic further on in the ovary. The nucleus has changed very much becoming nearly filled with a large homogeneous nucleolus. At the beginning of the fourth zone the eggs do not reach more than half way across the ovary; they soon elongate until they are arranged in a single row which completely fills it. Until the middle of this zone is reached the eggs are very thin but beyond this they gradually enlarge and shortly after entering the oviduct they assume a nearly spherical shape. A gradual change also takes place in the nucleus its size increasing with that of the egg. The nucleolus not increasing as rapidly as the nucleus becomes relatively much smaller.

Male:—My knowledge of the male productive organs is very fragmentary. In none of the series of sections did I succeed in getting a clear view of the relation of the parts to each other or be sure even that they all had been made out. All the parts were paired, the vas-defferentia undoubtedly uniting somewhere in the copulatory apparatus. The testis, Pl. XII, fig. 20, appears to be a single wide lobe containing cells in the different stages of spermatogenesis. The posterior part of the testis unites with a slightly larger portion which I took to be a seminal vesicle, principally from the fact that within it the cells did not show the different forms noticeable in the testis and also from a failure to differentiate in it the various zones.

Both the testis and the seminal vesicle before their union pass into a peculiar ovoid body. It is slightly inclined, the posterior end being somewhat higher than the anterior, and appears filled with a granular mass resembling very much the yolk in the eggs. Through this body, from end to end, runs the vas deferens which upon its exit swells slightly, and beginning to turn ventrad enters the base of the copulatory apparatus. In nearly all specimens it was filled with spermatozoa, but I was unable to trace it to its exit.

COPULALATORY APPARATUS.

Kaufmann (7) has already called attention to the large size of this apparatus in the *Cytheridae*, it being at first sight one of the most noticeable parts. It is very complicated, consisting of a number of chitinous pieces, both main parts and connecting strands, and a system of muscles which are nearly all of them connected entirely with the organ. All the parts are paired. Zenker (19) divides the entire apparatus into three parts:

1. Basal piece to join inner and outer parts.
2. Copulatory tube.
3. Clasping apparatus.

In *Entocythere* the basal piece is by far the largest part (shown in the figure as two pieces which are, however, firmly united) its length being more than half the height of the animal, Pl. XI, fig. 10. The anterior half has a rounded surface which in a natural position lies parallel to and almost touching the last upright strand of the chitinous framework which supports the legs. The posterior part, which is not more than half the length of the anterior, has all the other pieces articulated to it.

What I have taken to be the copulatory tube, fig. 10 F, arises from the basal piece just back of the clasping apparatus. It is abruptly curved and ends in a sharp-pointed piece. Being unable to follow the vas deferens I could not establish any connection between it and this tube and am not sure whether it or the shorter tube, fig. 10G, is the true copulatory one. The clasping apparatus consists of a single piece which is joined to the basal part just below the copulatory tube and is normally pointed in the same direction. The position and shape of this piece is shown plainly in the figure. To these parts I would add a connecting piece which passes from the upper part of the basal piece to connect with the loop of the framework already described.

I was able to observe several pairs in copula but did not see the animals unite or determine the length of time they remained together. The shell of the male is open clasping that of the female at least one-third of which is concealed. The mouth parts of the male lie along the dorsal edge of the female's shell; its legs are inactive, somewhat drawn up, and lie on either side. The second antennae of the male clasp the shell of the female, the large claws being inserted between the valves, reaching nearly to the eye. The first antennae remain free and most of the time beat slowly up and down. Naturally the clasping organs and copulatory tube point backward but they are now reversed and together with most of the basal past entirely within the shell of the female, entering a little above the middle of the posterior margin. During copulation the female crawls around carrying the male on her back.

The eggs are laid singly, attached to the basal part of the gills or to the long hairs near their base; sometimes, however, they are arranged in groups of from six to eight. The young when they leave the egg have the two pairs of antennae and the mandibles fully developed. Well back on the body are a pair of appendages, and near them two long setae which finally disappear. Claus in his description of the metamorphosis of *Cypris* figures the first larval, nauplius, stage as being without a fully developed mandible. In all the earliest stages of *Entocythere*, Pl. XI, fig. 7, I found the first three pairs of appendages similar, execpt in size, to the same appendages of the mature individual. The pair of appendages on the body, the prolegs, disappear but I am unable to say whether they disappear entirely or become changed into the first pair of permanent legs. Their position on the body is not so far forward as that of the first pair of legs.

Zoological Laboratory,
University of Wisconsin,
Madison, January 15, 1903.

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PLATE X.

All figures were drawn with a camera, Zeiss microscope.

EXPLANATION OF PLATE X.

Fig. 1. First antenna. D. 2. To the right a seta enlarged.
Fig. 2. Second antenna. D. 3. Outer view of right one.
Fig. 3. Mandible. D. 3. Same view as second antenna. The masticatory teeth are much thicker and heavier than here represented.
Fig. 4. Maxilla. D. 3. Same view as second antenna.
Fig. 5. Third leg. D. 3. Same view as second antenna.
Fig. 6. Muscle scars. D. dorsal A. anterior.

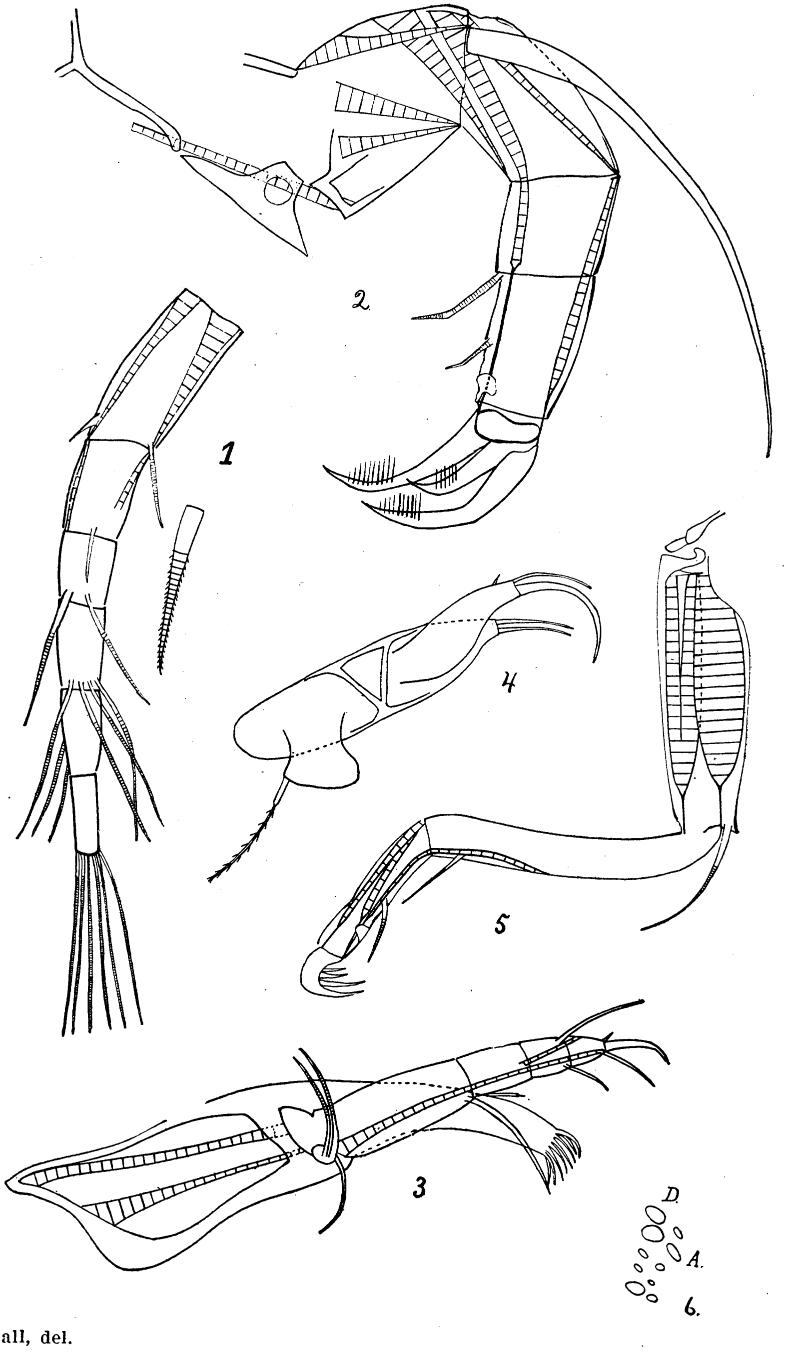

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PLATE XI.

EXPLANATION OF PLATE XI.

Fig. 7. Youngest stage. D. 2. The first three appendages, first antenna, second antenna, mandibles, have been drawn from one side only and the setae omitted. Of the fourth appendage both right and left have been drawn.

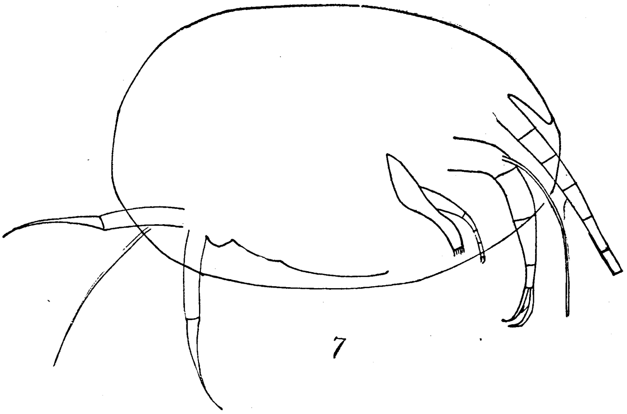
Fig. 8. Chitinous supporting framework of the legs. A. 2. A. anterior. D. dorsal.

Fig. 9. Diagrammatic view to show the relation of the various parts to each other. S. G., shell-gland. E., eye. A. G., adhesive gland. B., brain. U. L., upper lip. L. L., lower lip. Ovary dotted. The different regions of the alimentary tract have not been lettered. They can easily be distinguished as can the different parts of the nerve cord.

Fig. 10. Copulatory apparatus. D. 2. D., dorsal. A., anterior. C, connecting piece. B. B., two halves of basal piece. E., Clasping piece. F., probable copulatory duct.

Fig. 11. Four outline views of shells of females. All A. 3, D., dorsal. A., anterior.

Fig. 11. Three similar views of males. A. 3.



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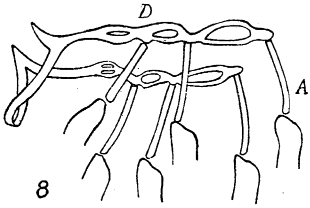

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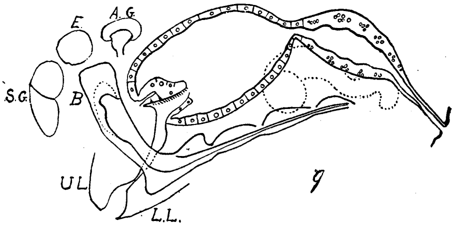

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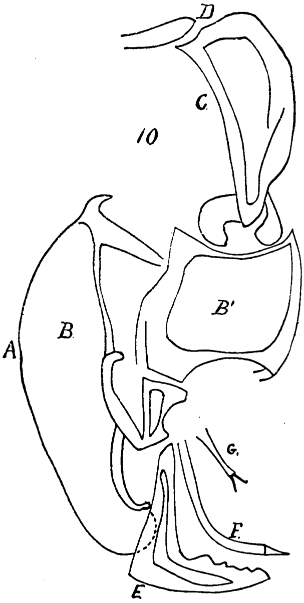

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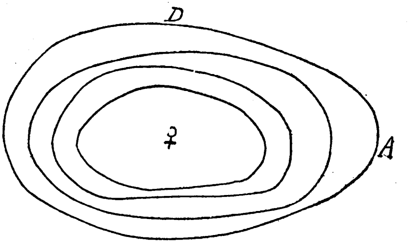

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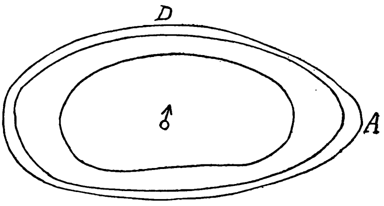

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PLATE XII.

EXPLANATION OF PLATE XII.

Fig. 12. Slightly diagrammatic, showing lateral view of upper and lower lips. D. 3. lg., Labial gland. so., sense-organ of upper and so, of lower lip. oes., oesophagus. mt., masticatory teeth of mandible. at., atrium. ro., Zenker's "rechenförmige Kauorgan." ing., infran-oesophageal ganglion connected by a nerve, ln., to sense organ of lower lip, so.

Fig. 12. Lower lip. D. 3., showing the chitinous supports.

Fig. 13. Zenker's "rechenförmige Kaunorgane."

Fig. 14. Part of wall of intestine. 1–12 Im. 3.

Figs. 15 and 16. Part of wall of stomach. 1–12 Im. 3.

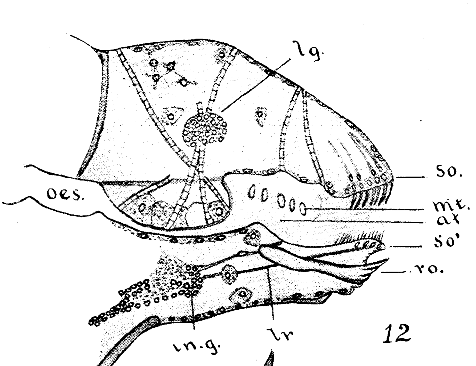
Fig. 17. Shell gland. A., anterior. D. 3

Fig. 17. Slightly enlarged view of bottom cell to show opening.

Fig. 18. Unicellular adhesive gland showing gland cell with its nucleus, N., and part of the secretion just below it. D. 2.

Fig. 19. Section through shell duplicature at anterior part of body. O., outer, and I., inner wall. S. G., shell-gland. Hyp., hypodermal cells. S. Hyp., large sub-hypodermal cells.

Fig. 20. Male reproductive organs. D., dorsal. A., anterior. S. V., seminal vesicle. V., vas deferens.



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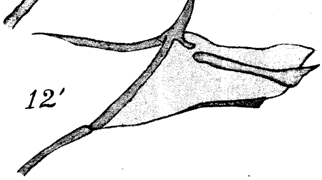

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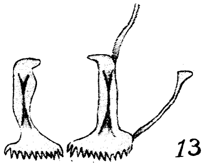

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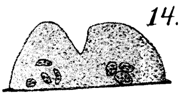

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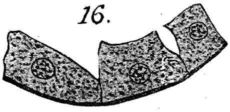

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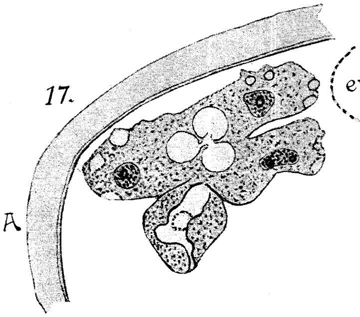

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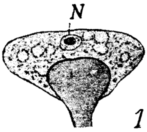

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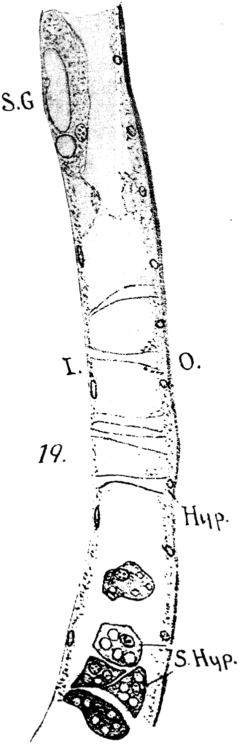

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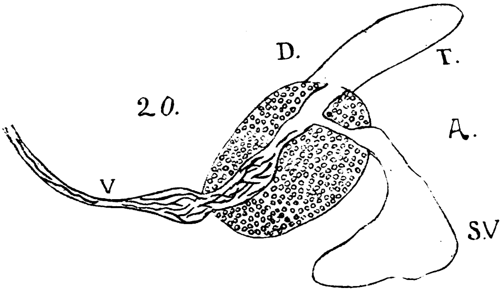

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PLATE XIII.

EXPLANATION OF PLATE XIII.

Fig. 21. Sagittal section of brain through the center. D. 3. opt. g., optic ganglion. supr. g., supra-oesophageal ganglion. oes., oesophagus.

Fig. 22. Section through brain, but a little to one side of the preceding. D. 3.

Fig. 23. Section of brain cut in line drawn from a to b in fig. 21. D. 3. s. g., supra-oesophageal ganglion. ant. g1., antennulary ganglion. o. c., circum-oesophageal commissures. oes., oesophagus. ant. g2., antennary ganglion. inf. g., infra-oesophageal ganglion.

Fig. 24. Dorsal view of ventral cord, ganglion cells only showing. B. 3.

Fig. 25. Transverse section of second ganglion. B., dorsal. D. 3.

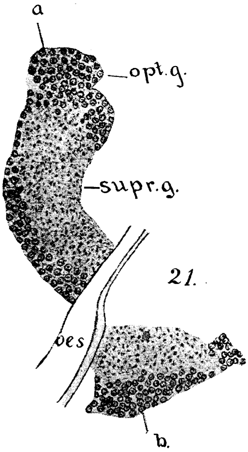
Fig. 26. Transverse section just a little anterior to the preceding.

Fig. 27. Ventral nerve cord, lateral view. B. 3.

Fig. 28. Section of eye. D. 3. rt., retinal cells. tp., tapetum. pg., pigment.

Fig. 29. Section of eye from above. D. 3. ant., anterior. pg., pigment cells. nu., nuclei of retinal cells.

Fig. 30 Ovary. d., dorsal. a., anterior. The figures represent the four different zones.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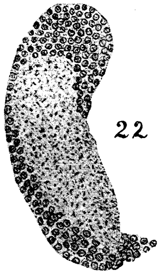
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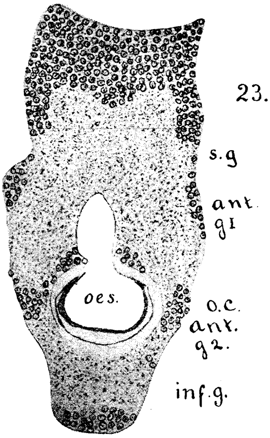
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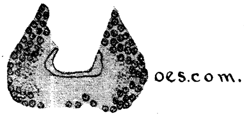
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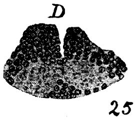
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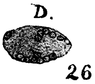
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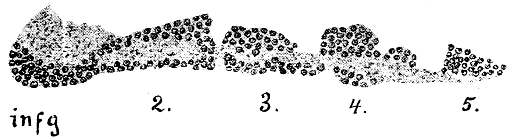
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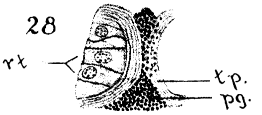
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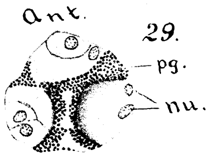
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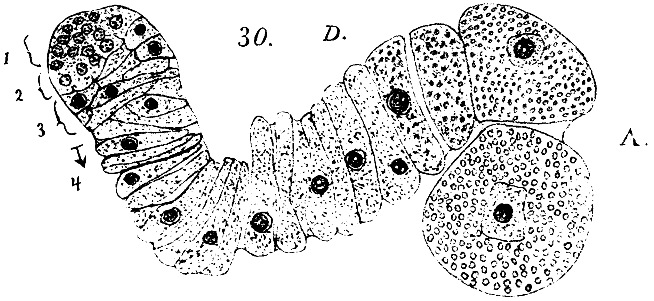
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W. S. Marshall, del.

TEN SPECIES OF ARRENURI BELONGING TO THE SUBGENUS MEGALURUS THON.

BY RUTH MARSHALL.

The work upon the genus *Arrenurus* Dugès has been carried on from the spring of 1893 up to the present time, with many interruptions. Collections have been made at several places in Wisconsin and one in Massachusetts. This paper embodies the results of the studies upon the species of the subgenus *Megalurus* Thon, most of the work having been centered on this group.

The Arrenuri form one of the most easily recognizable genera of the *Hydrachnidae*. They form a sharply defined, highly organized and well differentiated group, very rich in species. They are characterized by the possessession of a very hard, transparent, porous integument, an area of which is separated on the back by a circular furrow from the rest to form the so-called "dorsal shield"; and by great sexual diamorphism. The females have a more or less rounded form and closely resemble each other; while the males have a peculiar prolongation of the posterior end of the body, presenting numberless modifications in the different species and offering the chief specific characters.

Thon (1900) makes three subgenera of the Arrenuri. *Petiolurus* embraces species in which the posterior appendage is short, or altogether wanting and represented by humps on the dorsal side of the body; and in which there is a peculiar and characteristic structure, the "petiole," a small oblong chitinous structure at the extreme posterior end of the body. *Arrenurus pustulator* Müller is an illustration. Subgenus *Micrurus* has a short appendage as wide as the body; at the end of it is a deep incision in which lies a small petiole. *Arrenurus forpicatus* Neuman belongs to the group. The third subgenus, *Megalurus,* includes forms having a very long appendage, but the petiole is absent, or represented by a very small transparent projection. The species described in this paper all belong to this subgenus.

Thor erects still a fourth subgenus, *Truncaturus,* to include species which like *Arrenurus truncatellus* (Müller), *A. Knauthei* Koenike, *A. oblongus* Piersig, have neither petiole nor distinct body appendage, and so approach the females in form. This subgenus represents the least differentiated branch of the genus.

The appendage, the petiole, and the humps on the appendage and posterior part of the body which contain large glands and their openings, are probably all sexual characters. The area containing the openings of the genital organs is very similar in all species and both sexes of the Arrenuri. The openings are small slits on the ventral side of the body near the end, and are largest in the female. On each side is a semicircular plate in the female, and a narrow rim in the male; from these run wing-shaped lateral areas, the so-called "Napfplatten," large and broad in the female, narrow and long in the male, and often forming characteristic rolls between body and appendage.

In all Arrenuri the epimera, or ventral leg plates, are in three groups, and in the different species show no very striking differences. The palpi are claw-like. The legs bear long fine hairs and short bristles. The fourth pair are longest, and the fourth segment in the males bears a short process whose use is not clear. Besides having a probable use in sexual intercourse in the male, they are used somewhat differently than the other appendages in both sexes. They are often seen bent up close to the body and they have a great range of movement. They are often jerked violently backward, while the anterior three pairs are used as walking legs or oars. The last pair are sometimes used to remove debris from the body.

Arrenuri were collected at various times from the first of

April until the first of December. They are found in small numbers in bodies of shallow still waters where crustacea and water plants abound and where there is not too much decomposition. Spring-fed pools where the water is cold, like some of those at Big Springs in Adams County, flowing water, like the Wisconsin River, deep waters like Devil's Lake, are not frequented by these mites. They are often found in ponds where there is great fluctuation in the depth of the water; in one instance they were found again when the pond filled after having dried up. They prefer the ooze at the bottom, as shown by the actions of those kept in aquaria. They are seen to feed on small crustacea. Dull blue green is the predominating color. They are not very sensitive to drying, being protected by their thick skins.

The females are most abundant in the spring, the males not appearing till late spring or summer. In the fall more males are collected than females. Eggs are laid in dense masses of from ten to forty, surrounded by a gelatinous mass. The young hatch in a week or ten days, but have not been kept beyond the second larval stage. The adults are easily kept in aquaria.

There have already been described and recognized for the subgenus *Megalurus* the following species:

Arrenurus adnatus Koenike,
Arrenurus caudatus De Geer,
Arrenurus concavus Koenike,
Arrenurus conicus Piersig,
Arrenurus corniger Koenike,
Arrenurus coronator Thor,
Arrenurus cylindratus Piersig,
Arrenurus Dahli Piersig,
Arrenurus geminus George,
Arrenurus geniculatus Koenike,
Arrenurus globator Müller,
Arrenurus Koenikei Daday,
Arrenurus Krameri Koenike,
Arrenurus membranator Thor,
Arrenurus Moebii Piersig,

Arrenurus Mülleri Koenike,

Arrenurus securiformis Piersig (= *A. festivus* Koen. = *A. buccinator* Koch and Kramer),

Arrenurus Soari George,

Arrenurus Stjordaliensis Thor (var. *A. caudatus*),

Arrenurus tubulator Müller (= *A. medio-rotundus* Thor),

Arrenurus Zachariae Koenike.

Ten species of Arrenuri belonging to the subgenus *Megalurus* were collected, five of which appear to be new. The results of the study of this material will now be considered.

Arrenurus globator (Müller).

Fig. 1, *a—e*, Pls. XIV—XV.

Arrenurus globator Neuman, 1879; S. 88, Fig. 2, Tab. X.

Arrenurus globator Haller, 1882; S. 44.

Arrenurus globator Barrios et Moniez, 1887; S. 24–25.

Arrenurus globator Koenike, 1893; S. 12–16, Taf. I, Fig. 11–12.

Arrenurus globator Koenike, 1894 (a); S. 260.

Arrenurus globator Protz, 1895; S. 265.

Arrenurus globator Piersig, 1896 (b); S. 58.

Arrenurus globator Koenike, 1896; S. 212.

Arrenurus globator Pisarovic, 1896; S. 3.

Arrenurus globator Piersig, 1897; S. 279, Taf. XXVIII, Fig. 72.

Arrenurus globator Croneberg, 1899; Nr. 27, Fig. 26.

Arrenurus globator Thon, 1900; S. 108, Fig. 2, 6.

Arrenurus globator Piersig, 1901; S. 82, Fig. 18.

This is the most widely distributed and abundant of the Arrenuri collected; consequently it has been possible to study a large amount of material. It was one of the earliest forms described and one very widely mentioned in the accounts of all hydrachnologists. It has been found in all parts of Europe where collections have been made, and it is reported from Africa.

Arrenurus globator is characterized first by the long cylindrical appendage, slightly constricted at the base all around. The posterior end, where it widens out a little, is rounded with a slight indentation in the middle. A lateral view shows that the top of the appendage is nearly flat but slopes suddenly down in the posterior third. Near the rounded side corners are two small conical elevations; these and two other pairs of slight mounds, one in front and one back of the first mentioned, together with the position of the stout hairs, is seen in fig. 1, *a* and *c* (H,^{2} H,^{1} H^3).

The body is rounded, viewed either from above or below, with a slight bowing-in in the middle line and a little conical elevation in front of each eye. A lateral view shows that the anterior edges of the body are elevated and bear humps and several hairs. The genital areas form prominent rolls between body and appendage. The dorsal shield is almost circular. The color is blue-green with brown streaks and flecks. The entire length is 1.06 mm; the width, 0.56 mm; the appendage, 0.4 mm.

Neuman's figures (1879) and Piersig's (1897) show the appendage strongly humped up in the anterior part, a feature characteristic of the next species. The second joint of the palpus in the specimens examined bears on the inner face a patch of short blunt bristles. In other smaller points, such as the shape of the end of the appendage and the humps near the eyes, these individuals did not agree with figures of the hydrachnologists mentioned. But their abundance and wide distribution, together with the fact that there is a general agreement in the form of the body and appendage in a dorsal view, seems to justify the identification of these specimens with *A. globator*. A small amount of variation was found in this material.

A. globator fem. The body is broadly oval and the dorsal shield has the same form. Very characteristic are the small humps on the back as shown in fig. 1, *f*. In this it disagrees with earlier descriptions. The length is 0.8 mm, the width 0.66 mm.

Collections extending over several years were made in Lake Wingra and the Yahara River, Madison; small pools near Kilbourn; ponds near Big Springs; shallows of Lake Mason near Briggsville; Goose Pond near Jordan Lake, Adams County;

Mirror Lake at Delton; pools near Fond du Lac; stagnant waters near Lake Winnebago and other places near Appleton; Twin Islands and Mud Creek at Lake Spooner; and in small bodies of fresh water at Tarpaulin Cove and Nobska Light, near Wood's Hole, Mass.

Arrenurus megalurus, nov. var. of *A. globator* Müll.

Fig. 2, *a—f,* Pls. XIV—XV.

In collections containing *A. globator* there were often found closely related individuals with stouter bodies and appendages. They also show strong resemblance to *A. caudatus* De Geer and *A. Stjordalensis* Thor.

The body is longer than wide and slightly angular, and is depressed between the eyes. The most characteristic feature is a conical projection in front of each eye, larger than the same humps noted in *A. globator.* The dorsal shield is slightly eight-sided. A lateral view shows the anterior side walls strongly arched; in this it resembles *A. globator* and differs from *A. caudatus.* The appendage differs from the nearest related forms in being greatly arched up in the middle; and in the shape of the end, the middle part of which here runs out beyond the side corners with a slight rounded incision. In lateral view the form is like that figured by Piersig and Neuman for *A. globator.* In other details it closely resembles the form here identified as *A. globator.* The differences between *A. megalurus* and *A. caudatus* are best seen by comparing the lateral views. In the latter, the region inside the dorsal line is strongly arched and the appendage is lower. In both dorsal and ventral views, the appendage of *A. megalurus* is seen to be constricted at the base, narrower here than at the end, the difference being greater than in *A. globator,* and forming in this respect a marked contrast to *A. caudatus.* The same thing is true of the genital areas which here form rolls extending beyond the body walls. In legs, palpi, epimera and hairs the variety closely resembles the species.

The difficulty of identifying these individuals has been increased by finding some degree of variation among them.

These variations were in the structures already mentioned (Fig. 2, *e* and *f*). There were several gradations in the size of the conical elevations in front of the eyes, from small ones like those found in *A. globator* scarcely projecting beyond the body edge, to the large horns of the more decided types of *A. megalurus.* There were likewise gradations between the flat-topped appendage with rounded and slightly indented end of the one type, and the strongly arched appendage with bowed-out and more deeply indented end of the other. The flat-topped form predominated. Some individuals in dorsal view resemble *A. globator* most; in lateral view, the variety. There is a good deal of likeness here to *A. tubulator* Müller. In view of these considerations, it seems best to regard these Arrenuri as a variety of *A. globator* and connected with it by intermediate forms.

The length of *A. megalurus* is 1.12 mm; width, 0.6 mm; appendage, 0.45 mm. The color is dark brown-green with indistinct darker markings.

A. megalurus fem. is hardly to be distinguished from *A. globator* fem.

Arrenurus manubriator, nov. spec.

Fig. 3, *a—e,* Pls. XV—XVII.

Several individuals found in collections with *A. globator* have been erected into this new species. The name, referring to the resemblance of the appendage to a handle, has been suggested by Dr. Wolcott of the University of Nebraska. In dorsal aspect these mites closely resemble *A. globator* but lack the little horns in front of the eyes; and the appendage is nearly the same width throughout. Viewed laterally it is not so high nor its humps so pronounced; the dorsal shield is higher and the side walls of the body do not rise up so high. *A. manubriator* more nearly resembles the forms described as intermediate between *A. globator* and *A. megalurus.*

The form of the body, its epimera, dorsal shield and genital area resemble these structures in Piersig's figures for *A. tubulator.* The appendage here, however, is a trifle wider at the end than anywhere else, and is usually slightly bowed-in in the middle line. The middle of the appendage is slightly arched as seen laterally. There is some variation in the form of this structure.

A peculiarity of the palpi is the nearly oblong form of the fourth segment; the fifth is small and forked. The whole limb resembles that of *A. Birgei* nov. spec. The first and second pairs of legs bear the usual stiff hairs and spines; their last joints are peculiar in being the longest and in bearing many fine short hairs. The third pair of legs have long fine hairs on the third, fourth and fifth joints. In the fourth pair of legs, all segments but the first and the last bear many long hairs; the process on the fourth is long and bears the usual bunch of hairs.

The color is dull blue-green with indistinct flecks of brown as in *A. globator*. The entire length is 0.9 mm; the width, 0.57 mm; the length of the appendage, 0.37 mm.

Arrenurus securiformis Piersig.

Fig. 4, *a—c,* Pl. XVIII.

Arrenurus buccinator Piersig, 1894 (a); S. 414.
Arrenurus securiformis Piersig, 1894 (b); S. 378.
Arrenurus buccinator Kramer, 1895; S. 1–5, Fig. 1.
Arrenurus festivus Koenike, 1895; S. 378, Fig. 2.
Arrenurus festivus Koenike, 1896; S. 213.
Arrenurus securiformis Piersig, 1896; S. 58.
Arrenurus securiformis Piersig, 1897; S. 282–84, Fig. 75.
Arrenurus securiformis Piersig, 1901; S. 83.

Nine individuals found in a small pond near Nobska Light, Wood's Hole, Mass., in August, 1899, are clearly to be identified as *A. securiformis* Piersig. The form of the appendage is the most distinguishing feature. The prominent hump near the posterior end has a semicircular form (fig. 4, *a* and *c*, H[1]). Just back of it are two little projections close together, and lying back and between them is a very small conical projection (E). In the slight indentation at the extreme end is another tiny pointed process which may represent the petiole (P).

The length is 1.2 mm; the width, 0.6 mm; and the height, 0.55 mm. The color is a light blue-green with dark flecks and a touch of red on the dorsal shield.

Arrenurus cardiacus, nov. spec.

Fig. 5, *a—e*, Pls. XVII, XVIII.

This form is most closely related to *A. securiformis* Piersig and *A. cylindratus* Piersig, from both of which it differs in the structure of the posterior part of the appendage.

In form the body is much like *A. securiformis*. The dorsal shield is oblong and the genital area forms prominent rolls between body and appendage. The fourth pair of epimera are scarcely wider than the third and the posterior border is concave, corresponding with the position of two little stigmata bearing hairs lying just back. When viewed laterally the body is seen to be strongly arched on the dorsal side.

The appendage is much lower than the body from which it is sharply marked off. There is a constriction at the base and another in the last third. It is widest near the end and the side corners are prominent. From this point there is a strong bowing-out posteriorly with a deep and wide bay in the center. A slight rounded mound lies in the bottom of this bay, and other small ones lie in this region as shown in the figures (fig. 5, *a* and *c*, $H,^2$ $H,^3$ H^4). Anterior to this deep and wide bay is the second distinguishing feature of this species and the one which has suggested its name: it is a broad heart-shaped hump, the point directed forward (H^1). This hump is similar to that in *A. cylindratus* in the same place, but is wider. It is the point of this hump which forms the prominent elevation on the appendage in the lateral view. The position of the numerous hairs is seen in the figures.

The palpi show the usual structure. The inner edge of the fourth joint is drawn out into a broad process on which grows a broad blade-like hair. The small curved claw-like fifth segment is bifurcated. The mandibles are shown in fig. 5, *e*.

The three anterior pairs of legs are like those of *A. securiformis.* The fourth legs are characterized by the presence of many little thorn-like bristles on the fourth and fifth joints, and by the shortness of the last two joints. The longest and most numerous hairs are on the fifth joint, and the fourth has a prominent process bearing a small bunch of stiff curved hairs.

Five males of *A. cardiacus* were found in Goose Pond, Adams County, a small, shallow, stagnant body of water filled up with water plants. The color of the specimens was deep indigo blue with lighter brown patches on the anterior end of the body and the middle of the appendage.

The length is 1.3 mm; width, 0.66 mm; appendage, 0. mm; first leg, 0.78 mm; fourth leg, 1.05 mm.

A few females were found. They have the usual form and structure of female Arrenuri. The body is ovate with slight indentations. The dorsal shield is oval and reaches nearly to the posterior edge of the body. The epimera are like those in the males. The genital area is large and of nearly uniform width and extends nearly straight out. There are numerous hairs as shown in Fig. 5, *g* and *h*. The color is the same as in the male. The length of the body is 1.06 mm; the width, 0.94.

Arrenurus parallellatus nov. spec.

Fig. 6, *a—e*, Pls. XVI—XVIII.

The name of this new species is suggested by the form of the appendage, the sides of which are nearly parallel. The and has two low humps on each side projecting back equally (Fig. 6, *a* and *c*, H^1, H^2). In the middle line is a deep rounded bay, narrowest at the mouth, into which projects a little finger-like process curved up dorsally (P). In a lateral view of the animal it can sometimes be seen through the semi-transparent rounded corners of the appendage, like the figure given by Piersig for the petiole of *A. globator* (Deut. Hydrach., fig. 72, *e*). This structure may represent a petiole here. Just anterior to it lies a pair of little projections rising each from the summit of a little hump, the points of which turn outward in the form of little hooks (X). Again, just forward of these is a pair of long triangular thickenings of the integument, the points toward the little projections just described (T). A lateral view shows that the appendage is moderately low, the highest point a slight hump in the anterior half. There are five pairs of stiff hairs on the appendage.

The form of the body corresponds closely with that of *A. securiformis*. The dorsal line runs over on the appendage and encloses an obovate area. The body is arched in the middle and has no large humps. There are numerous short stiff hairs. The fourth pair of epimera are unusually wide. The genital area forms outstanding rolls at the base of the appendage.

The limbs show the characteristics common to Arrenurus males. The third, fourth and fifth segments of the last legs bear a great many long fine hairs, as well as many shorter bristles. The usual process is found on the fourth joint. The last segment of the palpi is forked, and the fourth is the longest.

The color is pale dull green. The length of the body is 1.15 mm; width, 0.725 mm; the height, 0.625 mm.

Eight specimens of *A. parallellatus* were found in July and August, 1899, with *A. securiformis* at Wood's Hole, Mass.

Arrenurus corniger Koenike.

Fig. 7, *a—e*, Pl. XV.

Arrenurus corniger Koenike, 1894 (b); S. 276, Fig. 1.

Arrenurus corniger Piersig, 1901; S. 84.

This form is easily recognized by the large cone-shaped hump on the anterior dorsal part of the appendage (Fig. 7, *a* and *c*, H^1). The horn-like projections on the anterior borders of the first two pairs of epimera are also characteristic features. The petiole mentioned by Koenike was not found. The posterior of the three little humps near the end of the appendage (H^3) are pointed. The slighter form of the appendage, the slanting position of the genital areas, the more numerous hairs, are details in which the individuals examined do not conform exactly to Koenike's text-figure. The body is 1.02 mm. long, 0.57 mm wide, and the appendage is 0.42 mm long. The color is light blue green.

Koenike's paper did not include any account of the limbs; a description is therefore added here.

The palpi show no striking peculiarities. The fifth segment is unforked and bears a bristle; the fourth is the largest and has a blade-like bristle on the outer edge. The legs increase in size from the first to the fourth. Each ends in two pointed claws. The first and second pairs bear a few bristles and thorns with short fine hairs on the last joint. The third pair of legs resemble the anterior pairs but have more bristles, besides a few long swimming hairs on the third, fourth and fifth segments. The fourth pair of legs have thorns or bristles on all segments; the third, fourth and fifth segments having in addition long swimming hairs. The fourth segment is nearly twice as long as the relatively short sixth; the process so characteristic of male Arrenuri is hardly developed. The first leg is 0.56 mm. long; the fourth, 0.77 mm.

This is one of the rarer Arrenuri, only five individuals having been found, and the females are unknown. These specimens were collected in Lake Wingra, Lake Mason shallows, and the borders of Green Lake.

Arrenurus cylindratus Piersig.

Fig. 8, *a—d,* Pl. XVII.

Arrenurus cylindratus Piersig, 1896 (a); S. 441.
Arrenurus cylindratus Piersig, 1897; S. 288–289, Fig. 112.
Arrenurus cylindratus Piersig, 1901; S. 84–85.

This species has a large stout body with an appendage less than half as long. It resembles *A. Krameri* Koenike and *A. securiformis* Piersig in general form and in the structures on the appendage, but differs from both in the longer body and in the details of the shorter appendage. It is one of the largest as well as rarest of the Arrenuri. Only one individual was found; this was in Mirror Lake, September, 1893. The color was a dull brownish green. The entire length was 1.15 mm; width, 0.7 mm; length of the appendage, 0.53 mm.

The body is slightly arched, and the dorsal shield is higher than the side walls. Several short hairs were found here. The dorsal line runs over on the appendage. The first and fourth pairs of ventral plates are the largest. The first are closely united, all are fully outlined, and no peculiar pores or markings were found,—in all of these points differing from Piersig's figure (Deut. Hydrach., fig. 112, *a*). The genital areas are large, pear-shaped, and extend straight outward to form rolls at the base of the appendage.

The appendage is constricted a little at the base, broadens out and becomes slightly higher in the middle, and then narrows conspicuously near the end where it is again slightly wider. The end bows out a little and has a small depression in the middle line where lies a little low rounded hump. Small elevations which show as light scallops in dorsal or ventral view form, when viewed laterally, a conspicuous corner projection on each side of the appendage (Fg. 8, *a* and *c*, $H,^3$ E). Just in front of the last constriction of the appendage is a pair of small round-topped humps close together in the middle line (H^2).

The palpi are short and stout. There are a few hairs, most of them on the second joint, with three bristles in a bunch at the anterior end on the convex side, while another is found on the inner side. The fourth segment has a broad curved bristle on the anterior edge.

The first pair of legs have a few short coarse hairs and thorns on every segment but the last, which is provided with a row of finer short hairs. The second pair of legs resemble the first, but have a few fine hairs on the fourth and fifth segments as well as some short ones on the sixth. The third pair of legs bear longer hairs and bristles, the former confined mostly to the third and fourth segments. On the last pair of legs all segments have several bristles and thorns. The third, fourth and fifth joints have many fine hairs. The process on the fourth joint is moderately stout and bears four short, curved, stiff hairs. The length of this pair of legs is 1.15 mm. All of the joints except the last are stout.

Arrenurus conicus Piersig.

Fig. 9, *a—d,* Pl. XVIII.

Arrenurus spec. Piersig, 1893; S. 311.
Arrenurus conicus Piersig, 1894 (a); S. 413.
Arrenurus conicus Piersig, 1897; S. 291–294, Fig. 73.
Arrenurus conicus Piersig, 1901; S. 86–87, Fig. 19–20.

Only one individual belonging to this species was found, and this was in Lake Wingra, August 6th, 1902. It was readly identified with Piersig's form by the broad, stout appendage with constricted base and very narrow end. But instead of four little scallops, it ended in three, the middle one longest. As seen from the side, the region inside of the dorsal line is depressed, and the appendage is higher than shown by Piersig. On the dorsal side of the appendage were found two little oval, light colored spots just before the lateral constriction near the end (Fig. 9, *a, d*). The last segment of the fourth leg is slightly curved; the fourth bears the usual process. The length was found to be 1.16 mm.; the width, 0.7 mm.

Arrenurus Birgei nov. spec.

Fig. 10, *a—f,* Pls. XVI—XVII.

This form with its moderately long appendage stands between the forms like *A. globator* with this organ enormously developed, and species like *A. oblongus* Piersig and *A. truncatellus* Müller, where the short appendage and body are not sharply marked off from each other. However, the appendage in *A. Birgei* though short, is much narrower than the body and clearly marked off from it in the dorsal and ventral aspects.

The body is rounded and bowed in a little between the eyes. The middle lateral walls are nearly parallel as seen dorsally. The body is moderately elevated, highest in the middle, where it is nearly flat. The area of the dorsal shield is slightly broader than long and is a little depressed. From here on the body slopes gradually to the posterior end of the appendage, the only interruptions being a rounded hump just before the end of the appendage, and a pair of low humps in the last half of the appendage (fig. 10, *a* and *c, b*). The end of the appendage is bowed out a little in the middle, scarcely scalloped. The sides of the appendage are nearly parallel. There are several stout hairs whose positions are indicated by the accompanying figures. The epimera show no peculiarities. The genital area is narrow, though not always as narrow as shown in Fig. 10, *b,* and resembles that of *A. truncatellus;* the outline is indistinct.

The distinguishing feature of the palpi is the great length of the fourth joint. The fifth is double-pointed. Bristles are not numerous. The legs named in order of length are the first, the third, the second, the fourth, with the greatest interval between the last two. The first and second are much alike, the segments increasing in length from the first to the sixth. All, especially the second and third, bear bristles and short curved hairs, excepting the sixth, which has many short fine hairs. The third pair of legs have more bristles and long hairs on the fifth segment. The last pair of legs are stout with the exception of the last segment; the fourth is longest and has the usual process with a tuft of hairs. The third segment has unusually long hairs and a short point on its distal extremity.

The color is light greenish blue, with indistinct markings as in *A. globator.* The length is 0.8 mm; the width, 0.5 mm.

Arrenurus Birgei is rather common. Several individuals were found in the following places: Lake Wingra, Mirror Lake, borders of Green Lake and Lake Spooner, pond at Tarpaulin Cove near Wood's Hole.

This species has been named for Dr. E. A. Birge of the University of Wisconsin, at whose suggestion this work on the Arrenuri was begun, and without whose continued assistance it could not have been carried on.

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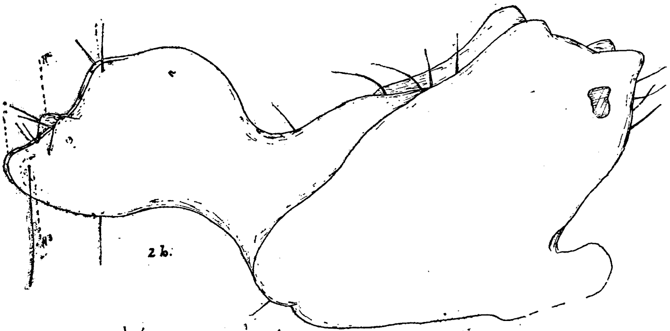
PLATE XIV.

All drawings are made with a camera lucida.

EXPLANATION OF PLATE XIV.

1 a, *Arrenurus globator* Müll., dorsal view.
b, *Arrenurus globator* Müll., ventral view.
c, *Arrenurus globator* Müll., lateral view.
d, *Arrenurus globator* Müll., 2d leg.
f, *Arrenurus globator* Müll., fem., dorsal view.
g, *Arrenurus globator* Müll., fem., ventral view.
2 b, *Arrenurus megalurus* nov. var., lateral view.
c, *Arrenurus megalurus* nov. var., palpi.
e, *Arrenurus megalurus* nov. var., intermediate form, dorsal
f, *Arrenurus megalurus* nov. var., intermediate form, lateral



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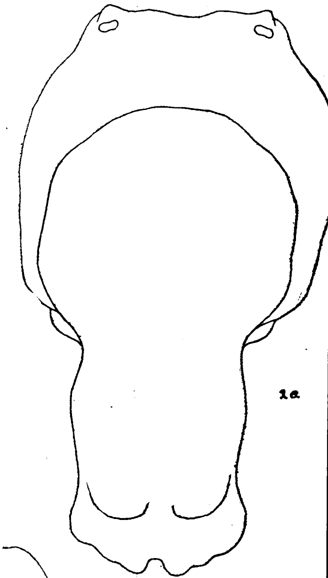

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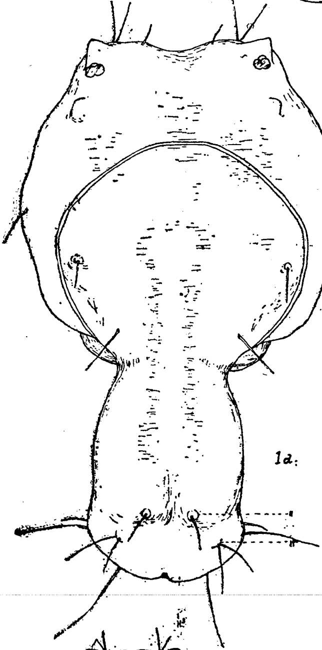

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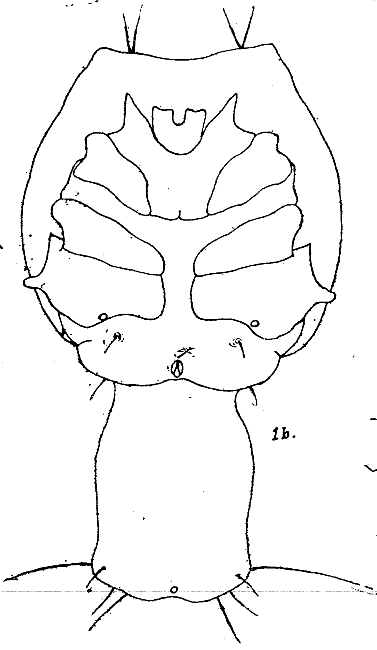

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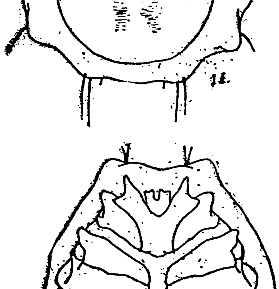

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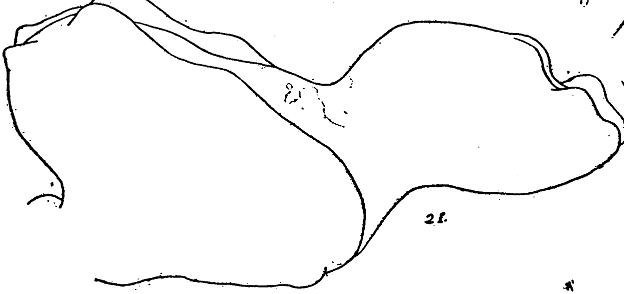

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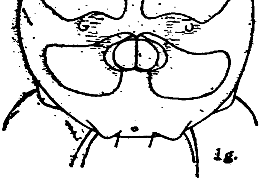

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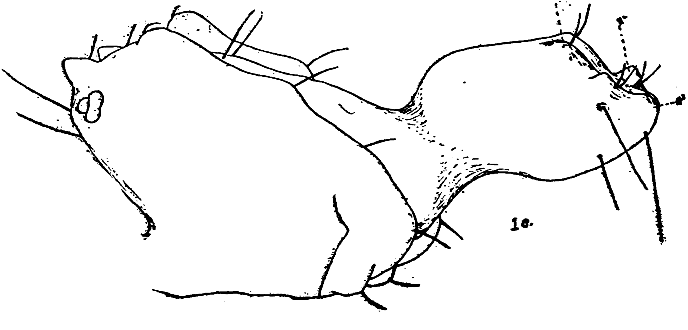
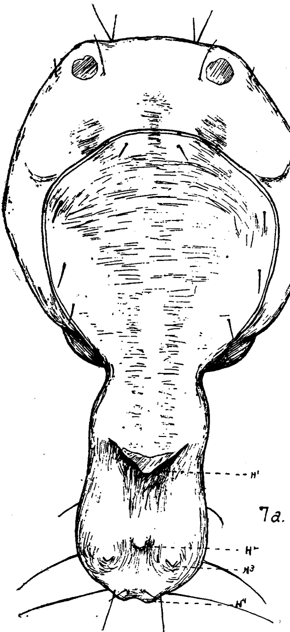


1e.

PLATE XV.

EXPLANATION OF PLATE XV.

1 e, *Arrenurus globator* Müll., 4th leg.
2 a, *Arrenurus megalurus* nov. var., dorsal view.
d, *Arrenurus megalurus* nov. var., 4th leg.
3 b, *Arrenurus manubriator* nov. spec., epimera.
7 a, *Arrenurus corniger* Koen., dorsal view.
b, *Arrenurus corniger* Koen., ventral view.
c, *Arrenurus corniger* Koen., lateral view.
d, *Arrenurus corniger* Koen., palpi.
e, *Arrenurus corniger* Koen., 4th leg.



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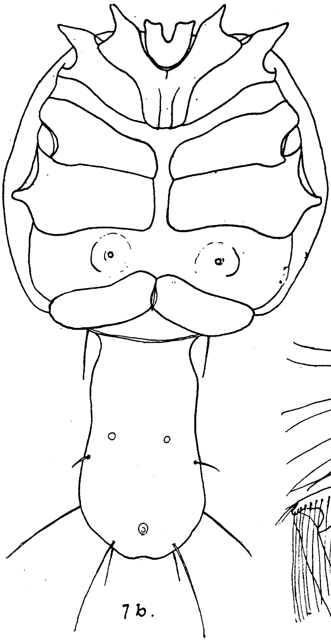

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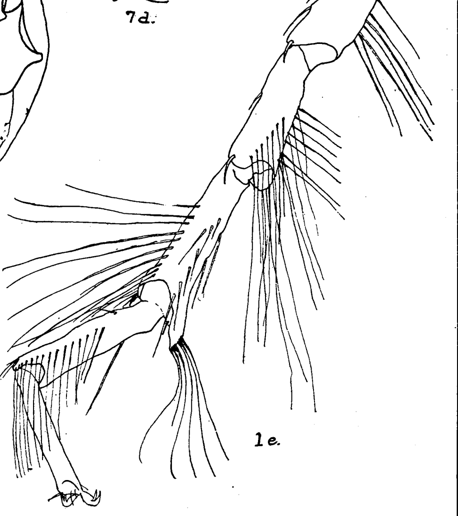
7d.



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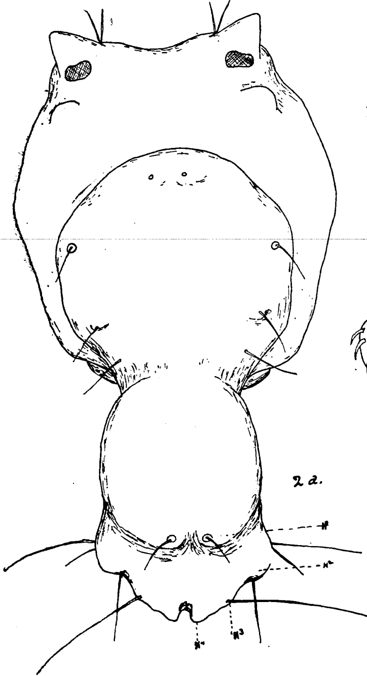

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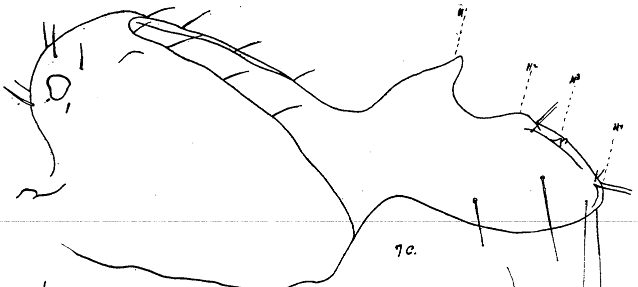

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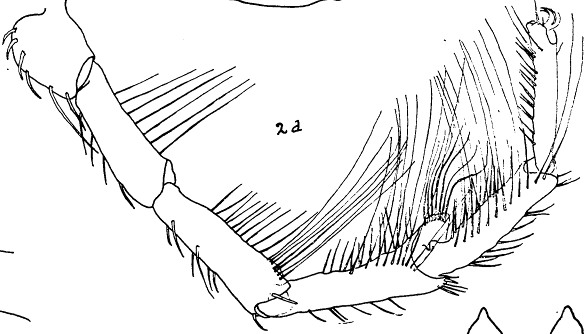

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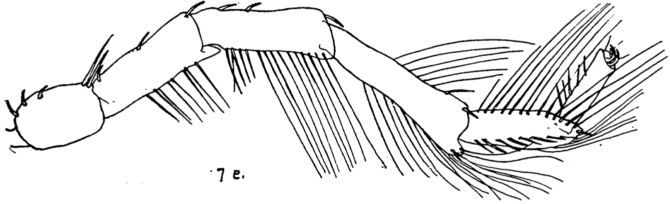

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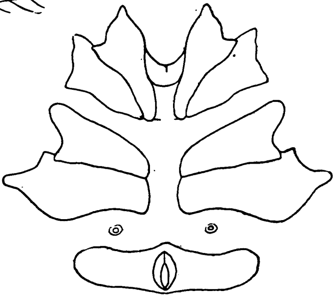
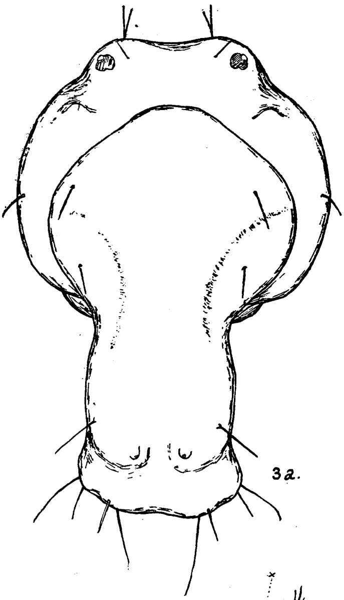


3b.

PLATE XVI.

EXPLANATION OF PLATE XVI.

3 a, *Arrenurus manubriator* nov. spec., dorsal view.
c, *Arrenurus manubriator* nov. spec., lateral view.
d, *Arrenurus manubriator* nov. spec., palpi.
6 a, *Arrenurus parallellatus* nov. spec., dorsal view.
b, *Arrenurus parallelatus* nov. spec., ventral view.
c, *Arrenurus parallellatus* nov spec., lateral view.
10 a, *Arrenurus Birgei* nov. spec., dorsal view.
b, *Arrenurus Birgei* nov. spec., ventral view.
c, *Arrenurus Birgei* nov. spec., lateral view.
d, *Arrenurus Birgei* nov. spec., palpi.
f, *Arrenurus Birgei* nov. spec., 4th leg.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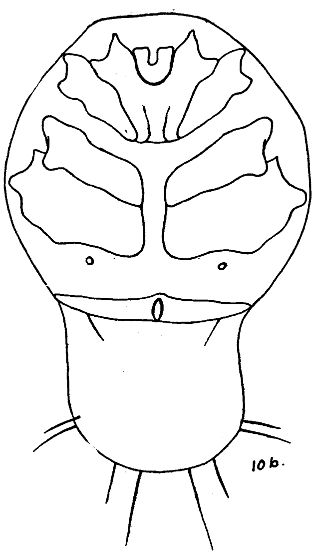
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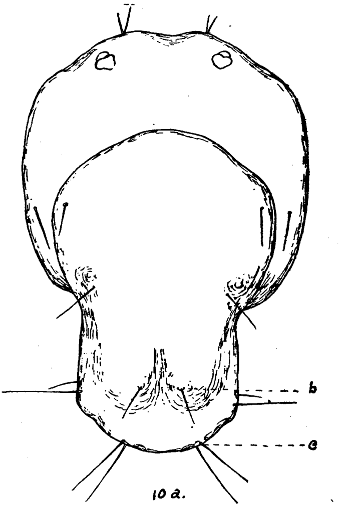

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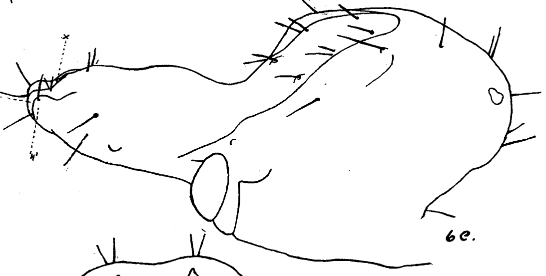

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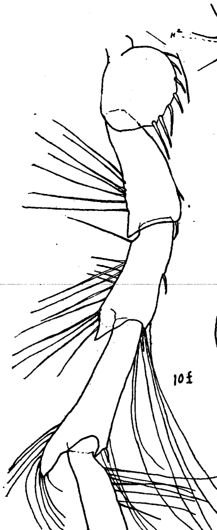
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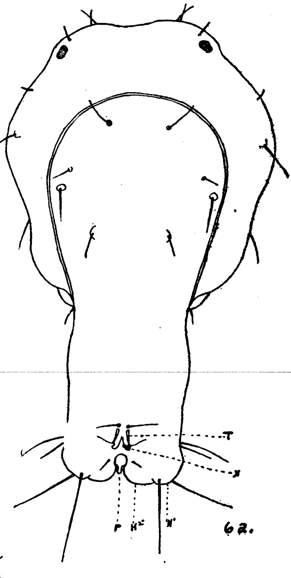

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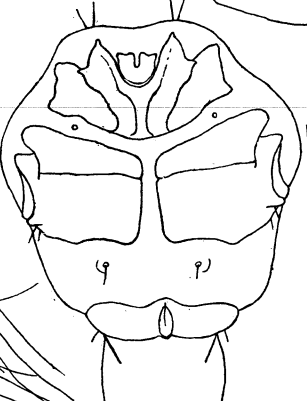

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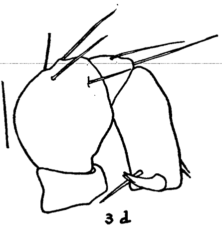

3d

10c.


3e.


10d.

PLATE XVII.

EXPLANATION OF PLATE XVII.

3 e, *Arrenurus manubriator* nov. spec., 1st leg.
f, *Arrenurus manubriator* nov. spec., 4th leg.
5 d, *Arrenurus cardiacus* nov. spec., palpi.
e, *Arrenurus cardiacus* nov. spec., mandibles.
f, *Arrenurus cardiacus* nov. spec., 1st leg.
g, *Arrenurus cardiacus* nov. spec., 4th leg.
h, *Arrenurus cardiacus* nov. spec., fem., dorsal view.
i, *Arrenurus cardiacus* nov. spec., fem., ventral view.
6 d, *Arrenurus parallellatus* nov. spec., palpi.
8 a, *Arrenurus cylindratus* Piers., dorsal view.
b, *Arrenurus cylindratus* Piers., ventral view.
c, *Arrenurus cylindratus* Piers., lateral view.
d, *Arrenurus cylindratus* Piers., 4th leg.
10 e, *Arrenurus Birgei* nov. spec., 1st leg.

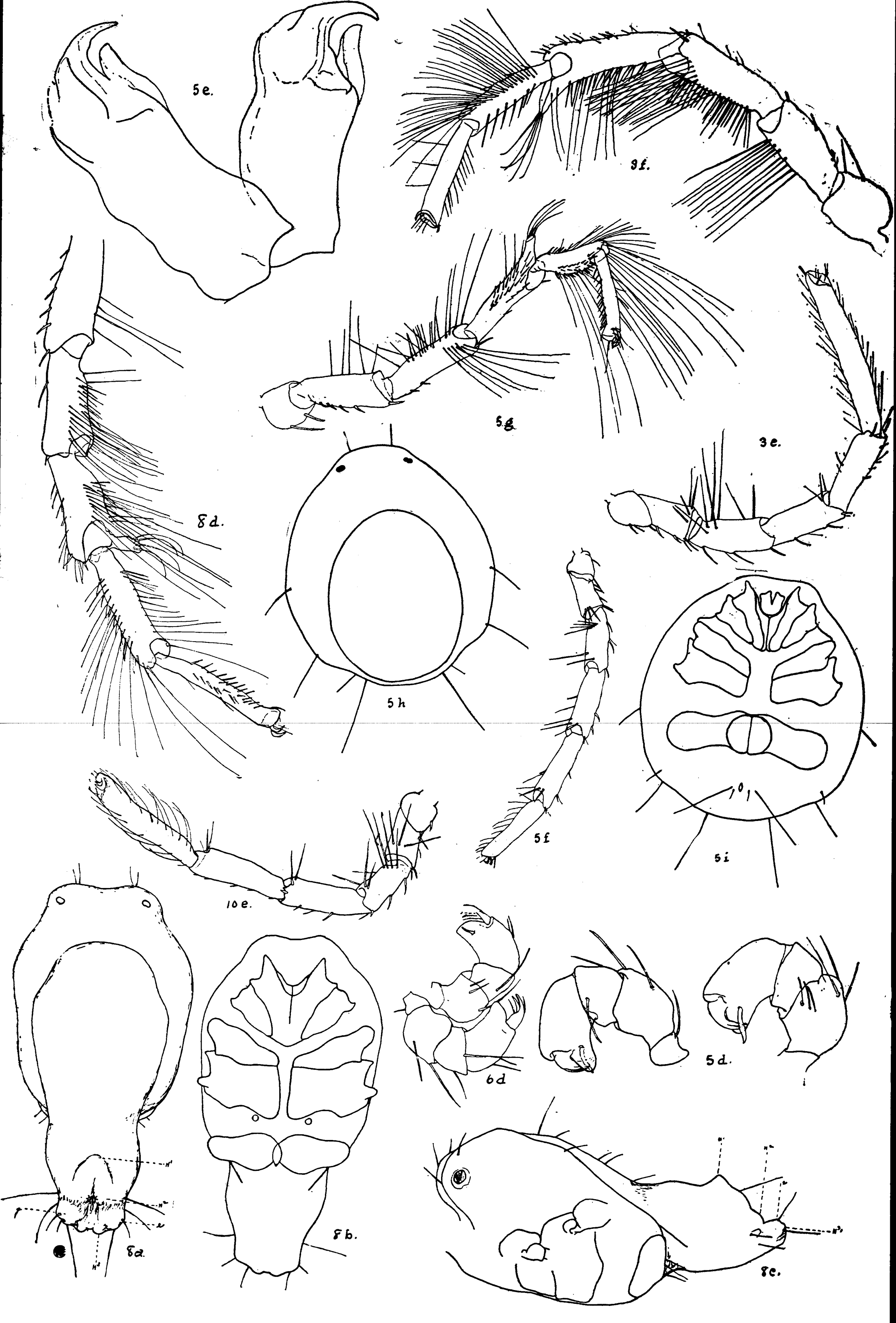
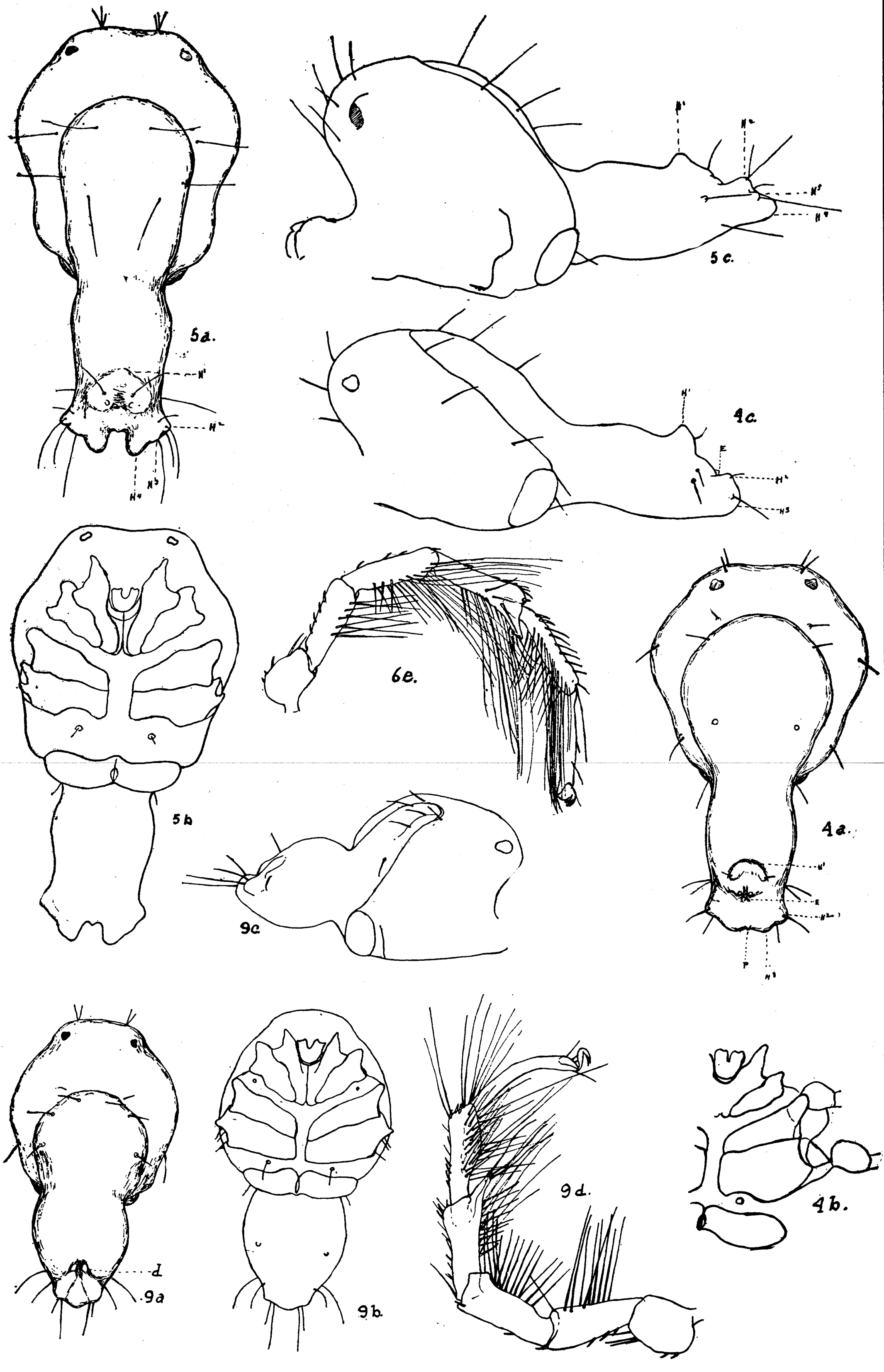

5e.
8f.
5g
3e.
8d.
5h
5i
5f
10e.
6d
5d.
8a.
8b.
8c.

PLATE XVIII.

EXPLANATION OF PLATE XVIII.

4 a, *Arrenurus securiformis* Piers., dorsal view.
b, *Arrenurus securiformis* Piers., epimera.
c, *Arrenurus securiformis* Piers., lateral view.
5 a, *Arrenurus cardiacus* nov. spec., dorsal view.
b, *Arrenurus cardiacus* nov. spec., ventral view.
c, *Arrenurus cardiacus* nov. spec., lateral view.
6 e, *Arrenurus parallellatus* nov. spec., 4th leg.
9 a, *Arrenurus conicus* Piers., dorsal view.
b, *Arrenurus conicus* Piers., ventral view.
c, *Arrenurus conicus* Piers., lateral view.
d, *Arrenurus conicus* Piers., 4th leg.


5a.
H¹
H²
H³
H⁴
5c.
H¹
H²
H³
H⁴
4c.
H¹
E
H²
H³
5b
6e.
4a.
H¹
E
H²
P
H³
9c
9a
d
9b.
9d.
4b.

NEW SPECIES OF THE FAMILY ATTIDAE FROM SOUTH AFRICA, WITH NOTES ON THE DISTRIBUTION OF THE GENERA FOUND IN THE ETHIOPIAN REGION

BY GEORGE W. PECKHAM AND ELIZABETH G. PECKHAM.

INTRODUCTION.

For several years we have been receiving collections of Attidae from South Africa, the largest ones coming from Mr. Guy A. K. Marshall, Mashonaland, Dr. H. Brauns, Cape Colony, and Mr. George F. Leigh and Mr. J. F. Quekett, Durban. We have also had loan collections for description, from Mr. W. F. Purcell, South African Museum, Cape Town.

Up to the present time, representatives of thirty families of spiders have been found in the Ethiopian Region, using that term in the sense in which it is employed by Mr. Wallace, in his Geographical Distribution of Animals, to include all of Africa south of the Desert of Sahara, Madagascar and the neighboring islands. A study of the eighty-six genera and two hundred and eleven species of Attidae found in this region confirms the soundness of the divisions proposed by Mr. Wallace, there being few instances of the disconnected distribution of genera, and not one instance of importance. We give, in Table I, the distribution in detail of the Ethiopian genera of the family.

TABLE I.—*Showing distribution of genera of Attidae found in Ethiopian region.*

GENUS.	ETHIOPIAN REGION.					Range beyond the region.
	Sub-regions.					
	Number of species.	East Africa.	West Africa.	South Africa.	Madagascar.	
Araegeus	2	....		....		
Kima	2			....		
Marengo	1			....		Ceylon, Java.
Mexcala	1			. .		
Myrmarachne	10	....	....	.	....	Cosmopolitan.
Quekettia	1				....	
Ælurillus	3	....		....		Europe. Siberia. Ceylon.
Æstenorchestes	1				....	
Alfenus	1			....		
Almota	1			....		
Asamonea	4		....		....	Oriental region.
Baryphas	3		....	....		
Baviola	1				....	
Bianor	1			....		Palaearctic. Nearctic. Oriental. Australian.
Brancus	2		....			
Carrhotus	2	....	....			Oriental.
Copocrossa	1			....		Oriental. Australian.
Cosmophasis	1	....	....	....	....	Oriental. Australian.
Cyllobelus	5	....		....	....	Oriental.
Cynapes	4				....	
Cyrba	3	....	....	....		Palearctic. Oriental. Australian.
Dendryphantes	1			....		Palaearctic. Oriental. Neotropical. Nearctic.
Echinussa	3				....	
Emertonius	1				....	Java.
Eucymachus	1	....				
Ergane	1				....	Oriental. Australian.
Euophrys	4			....		Nearctic. Neotropical. Europe. Japan.
Evarcha	1		....			Java.
Festinicula	1	...				Egypt.
Goleta	2				....	
Habrocestum	7			....		Europe. Ceylon. Nearctic.

TABLE I.—*Showing distribution of genera of Attidae found in Ethiopian region*—Continued.

GENUS.	ETHIOPIAN REGION.					Range beyond the region.
	Sub-regions.					
	Number of species.	East Africa.	West Africa.	South Africa.	Madagascar.	
Hasarius	1			....		Cosmopolitan.
Heliophanus	18	....	....	....	....	Europe. India.
Hispo	2				....	
Holcolaetis	1	....	....	....		
Homalattus	5		....	....		
Hyllus	7	....		....		Oriental. Australian.
Icius	1			....		Mediterranean Region. Central Asia.
Jasoda	1			....		
Jotus	1			....		
Klamathia	1			....		
Langona	2	....		....		Syria. India.
Linus	1	....		....	....	Oriental.
Macopaeus	2				....	
Malloneta	1		....			
Massagris	2			....		
Mendoza	1			....		
Menemerus	3			....		Cosmopolitan.
Modunda	1			....		
Mogrus	1	....		....		Malaysia.
Monclova	1			....		
Naetha	1	....		....		Europe. Red Sea.
Orsima	1		....			
Pachybellus	2	....	....	....		New Caledonia.
Pachypoessa	2		...	....		
Padilla	5				....	Taprobane. Java.
Pandisus	1				....	
Parajotus	1			....		
Paulostylus	4				....	
Pellenes	1			....		Palaearctic. Nearctic. Neotropical.
Peplometus	2		....			
Philaeus	1			....		Palaearctic. Nearctic. Neotropical.

TABLE I.—*Showing distribution of genera of Attidae found in Ethiopian region*—Continued.

GENUS.	ETHIOPIAN REGION.					Range beyond the region.
	Sub-region.					
	Number of species.	East Africa.	West Africa.	South Africa.	Madagascar.	
Phlegra	4		....	....		Palaearctic. Nearctic.
Plexippus	3			....		Cosmopolitan.
Pochyta	4		....		....	
Poessa	1			....		
Polemus	3		....			
Portia	2			....	....	India.
Pseudicius	4	....		....	....	Palaeartic. Nearctic.
Rhene	2	....			....	Paleartic. Oriental. Australian. Nearctic. Netropical.
Saitis	4		....	....		Palaeartic. Neartic. Neotropical. Oriental. Australian.
Salpesia	1				....	Oriental. Australian.
Sittacus	2			....		Palaearctic. Nearctic.
Sonoita	1			....		
Stenaelurillus	2	....				Thibet.
Tarne	1		....			
Telemonia	2		....	....		Asia. Japan. Oriental.
Thiratoscyrtus	1		....			
Thyene	11	....		....	....	Palaearctic.
Thyenula	1			....		
Tomocyrba	2				....	
Tularosa	2			....	....	
Tusitala	2			....		
Uxuma	1		....			
Valloa	2			....		
Viciria	7		....	...		Oriental.

Table II shows the distribution of spiders by families. In examining those that have genera in the Ethiopian Region we find the following cases of anomalous distribution.

Aviculariidae, 33 genera in Ethiopian Region, of which 6 have a disconnected distribution.

Aporoptychus, West Africa, South America.

Bolostromus, South Africa, South America.

Hermacha, South Africa, South America.

Cyclosturnum, West Africa, Central and South America.

Hapalothele, Madagascar, Australia, Central and South America.

Thelechoris, Madagascar, Central and South America.

Uloboridae, 4 genera in Eth. Reg., 2 with disconnected distribution.

Dynopis, Ethiopian Region, Australian Region, North and South America.

Menneus, Ethiopian Region, Australian Region.

Zoropsidae. 1 genus in Eth. Reg. Distribution disconnected.

Scotolathys, 1 species in Ethiopian Region and 1 species in North America.

Eresidae. 4 genera in Eth. Reg. Distribution normal.

Filistatidae. 1 genus in Eth. Reg. Distribution normal.

Sicariidae. 4 genera in Eth. Reg., 2 with disconnected distribution.

Sicarius, South Africa, South America, Galapagos.

Dymusa, 1 species in South Africa, 1 species in Antilles.

Leptonetidae. 1 genus in Eth. Reg. Distribution normal.

Oonopidae. 6 genera in Eth. Reg., 2 with disconnected distribution.

Ischnothyreus, West Africa, Philippines, Antilles.

Opopaea, South and West Africa, Philippines, South America, West Indies.

Dysderidae. 3 genera in Eth. Reg. Distribution normal.

Caponiidae. This family has, in all, only 3 genera. One of these is found in the Ethiopian Region, and nowhere else.

Prodidomidae. This family has, in all, 3 genera, 2 of them being Ethiopian, with normal distribution.

Drassidae. 18 genera in Eth. Reg., 3 with disconnected distribution.

Megamyrmecion, South and North Africa, North America.

Aphantaulax, Ethiopian Region, East Indies, Jamaica.

Laronia, West Africa, South America.

Palpimanidae. 3 genera in Eth. Reg. Distribution normal.

Zodariidae. 11 genera in Eth. Reg. Distribution normal.

Hersiliidae. 2 genera in Eth. Reg. Distribution normal.

Urocteidae. 1 genus in Eth. Reg. Distribution normal.

Ammoxenidae. This family has 1 genus and 3 species, and is confined to South Africa.

Pholcidae. 7 genera in Eth. Reg., 1 with disconnected distribution.

Micromerys, West Africa, Madagascar, Philippines, New Holland, Venezuela.

Theridiidae. 23 genera in Eth. Reg., 2 with disconnected distribution.

Thwaitesia, Madagascar, North Africa, Sumatra, South America.

Histagonia, South Africa, North America.

Argiopidae. 52 genera in Eth. Reg., 9 with disconnected distribution.

Brattia, West Africa, Philippines, South America.

Cyatholipus, South Africa, West Indies.

Orsinome, Madagascar, Polynesia, Malaysia.

Landana, West Africa, South America.

Dolichognatha, West Africa, South America, Taprobane.

Pronous, Madagascar, Taprobane, Central and South America.

Glyptogona, South Africa, Mediterranean Region, Central and South America.

Ursa, South Africa, Taprobane, South America.

Anapis, North and West Africa, South America, New Caledonia.

Mimetidae. This family has, in all, 6 genera and 30 species. 2 genera in Eth. Reg., with normal distribution.

Thomisidae. 49 genera in Eth. Reg., 1 with disconnected distribution.

Stephanopsis, Madagascar, Malaysia, Australia, South America.

Clubionidae. 47 genera in Eth. Reg., 4 with disconnected distribution.

Caloctenus, West Africa, South America, Malaysia.

Syrisca, Ethiopian Region, North and South America, West Indies.

Apochinomma, Ethiopian Region, Asia, Central and South America.

Ceto, Southeast Africa, Europe, Brazil.

Agelenidae. 10 genera in Eth. Reg. Distribution normal.

Pisauridae. 13 genera in Eth. Reg., 2 with disconnected distribution.

Ischalea, Madagascar, Mauritius, New Zealand.

Maypacius, Madagascar, Africa, North America.

Lycosidae. 9 genera in Eth. Reg. Distribution normal.

Oxopidae. 4 genera in Eth. Reg., 1 with disconnected distribution.

Hamataliva, East Africa, India, North and South America, West Indies.

It appears, from these observations, that the distribution of spiders presents no greater difficulties than the large groups of insects. The anomalous cases may be explained by supposing that the isolated species are the remains of genera which had, formerly, a wider distribution, the intermediate species having become extinct. It is probable that many difficulties will disappear when spiders have been thoroughly collected. We shall then have better opportunities for classification and many gaps will be filled. All deductions from the material at present available are tentative. Although ten thousand species have been described, there are doubtless twice as many that have not yet been discovered.

TABLE II.—*Showing the Distribution of Spiders, by Families.*

Family.	Regions.					
	Ethiopian.	Oriental.	Palaearctic.	Australian.	Nearctic.	Neotropical.
Liphistiidae		....				
Aviculariidae	....	....	....	....	....	....
Atypidae		....	....		....	....
Hypochilidae			....		....	
Uloboridae	....	....	....	....	....	....
Psechridae		....				
Zoropsidae	....		....			....
Dictynidae	....	....	....	....	....	....
Œcobiidae			....	....	....	....
Eresidae	....	....	....	....		
Filistatidae	....	....	....	....	....	....
Sicariidae	....	....	....	....	....	....
Leptonetidae	....	....	....		....	....
Oonopidae	....	....	....	....		....
Hadrotarsidae				....		
Caponiidae	....					....
Dysderidae	....	....	....	....	....	....
Prodidomidae	....	....	....	....	....	....
Drassidae	....	....	....	....	....	....
Palpimanidae	....	....	....	....		....
Zodariidae	....	....	....	....	....	....
Hersiliidae	....	....	....	....		....
Pholcidae	....	....	....	....	....	....
Theridiidae	....	....	....	....	....	....
Archeidae	....					....
Mimetidae	....	....	....	....	....	....
Argiopidae	....	....	....	....	....	....
Thomisidae	....	....	....	....	....	....
Platoridae						....
Clubionidae	....	....	....	....	....	....
Urocteidae	....		....			
Agelenidae	....	....	....	....	....	....
Pisauridae	....	....	....	....	....	....
Lycosidae	....	....	....	....	....	....

TABLE II.—*Showing the Distribution of Spiders, by Families*—Cont.

Family.	Regions.					
	Ethiopian.	Oriental.	Palaearctic.	Australian.	Nearctic.	Neotropical.
Senoculidae						....
Oxyopidae	....	....	....	....	....	....
Attidae	....	....	....	....	....	....
Ammoxenidae	....					

The distribution of spiders must depend very largely upon their habit of ballooning. On warm breezy days in the fall of the year, the young of many species may be seen, often in immense numbers, poised upon some elevated spot, a post, a rock, or perhaps a tall blade of grass, with spinnerets uplifted. In this position threads of gossamer are emitted and are drawn out to a great length by the wind, which finally lifts them and bears them away to fresh fields. Two cases have been observed which show that, under favorable conditions, spiders may be carried several hundred miles. Darwin notes that at a distance of sixty miles from land, while the "Beagle" was sailing before a steady, light breeze, the rigging was covered with numbers of small spiders with their webs;[1] and Capt. George H. Dodge, when more than two hundred miles from land, once found the masts and rigging of his vessel covered with innumerable little ballooning spiders.[2] In this instance the voyagers, after a pause, disappeared as they had come, on the wings of the wind. These migrations occasionally take place on a scale of astonishing magnitude. Quantities of wasted webs,—filaments snapped off by the breeze before the spider succeeds in mounting, are carried high into the air, where they become tangled together in flocculent masses, to fall again to the earth in showers of gossamer. One of these is described by Gilbert White,[3] as covering eight miles of terri-

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[1] Voyage of the Beagle, Vol. III, p. 187.

[2] McCook, American Spiders and their Spinning-work. Vol. II, p. 273.

[3] Natural History of Selbourne, Letter LXV.

tory. W. H. Hudson tells of how he once found a band of gossamer on the ground, twenty yards wide and more than two miles long, so thickly covered with spiders that were attempting to fly that they were unable to get off comfortably. As soon as one threw out its lines they became entangled with those of another, lanced out at the same moment, but notwithstanding this difficulty numbers were continually floating off on the breeze.[1]

In the light of these facts it seems probable that Madagascar received its spider fauna from Africa, two hundred and fifty miles away. While it has some affinities with the Oriental Region, they are not of sufficient importance to require the hypothesis of an intervening continent.

In *Psyche* for April 1902, we published descriptions of some South African Attidae, without illustrations. These descriptions are repeated below, with figures illustrating the genera and species.

SOUTH AFRICAN ATTIDAE.

PLURIDENTATI.

Macopaeus madagascarensis sp. nov.

Plate XIX, fig. 5.

♀. Length 4.5 mm. Legs $4\overline{23}$, first pair missing; metatarsi and tarsi very slender.

We have one badly damaged specimen. The eye-region is covered with long bright red hairs, the rest of the cephalothorax being rubbed bare excepting a white band which runs around the margin and across the clypeus. The brown falces are, on the front faces, thickly set with short, stiff, projecting white hairs. The abdomen is dark, with a lighter patch on each side in front, and seems to have been covered with beautiful iridescent scales, the reflections being purple and blue. The legs are long and not especially slender, excepting the terminal joints; they are brown and show patches of the

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[1] Naturalist in La Plata, p. 186.

same brilliant scales. The superior margin of the falx has three teeth, one near the insertion of the fang, and two opposite its tip. The inferior margin has five small teeth, close together.

We have one female from Madagascar. M. Simon has compared this with the type, *spinosus,* and finds it to be a different species. The two must be distinguished by the epigynes.

Portia durbanii sp. nov.

Plate XIX, figs. 2, 2a, 2b.

♂. Length 7mm. Legs 1423, first and second pairs thickened and first pair fringed.

In this species the highest point of the cephalothorax is at the second row of eyes, the third row being placed well down on the posterior slope.

The general color is brown. The eye-region, clypeus and falces are covered with brownish-white hairs. The thoracic part and sides are rubbed nearly bare in our specimens, but seem to have been covered with yellow hairs. The abdomen has a uniform covering of yellow iridescent hairs, and over this a scattering of long black hairs. The legs are brown with short yellow hairs and black spines. The first leg has a very heavy black fringe on the tibia, a shorter, thinner fringe on the femur, and a still slighter one on the patella. The palpus is brown with black hairs, and has apophyses on the femur and patella. The falces are long and vertical. The venter has yellow metallic hairs on the sides and a wide longitudinal black band down the middle.

We have three males from Durban, sent by Mr. Quekett.

Sonoita gen. nov.

Plate XIX, figs. 4, 4a, 4b, 4c.

The cephalothorax is moderately high, with the sides rounding out from the front end to the widest point which is in the middle of the thoracic part. They also round out from above downward, the lower part being wider than the upper. The highest point is at the dorsal eyes, there being a fall in both directions, that of the cephalic part being steeper than the thoracic. The front half of the thoracic part is very full and convex on top, giving a rounded upper surface, while the second half slopes off abruptly. The quadrangle of the eyes occupies nearly one-half of the cephalothorax, is only one-fifth wider than long, and is about equally wide in front and behind. The front row of eyes is strongly curved downward. The middle are less than twice as large as the lateral, and all are subtouching. The eyes of the second row are larger than is usual in this family, and are placed nearer the first than the third row. The third row is plainly narrower than the cephalothorax. The falces are short and vertical, the lower margin being armed with several teeth. The sternum is rather long, is contracted in front and behind, and truncated in front. The first coxæ are separated by the width of the labium which is as wide as long. The palpus has all the joints short, the tarsus being palette-shaped.

The large eyes of the second row bring this genus into relation with several genera which Simon groups under *Boetheae, Cocalodeae, Cocaleae and Lineae,* but *Boethus* and *Portia* have the first row of eyes curved upward. *Cocalodes* is quite differently shaped, resembling *Lyssomanes; Cocalus* and *Phaeacius* have abnormally long spinnerets, and in *Linus* the thoracic part falls in one very steep slant from the third row of eyes.

The type of *Sonoita* is a new species from South Africa.

Sonoita Lightfootii sp. nov.

Plate XIX, figs. 4–4c.

♂. Length 5 mm. Legs $4\overline{312}$, the first pair a little the stoutest, with a ridge of stiff spiny dark hairs under the tibia.

Our single specimen has been rubbed nearly bare. The dark cephalothorax shows some patches of white hairs around the eyes and on the sides, and brownish-white hairs grow thickly on the clypeus, on the broadened upper surface of the palpus, in patches on the mottled brown and yellow legs, and on the lower sides of the abdomen. There is a thick bunch of these hairs at the front end of the abdomen, and the bare integument shows two golden-brown bands, beginning at this point and diverging a little as they pass backward to beyond the middle of the dorsum. Further back, just in front of the spinnerets, is a central patch of the same color. The rest of the abdomen is dark brown.

We have one male of this species from Cape Colony. We have named it for Mr. R. M. Lightfoot of Cape Town.

Cyrba dotata sp. nov.

Plate XIX, fig. 6.

♀. Length 6.7 mm. Legs $4\overline{13}2$, first pair stoutest, second next.

The front eyes form a straight row, the lateral being plainly further back than the middle, and more than half as large. The second row is a little nearer the third than the first. The third is nearly as wide as the cephalothorax at that place. The tibia of the first leg has three pairs of spines, and that of the second three posterior and two anterior spines. The metatarsi of the first and second have two pairs of very long spines.

Our specimen seems to have been covered with short yellow and long white hairs, but as these are nearly all rubbed away we describe it as it appears under alcohol. The cephalothorax is black, with a central longitudinal brown band on the thoracic part. The legs are brown excepting some blackish patches on the undersides of the first and second. The abdomen has the sides brown, streaked and mottled with black. The front central part is white. A black herring-bone stripe begins just in front of the middle and runs to the end, the spaces on the sides being occupied by five pairs of white spots. The clypeus has a thin fringe of whitish-brown hairs. The falces are brown, stout, and vertical. The palpi are thickly covered with brown and white hairs.

We have one female from Newlands, Cape Peninsula, collected by Mr. Purcell.

Massagris mirificus sp. nov.

Plate XIX, figs. 1, 1a.

This species has the quadrangle of the eyes as long as wide. The cephalic plate is golden, marked with two black spots.

♂. Length 4 mm. Legs, $\overline{41}\overline{32}$, first pair a little thickest.

The cephalothorax is moderately high, and is flattened above. The cephalic part has a constriction behind the first row of eyes from which the sides widen out to a point just back of the third row. The quadrangle of the eyes is as long as wide, is plainly wider in front than behind, and occupies one-half of the cephalothorax. The front row is curved downward, with the eyes all close together, the middle being twice as large as the lateral. The second row is plainly nearer the first than the third, and the third is much narrower than the cephalothorax at that place. The falces project slightly, and are moderately long and stout. The clypeus is narrow. The sternum is long, truncated in front and pointed behind. The coxæ of the first pair are separated by more than the width of the labium, which is as wide as long, and less than half as long as the maxillæ. The first and second legs have a single spine on the tibia. The metatarsus of the first has one pair and the metatarsus of the second, a single spine. In *M. constrictus* E. S., there are no spines on the tibiæ of the first and second, while the metatarsi have one pair.

We have a rubbed specimen. The cephalothorax is dark brown excepting black spots around the eyes and a reddish-yellow region on the cephalic plate, on which are two black spots. There are some pale yellow hairs on the thoracic part, and yellowish-white hairs on the clypeus. The abdomen is pale brown, with dark brown mottling on the sides, and two rows of white patches on the dorsum. There is a thin covering of white hairs. The palpi are dusky brown, the falces dark brown. The legs are light yellow, excepting the femoral joints which are dusky.

We have one male from Mr. Quekett, Durban.

Copocrossa bimaculata sp. nov.

Plate XIX, figs. 7, 7a.

The abdomen is yellowish with a round black spot, on each side, behind the middle.

♂, (not quite mature). Length 4.5 mm. Legs 1423, first pair much the stoutest, second next.

Both cephalothorax and abdomen are low and flattened. The cephalic and thoracic parts form a flat plate which narrows to a blunt point at the posterior end, and from this the sides slant outward, the fall in the eye-region being not far from vertical. There is a slight widening out of the cephalothorax behind the dorsal eyes. The quadrangle of the eyes is one-fifth wider than long, is wider behind than in front, and occupies a little more than one-third of the cephalothorax. The anterior eyes are close together in a row that is very slightly bent downward, the middle eyes being more than twice as large as the lateral. The second row is plainly nearer the first than the third, and the third is nearly as wide as the cephalothorax at that place. The cephalothorax is about twice as long as wide. The clypeus is very narrow, and the falces are short and weak. The sternum is long and narrow. The labium is as wide as long and the coxæ of the first pair of legs are separated by less than its width. The first leg has the femur and tibia much enlarged. The spines are rather long and stout. The tibia has two above and three below, those underneath having stiff black hairs between the rows, and the metatarsus has two pairs. The second leg has lighter spines, two, one behind the other, on the tibia, and one pair and one single spine on the metatarsus; the third and fourth are almost unarmed. The spinnerets are underneath the abdomen, the posterior end of which projects over them in an obtuse point, very much as in Simon's drawing of *Copocrossa tenuilineata* (Hist. Nat. des Araignées, p. 474).

Our specimen has been rubbed bare, the only hairs remaining being some whitish ones along the line of the eyes. The cephalothorax is yellowish-brown above and a shade darker on the sides, and seems to have had two black spots above on a line with the eyes of the second row. The abdomen is yellowish with two parallel, longitudinal bands, on each of which, just back of the middle, is a perfectly circular black spot. The contour of the abdomen is such that only the inner edges of these spots are on the flattened upper surface. The legs are yellow, the first pair being the darkest.

We have a single male from Durban, Natal, sent to us by Mr. Quekett.

UNIDENTATI.*

Telemonia aequipes sp. nov.

Plate XIX, figs. 3–3c.

♂. Length 4.5 mm. Legs $1\overline{43}2$, first and second a little the stoutest, first, third and fourth nearly equal in length.

The cephalothorax is high and convex, the highest point being between the second and third rows of eyes. The cephalic part is only very slightly inclined, but the thoracic falls in a steep rounded slope. The sides are gently rounded out so that the cephalothorax is nearly as wide as long. The quadrangle of the eyes is nearly equally wide in front and behind. The first row is straight, with the middle eyes subtouching and less than twice as large as the lateral, which are separated from them. The second row is halfway between the others and the third is narrower than the cephalothorax. The clypeus is rather high. The falces are strong, projecting, and divergent, with a single slender tooth near the distal end, on the inferior margin, and a long fang. The tibiæ of the first and second legs have three pairs of long slender spines, underneath, and the metatarsi have lateral as well as inferior spines. The sternum is rounded in front and slightly pointed behind. The first coxæ are separated by more than the width of the labium which is about as wide as long.

We have two rubbed specimens. Both cephalathorax and abdomen show patches of brilliantly iridescent white scales, and

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*While *Thyene* is included in the Unidentati, one species, *crudelis*, has a compound tooth on the lower margin of the falx.

there are short white hairs on the clypeus. The general ground color is dark, although one abdomen has a pale central streak. The palpi are dark, and the legs dark with pale spots, which seem to have been covered with white hairs. The falces are light brown, and faintly iridescent.

We have two males from Mr. Quekett, Durban.

Heliophanus Marshii sp nov.

Plate XX, figs. 4, 4a.

♂. Length 4.5 mm. Legs 1$\overline{42}$3, first pair stoutest.

The front eyes are near together in a slightly curved row, the middle being about twice as large as the lateral.

In our specimen the cephalothorax is dark brown, rubbed almost bare, but showing some thinly set white scales on the sides. The abdomen is black, encircled by a pure white band, and having three pairs of white spots on the back. The venter has a thin covering of white hairs. The legs are brown, plainly lighter in color than the body. The palpus is darker brown. The falces project slightly, are rather long, and are brown in color.

This species is named for Prof. Marsh of Ripon, Wisconsin. We have one male from Camp's Bay, Cape Peninsula, collected by Mr. Treleaven.

Heliophanus Beardii sp. nov.

Plate XX, figs. 6, 6a.

♀. Length 6 mm. Legs 4312, nearly equal in stoutness.

The cephalothorax is darker than the abdomen, bronze-brown in color, and has a narrow white transverse band behind the dorsal eyes. There is a narrow white band around the margin of the cephalothorax, and above this, on the cephalic part, the sides are white as far back as the transverse band. The abdomen is bronze-brown with metallic scales. There is a white basal band which runs back on the sides beyond the middle of the abdomen and is thickened at the ends. Further back on the sides, just in front of the spinnerets, is a pair of white spots. These are almost united by a narrow white line. On the middle of the dorsum are two white bars which are sometimes broken. These extend downward, on the sides, to meet the basal band. The palpi are dark at the proximal end, and light yellow in the distal half. The legs have the femora dark. The patellæ and tibiæ are light yellow above with a longitudinal dark band on each side. This coloring is most distinct on the first and second pairs. The metatarsi and tarsi are light. All the legs have white hairs.

This species has been collected at Signal Hill by Mr. Purcell and Mr. Lightfoot, at Bergvliet and Cape Town by Mr. Purcell, and at Camp's Bay and Retreat Flats by Mr. Treleaven. It is named for Mr. H. Beard, who has collected Attidæ at Wynberg.

Heliophanus deamatus sp. nov.

Plate XX, figs. 3–3c.

♂. Length 5 mm. Legs $14\overline{32}$, first pair stoutest.

We have but one specimen. It is black and seems to have been covered with yellow hairs which have a slight metallic luster. The margin of the cephalothorax has a pure white line. The clypeus is narrow and bare. The legs are dark, the tarsi and metatarsi being lighter. The falces are vertical and rather long and brown in color. The palpus has a long curved apophysis on the femur and a shorter one on the tibia, the tarsus being covered with yellowish hairs.

Collected by Mr. Marshall in Mashonaland.

Heliophanus clarus sp. nov.

Plate XXI, figs. 6, 6a.

♀. Length 4.5 mm. Legs $4\overline{31}2$, pale, with fine black spines, and equally thick.

The markings are black on a ground color of snow-white hairs, the cephalothorax having two conspicuous black spots in the middle of the thoracic part and, around the margin, a black band which widens out at the posterior end. When the hairs are rubbed off the eye-region is seen to be jet-black, and the other parts reddish-brown. Around the eyes, and on the retreating clypeus are some bright reddish hairs. On the abdomen there is a wavy black band down each side of the dorsum, and, between these, an elongated spot on the anterior part, another at the spinnerets, and a pair of black spots just behind the middle. A black band passes around the base and ends, on each side, in a short oblique band, and parallel with this, a little further back is another short band. At the posterior end there is, on each side, a pair of short transverse black bands. These marks are much blacker and more distinct in one specimen than in the other. Where the white hairs are rubbed off from the other parts the color is pale brown. The venter is pale brown with a spear-shaped black mark at the posterior end. One specimen has also a pair of oblique spots, one on each side of the spinnerets. The legs are pure white with delicate black spines, and the palpi and falces are yellowish. The sternum is black and the mouth-parts light brown.

We have two females from Salisbury, Mashonaland, sent to us by Mr. Marshall.

Heliophanus Prattii sp. nov.

Plate XX, figs. 7–7b.

♂. Length 3 mm. Legs 1432, femur of the first thickened.

Of this very brilliant little species we have but a single specimen, which has suffered from rubbing. The integument is black, covered with bright red and green metallic scales, varied by snow-white spots and lines, the pattern being indistinguishable. The legs are black as far as the tarsi, which are light brown. On the upper part of each leg are two fine white lines running throughout its length. The palpus is black with a line of white hairs above. The clypeus and the weak parallel falces slant backward. The femur of the palpus has a double apophysis.

We have one male from Willowmore, South Africa, sent to us by Dr. Brauns.

Heliophanus Marshallii sp. nov.

Plate XX, figs. 5–5b.

♂. Length 5 mm. Legs 4132, nearly equal in thickness.

This species has a long, straight, stout apophysis on the patella of the palpus.

In our specimens the cephalothorax, which has a black and glistening integument, has been rubbed, so that only a few white hairs on the thoracic part, and in a band around the sides, remain. The abdomen has three white bands, one in the middle and one on each side, all reaching the spinnerets. The spaces between the bands are black but seem to have been covered with yellow hairs. The legs are dark brown except the tarsi, which are yellow. The palpus is black with snow-white hairs. The falces are short, and moderately stout, and are brown in color.

H. Marshallii is almost exactly like *H. debilis* E. S. and *H. patellaris* E. S. in color, and each of these species has a patellary apophysis. In *debilis* and *patellaris,* however, the apophysis stands out at a wide angle, while in *Marshallii* it extends in a line with the palpus. *Marshallii* is larger than the other species and has dark legs with yellow tarsi. In *debilis* the legs are all light yellow, and in *patellaris* they are either entirely yellow, or entirely brown.

This species is named for Mr. Guy A. K. Marshall, who has made most valuable investigations in Mimicry and Warning Colors. We have two males from Durban.

Heliophanus modicus sp. nov.

Plate XX, fig. 2.

♀. Length 5 mm. Legs $43\overline{12}$.

The ground color is black on the cephalothorax, brown on the abdomen. The cephalothorax has white bands low down on the sides, while the upper surface seems to have been thinly covered with yellowish-white hairs. The rings around the eyes of the front row are white. The abdomen has a wide herring-bone stripe and an encircling band, white. The legs and palpi are pale brown. The falces are weak and vertical, and dark brown in color. The very narrow clypeus is marked by a white line.

We have several females from Algoa Bay and Durban.

Almota gen. nov.

Plate XX, figs. 1–1c.

The cephalothorax is high with the sides parallel and vertical in front, and widening out very slightly behind. The cephalic plate is not inclined, but the thoracic part slopes rather steeply from the third row of eyes. The quadrangle of the eyes is one-third wider than long, is wider behind than in front, and occupies fully one-half of the cephalothorax. The front eyes are rather large and close together, in a straight row, the middle being twice as large as the lateral. The second row is halfway between the other two, and the dorsal eyes, which are uncommonly large, form a row as wide as the cephalothorax at that place. The clypeus is only a line. The sternum is truncated in front. The anterior coxæ are separated by fully the width of the labium, which is about as wide as long. The first leg has three pairs of spines under the tibia and two pairs under the metatarsus. The spines on the other legs are sparse and weak, the metatarsi of the third and fourth having apical circles. On the tibiæ of these legs the circles are incomplete. The falx has a single tooth on the lower margin.

This genus differs from *Cosmophasis* in having the front eyes relatively much larger, and close together, instead of separated, with the middle less than twice as large as the lateral. In *Cosmophasis,* moreover, the dorsal eyes are smaller than the lateral and form a row plainly narrower than the caphalothorax, which widens out below.

Almota Quinii sp. nov.

Plate XX, figs. 1–1e.

♂. Length 3.5 mm. Legs 4132, first a little the stoutest.

This species has the body and the palpi dark, while the legs are pale. Our specimen has been rubbed. The cephalothorax seems to have been covered with short yellow hairs excepting on the face, under the lateral eyes, where the hairs are white. The abdomen is cylindrical, and has a wide band of yellow hairs down the middle and a wide black region on each side. The whole seems to have been covered with silvery iridescent scales, which extend on to the venter. The palpi are black with white hairs. The legs are pale yellow, the first pair having a smoky brown band underneath the femur and along the outer side of the patella, tibia and metatarsus. The falces are small, and are pale brown in color.

We have one male from Cape Colony, Africa.

Cyllobelus australis sp. nov.

Plate XXI, figs. 2, 2a.

The abdomen is dark, prettily marked with white dots and lines.

♀. Length 5 mm. Legs 4132, first pair somewhat stouter than the others. The fourth exceeds the third by the tarsus and nearly all of the metatarsus.

The cephalothorax is moderately high, and is narrow in front, widening from the second row of eyes to a point a little in front of the posterior end, and well behind the dorsal eyes. The cephalic part is but slightly inclined, while the thoracic falls in a rounded slope from the third row of eyes. The quadrangle of the eyes occupies two-fifths of the cephalothorax. The anterior eyes are close together in a curved row, the middle being less than twice as large as the lateral. The second row is a little nearer the first than the third which is nearly as wide as the cephalothorax at that place. The sternum is oval. The first coxæ are separated by more than the width of the labium, which is about as wide as long. The falces are vertical and parallel, with a single tooth on the lower margin.

The clypeus is dark, edged with short white hairs. Under each lateral eye are two fine white lines running horizontally outward, which have a very ornamental effect. The cephalothorax is dark brown with a covering of yellowish hairs and a pure white marginal band. The abdomen is covered with metallic yellowish scales, which give a dark effect, and rather long brown hairs, the pattern being in snow-white spots and dashes. There is a spot in the middle of the front end, with some oblique lines a little further back, on each side. Down the length of the dorsum are two rows of white dots made up of six pairs. On each side, halfway of the length, is a triangular spot, pointing backward, and further back, another white spot, so low down as to be nearly invisible from above. The palpus is dark brown with white spots on the patella and tarsus. The legs are brown, the first pair darker than the others and having three bright white spots on the inner side, one on the patella, one at the distal end of the tibia, and one on the tarsus. The under parts are of a dull silvery color.

We have one female from Algoa Bay, sent by Dr. Brauns.

Cyllobelus chionogaster E. S.

Plate XXI, figs. 1–1c.

Length, ♂ 4.5–6 mm. ♀ 6–7.3 mm. Legs, ♂ 4132, first pair darkest and stoutest, with fringes; ♀ $41\overline{32}$, femur of the first with a small tuft of dark hairs at the distal end.

The cephalothorax has rufus hairs above and a wide snow-white band which runs across the clypeus and along the sides, but is broken behind. The abdomen is glistening bronze-brown on the dorsum, whitish on the lower sides. The male has a single white spot above the spinnerets. In the female there are some white scales at the front end, one, two, or three pairs of oblique white bars on the middle of the back, a white spot on each side, low down, at the posterior end, and a single white spot just in front of the spinnerets. In the male the first legs are dark, excepting the metatarsus and tarsus which are pale, and there is a single fringe of dark hairs on the femur and a double fringe, also dark, on the tibia. The other legs are pale, more or less distinctly marked, with two longitudinal dark lines. In the female the legs are of medium brown. The falces project a little, and are brown in color, as are the mouth-parts and sternum, but the coxæ are pale.

This species, which closely resembles *C. australis,* is very common in South Africa, and we have many specimens from Algoa Bay, Cape Colony and Mashonaland.

Saitis sapiens sp. nov.

Plate XXI, figs. 5, 5a.

♂. Length 4.8 mm. Legs 1342, first pair stoutest, second next.

The cephalothorax is high, with the cephalic plate inclined forward. The thoracic part slopes very little in the first half, and then much more abruptly. The sides slant outward but little, and are plainly widest behind the dorsal eyes. The quadrangle of the eyes is a little wider in front than behind, is one-fourth wider than long, and occupies two-fifths of the cephalothorax. The front eyes are a little separated and form a curved row. The lateral eyes are rather small for this genus, but are more than half as large as the middle eyes. The second row is a little nearer the first than the third, and the third is almost as wide as the cephalothorax. The sternum is rounded behind and truncated in front. The anterior coxæ are separated by more than the width of the labium, which is as wide as long. The clypeus is one-half as wide as the middle eyes. The falces are vertical, and rather long and stout.

The upper part of the cephalothorax is covered with bright red hairs. A curved white band, just below the eyes, runs along the upper sides and crosses the thoracic part, and from this a central white band passes forward on the cephalic plate. The hairs around the eyes are very bright. In our specimens the lower sides of the cephalothorax are rubbed bare, excepting a white band around the margin. Some white hairs are left on the clypeus, and on the front faces of the falces. The abdomen has a wide white band at the base which curves downward over the sides, and a central white band connects this with a second and third curved transverse white band. On either side is a black band, sometimes broken into spots, and all around and among the black and white markings, and covering the back of the abdomen behind the middle, are bright red hairs. The upper surface of the palpus is covered with white hairs. The legs are dark with some pale spots, and have a good many white and red hairs.

We have seven males from Mashonaland, sent by Mr. Marshall. The figure shows the spider as it appears under alcohol.

Saitis Leighii sp. nov.

Plate XXI, figs. 4, 4a.

The cephalothorax is longer and heavier than the abdomen, and both cephalothorax and abdomen are darker in the middle than on the sides.

♀. Length 6.5 mm. Legs 1342, first pair heaviest, second next.

The cephalothorax is high and convex, rounding from the dorsal eyes forward to the first row, and backward through half the thoracic part, the posterior slope, behind this point, being much steeper. The sides are widest at about the point of the third row of eyes, where they are parallel for a little distance, the contraction in front and behind, being inconsiderable. The quadrangle of the eyes is one-third wider than long, is wider in front than behind, and occupies about two-fifths of the cephalothorax. The front eyes are large and close together in a curved row, the middle eyes being less than twice as large as the lateral. The clypeus is two-thirds as wide as the middle eyes. The second row is halfway between the first and the third, and the third is nearly as wide as the cephalothorax. The falces are moderately long and stout and the labium is wider than long. The first leg has three pairs of spines on the tibia and two pairs on the metatarsus.

The cephalothorax has the cephalic plate and the lower sides black, and the thoracic part reddish brown, while the upper sides are covered with a mixture of white and red hairs. The front eyes are surrounded by rings of red hairs, and above this row is a band of white hairs. The middle of the abdomen is occupied by a wide, dark brown, velvety band which has a chevron in the posterior part and ends in a point at the spinnerets. The sides are covered by wide bands of white hairs with which some bright red hairs are intermixed. The legs are of a medium brown color, those of the first pair being darkest, and having the femoral joints black.

We have a single male sent to us by Mr. George F. Leigh, from Durban, Natal.

Saitis mundus sp. nov.

Plate XXI, figs. 3, 3a.

♂. Length 4.3 mm. Legs $\overline{31}42$, nearly equal in thickness.

The cephalothorax is high and slopes in both directions from the dorsal eyes, the cephalic slope being more rounded than the thoracic. The sides, which are vertical and parallel in front, widen out at a point well back of the dorsal eyes. The quadrangle of the eyes is one-fourth wider than long, is wider in front than behind, and occupies two-fifths of the cephalothorax. The front eyes are large and close together, in a straight row, the middle being less than twice as large as the lateral. The second row is halfway between the first and the third, and the third row is as wide as the cephalothorax at that place. The sternum is truncated in front, and the anterior coxæ are separated by more than the width of the labium, which is as wide as long.

The cephalothorax has a black ground with a covering, above, of rich red hairs. The thoracic part has a yellowish spot just back of the dorsal eyes, and the sides are covered with yellowish-white hairs. Around the front eyes are rings of red hairs, and the clypeus has a tuft of white hairs in the middle. The abdomen is dark on the sides and has a pale band down the middle, the whole being covered with yellow hairs. In a rubbed specimen there is a double row of dark dots down the middle band, and the base and sides have streaks of black which curve up over the posterior part to form chevrons on the dorsum. The legs are pale with dark rings. In one specimen the first pair has a black streak along the inner faces of the metatarsus, tibia, and distal end of the patella. The palpus is light colored with yellow hairs.

We have two males from Gazaland, Mashonaland, sent by Mr. Marshall.

Pochyta solers sp. nov.

Plate XXII, figs. 1–1b.

♂. Length 4 mm. Legs $1\overline{43}2$, first pair slightly stoutest.

This is a dark species the legs being black with pale marks.

The anterior eyes form a straight row, the middle being twice as large as the lateral. The sternum is narrow behind and broad in front where it is widely truncated. The front coxæ are separated by more than the width of the labium. The tibia of the first leg has three pairs, and the tibia of the second two pairs of spines besides laterals. The metatarsus of the first and second have two pairs and laterals.

Our single specimen is somewhat rubbed, especially on the cephalothorax, which appears black, with a white band around the margin and reddish hairs about the eyes. The retreating clypeus has some white hairs. The abdomen is slender and pointed, the color being dark with a covering of dull golden metallic scales. At the middle point of the back is a transversely elongated white spot. The lower sides are whitish. The venter and sternum are black. The falces are brown in color and are oblique and divergent, with a curved fang. The palpus is dark with snow-white hairs on the upper side of the patella. In the first and second legs the coxa and trochanter are brownish, in the others, white. The first leg is black excepting a brownish spot in the middle of the tibia, and the proximal half of the metatarsus, which is white. In all the other legs the proximal half of the femur, a spot in the middle of the tibia, and the metatarsus and tarsus are white, the other parts being black.

We have one male from Gazaland, Mashonaland, sent to us by Mr. Marshall.

Parajotus gen. nov.

Plate XXII, figs. 2–2d.

The cephalothorax is rather high and convex, the highest point being a rounded elevation in front of the dorsal eyes. From this point it falls, in a very long slope, to near the posterior end, the upper surface being narrowed behind to form a horse-shoe shaped plate from which the thorax slopes on the sides and behind. The cephalic part is also inclined forward. The sides are a little contracted in front and behind, the widest point being behind the dorsal eyes. It is but little wider below than above. The quadrangle of the eyes is one-third wider than long, is wider behind than in front, and occupies two-fifths of the cephalothorax. The front eyes are all large, and form a straight row in which the middle eyes are close together and plainly less than twice as large as the lateral, which are a little separated from them. The second row is halfway between the other two. The dorsal eyes are as large as the lateral and form a row which is nearly as wide as the cephalothorax. The males, as in *Tusitala,* have ridges of long, stiff hairs on the front of the falces. There are both inferior and lateral spines on all the legs, the tibiæ of the first and second having three pairs below, and the metatarsi two pairs, besides lateral spines. The sternum is oval. The coxæ are separated by fully the width of the labium, which is a little longer than wide.

Parajotus resembles *Jotus* and the allied genera but differs in having the quadrangle of the eyes plainly wider behind than in front.

Parajotus obscurofemoratus sp. nov.

Plate XXII, figs. 2–2d.

The femur of the first leg is dark and iridescent, in contrast with the other joints.

♂. Length, 6.5–8 mm. Legs $1\overline{43}2$, nearly equally stout.

Our specimens are badly rubbed, so that we can form no clear idea of the markings. There are some reddish hairs left around the eyes and on the cephalic plate. On the sides of the thoracic part are wide bands of white hairs, sharply outlined by black bands above and below, and ending abruptly at the dorsal eyes, while the hairs on the sides of the cephalic part are black. The clypeus is brown and is one-third as wide as the large middle eyes. The falces are long, stout, projecting, brown in color, and have, on the front faces, ridges of long stiff black hairs. The abdomen has some long white and reddish hairs at the front end, and has white bands on the sides. In the middle there seems to have been a band of reddish hairs running backward for two-thirds the length of the dorsum, and behind this are indistinct dark and light chevrons. The sides are more or less streaked. The first legs have the femoral joints dark and iridescent in whole or in part, making a contrast with the other joints, which are much lighter, and this is true in a less marked degree of the second legs. The first and second pairs have fringes of black hairs under the femur and of light yellow hairs under the patella and tibia. The third and fourth legs are light yellow with dark spots. The palpi are usually dark and are covered with long stiff black hairs.

We have several males from Durban.

Euophrys Purcellii sp. nov.

Plate XXII, figs. 5, 5a.

The males of this species have, under alcohol, a central light colored longitudinal streak throughout the length of the cephalothorax, and a wide light band on the abdomen.

♂. Length 3.6 mm. Legs $14\overline{23}$, first pair plainly stoutest, second next.

The distinct light colored longitudinal band which is seen down the middle of both cephalothorax and abdomen when the spider is under alcohol, disappears when it is dry. The whole integument is brown with a slight covering of white or yellowish hairs on the upper surface, growing thicker on the sides of the abdomen. The retreating clypeus is covered thickly with bright yellow hairs which grow also on the sides as far around as the third row of eyes. The falces are parallel, short and rather stout. Their color is brown, and they have fine, transverse, white lines across the front faces, each line being made of a succession of single hairs. The palpi are brown, the tarsi a little paler than the other joints and covered with white hairs. The legs are brown, lightest on the metatarsi and tarsi. The first and second legs show a bluish, iridescent sheen on the patella and tibia, these two joints and the femur being much stouter than the metatarsus and tarsus, especially in the first leg. The front eyes form a straight row, the middle being less than twice as large as the lateral.

We have two males from Signal Hill, Cape Peninsula, collected by Mr. R. M. Lightfoot. The species is named for Mr. W. F. Purcell, of the South African Museum, who has made valuable contributions to the knowledge of Arachnology in South Africa.

Euophrys Simonii sp. nov.

Plate XXII, figs. 4–4b.

♂. Length 5 mm. Legs $\overline{4312}$, those of the first pair stoutest and having a double fringe.

The cephalothorax is moderately high and is narrow in front, widening rather sharply behind the first row of eyes to its widest point, at the third row. Behind this it contracts in a rounded line to the posterior end. The highest point is at the third row of eyes from which the fall is rather steeper in front than behind. The front half of the thoracic part is convex and rounded. The quadrangle of the eyes occupies about two-fifths of the cephalothorax, is one-fourth wider than long, and is plainly wider behind than in front. The eyes of the first row are rather large, the middle being less than twice the lateral, subtouching, and form a straight row. The second row is about halfway between the others. The third, is but little narrower than the cephalothorax. The sternum is rounded, and truncated in front. The anterior coxæ are separated by a little less than the width of the labium, which is about as wide as long, and only half as long as the maxillæ. The falces are long, oblique, and strongly divergent, with a long curved fang, and one strong tooth on the lower margin. They are light brown and iridescent.

We have but one specimen. There is a band of pure white hairs around the lower sides of the cephalothorax, a central white spot on the cephalic, and another on the thoracic part. The rest of the cephalothorax seems to have been covered with rufus hairs. The clypeus has long white hairs. The falces, pale brown in color, are nearly bare. The abdomen is rufus with a whitish band down the middle and one on each side. The legs and palpi are mottled with lighter and darker brown, and have a good many white hairs. The first leg has a black line on the upper face of the femur, and a fringe of mixed black and white hairs on each side of the femur, patella, and tarsus.

We have one male from Cape Colony, South Africa, sent to us by Dr. Brauns. The species is named for our friend M. Eugène Simon.

Euophrys Leipoldtii sp. nov.

Plate XXII, fig. 6.

♀. Length 6 mm. Legs $\overline{34}\overline{12}$, nearly equal in thickness.

The cephalothorax is dark colored with wide white marginal bands on the sides which do not meet behind. The clypeus has white and red hairs which grow also around the eyes of the first row. A white band runs back on each side including the three lateral eyes, uniting with its fellow behind the dorsal eyes and extending for a short distance on the middle of the thoracic part. The abdomen has a covering of red hairs, and a white basal band. The legs have the femora dark colored, as are also the patella and tibia in the first pair, the metatarsus and tarsus being light colored. The other legs have the patella and tibia barred with light and dark, while the metatarsus and tarsus are light. All the legs have short white hairs.

We have four females from Clanwilliam, Cape Colony, collected by Mr. C. M. Leipoldt, for whom we have named the species.

Euophrys infaustus sp. nov.

Plate XXII, fig. 7.

♀. Length 5.5 mm. Legs $43\overline{12}$, first pair a little the stoutest.

The dark cephalothorax is covered with white hairs, while the abdomen is clothed with silky, golden hairs. There are three pairs of black dots on the back. The legs, clypeus and falces are brown with a good many short white hairs.

We have one female from Mashonaland, sent by Mr. Marshall.

Mendoza Carlinii sp. nov.

Plate XXIII, figs. 6–6c.

Length, ♂ 5.5 mm; ♀ 10.7 mm. Legs, ♂ $\overline{41}\,\overline{32}$, ♀ 4312. first pair stoutest.

This is a flat gray species with the light, foliated, abdominal band characteristic of the Marptusa Group.

The quadrangle of the eyes occupies one-third of the cephalothorax. The tibia of the first leg has two pairs of spines with laterals, the tibia of the second, two serial spines. The metatarsi have two pairs in both first and second.

In the male the cephalothorax has a dark background, with reddish hairs on the sides and bright red hairs around the eyes. There are three longitudinal white streaks on the cehpalic part, and on the thoracic there is a large central patch of white. The band around the margin and across the clypeus is pure white, and there is a bunch of white hairs at the insertion of the falces.

The abdomen has a scalloped white band low on the sides, which is edged, above, with velvety black. The upper part of the back is covered with white and reddish hairs, the white ones concentrating to form a central patch at the front end, two curved bands in the middle, and a series of chevrons on the posterior part. The legs have patches of white and red hairs, and the upper surface of the femur of the palpus is covered with snow-white hairs.

In the female the cephalothorax is black with a snow-white band around the margin and a longitudinal white band on the thoracic part. The abdomen is black with a wide longitudinal, foliated band of mixed white and red hairs. On this band is a series of black chevrons. The legs are black with some short light-colored hairs. The palpus has the proximal end of the femur black, and the other parts light yellowish brown, with long, white hairs. The clypeus is dark and is almost hidden by the heavy, projecting, darkly iridescent falces. The under parts are brown excepting the sternum, which is black, with long, yellowish-white hairs.

We have a male and a female from Mashonaland, sent by Mr. Marshall.

Philaeus manicus sp. nov.

Plate XXIV, figs. 1, 1a.

♂. Length 8 mm. Legs $\overline{13}42$, stout and hairy.

In its general appearance this species strongly resembles *Phidippus,* but its characteristics bring it into the genus *Philaeus.* There is one conical tooth on the inferior margin of the falx.

The quadrangle of the eyes is one-fourth wider than long, is a little wider behind than in front, and occupies two-fifths of the cephalothorax. The front row is a little curved, all the eyes being small, the lateral being more than half as large as the middle and separated from them. The thoracic part is plane through half its length, and then falls. The second row of eyes is half way between the others, and the third is much narrower than the cephalothorax. The lip is longer than wide.

The whole spider is black covered with grayish-rufus hairs. There are some white hairs over the first row of eyes and on the clypeus, and the abdomen has stiff black hairs sprinkled over it. The first and second legs are black excepting the patellæ, which are reddish. The third and fourth are covered with rufus hairs. The palpi are black excepting the tarsi, which are brown with white hairs. The falces are black, without iridescence.

We have one male from Manica Mts., Mashonaland, sent by Mr. Marshall.

Dendryphantes Purcellii sp. nov.

Plate XXIV, figs. 11–11b.

Length, ♂, ♀, 4.5 mm. Legs, ♂ $14\overline{23}$, ♀ $\overline{41}\,\overline{23}$, first pair stoutest, especially in the male.

The general color is bright rufus, resulting from a mixture of white and yellowish-red hairs. When these are rubbed off the cephalothorax is dark, almost black on the sides, golden, with two black spots, on the eye region, while the abdomen is light colored with dark specks and blackish lines. In perfect specimens the cephalothorax is bright rufus with a band of snow-white hairs around the margin; these hairs grow longer on the clypeus. The abdomen is rufus with a whitish basal band, two longitudinal white bands on the anterior part and three pairs of white transverse bands, alternating with black, behind. The legs are yellowish in the female and brown in the male, the first and second pairs much darker than the others.

The tibia of the first leg has three pairs of spines; of the second, two uniserial and two subapical spines. The metatarsi of the first and second have two pairs. The palpi are yellow in the female and dark brown in the male. The falces are small and vertical in both sexes.

We have two males and two females from Bergvliet, Cape Peninsula, sent by Mr. W. F. Purcell, for whom we have named the species.

Baryphas ahenus E. S.

Plate XXIV, figs. 2–2b.

Length, ♂ ♀, 6–10 mm. Legs, ♂ $\overline{1342}$, stout, black and hairy, ♀ $\overline{34}12$.

This species varies greatly in color, size and marking. The ground color is black. The male has the upper part, the margin of the cephalothorax and the clypeus covered with white scales, sometimes tinged with red. The falces are dark and iridescent. The female has the whole cephalothorax, the clypeus, the palpi, the front faces of the falces, and a great part of the first and second pairs of legs covered with red scale-like hairs, the front face of the femur, in the first and second legs of both male and female, being sown with tiny white scales. The abdomen is dark with white, reddish, or red marks, consisting of a central spot, a band around the front end which sometimes runs halfway, and sometimes all the way along the sides, and two pairs of bars on the sides, continuous with the encircling band, one at the middle point and one farther back. These bars are sometimes transverse, and sometimes oblique, and often one pair is transverse and the other oblique. The legs are black with black hairs, which are especially long on the first and second pairs.

We have many specimens from Mashonaland, Natal, and Cape Colony.

Hyllus Treleavenii P.

Plate XXIII, figs. 3, 3a.

♀. Length 13 mm. Legs $\overline{34}12$.

In our specimen the cephalothorax is rubbed almost bare, showing the integument to be dark red on the sides and lighter above. There seem to have been many light yellow and reddish hairs on the sides and over the back. Around the eyes of the first row and on the clypeus are long reddish hairs, and white hairs with a yellow tinge cover the front faces of the falces. The abdomen has a covering of short reddish-gray hairs with long white hairs scattered over it. Down the middle is a herring-bone stripe of white, and a white band around the base is continued on the sides to the middle point, where it ends in a conspicuous somewhat triangular white spot. Further back, on each side, is a crescent-shaped white spot. The legs are all hairy, especially the first pair, which has long black and white hairs below. Their general color is dark, but the metatarsi and tarsi of the first legs, as well as the distal ends of the metatarsi and the whole of the tarsi of the third and fourth, are lighter colored.

We have a single female from Mashonaland sent by Mr. Guy A. K. Marshall. We have named the species for Mr. F. Treleaven of Cape Town.

Hyllus moestus sp. nov.

Plate XXIII, figs. 5, 5a.

♀. Length 14.3 mm. Legs $34\overline{12}$, first and second stoutest.

The color of the integument of the cephalothorax is bright red on the sides, where there are alternating bands of black and yellowish white hairs, and dark red on the upper surface, with black spots around the eyes. Down the middle of the thoracic part is a wide band of yellow hairs, and long yellow hairs cover the clypeus, falces, and palpus. The front end of the abodmen is streaked with black and yellow. Down the middle the color of the integument is bright red, and on this band are four pairs of oblique yellowish spots (the hinder ones uniting to form chevrons), from the center of each of which there comes off a long white bristle. The sides are black, each with four large yellow spots. The legs are dark reddish-brown covered with short black and yellow hairs and long whitish hairs. The venter is of a uniform light brown color.

We have one female from Durban, sent by Mr. Quekett.

Hyllus perspicuus sp. nov.

Plate XXIII, figs. 2–2b.

Length, ♂ 8–10.5 mm; ♀ 9–10.5 mm. Legs, ♂ 1342, first pair plainly longest; ♀ 3412.

We have one very dark female from Durban in which the markings are perfectly preserved. The cephalothorax is black with narrow white bands around the lower sides, which do not meet behind. There is a white bar just below each dorsal eye, and a median white band beginning between the dorsal eyes and passing back for two-thirds the length of the throacic part. There is a white spot near the middle of the cephalic part, and a white patch in front of each dorsal eye. Over the first row of eyes are some grayish white hairs. The clypeus has whitish hairs and under each lateral eye are three white lines alternating with dark lines. The abdomen is velvety black with a white median spot at the front end and a pair of longitudinal snow-white lines on the anterior part of the dorsum. Behind this is a series of four white spots. In some lights the abdomen shows green reflections. Each side has a short oblique white line in front and a scalloped white band behind. The legs are dark with longitudinal white lines.

Our other specimens, which are more or less rubbed, have the black intermixed with dark reddish-brown. In the male the white bars below the dorsal eye are continued and meet on the thoracic part. The abdomen is dark brown or black and has a broken white band down the middle, which, in the females, forms white chevrons alternating with black ones. The falces are heavy, projecting, dark reddish-brown in color, with some short white hairs. The palpus is dark, that of the female having a bunch of white hairs at the tip.

Besides the female from Durban we have three specimens from Mashonaland and two from Zanzibar, the latter being the larger.

Hyllus natalii sp. nov.

Plate XXIII, figs. 4, 4a.

♀. Length 12 mm. Legs 3412, all stout and rather hairy.

The cephalothorax is reddish-brown with black spots around the eyes. The sides are thinly clothed with white hairs and there seems to have been a median white band on the thoracic part. On the clypeus, falces and palpi are long whitish hairs. The abdomen is black with a whitish band down the middle, on which is a pattern in fine black lines. On each side, are three yellowish-white spots. The legs are dark brown, with a good many long white and black hairs. There are ridges of black hairs under the tibia in the first and second. The venter is black in the middle with a light band on each side.

The dark venter in *natalii* and the light venter in *moestus* distinguish these two species from each other. In the female of *perspicuus* the venter is light with a dark line down the middle, and in *Treleavenii* it is covered with silvery hairs.

We have one female from Natal, sent by Mr. Quekett.

Modunda aperta sp. nov.

Plate XXVI, figs. 9, 9a.

♂. Length 6 mm. Legs $1\overline{34}2$, first heavily thickened.

The quadrangle of the eyes is about one-fourth wider than long, is a little wider behind than in front, and occupies only two-fifths of the cephalothorax. In the type of this genus the quadrangle occupies about half of the cephalothorax. The cephalothorax is long, rather low, and very flat, the sides rounding out slightly from in front backward and from above below. The first row of eyes is straight, the eyes being close together, the middle nearly three times as large as the lateral. The second row is a little nearer the first than the third. The third row is a little narrower than the cephalothorax. The sternum is attenuated in front. The anterior coxæ are separated by the width of the labium, which is about as wide as long. The falces are thick, vertical and parallel, with small fangs, and have a single conical tooth on the inferior margin.

This is a slender, brilliant species. The ground color is black with iridescent reflections, and the markings are formed of thick white scales which are also iridescent. The cephalic part is covered with these scales and there is a central longitudinal band on the thoracic part. A band in the middle of each side extends from the lateral eye halfway through the thoracic part. The abdomen, which is narrow and tapering, has a central band throughout half its length, from the end of which a bright pink and green iridescent band extends to the spinnerets. On the sides are two or three parallel pairs of oblique white bands, the ends of the first pair meeting the central band at an angle, at the front end of the abdomen. On the sides of the iridescent band which occupies the posterior half of the dorsum are two pairs of transversely elongated spots, which are pure white, without iridescence. The external spinnerets are long and rather hairy. The clypeus has some long white hairs. The palpi are covered with white scales above. The legs are dark with many patches of white iridescent scales. In the third and fourth pairs the tarsi are pure white tipped with black. The first leg has the femur, patella and tibia much enlarged, and the patella, tibia and tarsus have a short fringe of black and white hairs below. Under the tibia are three pairs of stout spines, and under the metatarsus, two pairs. The third and fourth pairs have some small spines, unlike the type of this genus, *M. phragmitis,* in which these legs are unarmed.

We have two males and one female from Gazaland, Mashonaland, sent by Mr. Marshall.

Pseudicius Braunsii sp. nov.

Plate XXVI, figs. 1, 1a.

♂. ♀. Length 5 mm. Legs 1432, first much the stoutest in both sexes, and longer in the male than in the female.

The cephalothorax is dark with a white marginal band which crosses the clypeus. Above this, on the sides, are reddish hairs.

There is a median longitudinal white band on the upper surface of both cephalic and thoracic parts. The abdomen has a central white band, on each side of which are reddish brown bands, and below these again, white bands. The legs are all dark colored except the tarsi which are light. The first leg in the female has the femur, patella and tibia very much enlarged, with one or two short spines under the tibia. In the male there is one spine on the tibia, and two pairs of spines under the metatarsus.

We have one male and one female from Willowmore, Cape of Good Hope, sent to us by Dr. Brauns.

Pseudicius africanus sp. nov.

Plate XXVI, figs. 2, 2a.

♀. Length 5.5 mm. Legs –432 . The first pair, which is lacking, was probably the longest.

The cephalothorax is covered with white hairs. The abdomen is also white with three pairs of large dark brown spots which grow smaller toward the posterior end. The legs are light yellow.

We have one female from Cape Colony, sent to us by Dr. Brauns.

Pseudicius bipunctatus sp. nov.

Plate XXVI, figs. 3, 3a.

♀. Length 4.5 mm. Legs 4132, first pair stoutest.

The cephalothorax is low and flat, slightly wider in the thoracic than in the cephalic part. The front eyes are all separated and form a row that is curved downward, the middle being twice as large as the lateral. The second row is about halfway between the other two, and the third row is as wide as the cephalothorax. The tibia of the first leg has a single spine below. The metatarsus has two pairs and a lateral spine. The tibia of the second is unarmed. The metatarsus of the second has a row of two spines.

The cephalothorax is covered with mixed white and rufus hairs except two red bands, one on each side of the cephalic part. There is a black line around the margin. The hairs around the front eyes and on the clypeus are white. The abdomen has indistinct transverse bands of black alternating with bands of mixed white and rufus hairs. Near the posterior end is a large white spot on which is a dark crescent, and behind this are two oblique black spots each bearing a snow-white dot. The legs and palpi are pale brown with white hairs.

We have a single female from Willowmore, Cape Colony, sent by Dr. Brauns.

Sittacus designatus sp. nov.

Plate XXII, fig. 3.

♀. Length 5 mm. Legs $\overline{43}12$, first and second pairs stouter than the others.

The cephalothorax is only moderately high and is rather flat above, slanting off in front of the third row of eyes, and behind the middle of the thoracic part. It is long and has the sides nearly parallel, there being a slight widening from front to back. The front eyes are a little separated and form a curved row, the middle being less than twice as large as the lateral. The second row is slightly nearer the third than the first, and the third row is nearly as wide as the cephalothorax at that place. The tibiæ of the first and second legs have three pairs of spines, and the metatarsi two pairs, without lateral spines. The labium is as long as wide.

The cephalothorax is dark colored, and, in our single specimen, is rubbed bare with the exception of the cephalic part, which seems to have been covered with bright red hairs. The coloring of the abdomen is very rich. The central part of the dorsum is black, with an intermixture of red hairs. A band which crosses the anterior end and runs back on each side beyond the middle, a slender central longitudinal line on the anterior part, and a pair of spots at about the middle point of the dorsum, are all light yellow edged with red, and on each side of the spinnerets is a bright snow-white spot. The legs have the proximal joints dark brown, and the metatarsi and tarsi lighter. The palpus has nearly all of the femur dark brown, but the very end of this joint, and the patella, tibia and tarsus, are light yellow. There are white hairs on all the joints, but on the tarsus these are found only on the outer side, while within, and at the end, there is a short fringe of black hairs.

The falces are parallel and moderately long and stout, dark and glistening in color. The clypeus is rather wide, and slants backward. The first row of eyes is slightly curved, the middle being less than twice as large as the lateral.

We have one female from Willowmore, Cape of Good Hope, sent to us by Dr. Brauns.

We put this, and the following species, into the genus *Sittacus* with some hesitation, since the inferior margin of the falx is armed with a conical tooth.

Sittacus Uphamii sp. nov.

Plate XXIII, figs. 1–1c.

Length, ♂ 5.5 mm; ♀ 7.5 mm. Legs, ♂ $1\overline{43}2$, first pair much the longest but scarcely stouter than the others; ♀ $\overline{431}2$, first slightly stoutest.

The cephalothorax is rather high. The cephalic part is inclined. The thoracic is nearly level for the first half, and then slopes rather steeply. The sides round out rather widely behind. The front eyes form a straight row, the middle being less than twice as large as the lateral. The second row is halfway between the others and the third row is nearly as wide as the cephalothorax at that place. The maxillæ are narrowed and bluntly pointed on the outer edge. The labium is a little longer than wide. The tibiæ of the first and second legs have three pairs of spines below besides laterals, and the metatarsi have two pairs and laterals.

So far as can be judged from our specimens the male has a dark cephalothorax with bright yellow or rufus hairs on the sides and around the eyes and a longitudinal band of white hairs down the middle of the thoracic part. The abdomen is of a light brown color and has a series of dark brown chevrons, not formed by hairs, on the posterior half, while the anterior part has a dark region on each side, with a pale central band between. In one specimen these dark regions are reduced to outlines, and two pairs of black dots appear in the middle. On the sides the light ground color is speckled with brown. Over all is a sparse growth of rather long pale hairs. The legs are light colored with a smoky brown tinge on the femur, tibia and metatarsus of the first. The palpus is brown with light hairs. The clypeus has a border of short white hairs. The falces are oblique and rather long, of a dark brown color, with some whitish scales.

In the female the upper surface of the cephalothorax is covered with brilliant golden-red hairs, and the sides with pale yellow hairs. The central band is pale yellow, and is prolonged on to the cephalic part in a long point. The hairs around the eyes are yellowish-white. The abdomen has a pale brown ground color and is covered with a rather indistinct pattern of bright red spots and white streaks, all formed of hairs, this being, probably, the condition of the males also, when well preserved, since the red spots follow the pattern of the dark parts on the abdomen of the male, although the chevrons on the posterior part are not distinct. The legs and palpi are light brown. The falces are vertical, and paler than in the male. The hairs on the edge of the clypeus are long and white.

We have a male from Kalk Bay Mountains, Cape Peninsula, collected by Mr. R. M. Lightfoot, a second male from Wynberg, Cape Peninsula, collected by Mr. H. Beard, and a female from Newlands, Cape Peninsula, collected by Mr. W. F. Purcell.

Bianor rusticulus sp. nov.

Plate XXIV, fig. 12.

♀. Length 6.3 mm. Legs $1\overline{43}2$, all short, first plainly stoutest, second next.

The eyes of the first row are close together in a slightly curved line, the middle being twice as large as the lateral. The second row is plainly nearer the first than the third. The quadrangle occupies three-fifths of the cephalothorax.

We have but one specimen, which is badly rubbed and has the abdomen crushed. The body seems to have been nearly covered with hairs of a reddish golden color. The cephalothorax has a white line around the lower margin. The face presents a rather striking appearance, since the golden hairs surround the eyes and form bands under the lateral eyes, while the lower part of the clypeus is covered with long white hairs which extend to the lower edges of the middle eyes, pass below the yellow bands as far as the second row, and grow down over the front faces of the falces. The palpus is brown covered with white hairs, and the legs are dark brown.

The tibia of the first leg has three long spines on the anterior side and two short ones on the posterior. The tibia of the second has a row of two spines. The metatarsi of the first and second have two pairs.

We have a single female, collected by Mr. R. M. Lightfoot, at Clanwilliam, Cape Colony.

Valloa gen. nov.

Plate XXIV, figs. 9–9c.

The cephalothorax is high with the cephalic part plane and inclined forward, while the thoracic drops abruptly from the third row of eyes. From above, the cephalic part appears to occupy nearly the whole cephalothorax. The sides are vertical, and are widest at the dorsal eyes and narrow in front, the angle being rather sharp. The quadrangle of the eyes occupies plainly more than half of the cephalothorax, is much wider behind than in front, and at its widest point is from one-fourth to one-third wider than long. The front eyes are close together in a very slightly curved row, the middle being twice as large as the lateral. The second row is a little nearer the first than the third, and the dorsal eyes are placed on the angles, forming a row as wide as the cephalothorax. The falces are short and vertical. The sternum is pointed behind and truncated in front. The anterior coxæ are separated by more than the width of the labium, which is wider than long and half as long as the maxillæ, which are short. The tibia of the first leg has three pairs of long, stout spines. The tibia of the second has a row of two or three spines. The metatarsi of the first and second have two pairs of long spines.

This genus differs from *Rhene* and *Homalattus* in the angular sides of the cephalothorax, in having the first row of eyes curved upward, the tibia of the first leg longer than the patella, and armed, and the metatarsus of the first leg longer than the tarsus. We have two species from Cape Colony, *V. modesta,* the type, and *V. elegans.*

Velloa modesta sp. nov.

Plate XXIV, figs. 9–9c.

♂. Length 3.2 mm. Legs 1432, first much the stoutest, with a brush of hairs under patella and tibia.

The cephalothorax seems to have been covered with short, scale-like bronze hairs. There are a few white hairs on the sides. The abdomen is rubbed. It is glabrous, of a bluish color, and seems to have had a large white spot at the base. The first leg is dark excepting the metatarsus and tarsus, which are light. There is a stout bunch of dark hairs under the patella and tibia. The tibia has a single row of three stout spines below, and the metatarsus two pairs of spines. The other legs have a longitudinal light streak on the upper surface of all the joints excepting the metatarsus and tarsus, with a dark streak on each side. The patellæ and tibiæ are also slightly darkened at the ends.

We have one male from Kalk Bay, Cape Colony, collected by Mr. Lightfoot.

Velloa elegans sp. nov.

Plate XXIV, fig. 10.

♀. Length 3.6 mm. Legs 1423, first much the stoutest, with a fringe of black hairs under the femur, patella and tibia.

Both cephalothorax and abdomen seem to have been covered with rosy, iridescent scales. The first leg has the first three joints black and the metatarsus and tarsus yellow. There is a short black fringe on the upper side of the tibia, and a longer one under the femur, tibia and patella. The tibia has a single row of three spines, and the metatarsus a double row of two spines below. In the other legs the femur is dark and the other joints light.

We have one female from Retreat Flats, Cape Colony, collected by Mr. Purcell.

Homalattus Marshallii sp. nov.

Plate XXIV, fig. 6.

Length, ♂. ♀. 4 mm. Legs, ♂ 1423, ♀ 4132, first much the stoutest in both sexes.

The whole spider is covered with yellowish hairs. The first leg has a fringe of dark hairs under the tibia, where there are also two spines. The metatarsus of the first leg has two pairs of spines below, and is about as long the the tarsus. The male is easily recognized by the tibia of the palpus, which has a very long, blunt apophysis, on the sides and end of which are long, dark brown hairs. The middle eyes of the first row are subtouching, and the lateral are a little separated from them. This row is straight.

We have a male and female from Mashonaland, sent to us by Mr. Marshall.

Homalattus similis sp. nov.

Plate XXIV, fig. 7.

♀. Length 5 mm. Legs 4132, first pair stoutest, with a slight fringe and two spines under the tibia.

This species is close to *Marshallii,* being covered with yellowish-white hairs, but around the eyes and on the clypeus the hairs are bright red, and the middle eyes of the first row are plainly separated from each other, while the lateral are widely separated from them. This row is straight.

We have a single female from Mashonaland.

Homalattus obscurus sp. nov.

Plate XXIV, fig. 8.

♀. Length 4 mm. Legs 4123, first pair stoutest.

The cephalothorax is black, and the abdomen, legs, palpi, and falces, dark brown. The whole spider seems to have been covered with white hairs, which grow thick on the upper part of the falces and around the eyes. The metatarsus of the first leg has two spines below, but the tibia has neither fringe nor spine. The first row of eyes is slightly curved downward and the lateral are well separated from the middle eyes.

We have a female from Burgvliet Flats, collected by Mr. Purcell.

Homalattus punctatus sp. nov.

Plate XXIV, figs. 5, 5a.

♀. Length 6–8 mm. Legs 4123, first pair very stout, with black fringes.

The body and legs are of a bright reddish-brown color, covered with golden hairs. On the cephalothorax these hairs are long and look as though they had been brushed upward and forward. Just above the first row of eyes is a narrow line of white hairs, but on the clypeus, and the front faces of the falces, they are yellow. On the abdomen the golden hairs are shorter.

There are three pairs of impressed dots down the middle, and the whole surface is covered with small white spots, each with a brown ring around it. These white spots are arranged in six curved transverse bands, with a few extra ones in the middle line. The legs and palpi are thickly covered with yellow hairs. The metatarsi and tarsi of the first pair are black. The first leg has the femur, tibia, and distal end of patella thickened, while the proximal end of the patella is slender. On the upper side of the femur is a single fringe, which is white at the proximal end and black further along; and under the patella and tibia is a double fringe, yellow on the inner, and black on the outer side. In some specimens the yellow hairs on the legs and clypeus have a distinctly reddish tinge. The first row of eyes is straight, with the lateral well separated from the middle eyes.

We have five females from Durban, three sent by Mr. J. F. Quekett, and two by Mr. G. F. Leigh.

Rhene Banksii P.

Plate XXIV, figs. 4–4b.

♀. Length 4.5. Legs 1423, first plainly stoutest, with short fringe of hairs on under side of patella and tibia.

The cephalothorax is a little wider than long, and slants upward from the anterior eyes. The quadrangle is plainly wider behind than in front, is much wider than long, and occupies two-thirds of the cephalothorax. The anterior eyes form a straight row, and are close together, the middle being less than twice as large as the lateral. The second row is close to the first. The sternum is widest in the middle, pointed behind, and truncated in front. The anterior coxæ are separated by barely the width of the labium, which is longer than wide. The falces are short, vertical and parallel.

The cephalothorax is dark with two white spots on the cephalic plate just in front of the dorsal eyes, and a curved white band on the front part. There is a white longitudinal line on the middle of the thoracic part, and a good many white hairs are seen on the sides. The abdomen is dark, with six white dots forming a curved line around the anterior end, and a transverse line of white dots in front of the middle of the dorsum. Near the posterior end is a large central white spot, from which a curved white line runs down on each side. There are some scattered white hairs on the clypeus. The first leg is dark with a short dark fringe under the patella and tibia, and a white spot at the distal end of the femur. The other legs have white rings at the ends of the joints, and are dark colored, excepting the tarsi and the proximal halves of the metatarsi, which are light.

This species is named for Mr. Nathan Banks. We have a single male from Cape Town, sent by Dr. Brauns.

Rhene biguttata sp. nov.

Plate XXIV, figs. 3–3c.

A brown species with two white spots on the posterior part of the abdomen.

♂. Length 5.3 mm. Legs 1423, first pair much the stoutest.

The cephalothorax and abdomen are of a dark reddish-brown color. A small plate, on the front upper cephalic part, has the integument roughened by punctate indentations. This plate shows most distinctly under alcohol. There is a narrow line of white hairs above the first row of eyes, the sides are covered with white hairs, and a central white line runs up on the thoracic part between the dorsal eyes. The abdomen has whitish hairs around the front end. There are four indented dots on the dorsum, in front of the middle, and toward the posterior end are two large, round, snow-white spots, well separated from each other. The clypeus is brown, and is two-thirds as wide as the middle eyes of the first row. The falces are longer than the face, stout, and brown in color. The palpi are very dark brown. The first leg has the joints much thickened, especially the tibia and patella, which have, underneath, a long fringe of black hairs. This leg is very dark, especially toward the end. The other legs are reddish brown with rings of white hairs at the joints.

It may be that this specimen has lost, by rubbing, hairs which would form other marks upon cephalothorax and abdomen.

We have one male, sent by Mr. Leigh, from Durban.

Jasoda P. 1902.

Plate XXVI, figs. 10, 10a.

The cephalothorax is high, with the sides nearly vertical and not far from parallel, although there is a slight swelling at the dorsal eyes, beyond which there is a very gradual contraction toward the posterior end. The cephalic part is a little inclined forward and the thoracic rounds off directly behind the dorsal eyes, falling more steeply after the first half. The quadrangle of the eyes occupies two-fifths of the cephalothorax, is nearly twice as wide as long, and is a very little wider behind than in front. The first row is curved downward, the eyes being small, and all separated, the lateral by nearly their diameter from the middle. The middle eyes are less than twice as large as the lateral. The second row is a little nearer the first than the third, and the third is nearly as wide as the cephalothorax. The falces are vertical, long, heavy, and parallel, with a short fang. There is one conical tooth on the inferior margin. The sternum is oblong, narrowing in front and behind and truncated in front. The first coxæ are separated by about the width of the labium, which is longer than wide.

In the type species the inferior spines on the tibia of the first leg are 3–2, on the tibia of the second, 3–1, and on the metatarsi of the first and second, 2–2. All four joints have lateral spines.

The eyes of this genus resemble those of *Euryattus* and *Simactha,* but these genera belong respectively to the Pluridentati and the Fissidentati. Moreover, the joints of the palpus are differently formed and proportioned, being flattened, with the tibia much longer than the tarsus, in *Euryattus* and *Simaetha.*

The type is a new species from Mashonaland.

Jasoda Woodii P.

Plate XXVI, figs. 10–10b.

♂. Length 7 mm. Legs 1342, not slender, nearly equal in thickness.

In our single specimen the cephalothorax and abdomen are both rubbed so that no idea of the markings can be formed. The cephalothorax is dark, almost black, with violet reflections. The abdomen is also dark but not glistening, and shows some long white hairs at the anterior end and on the sides. There are some long whitish hairs on the falces at the lower outer corner. The legs are light brown with slender black spines. The palpi are covered with white hairs.

We have one male sent to us by Mr. Guy A. K. Marshall, from Mashonaland, South Africa. The species is named for Mr. J. Wood, who has collected Attidæ at East London, Cape Colony.

KEY TO SPECIES OF THYENE FOUND IN SOUTH AFRICA.

MALES.

1	Abdomen marked with longitudinal bands	2
	Abdomen marked with transverse bands............	*natalii*
2	Cephalic part swollen in front, but not widely......	3
	Cephalic part widely swollen in front	*bucculentum*
3	Lower margin of falx with a single conical tooth....	4
	Lower margin of falx with a compound tooth.......	*crudelis*
4	Tube of the palpus not notched.......	5
	Tube of the palpus distinctly notched in front......	*australis*
5	Median abdominal band edged with red............	*Ogdenii*
	Median abdominal band not edged with red.........	*Leighii*

Ogdenii, *Leighii*, *crudelis* and *australis* are easily distinguished by the mouth parts, or by the apophyses on the palpi.

FEMALES.

1	Abdomen marked with longitudinal bands	2
	Abdomen marked with transverse bands	*natalii*
2	Femur I with transverse striae.....................	3
	Femur I without transverse striae..........................	*bucculentum*
3	Legs $\overline{1342}$..	*pulchra*
	Legs $\overline{34}$ $\overline{12}$	*Ogdenii*

Thyene Ogdenii sp. nov.

Plate XXV, figs. 2–2d.

Length, ♂ 7 mm, ♀ 8 mm. Legs, ♂ $1\overline{34}2$, ♀ $\overline{34}\,\overline{12}$, first and second pairs stoutest.

The quadrangle of the eyes is wider behind than in front and the middle eyes of the first row are fully twice as large as the lateral, which are separated from them. This row is straight. The third row is narrower than the cephalothorax.

In the male the cephalothorax is brown with a transverse patch of yellowish hairs just above the eyes of the first row. These eyes are surrounded by reddish hairs. There is also, just below the lateral eyes, on the sides, a narrow band of yellowish hairs, and a median longitudinal band of the same color passes backward from between the dorsal eyes, but does not reach the lower border. There are bunches of scattered hairs just behind the lateral eyes. The first legs are darker in some specimens than in others, varying from yellowish-brown to blackish-yellow. The femur is light above and dark below, with transverse dark bands in front. The tarsi are lighter than the other joints. The second leg is lighter colored than the first, the femur being light above and dark below, and the rest light yellow. The other legs are yellow. In some specimens the tarsi and metatarsi of the three posterior pairs are white. The abdomen has the sides brown, deeper in front than behind. There is a median longitudinal yellowish-golden band—the anterior half being more yellowish, and the posterior more golden. On either side of this band is a narrow reddish line. In the posterior half, in the reddish line, are three pairs of small white spots. Some specimens have the brown color on the sides tending to break up into large spots. Low down on the posterior sides are some oblique white bands. The falces are dark brown, moderately long and stout, and slightly projecting.

In the female, of which we have only rubbed specimens, the cephalothorax is yellow. Above the first row of eyes, the whole cephalic plate seems to have been covered with golden-yellow hairs, the first eyes being surrounded by lighter yellow hairs. There are narrow bands of red hairs on each side, below the eyes, and some scattering long black hairs behind the anterior lateral eyes. The abdomen is yellow marked with a number of small black spots. There is a yellowish golden, median longitudinal band, on either side of which are red bands. Just above the spinnerets the two bands unite. In the posterior half, in the red bands, are three or four pairs of white spots. In some specimens the red bands are absent. The legs are yellow, the femur of the first having transverse dark striæ in front.

This species is nearest *Leighii*, from which it is distinguished by the following points: *Ogdenii* is a smaller and lighter colored species with the relative length of the legs 1342 instead of 1324; in *Ogdenii* the spines under the tibia of the first are placed, along the length of the joint, at nearly equal distances, while in *Leighii* the two at the proximal end (one on the anterior and one on the posterior face), are much more widely separated from those at the distal end than these are from each other, those at the distal end being also separated from each other by unequal distances. Both species have two small lateral spines on the tibia of the second.

We have this species from Mashonaland (Mr. Marshall), Durban (Mr. Quekett), and Algoa Bay (Dr. Brauns). It is named for Dr. H. V. Ogden, of Milwaukee.

Thyene Leighii sp. nov.

Plate XXV, figs. 1–1c.

This species has a light and a dark variety, and varies considerably in size.

♂. Length 9.5 mm. Legs $13\overline{24}$, first pair stoutest, second next.

The quadrangle of the eyes occupies two-fifths of the cephalothorax and is equally wide in front and behind. The front eyes are a little separated and form a straight row, the middle being twice as large as the lateral. The second row is plainly nearer the first than the third, and the third is much narrower than the cephalothorax.

The cephalothorax is dark brown with a patch of white hairs above the first row of eyes. A white band runs along the upper side of the lateral eye of the first row, and below and behind the dorsal eye, and a patch of white on the thoracic part extends only halfway down the slope. When not rubbed the cephalothorax has reddish hairs around the white spots and around the eyes. The abdomen on the sides is dark, or is pale brown with black hairs. In the middle of the first half is a white band, and behind this is a metallic brown band with three or four small white spots on each edge. When the abdomen is looked at from the side a curved white band is seen, which starts low down at about the middle point and runs backward and downward to the end of the venter. The legs and palpi are brown, the front face of the femur of the first leg being marked with dark, transverse striæ, which are faintly repeated on the femur of the second. The falces project and are short and broad, of a dark brown, somewhat iridescent color, and thinly covered with short white hairs. The fangs are strong. The spines on the tibia of the first leg are in two rows, four in front and three behind (see drawing), or, in some individuals, four in front and two behind. The tibia of the second leg has the spines 3–3 or 3–2. The metatarsus of the first has two pairs.

We have several males from Durban. The species is named for Mr. George F. Leigh of that city.

Thyene pulchra sp. nov.

Plate XXV, figs. 3, 3a.

A brilliant species with red. white and black markings.

♀. Length 8 mm. Legs $13\overline{42}$, first and second pairs stoutest.

The general color of the integument is dark reddish-brown. The cephalic plate is covered with red and white scales, while the thoracic part and the sides have streaks of black and white hairs, with some red intermixed, running upward from the margin. The front eyes have white hairs around the lower half of their circumference and reddish hairs above. The middle of the clypeus has long, bristly white hairs, and on each side, under the lateral eyes, are three white streaks on a red ground. The falces are dark brown with white scales on the front faces. There are tufts of long black hairs behind the lateral eyes. The abdomen has the front end and the lower sides covered with black hairs, more or less streaked with white. The middle of the dorsum, in front, is covered with a mixture of white and red hairs, while behind is a short central white band, with wide bands of rich red on each side, cut by two pairs of white bars, edged with black. The red bands join behind to form a red region above the spinnerets. The palpi are light colored and are thickly covered with long white hairs. The legs are brown or yellow, sometimes having dark spots. The femoral joints in the first, second and third pairs are marked with dark transverse striæ on their front faces, and the first and second legs have a good many white scales, besides thin fringes underneath, which are white under the femora and black under the patellæ and tibiæ. The tibia of the first leg has three pairs of spines, and the metatarsus two pairs.

The quadrangle of the eyes is equally wide in front and behind. The front eyes are in a slightly curved row with the middle twice as large as the lateral, which are a little separated from them.

We have five females from Durban.

Thyene natalii sp. nov.

Plate XXV, figs. 4–4b.

♂. Length 5–8 mm. Legs 1342, first plainly stoutest and longest.

♀. Length 7.5 mm. Legs 3412, first plainly stoutest, third and fourth plainly longest.

The quadrangle of the eyes occupies about one-half of the cephalothorax and has the sides nearly parallel. The anterior eyes are close together in a straight row, the middle being twice as large as the lateral. The second row is plainly nearer the first than the third, and the third is a little narrower than the cephalothorax.

We have several specimens, but all of them are rubbed. The cephalothorax, in the male, is dark brown on the cephalic plate and in a wide band around the lower sides and back, and has a light yellowish brown band around the upper sides and across the anterior thoracic part. The eye-region and the anterior thoracic part seem to have been covered with gold and silver iridescent scales, and the face is marked with three lines of the same scales which run around below the lateral eyes on to the thoracic part. There are rings of red hairs around the middle eyes, and tufts of black hairs behind the lateral eyes. The cephalothorax of the female is like that of the male excepting that the color of the integument is light brown, with some black spots on the eye region, and that it lacks the tufts. The abdomen in both sexes is marked with transverse bands of bright red hairs and silvery iridescent scales. Under alcohol, some black chevrons appear on the posterior part. In the male the femur of the first leg is dark and glistening, the tibia and patella are lighter, the metatarsus is light at the proximal and dark at the distal end, and the tarsus is dark. The femur of the second is light at the proximal and dark at the distal end, and from this point the leg shades from dark to light at the tip. The third and fourth legs are light. The tibia of the first leg has seven inferior, serial spines, four in front and three behind, and the metatarsus has two pairs. In the female the legs are yellow, the femur of the first being marked, on the front face, with dark striæ, which are repeated, with less distinctness, on the femur of the second. The tibia of the first has four anterior and three posterior spines and the metatarsus has two pairs. The falces are vertical, stout, and rather long. They are dark colored in the male and yellow in the female. The tube of the male palpus is much coiled.

We have one female and several males from Durban.

Thyene crudelis sp. nov.

Plate XXV, figs. 5–5d.

♂. Length 7.5 mm. Legs $\overline{13}24$, first pair stoutest, second next.

The quadrangle of the eyes is plainly wider in front than behind. The first row is curved, with the lateral separated from the middle eyes, which are scarcely twice as large. The third row is much narrower than the cephalothorax.

The coloring is almost identical with that of *Ogdenii.* The cephalothorax is dark brown with tufts of long black hairs behind the lateral eyes of the first row. There are yellowish-white iridescent scales arranged in a band above the first row of eyes, in bands along the upper sides, and in a large central spot on the thoracic part. The abdomen is very dark on the sides, with a central band on the anterior part made up of whitish scales like those on the cephalothorax, and, behind this, a dark green metallic band. The whole of this central region is edged with bright red, and in the red, on the posterior part, are several pairs of white spots. The white curved lines on the lower sides are like those in the other species. The falces project slightly, and are broad and strong, with a stout compound tooth below. They are dark brown, and have white iridescent scales and long white hairs on the front faces toward the inner sides. The legs are of a medium brown color, the first pair scarcely darker than the others, the femoral joints of the first and second with dark transverse striæ in front. The tibia of the first has, underneath, four spines on one side and three on the other, placed at nearly equal distances, more like those of *Ogdenii* than of *Leighii.* The metatarsus has two pairs. The maxillæ differ in shape from those of the other species (see drawing), and are light brown with the inner upper edges white. The palpi are light brown with white iridescent scales on the femur and tibia.

We have two males from Durban.

Thyene australis sp. nov.

Plate XXV, fig. 6.

♂. Length 6.5 mm. Legs $1\overline{34}2$, first pair stoutest and darkest, second next.

The quadrangle of the eyes occupies nearly one-half of the cephalothorax and is a little wider behind than in front. The front lateral eyes are a little separated from the middle eyes, and with them form a curved row, the middle being scarcely twice as large as the lateral. The third row of eyes is much narrower than the cephalothorax.

The cephalothorax is dark brown with yellowish-white hairs in a band above the first row of eyes, in a central spot on the thoracic part, and in bands along the upper sides. There are red rings around the front eyes. The abdomen has a central band which is covered with yellowish-white hairs in front and is brown and metallic behind. This band is edged with red, and in this color, in the posterior half, are several pairs of white dots. The sides are dark, almost black, where they meet the red bands, and have curved white bands low down behind. The palpi are dark brown. The falces are stout, slightly projecting, and iridescent brown in color, with some white hairs in front. The first legs are dark brown, the others yellow. The front face of the femur, in the first and second pairs, is black, without striæ. The tibia of the first has, below, three spines behind, and four in front, placed at nearly equal distances; the tibia of the second has two in front and three behind. The metatarsi have two pairs. The venter is dark, the coxæ are yellow, and the maxillæ brown with white on the inner front edges.

We have a single male from Algoa Bay.

Klamathia gen. nov.

Plate XXVI, figs. 4–4c.

The cephalothorax is high and not very convex, highest at the dorsal eyes, from which point it slopes a very little forward, and more decidedly, but still gradually, backward, the fall becoming steeper after the first half of the thoracic part. The narrowest point is in front, the sides spreading out widely to the middle of the thoracic part, so that the cephalothorax has a rounded appearance. The quadrangle of the eyes is nearly twice as wide as long, is wider behind than in front, and occupies two-fifths of the cephalothorax. The front eyes are moderately large and form a straight row. The middle eyes are close together and are twice as large as the lateral, which are separated from them. The second row is slightly nearer the first than the third, and the third row is plainly narrower than the cephalothorax. The sternum is round. The anterior coxæ are separated by the width of the labium which is longer than wide. The falces are strong and are rounded out in front. All the legs are spined. The first pair has, besides lateral spines, three pairs under the tibia, and two pairs under the metatarsus.

Klamathia is most nearly related to *Thyene,* but differs from that genus in having the quadrangle of the eyes nearly twice as wide as long.

Klamathia flava sp. nov.

Plate XXVI, figs. 4–4d.

♂. Length 8 mm. Legs 1342, second, third and fourth not differing much in length; first pair stoutest.

This is a yellow species with black spines, black spots around the eyes, and four indented dots on the abdomen.

The body, legs, palpi and falces are yellow or yellowish-brown. Our specimens are rubbed nearly bare but there remain thick white hairs on the clypeus and around all the eyes, while above the eyes, both in front and on the sides, there are bright red hairs. There is a white line around the lower margin of the cephalothorax. The abdomen and legs have a thin scattering of black and white hairs. The palpus has some rather long white hairs. The falces are stout and bulge out in front; they have a single tooth on the lower margin. On the inner and lower edges are long white hairs.

The first leg has, besides lateral spines, three pairs under the tibia, and two under the metatarsus, this latter joint having no lateral spines. The tibia of the second has two pairs below, besides a single spine near the proximal end, and lateral spines. The metatarsus has two pairs and lateral spines.

We have several males from Durban.

Viciria morigera sp. nov.

Plate XXVI, figs. 6–6b.

♂. Length 9 mm. Legs $3\overline{42}1$, first and second pairs stoutest.

This is a light colored species, ornamented with red and white bands.

The cephalothorax is light yellowish-brown. The hairs on the eye-region form a white ground with a bright red V in the middle, the apex being between the large eyes of the first row, and a red band on each side. The hairs around the eyes of the first row are bright red. The middle of the clypeus is white, but from under the lateral eyes three bands, a red between two white ones, pass backward below the side eyes and curve upward over the thoracic part. The white bands meet, but the red ones end in two large dark spots within and behind the dorsal eyes. On the lower sides are some scanty black and white hairs. The striking and handsome appearance produced by the bands is so unlike anything found in other South African species of *Viciria* as to easily distinguish *morigera*. The abdomen, in our specimens, is rubbed, but the marking seems to have been two transverse curved bands and a median longitudinal band, all red, on a ground of white hairs. The falces are light brown. The legs are yellow, with black hairs and long spines. The tibiæ of the first and second have, besides lateral spines, four pairs below, and of these, the two spines nearest the proximal end are double, two coming out from the same point of insertion. The inner spine next in order is also double, although its mate on the other side is single. This peculiarity marks off *morigera* from *V. alba, V. flavipes, V. parmata* and *V. niveimana,* all of which have three pairs of ordinary spines under the tibia of the first. The metatarsus of the first has two pairs of inferior, and two pairs of lateral spines. On the third and fourth legs the spines are numerous but irregular. The palpi are yellow with white hairs. The under surface of the body is pale yellow with a dark central streak on the venter, and brownish mouth-parts.

We have two females from Durban.

Viciria flavipes sp. nov.

Plate XXVI, fig. 7.

This is a yellow species with a red V on the cephalic plate and pink iridescent scales on the abdomen.

♀. Length 8.2 mm. Legs 31$\overline{42}$, nearly equal in thickness.

There are white hairs on the cephalic plate which contrast with a red V which has its apex between the middle eyes of the first row, and a red band on each side, passing from between the lateral and middle eyes back around the small eye of the second row, and below it on to the side. There is also a small red spot in front of each dorsal eye. The sides and thoracic part seem to have been covered with white hairs. The abdomen has a white band across the front end, and behind this a transverse band of pink iridescent scales. From this a median band of light brown metallic scales, growing darker as it goes backward, and edged with white in the posterior part, passes to the spinnerets. On either side are alternate bands of white hairs and light brown metallic scales. The clypeus is covered with white hairs. The legs are yellow with dark punctate dots and brown spines. On the tibia of the first are inferior and lateral spines, the former being sometimes slightly irregular, and sometimes arranged in three pairs. The tibia of the second has three on the posterior and two on the anterior side, with lateral spines. The metatarsi of the first and second have two pairs. The palpi are white, the falces yellow. The under surface is yellow with a broad sooty-black band throughout the length of the venter. *Flavipes* resembles *morigera* but the double spines of that species serve to distinguish it.

We have females from Durban and Willowmore.

Viciria alba sp. nov.

Plate XXVI, fig. 8.

A rather large, pale species.

♂. Length 10.3 mm. Legs $31\overline{24}$, nearly equal in length, first and second pairs slightly stouter than the others.

The cephalothorax, with the exception of the eye region, is smooth and pale. The region enclosed by the eyes is covered with light, silky, iridescent hairs, and is surrounded by a ring of beautiful red spots which are placed around and between the eyes, two of them appearing between the eyes of the third row.

The abdomen, in our specimen, has been rubbed, and shows a pale, smooth surface, covered with reticulating dark lines, and some patches of silky hairs like those on the eye region. Just in front of the spinnerets there is a dark spot. The venter, which is pale with reticulating lines, shows a similar dark spot at the posterior end. The sternum is yellow. The mouth-parts are white, tipped with black. The falces are large, long and vertical, and are pale, with reddish fangs. The legs are white tipped with black and have many black spines, the tibia of the first and second having three, and the metatarsi two pairs without lateral spines. The palpi are white with dark specks and long white hairs.

We have one female from Salisbury, Mashonaland, sent by Mr. Marshall.

Viciria parmata sp. nov.

Plate XXVI, figs. 5, 5a.

♂. Length 9.5 mm. Legs $1\overline{23}4$, first and second pairs plainly stoutest, and third pair stouter than fourth.

This is a dark species with white markings. The legs are dark and hairy excepting the metatarsi and tarsi which are yellow.

In one of our specimens the third and fourth pairs of legs are light, and the abdomen is pale brown with a black band around the front end, but as a usual thing the body, legs and palpi are dark brown or black. So far as we can judge of the markings, the upper surface of the cephalic plate is dark with a central white band, while bright red hairs surround the eyes. The sides have wide black bands at the lower margin, and, above these, wide white bands which curve up on to the thoracic part. The abdomen has a median longitudinal band of silvery metallic scales, which become iridescent in the posterior half. The legs of the first pair have, on the patella and tibia, moderately long black fringes above and below, and the first and second legs have the femur iridescent. The third and fourth legs are more brownish than the first and second, and all four pairs have the metatarsi and tarsi yellow or white. The falces project a little, and are long and strong. They are black, with slight iridescence, and have some long white hairs on the inner sides, and a bunch of white hairs opposite the fang. The clypeus has a few long white hairs.

In the light brown variety the coxæ and trochanters grow pale from the first to the fourth pair, while in the dark variety these joints are black.

We have several males from Durban.

Pellenes rufoclypeata sp. nov.

Plate XXVII, figs, 1, 1a.

In this species the high clypeus is red.

♂. Length 4.9 mm. Legs $\overline{1}342$, first and second stoutest.

The cephalothorax is high and convex, rounding off in both directions from the dorsal eyes. It is a little the widest in the middle of the thoracic part. The quadrangle of the eyes is about equally wide in front and behind. The front middle eyes are close together, the lateral being more than half as large and a little separated from them. This row is slightly bent. The second row is about halfway between the others, and the third row is nearly as wide as the cephalothorax. The falces are moderately long and strong, with one tooth on the inferior margin. The sternum is rounded and truncated in front. The anterior coxæ are separated by more than the width of the labium, which is as wide as long.

The ground color of the cephalothorax is brown, darker in the thoracic than in the cephalic part. From the hairs that are left on our specimen the upper surface and sides must have been covered with white and bright red hairs, and there are two white bars on the thoracic part. Around the front eyes, and covering the high clypeus are short hairs of a crimson color, quite different from that of the red on the back of the spider, which has a shade of yellow. The abdomen is paler than the cephalothorax and is more or less mottled with black. It seems to have been covered with red and white hairs, but with the exception of a white band around the front end and three white bars on the sides, the pattern is indistinguishable. The palpus is dark with a spot of white hairs on the tibia and one on the patella. The first and second legs are dark brown with slight black fringes under the tibiæ. The third and fourth legs are light brown, barred with dark.

We have one male from Durban, sent by Mr. Leigh.

Pellenes Beanii sp. nov.

Plate XXVII, figs. 2—2c.

Length, ♂ ♀ 4.5 mm. Legs, 1342, first much the stoutest.

The cephalothorax is moderately high, the cephalic and thoracic parts being nearly on the same plane, the cephalic part slanting forward a little, while the thoracic falls very slightly in the first half, and then abruptly. It is a little narrower in front than behind, the sides being parallel in the middle. The quadrangle of the eyes occupies about two-fifths of the length, is one-third wider than long, and wider behind than in front. The anterior eyes are all subtouching, and form a straight row, the middle being twice as large as the lateral. The second row is halfway between the other two, and the third is as wide as the cephalothorax at that place. The falces are short, vertical and parallel, with a short fang and one tooth on the lower margin. The sternum is oval, and truncated in front. The coxæ of the first legs are separated by the width of the labium, which is as wide as long.

In the male the cephalothorax has a dark ground color. A white band crosses the clypeus, just above the falces, and widening as it goes backward, extends around the lower margin. A second white band passes along the upper sides of the cephalic part, just below the eyes, and crosses the upper surface behind the dorsal eyes. On the cephalic plate is a white region which is wide over the first row of eyes, and narrows to a point, between the dorsal eyes. On the front faces of the falces are two or three fine lines of white hairs. The abdomen is of a dark reddish-brown color with three curved transverse white bands across the dorsum. Behind the second band is a central white spot, and a central longitudinal white line connects the third band with the spinnerets. The sides are streaked with yellowish-white hairs, which are also found on the venter and sternum. The palpus has the femur, patella and tibia covered with white hairs, while the tarsus is dark. The legs of the first pair, which are much stouter than the others, have the femur, patella and most of the tibia light yellowish-brown, while the extreme end of the tibia, the metatarsus and the tarsus are darker colored. There is a light fringe of white hairs running along the under face of the femur and the inner face of the patella and part of the tibia, black hairs being intermixed on these latter joints, and there is a short fringe of light and dark hairs on the upper edges of the patella and tibia. The other legs are dark brown with sparse short white hairs.

In the female the ground color is darker, the cephalic region has the sides entirely covered with white hairs, and the shape of the white region on the cephalic plate is reversed, since it begins in a point between the anterior middle eyes and has its broad end in front of the dorsal eyes. The sides of the abdomen are white. In other respects it resembles the male.

We have one male and one female from Algoa Bay, South Africa, sent to us by Dr. Brauns.

Habrocestum.

We have four new species of *Habrocestum* from South Africa, *dotatum* from Mashonaland, *luculentum* from Cape Colony, *Laurae* and *Annae* from Durban. They all have the mouth-parts small, and the labium as wide as long; and in all, the quadrangle of the eyes is a little wider in front than behind.

Habrocestum Laurae sp. nov.

Plate XXVII, figs. 5, 5a.

♀. Length 5.1 mm. Legs $3\overline{412}$, about equal in thickness.

The first row of eyes is curved upward, the middle eyes being nearly twice as large as the lateral, which are separated from them. The second row is halfway between the other two. The sternum is oval and not much longer than wide.

The cephalothorax and abdomen are thickly covered with a mixture of short white, red and black hairs, the markings being formed by a concentration of one or another of the colors. On the cephalothorax, between the dorsal eyes, are two white spots, close together, and just in front of these, two more, which are a little separated. The abdomen has fine black points on the base and sides, a white spot edged with black on the middle of the dorsum, and back of this two curved dark bands, like a parenthesis. There are white rings around the eyes, and long snow-white hairs on the wide clypeus. The falces, which are moderately long and stout, are brown with a few white hairs. The palpi are pale with white hairs. The legs, with the exception of the proximal ends, which are pale and hairless, are rather dark, and are covered with hairs like those on the body.

We have two females from Durban.

Habrocestum Annae sp. nov.

Plate XXVII, figs. 4, 4a.

♀. Length 6 mm. Legs 3412, first and second a little stoutest.

The first row of eyes is straight with the middle eyes less than twice as large as the lateral, which are scarcely separated from them. The second row is nearer the first than the third. The sternum is oval and long.

The cephalothorax is covered with a mixture of red and white hairs, the white predominating on the sides and the red above. On the upper sides, just below the eyes, these hairs form two short longitudinal white bands, with red between. The face has, below the lateral eyes, four white lines on a dark background, the lower two of which cross the wide clypeus. These lines pass around, on the sides, to a point just behind the lateral eyes. The falces are rather short and stout, brown in color, with some long white hairs. The abdomen is also covered with white and red hairs, the front end being whitish. Two slender white lines run back, on the dorsum, to the middle point, and behind this is a series of lighter and darker chevrons. On each side are two curved white bands. The palpi are brown with white hairs. The legs have the proximal ends pale, but are otherwise brown with a good covering of white and red hairs.

We have two females from Durban.

Habrocestum dotatum sp. nov.

Plate XXVII, figs. 6, 6f.

Length, ♂ 6.5 mm., ♀ 7 mm. Legs, ♂ 1342, ♀ 3412; first and second stoutest.

The sternum is oval in the female, round in the male. The falces are long and rather stout. The first row of eyes is curved downward, with the middle twice as large as the lateral in the male, and nearly twice in the female. The lateral are a little separated from the middle eyes. The second row is nearer the first than the third.

The male is brown, much darker than the female. The eye-region is covered with dull golden hairs. On the thoracic part are some patches of yellow hairs and six white spots, one under each dorsal eye, a smaller one further back, and two behind, on the thoracic slope. There are bristly white hairs on the clypeus and also on the falces, particularly running down the outer sides. Under the lateral eyes are short white hairs marked by two dark lines. The abdomen is black on each side, above, with white hairs at the base and in a central band, the latter being edged with yellow. It is crossed by a curved yellow band, behind the middle. The sides are covered with yellow hairs, and have three oblique snow-white spots. The legs are dark brown with black hairs underneath. Above there are patches of short yellow hairs, and spots of pure white hairs at the proximal ends of the joints. On the tarsi of the first and second legs these white hairs grow upon a yellow ring. The palpus has some white hairs, but many more black ones. The venter is pale, with a dark line down the middle, and dark sides.

In the female the eye-region is covered with dull golden hairs. On the sides and thoracic part streaks of yellow and black hairs run upward from the margin. The middle of the clypeus, the falces and the palpi are covered with bristly white hairs, the falces having also some short black bristles. Under the lateral eyes, running backward, are alternate lines of white and yellow hairs, very characteristic and striking in appearance. The abdomen is mottled with black and yellowish hairs, there being a darkening of color on each side of the middle. The sides are marked with three oblique white bands.

Under alcohol the abdomen has a light colored longitudinal band, of irregular outline, down the middle, and mottled blackish bands, which are more or less broken into large spots, on the sides. In the posterior third a curved yellow line comes up over each side and runs into the central band, which, behind this point, is broken into two or three chevrons by the crossing of dark lines. Just above the spinnerets is a large dark spot. Below the dark side bands the abdomen is light colored. The venter is light with three fine longitudinal dark lines. The palpi are light, with long light hairs, and two small dark spots on the dorsal face. The legs are yellowish-brown with a few dark spots. Under the tibiæ of the first and second are three pairs of spines, and under the metatarsi, two pairs. The third and fourth legs have strong spines, not in pairs.

We have one male and several females from Mashonaland, received from Mr. Workman, and Mr. Marshall.

Habrocestum luculentum sp. nov.

Plate XXVII, figs. 3, 3a.

♂. Length 3.5 mm. Legs $31\overline{42}$, first pair stoutest, third much the longest.

This is a small species with the cephalothorax longer than the abdomen. The first row of eyes is a little curved upward, the middle eyes being less than twice as large as the lateral, which are close to them. The second row is nearer the third than the first. The sternum is small and almost round. The clypeus is wide.

The integument is black. The eye-region is covered with reddish hairs, excepting a wide white central spot which runs forward between the large eyes of the first row. The thoracic part, in our specimen, is rubbed bare. The abdomen is also somewhat rubbed, but seems to have had the back covered with reddish hairs, a white band around the base and sides, and a wide transverse white band a little way in front of the spinnerets. The front faces of the first and second legs are black. The legs are otherwise brown, and seem to have been well covered with short white and red hairs. The palpi are entirely covered with long, snow-white hairs. The falces are short and weak, and brown in color.

We have one male from Cape Colony.

Langona avara sp. nov.

Plate XXVIII, figs. 5, 5a.

♂. Length 5 mm. Legs $34\overline{12}$, almost equal in thickness.

The cephalothorax is long and rather narrow in front. The front row of eyes is plainly curved, the second row is nearer the third than the first, and the third is nearly as wide as the cephalothorax. Our specimen is damaged so that we cannot be sure of the color. The whole spider is black with a covering of mixed white and red hairs on the cephalothorax and three longitudinal bands of the same hairs on the abdomen, one central, which in our specimen is interrupted, perhaps from the rubbing away of hairs, and the others low on the sides. The face view is very striking. The four anterior eyes, instead of being of the usual dull, opaque hue, are bright, emerald green in a setting of pale red hairs, which surround them and cover the wide clypeus. Above the red hairs, forming a sort of eyebrow, is a projecting ridge of stiff black hairs. The legs are light brown, with black and white hairs and pale spines. The palpi are covered with light brownish hairs. The falces are weak and pale.

We have one male from Manica Mts., Mashonaland, sent by Mr. Marshall.

Phlegra imperiosa sp. nov.

Plate XXIII, figs 7, 7a.

♀. Length 5.8 mm. Legs 4312, first pair stoutest, second next. Fourth longer than third by metatarsus and tarsus. Tibiæ of first and second with three inferior spines and one lateral; metatarsi with two pairs below.

This is a brown species, the cephalothorax being a little darker in color than the abdomen and legs.

The quadrangle of the eyes is very short, occupying scarcely one-third of the cephalothorax. The anterior eyes are subtouching, in a curved row, the middle being less than twice as large as the lateral. The second row is plainly nearer the first than the third. The third row is nearly as wide as the cephalothorax at that place, the eyes being large and prominent. The cephalothorax, abdomen, and legs are covered with a mixture of red, black, and white hairs, giving a uniform bright brown tint. Around the lower edge of the cephalothorax is a white line edged with black, and on the clypeus the hairs are white. The under parts are brown, the labium and maxillæ being tipped with white. The small, retreating falces are brown.

We have two females from Robben Island, Table Bay, Cape Peninsula, collected by Mr. R. M. Lightfoot.

FISSIDENTATI.

Tusitala P. 1902.

Plate XVIII, figs. 2–2b.

The cephalothorax is high, with the sides sloping outward from the upper surface and widening in a gentle curve from front to back, the widest point being behind the dorsal eyes. The cephalic part is inclined forward, and the thoracic rounds off rather steeply from the third row of eyes. The quadrangle occupies from two-fifths to nearly one-half of the cephalothorax, is one-third wider than long and is wider behind than in front. The first row of eyes is straight or a little curved down; the eyes are large, the middle being less than twice the size of the lateral and subtouching, while the lateral are well separated from them. The second row is equally distant from the first and third or is a little nearer the first, and the third is narrower than the cephalothorax. The falces are long, strong, and vertical, and are bowed, with a compound tooth on the inferior margin. The males have a stiff ridge of hairs on the front face. The sternum is oblong and truncated. The first coxæ are separated by about the width of the labium, which is longer than wide.

This genus is founded upon *T. barbata* and includes *T. hirsuta* and *T. Braunsii,* both from South Africa.

Tusitala barbata P.

Plate XVIII, figs. 2–2d.

♂. Length 6.5 mm. Legs 1432, about equal in thickness. The first pair is plainly the longest but the others do not differ much in length.

The cephalothorax is covered with a mixture of red, yellow and white hairs, the red predominating on the sides, and the white on the upper surface. The clypeus is less than half as wide as the middle eyes of the first row, and is yellow with a few white hairs. The falces are light brown, and have a remarkable ornament in the shape of a long ridge of stiff hairs down the front face. These hairs stand out stiffly, but their tips curve inward to meet those of the opposite side in the middle line. Their color is snowy-white on the upper half and deep black on the lower. The palpus is slender with long joints, the tibia much exceeding the tarsus. The femur and tarsus are dark colored, the patella and tibia, pale. The legs are brown with darker bars. The abdomen is covered with a mixture of gray and brown hairs. There is a white band around the base, and the posterior dorsum has some indistinct white chevrons.

We have six males from Algoa Bay, South Africa, sent to us by Dr. Brauns.

Tusitala hirsuta P.

Plate XXVIII, figs. 3, 3a.

♂. Length 8 mm. Legs 1234, first and second a little the stoutest.

In our single specimen the cephalothorax is much darker than the abdomen but both are rubbed quite bare of markings excepting some long white hairs at the front end of the abdomen. The clypeus is as wide as the large eyes of the first row, and is brown with long white hairs. The falces are long and strongly bowed, approaching each other at the extremities. They have ridges of stiff hairs, as in *T. barbata*, on the front faces, which are light brown in color and grow longer and thicker in the lower than in the upper half. The palpus is long and slender, the tibia being much longer than the tarsus. The patella and tibia are much lighter in color than the femur and tarsus. The legs are brown, the first and second pairs being darker than the third and fourth.

We have one male from Zululand, given to us by Rev. Henry C. McCook.

Tusitala Braunsii, P.

Syn. Monclova Braunsii P., 1902. Upon further study we believe that *Monclova* P. should be included in the genus *Tusitala*.

Plate XXVIII, figs. 1, 1d.

♀. Length 7 mm. Legs $\overline{43}\overline{12}$, the third and fourth plainly longer than the first and second.

The spider is covered with a mixture of white, black, and bright rufus hairs, the different colors predominating on different parts so as to form the markings. Thus the cephalic plate is bright rufus and the middle line on the thoracic part pure white, while the abdomen shows a white band around the anterior end, and, on the posterior part of the dorsum, wide alternating transverse bands of rufus and black. These bands are not parallel but run upward and forward from the sides. The clypeus has long white hairs, and these are continued, rather sparsely, on to the falces. The legs are not conspicuous, being of a light brown color with darker rings and white hairs. The light brown palpus is covered with white hairs.

We have four females, sent by Dr. Brauns, from Cape Colony.

Tularosa gen. nov.

Plate XXVIII, figs 4–4c.

This genus belongs to the Fissidentati, as the inferior margin of the falx bears a compound tooth. The indentation on one side, however, is sometimes more marked than on the other.

The species are of medium size. The cephalothorax is rather high, and, in the males, is so widely rounded as to make the outline almost circular, while in the females it is plainly longer than wide, and is widest in the thoracic part. The highest point is at the dorsal eyes, the slope in the cephalic and in the anterior thoracic parts being very slight. The quadrangle of the eyes is one-third wider than long, is a little wider in front than behind, and occupies two-fifths of the cephalothorax. The front eyes are large, close together, and form a straight row, the middle eyes being twice as large as the lateral in the males, and less than twice in the females. The second row is halfway between the first and the third, or is nearer to the first. The third row is narrower than the cephalothorax, especially in the males. The sternum is oval and is truncated in front. The front coxæ are separated by the width of the labium, which is longer than wide in the male, and about as long as wide in the female. On the first and second legs the tibia has three pairs of inferior spines and the metatarsus two pairs. There are lateral spines excepting on the metatarsus of the first, where they are lacking. The third and fourth legs have numerous spines. We have two species of *Tularosa, Ogdenii,* and a second one, still unpublished.

Tularosa Ogdenii sp. nov.

Plate XXVIII, figs 4–4d.

♀. Length 8.5 mm. Legs $\overline{34}\overline{12}$, first pair a little the stoutest, third and fourth plainly longest.

The cephalothorax is not at all convex but slopes gradually in both directions, from the dorsal eyes.

Under alcohol the sides and back of the cephalothorax are yellow, with a black margin and a band of dark spots which crosses the thoracic part and passes forward along the sides, while the eye-region is bright reddish-brown, with a black border, which forms a deep scallop between the dorsal eyes. The abdomen appears yellow, mottled with brown.

Our specimens are somewhat rubbed. When dry, patches of yellow and red hairs appear on the cephalothorax, the red coming out brightly around the dorsal eyes. Above the front eyes the hairs are yellow, on the clypeus they are white, and on the yellow palpus they are yellowish-white mixed with black. The falces are reddish-brown, like the eye-region. The abdomen seems to have been covered with light yellow hairs, a curved transverse band of red hairs crossing the back behind the middle. Back of this, on each side, is an elongated spot of dark brown hairs, surrounded by red hairs. The legs are yellow, with short yellow hairs and black spines. The first leg has one dark spot under the femur, and two under the tibia. The venter is yellow with some dark specks.

We have numerous females from Mashonaland and Durban. The species is named for our friend Dr. H. V. Ogden, of Milwaukee.

Mexcala P. 1902.

Plate XXIX, figs. 1–1d.

The cephalothorax is moderately high. It widens out more below than above, and is broader in the posterior part than in front. The quadrangle of the eyes occupies a little more than one-third of the cephalothorax, is one-sixth wider than long, and is equally wide in front and behind. The anterior eyes are moderately large, the middle being less than twice as large as the lateral, and form a slightly curved row. The middle eyes are subtouching, with the lateral a little separated from them. The second row is halfway between the other two. The third row is a little narrower than the cephalothorax. The falces are vertical and stout, with a short fang, and have one conical tooth on the inferior margin. The sternum is truncated in front. The first coxæ are separated by about the width of the labium, which is longer than wide. The pedicle is not visible. There are no constrictions. The abdomen is narrow in front and then widens.

Mexcala is distinguished from the other ant-like genera of this region by having a single conical tooth on the inferior margin of the falx.

Mexcala rufa P.

Plate XXIX, figs. 1–1d.

♂. Length 8 mm. Legs 4132, almost equal in stoutness, femora slightly thickened.

The cephalothorax is dark colored with a few black hairs on the eye-region, and some tiny white scale-like hairs on the front of the falces, and the lower edge of the clypeus, which pass around a little way, on to the sides of the cephalic part. The legs and palpi are black. The abdomen in our specimen is rubbed, but seems to have been entirely covered with golden-yellow hairs which shade to white on the venter.

We have one male from Cape Colony, sent to us by Dr. Brauns.

Mexcala elegans sp. nov.

Plate XXIX, figs. 2–2d.

♂. Length 6 mm. Legs 4132, all slender.

This species is not strikingly ant-like. It differs from *rufa* in having the first row of eyes straight, and in the coloring and size, but the palpi of the two are alike.

The body is covered with bluish-gray hairs, which look, under the microscope, like elongated scales. There are three transverse black bands on the cylindrical abdomen, which show best under alcohol. The front faces of the falces are covered with white, rice-like scales. The legs have the femoral joints dark colored while the patellæ, tibiæ and metatarsi are marked with longitudinal black and white lines, most distinct on the first and second pairs. In the first leg the tarsi are pure white, but in the others they have the longitudinal lines through a part of their length. The palpus has white hairs on the patella, tibia and tarsus, and a dark band on the upper side of the patella and tibia.

We have one mature and one immature male from Manica Mountains, Mashonaland, sent to us by Mr. Marshall.

Myrmarachne Marshallii sp. nov.

Plate XXIX, figs. 6–6b.

♂. Length 6.5 mm. Length of cephalothorax 3 mm. Length of falces 2.7 mm. Legs 4132.

♀. Length 6 mm. Legs $41\overline{32}$.

The whole spider is black, covered with fine yellowish pubescence. There is a deep constriction in the cephalothorax between the cephalic and thoracic parts, and a slighter one in the abdomen, near the anterior end. The female has two white rings on the abdomen, one in the constriction and one behind the middle. In the male the first leg has the femur, metatarsus and tarsus dark, while the patella and tibia are light with a dark line on each side. The second leg is yellow with black lines along the sides, more distinct in front than behind. The third leg has the coxa, trochanter and femur black and the other joints brown, with faint lines. In the fourth leg the coxa and trochanter are white, the femur is black, and the other joints are brown. The male has the palpus black and the falces brown, long, and horizontal, with a long curved fang, which has a hook near the base. The teeth on the lower margin are short and small, while on the upper they are long and numerous. The upper surface is rugose.

In the female the falces are short, vertical, parallel, and of a light reddish color. The palpi are light brown and have the tarsi enlarged. The first and second legs are light yellow with black lines on their front faces. The third leg is dark as far as the end of the patella, the other parts being light. The fourth leg has the coxa, trochanter, and proximal end of patella light yellow, and the rest dark.

We have a male and female and several immature specimens from Mashonaland, sent to us by Mr. Guy A. K. Marshall, for whom we have named the species.

In the genus *Myrmarachne* we have three males *(Marshallii, solitarius, ichneumon)*, and two females *(Marshallii, ichneumon)*. These are distinguished as follows: Of the males, *Marshallii* and *ichneumon* have at least seven teeth on the upper margin of the falx, while *solitarius* has three large teeth. In *Marshallii* the total length is 6.5 mm, and the fourth leg 9 mm. In *ichneumon* the total length is nearly 8 mm, and the fourth leg 6 mm. In *solitarius* the total length and the length of the fourth leg are both 4.5 mm. The two females are distinguished by their color and the epigynes.

Myrmarachne ichneumon E. S.

♀. Length 6.6 mm. Legs $4\overline{13}2$.

The front eyes are close together, in a row which is curved downward, the middle being nearly twice as large as the lateral.

The spider as a whole is yellow. The eye-region is black, and there seems to have been a white band in the post-ocular constriction. The pedicle is long. The first third of the abdomen, which is square, and ends in a raised ridge, seems to have been covered with white hairs. The middle third is covered with white hairs, and the posterior third is dark in front and covered with white hairs behind, excepting a dark line around the base of the spinnerets. The legs are yellow, with a longitudinal black line on the anterior faces of the patellæ and tibiæ, and a similar but less distinct line behind.

We believe that only the male of this species has been described, up to this time. We have several females, as well as a male, from Mashonaland, where they were collected by Mr. Marshall.

Myrmarachne solitarius sp. nov.

Plate XXIX, figs. 5, 5a.

Length, ♂. 4.5 mm. ♀. 5 mm. Legs $4\overline{13}2$.

The front eyes are close together in a row which is a little bent downward, the middle being nearly twice as large as the lateral. The pedicle is long.

The whole spider is dark colored. There are two constrictions, one just behind the third row of eyes and one near the front end of the abdomen, and each of these is encircled with a band of white hairs. Where the hairs are rubbed off, in the female, the color below is yellow. In the male the cephalic part is darker than the rest of the cephalothorax, and the abdomen, which is a good deal rubbed, is black and glabrous with a thin scattering of white hairs. Under alcohol the coloring of the legs is as follows: In the male all the femora are dark, those of the third pair being a little lighter than the others. The first leg has the patella and tibia yellow, the metatarsus dark, and the tarsus pale yellow. There are indistinct, longitudinal dark lines on the front and back sides of the patella and tibia. The second leg, excepting the femur, is light. The third leg has the patella yellowish-brown with a dark line in front, and the tibia, metatarsus and tarsus yellow. In the fourth leg the proximal half of the patella is light and the distal half is brown. The tibia and metatarsus are brownish yellow and the tarsus paler. The coxæ of the first and second pairs are light, of the third and fourth, dark. The trochanters of the first, second and fourth are light, the third, dark.

In the female the first leg has the proximal two-thirds of the femur and the whole of the metatarsus dark. The other parts are yellow with a narrow, dark, longitudinal line on each side, running as far as the metatarsus. The second leg is yellow, with a wide, dark, longitudinal band on each side, running as far as the metatarsus. The third leg has the femur dark and the other joints yellow. There is one longitudinal dark band on the patella, and a dark line on each side of the tibia and metatarsus. The fourth leg has the femur dark, the patella dark at the ends with a yellow ring in the middle, the tibia and metatarsus brown, but not so dark as the ends of the patella, and the tarsi yellow. The coxæ of the first and second legs are light; of the third, dark; and of the fourth, part dark and part light. The sternum, maxillæ and labium are brown. The falces are brown, and nearly vertical. The palpus is brown with a palette-shaped tarsus.

We have one female, collected by Mr. Lightfoot at Retreat Flats, and one male, collected by Mr. Purcell at Devil's Mountain, Cape Colony.

Kima P. 1902.

Plate XXIX, figs. 3–3d.

This genus belongs to the Ant-like Group. The cephalothorax is moderately high in the cephalic part, the thoracic falling gradually from a groove behind the dorsal eyes. The sides, nearly parallel throughout most of their length, contract, more or less, behind. The quadrangle of the eyes occupies two-fifths of the cephalothorax, is nearly as long as wide, and is equally wide in front and behind, or wider behind. The front row of eyes is straight or bent downward. The second row is plainly nearer the first than the third, and the third is nearly as wide as the cephalothorax. The falces are long, slightly divergent, and nearly horizontal, with a short fang. The inferior margin is unarmed, but the superior has a large compound tooth which is visible from above. The front coxæ are separated by more than the width of the labium, which is plainly longer than wide. The sternum has a long point behind and is truncated in front. There is a long pedicle, and the abdomen has a constriction in the middle.

The metatarsus of the first leg has two pairs of inferior spines, and the tibia three pairs, one near the proximal, and two near the distal end.

This genus is distinguished from *Quekettia* by its more antlike shape and by the abdominal constriction, as well as by the difference in the spines. *Kima* and *Quekettia* differ from *Araegeus* E. S., which also has no tooth on the inferior margin of the falx, by the shape of the sternum, which in *Araegeus* has a long point in front. The type species, *K. africana,* differs from *variabilis* in the following points: the sides of the cephalothorax contract suddenly, at the posterior end, forming a rather sharp angle, while in *variabilis* they round off gently; the quadrangle of the eyes is equally wide in front and behind, the front row being a little curved downward with the middle eyes about twice as large as the lateral; the relative length of the legs is different, and the coxæ of the first legs are black.

Kima africana P.

Plate XXIX, figs. 3–3d.

A large, ant-like species, with long slender legs and a long pedicle.

♂. Length 8 mm. Legs 4132, fourth much the longest.

We have but one specimen. The cephalothorax is without hairs, the color being dark reddish brown, deepening to black on the cephalic plate. The fourth legs are black throughout their length, but the others, although black near the body, shade to brown at the extremities. They are equal in thickness and are but scantily haired. The first leg has three pairs of spines under the tibia, and two pairs under the metatarsus. The palpi are black. The rather high black clypeus has a few short white hairs. The abdomen, which has a constriction in the middle, is covered with rich golden-yellow hairs, which shade to white on the venter. The falces are reddish-brown, and are flattened, with two teeth on the superior margin, at the distal end.

We have one male from Cape Colony, sent to us by Dr. Brauns.

Kima variabilis sp. nov.

Plate XXIX, figs. 4–4b.

A dark species, with long thin legs. The entire under surface is black excepting the coxæ of the first and second pairs of legs, which are perfectly colorless.

We have two males, one of which measures 11 mm. and the other 7.5 mm. in length. The relative length of the legs is 1432, the first and fourth being very much longer than the second and third, but all are equal in thickness.

The cephalic part is rather high. There is a groove behind the dorsal eyes, and from this point the thoracic part slopes gradually backward. The quadrangle of the eyes is a little wider behind than in front. The face is narrow, the front eyes forming a straight row, the middle being close together, while the lateral are somewhat separated from them and are more than half as large.

In our larger specimen the hairs are white, having perhaps, lost their color in the alcohol. The smaller one has the cephalothorax covered with yellowish-white hairs and the abdomen with yellow hairs, excepting a pure white band in the constriction, which runs down on each side of the venter. The first and second legs have the femur dark with pale streaks, the tibia and patella pale with a black band on each side, and the metatarsus and tarsus dark in the first pair and pale in the second. The third and fourth legs are mostly dark. The palpus is dark and the falces slightly bronze-colored. The under surface is dark, excepting the first and second pairs of coxæ, which are white, and make a striking contrast.

From Cape Town and Pt. St. John's.

Quekettia P. 1902.

The cephalothorax is rather low, and is narrow in front, widening out behind the third row of eyes and then contracting behind. The upper surface is flat and almost entirely on the same plane, there being the gentlest possible rise from the two ends to the dorsal eyes. It is a little wider below than above. The quadrangle of the eyes is very slightly wider than long, is wider behind than in front, and occupies two-fifths of the cephalothorax. The anterior eyes are subtouching, in a straight row, the middle being twice as large as the lateral. The second row is much nearer the first than the third, and the third row is not quite so wide as the cephalothorax. The falces are very short, vertical and parallel, with no tooth on the inferior margin. The sternum is oval, truncated in front. The first coxæ are separated by a little more than the width of the labium, which is as wide as long. The pedicle is not visible from above. The relative length of the legs is 4123, the first and second being short and much thickened, especially as to the femur and tibia. The type species is 6.5 mm. long.

The short chubby front legs are enough to distinguish *Quekettia* from others of the group. The type is our *Leptorchestes georgii* from Madagascar, *Ant-like Attidae,* p. 52.

This genus is named for Mr. J. F. Quekett, Curator of the Durban Museum, Natal, South Africa.

INDEX.

PLATE XIX.

EXPLANATION OF PLATE XIX.

Fig. 1, Massagris mirificus, male × 6; 1a, palpus.

Fig. 2, Portia durbanii, male × 4; 2a and 2b, palpus.

Fig. 3, Telemonia æquipes, male × 6; 3a, face and falces; 3b, mouthparts and underside of falces; 3c, palpus. The first row of eyes is really curved downward. The cephalothorax is drawn in a tilted position.

Fig. 4, Sonoita Lightfootii, male palpus; 4a, face and falces; 4b, side view of cephalothorax; 4c, sternum and mouthparts.

Fig. 5, Macopæus madagascarensis, epigynum.

Fig. 6, Cyrba dotata, epigynum.

Figs. 7 and 7a, Copocrossa bimaculata × 6.


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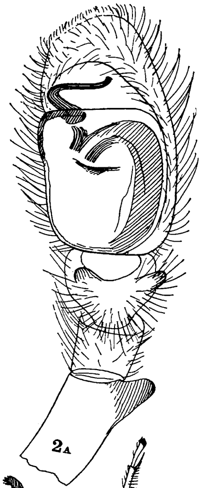
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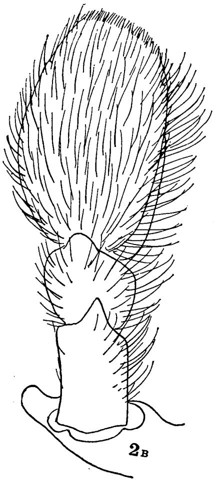
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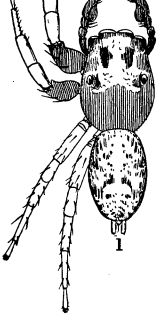
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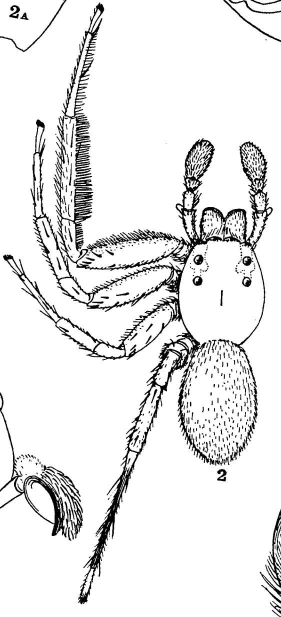
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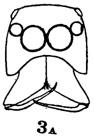
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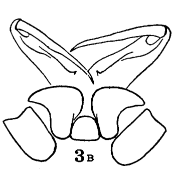
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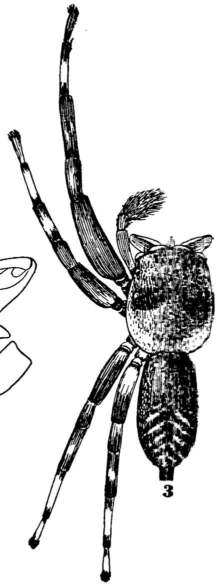
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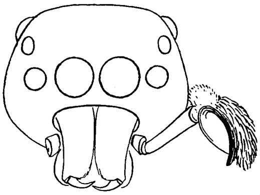
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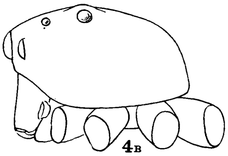
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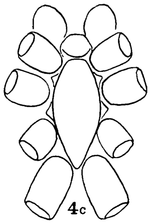
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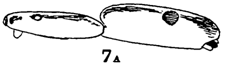
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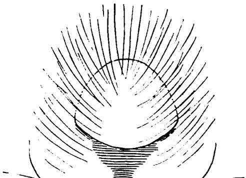
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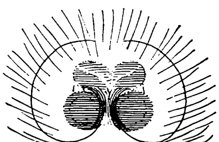
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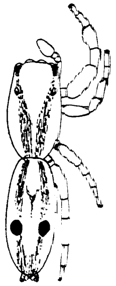
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PLATE XX.

EXPLANATION OF PLATE XX.

Fig. 1, Almota Quinii, male × 8; 1a, face and falces; 1b, side of cephalothorax; 1c, sternum and mouthparts; 1d and 1e, palpus.

Fig. 2, Heliophanus modicus, female × 8.

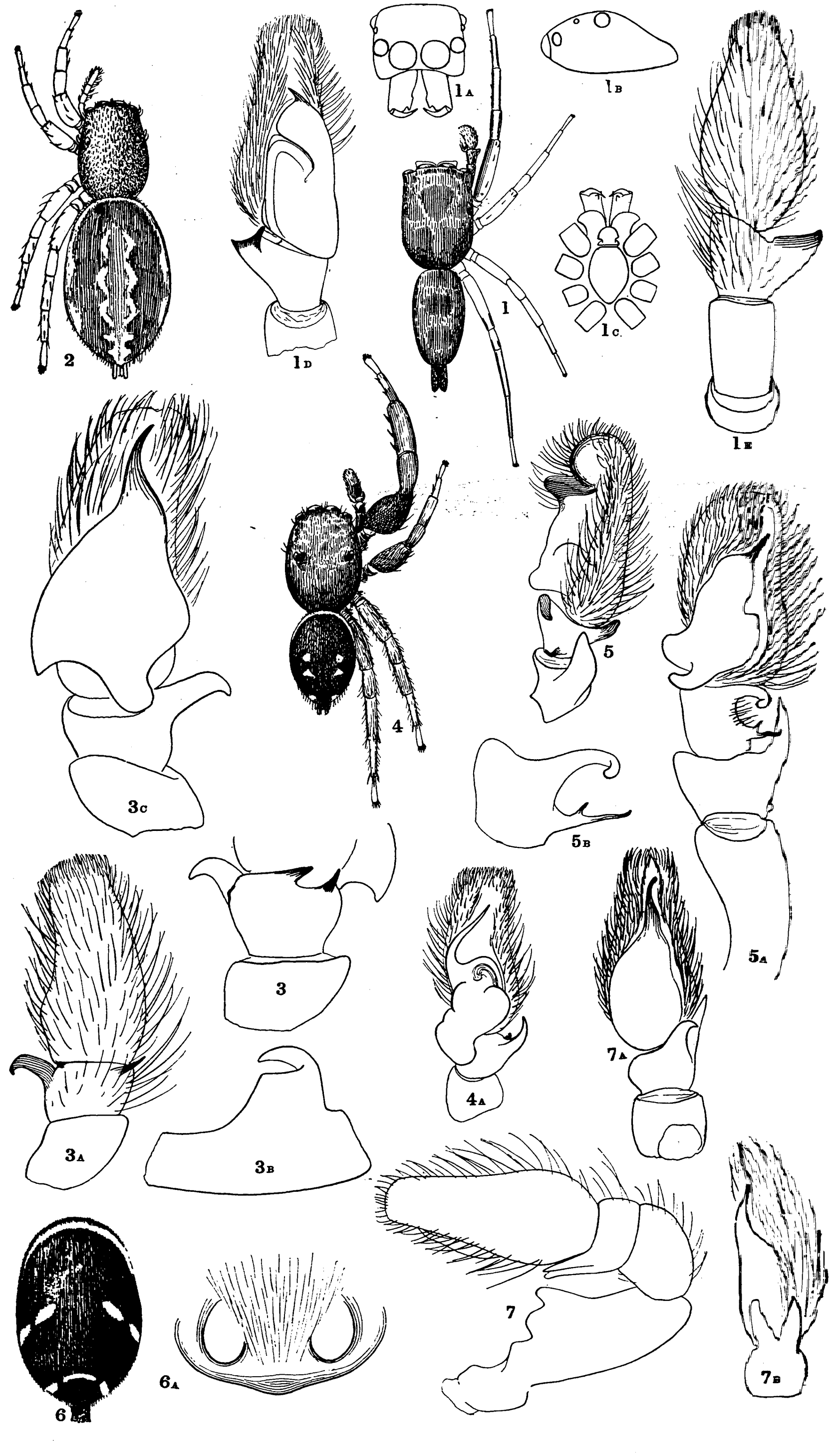
Fig. 3, Heliophanus deamatus, tibia of palpus, dorsal view tilted to one side; 3a, dorsal view of palpus; 3b, femur of palpus; 3c, under side of palpus.

Fig. 4, Heliophanus Marshii, male × 6; 4a, palpus.

Fig. 5, Heliophanus Marshallii, side view of palpus; 5a, under side of palpus; 5b, tibia of palpus.

Fig. 6, Heliophanus Beardii, abdomen of female × 8; 6a, epigynum.

Fig. 7, Heliophanus Prattii, palpus showing femur; 7a, under side of palpus; 7b, side of palpus.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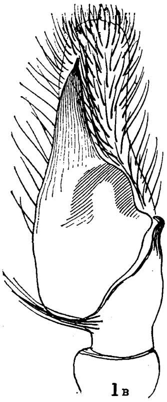
7B
6
6A

PLATE XXI.

EXPLANATION OF PLATE XXI.

Fig. 1, Cyllobelus chionogaster, male × 8; 1a, female × 8; 1b, palpus; 1c epigynum.
Fig. 2, Cyllobelus australis, female × 6; 2a, epigynum.
Fig. 3, Saitis mundus, male × 6; 3a, palpus.
Fig. 4, Saitis Leighii, male × 6; 4a, palpus.
Fig. 5, Saitis sapiens, male × 6; 5a, palpus.
Fig. 6, Heliophanus clarus, female × 6; 6a, epigynum.



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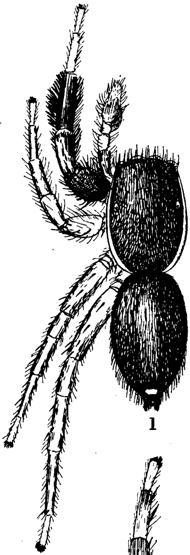

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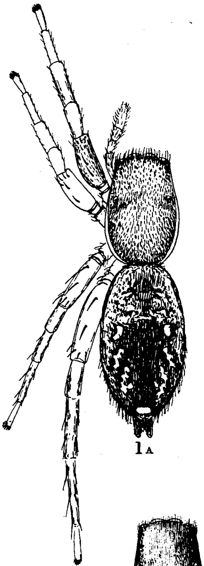

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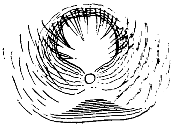

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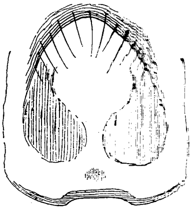

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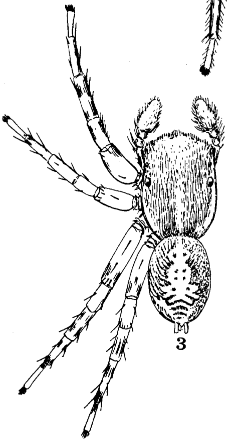

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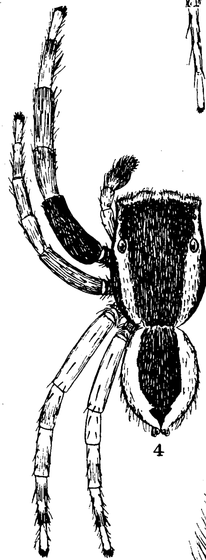

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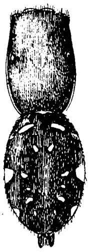

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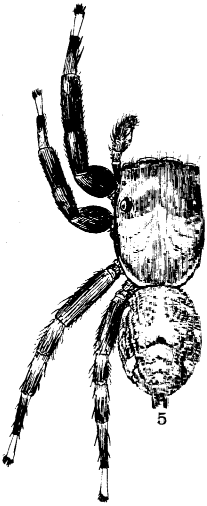

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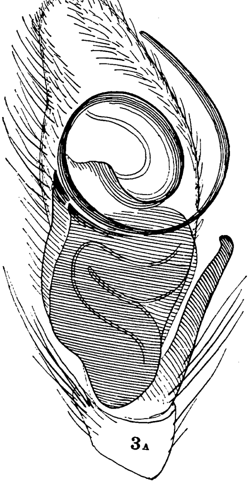

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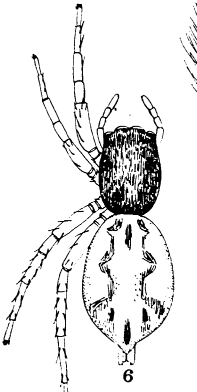

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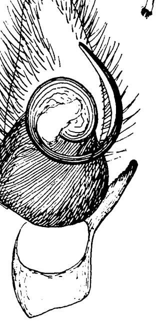

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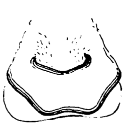

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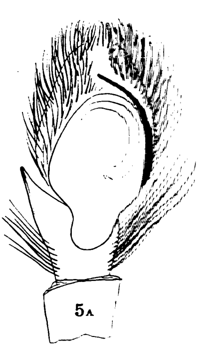


5A

PLATE XXII.

EXPLANATION OF PLATE XXII.

Fig. 1, Pochyta solers, abdomen of male × 6; 1a, palpus; 1b, face and falces.

Fig. 2, Parajotus obscurofemoratus, male under alcohol, × 4; 2a, palpus; 2b, sternum and mouth-parts; 2c, side of cephalothorax; 2d, face and falces. The last figure is incomplete because the hairs on the front of the falces have been omitted.

Fig. 3, Sittacus designatus, abdomen of female × 8.

Fig. 4, Euophrys Simonii, faces and falces of male; 4a and 4b, palpus.

Fig. 5, Euophrys Purcellii, male × 6; 5a, palpus.

Fig. 6, Euophrys Leipoldtii, epigynum.

Fig. 7, Euophrys infaustus, epigynum.

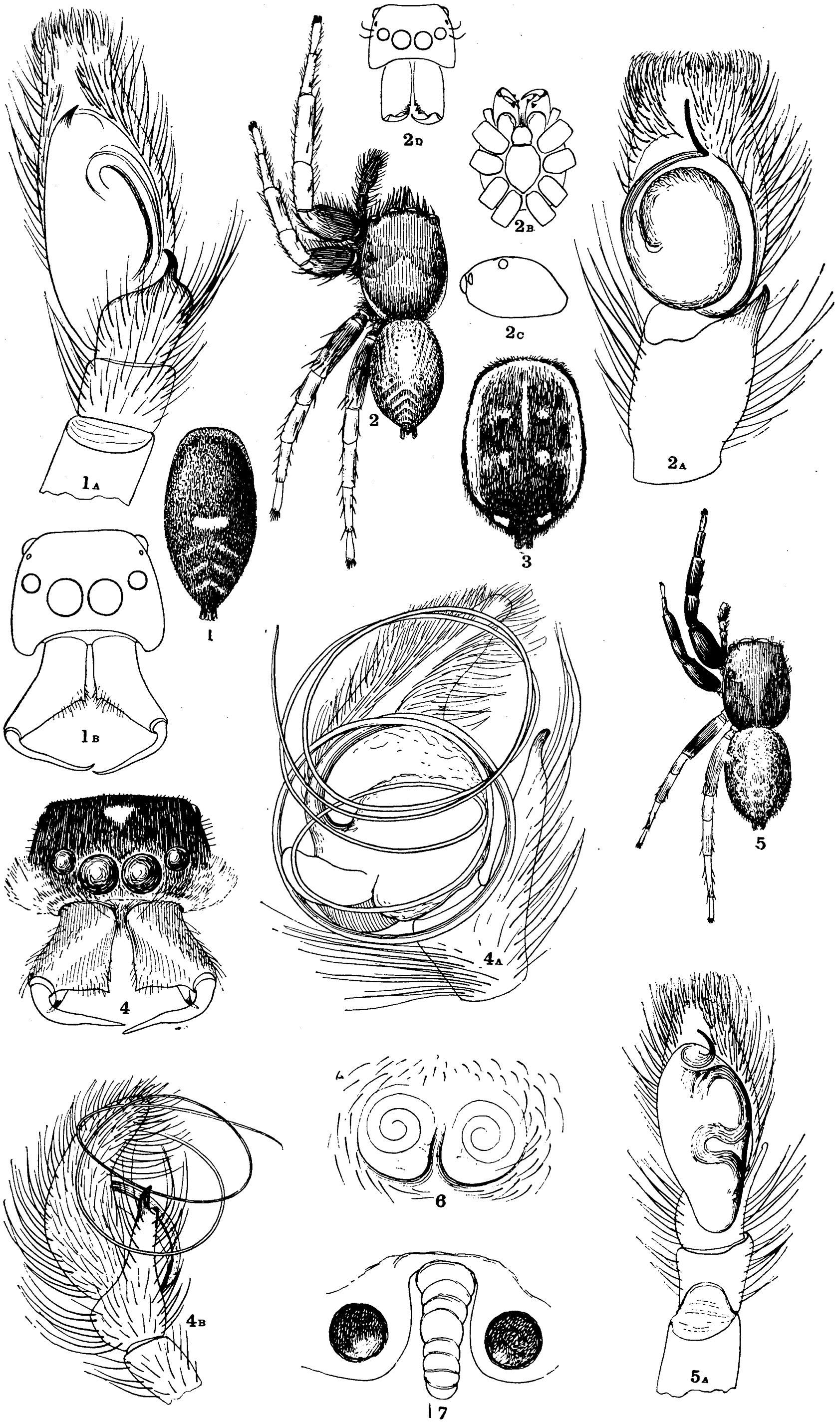

1A
2D
2B
2C
2
2A
1
3
1B
4
4A
5
4B
6
5A
7

PLATE XXIII.

EXPLANATION OF PLATE XXIII.

Fig. 1, Sittacus Uphamii, abdomen of female × 8; 1a and 1b, palpus; 1c, epigynum.

Fig. 2a, Hyllus perspicuus, abdomen of male × 4; 2b, abdomen of female × 4; 2b, palpus.

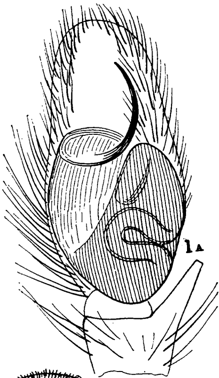
Fig. 3, Hyllus Treleavenii, female × 3; 3a, epigynum.

Fig. 4, Hyllus natalii, abdomen of female × 4; 4a, epigynum.

Fig. 5, Hyllus moestus, abdomen of female × 4; 5a, epigynum.

Fig. 6, Mendoza Carlinii, male × 6; 6a, female × 4; 6b, palpus; 6c, epigynum.

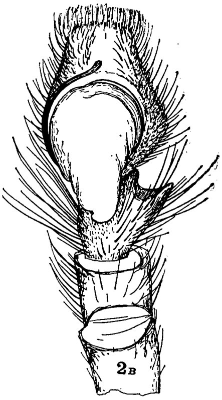
Figs. 7 and 7a, Phlegra imperiosa, two varieties of epigynum.


1A


1B


2A


2B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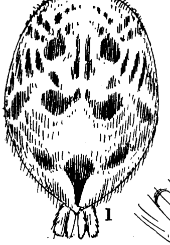
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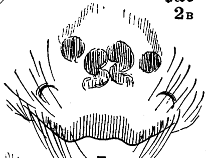
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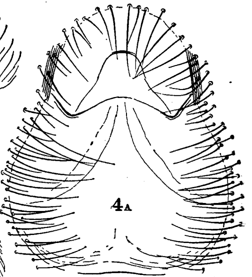
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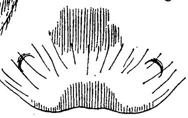
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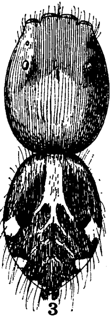
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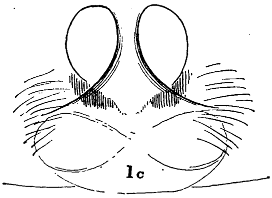
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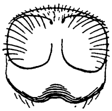
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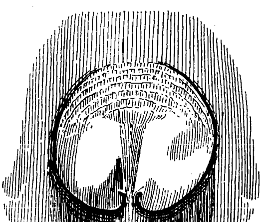
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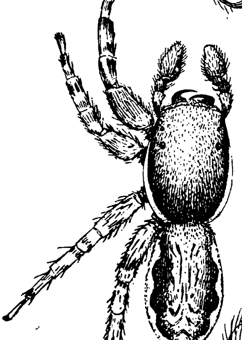
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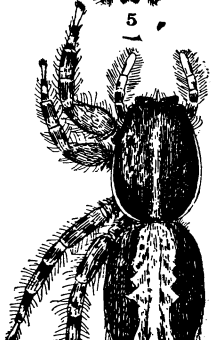
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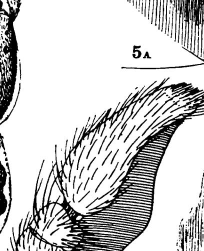
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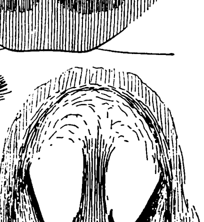

3A

PLATE XXIV.

EXPLANATION OF PLATE XXIV.

Fig. 1, Philæus manicus, male × 4; 1a, palpus.

Fig. 2, Baryphas ahenus E. S., male × 4; 2a, palpus; 2b, face and falces.

Fig. 3, Rhene biguttata, male × 6; 3a, falx from below; 3b and 3c, palpus.

Fig. 4, Rhene Banksii, male × 6; 4a and 4b, palpus.

Fig. 5, Homalattus punctatus, abdomen of female × 8; 5a, epigynum.

Fig. 6, Homalattus Marshallii, epigynum.

Fig. 7, Homalattus similis, epigynum.

Fig. 8, Homalattus obscurus, epigynum.

Fig. 9, Velloa modesta, male × 8; 9a, face and falces; 9b, sternum and mouthparts; 9c, side of cephalothorax.

Fig. 10, Velloa elegans, epigynum.

Fig. 11, Dendryphantes Purcellii, male × 6; 11a, palpus; 11b, epigynum.

Fig. 12, Bianor rusticulus, epigynum.

Plate XXIV.

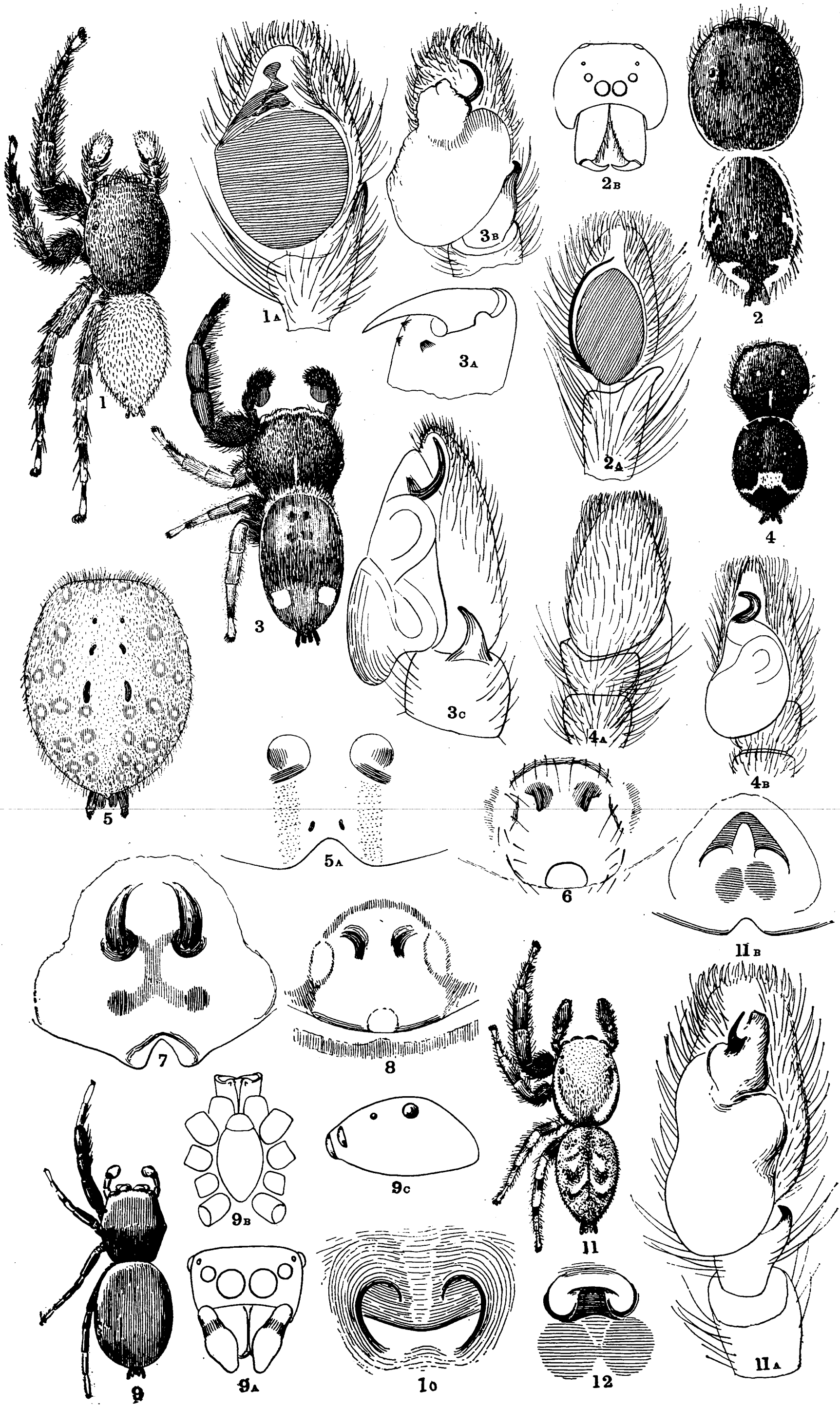


PLATE XXV.

EXPLANATION OF PLATE XXV.

Fig. 1, Thyene Leighii, male × 3; 1a, tibia of first leg; 1b, palpus; 1c, tibia of palpus.

Fig. 2, Thyene Ogdenii young female × 3; 2a, tibia of first leg of male; 2b, tibia of male palpus; 2c, mouthparts and falces from below; 2d, epigynum.

Fig. 3, Thyene pulchra, abdomen of female × 3; 3a, epigynum.

Fig. 4, Thyene natalii, female × 3; 4a, tibia of male palpus; 4b, epigynum.

Fig. 5, Thyene crudelis, abdomen of male × 3; 5a palpus; 5b, mouthparts and falces from below; 5c, tibia of palpus; 5d, tibia of first leg.

Fig. 6, Thyene australis, male palpus.

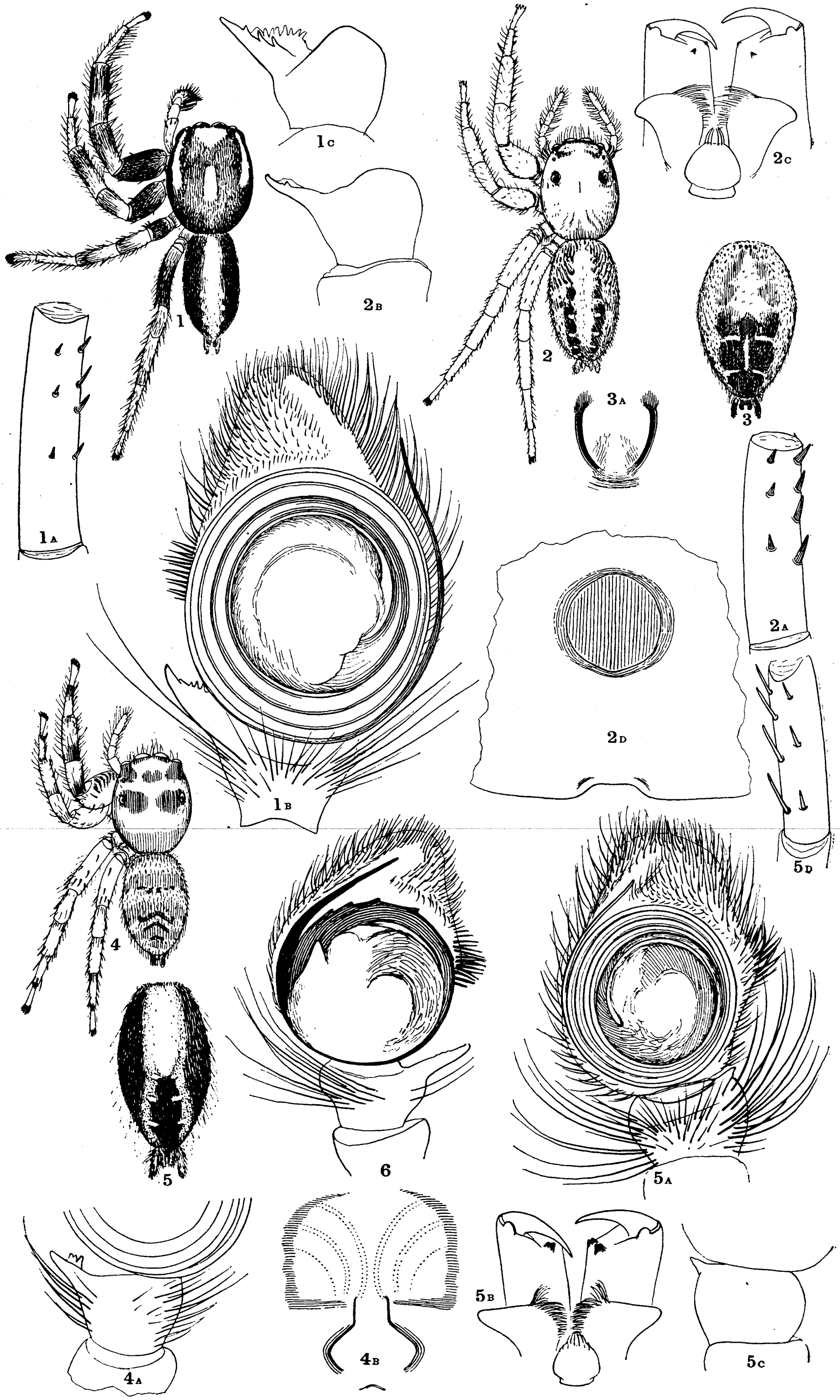

1
1A
1B
1C
2
2A
2B
2C
2D
3
3A
4
4A
4B
5
5A
5B
5C
5D
6

PLATE XXVI.

EXPLANATION OF PLATE XXVI.

Fig. 1, Pseudicius Braunsii, female × 8; 1a, male palpus.

Fig. 2, Pseudicius africanus, female × 8; 2a, epigynum.

Fig. 3, Pseudicius bipunctatus, male × 8; 3a, epigynum.

Fig. 4, Klamathia flava, male × 3; 4a, side view of cephalothorax; 4b, face and falces (the cephalothorax is drawn in a tilted position; the first row of eyes is really straight). 4c, sternum and mouthparts; 4d, palpus.

Fig. 5, Viciria parmata, male × 4; 5a, palpus.

Fig. 6, Viciria morigera, female × 4; 6a, epigynum; 6b, first leg from below, showing double spines on tibia.

Fig. 7, Viciria flavipes, epigynum.

Fig. 8, Viciria alba, epigynum.

Fig. 9, Modunda aperta, male × 6; 9a, palpus.

Fig. 10, Jasoda Woodii, face and falces of male; 10a, side of cephalothorax; 10b, palpus.

Plate XXVI.

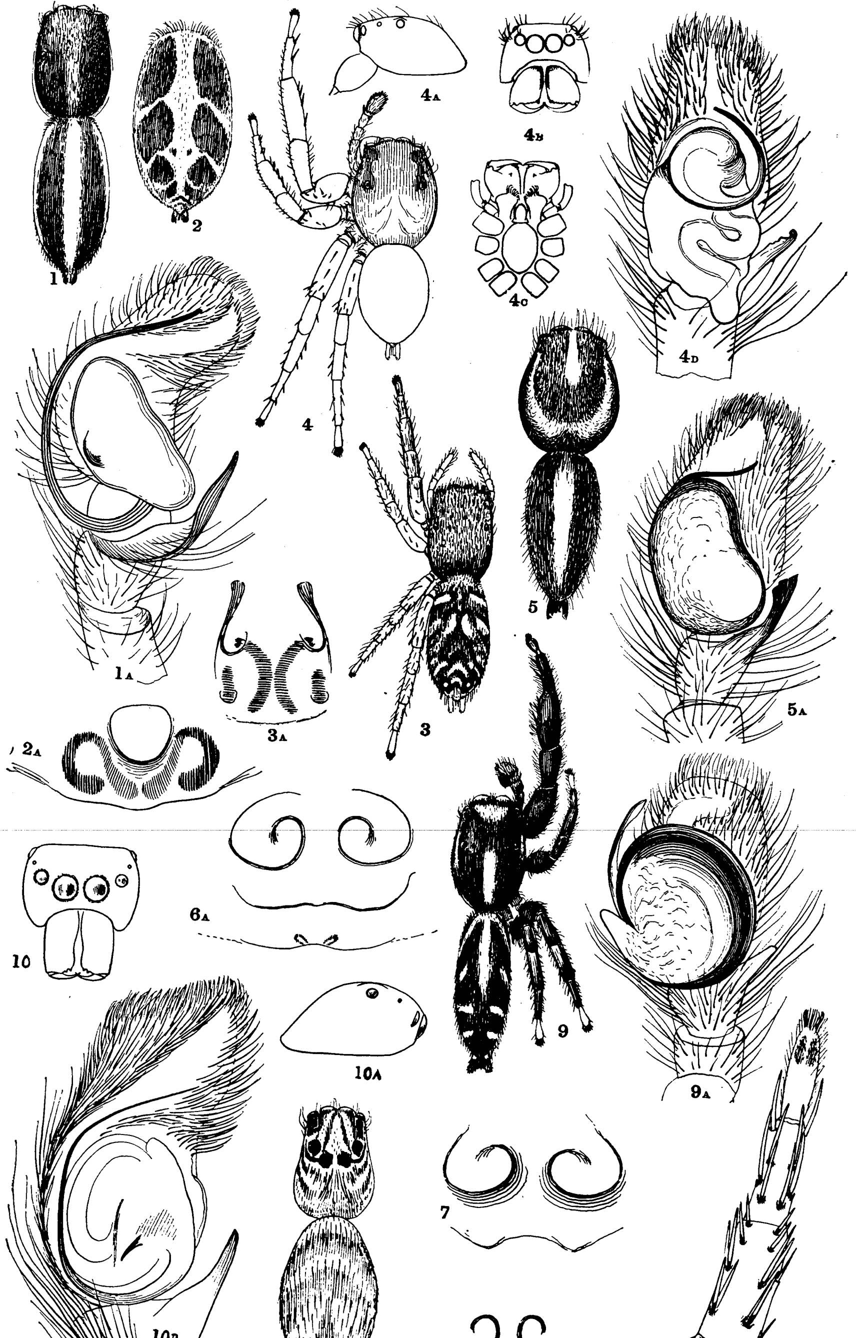


PLATE XXVII.

EXPLANATION OF PLATE XXVII.

Fig. 1, Pellenes rufoclypeata, male × 3; 1a, palpus.

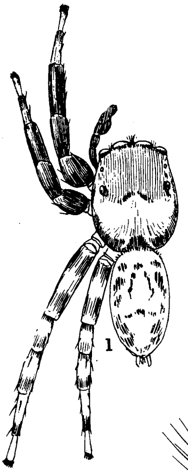
Fig. 2, Pellenes Beanii, female × 8; 2a, male palpus; 2b and 2c, varieties of epigynum.

Fig. 3, Habrocestum luculentum, abdomen of male, × 12; 3a, palpus.

Fig. 4, Habrocestum Annæ, abdomen of female × 4; 4a, epigynum.

Fig. 5, Habrocestum Lauræ, abdomen of female × 4; 5a, epigynum.

Fig. 6, Habrocestum dotatum, abdomen of female, under alcohol, × 6; 6a and 6b, varieties of epigynum; 6c, abdomen of male × 6; 6d, 6e and 6f, three views of palpus.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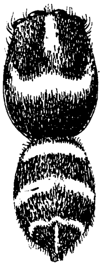
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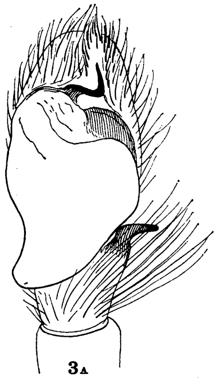
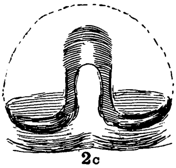

3A


1A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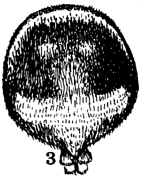
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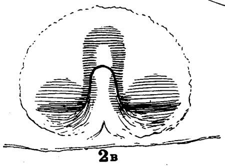
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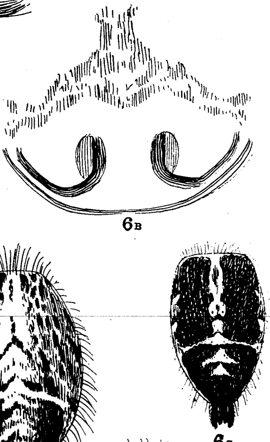
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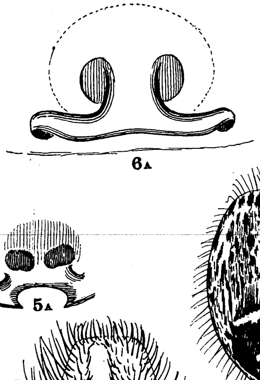
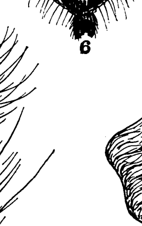

6A


4


4A


5A


5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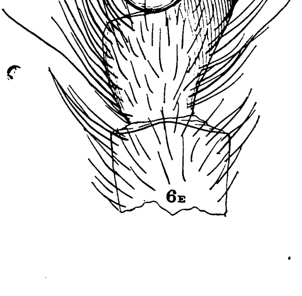
6C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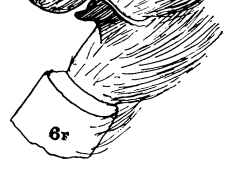
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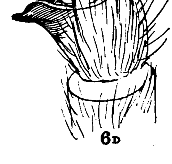

6D

PLATE XXVIII.

EXPLANATION OF PLATE XXVIII.

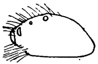
Fig. 1, Tusitala Braunsii, female × 4; 1a, side of cephalothorax; 1b, mouthparts and falces from below; 1c, face and falces; 1d, epigynum.

Fig. 2, Tusitala barbata, male × 5; 2a, face and falces; 2b, sternum, mouthparts and falces from below; 2c, palpus, showing bulb; 2d, palpus, showing relative length of joints.

Fig. 3, Tusitala hirsuta, palpus, showing relative length of joints; 3a, palpus, showing bulb.

Fig. 4, Tularosa Ogdenii, female × 4; 4a, side of cephalothorax; 4b, cephalothorax from in front; 4c, falces from below; 4d, epigynum.

Fig. 5, Langona avara, male × 6; 5a, palpus.



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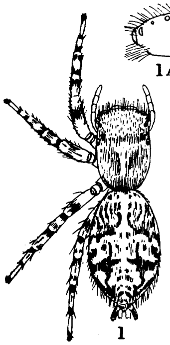

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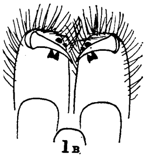

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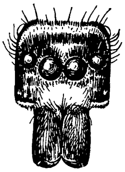

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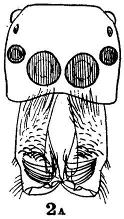

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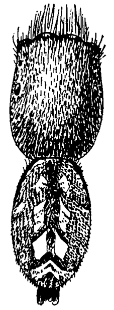

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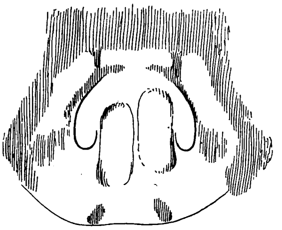

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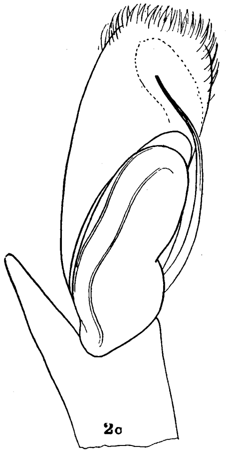

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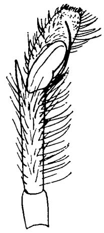
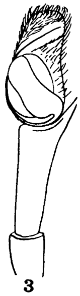


2D

2B



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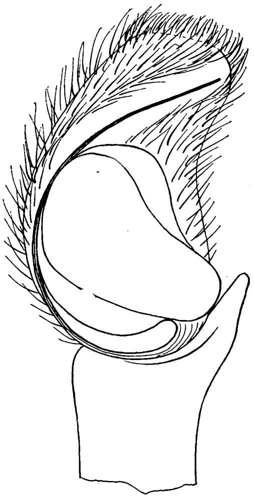

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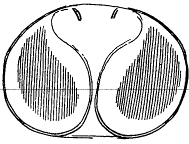
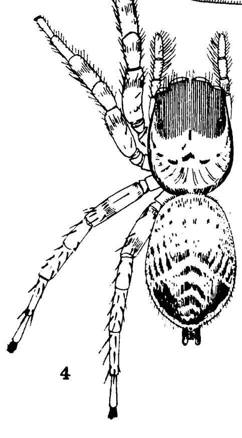


4L

4A



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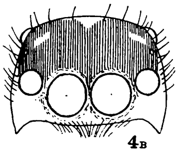

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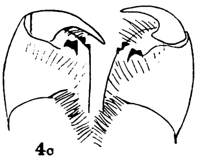

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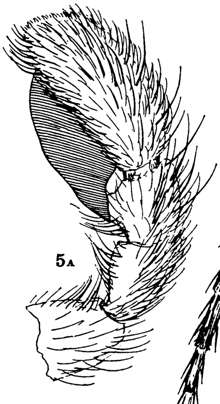


5A

5

PLATE XXIX.

EXPLANATION OF PLATE XXIX.

Fig. 1, Mexcala rufa, male × 4; 1a, palpus; 1b, side of cephalothorax; 1c, sternum and mouthparts; 1d, mouthparts and falces.

Fig. 2, Mexcala elegans, male × 4; 2a, sternum and mouthparts; 2b, side of cephalothorax; 2c, palpus; 2d, young female × 4, under alcohol.

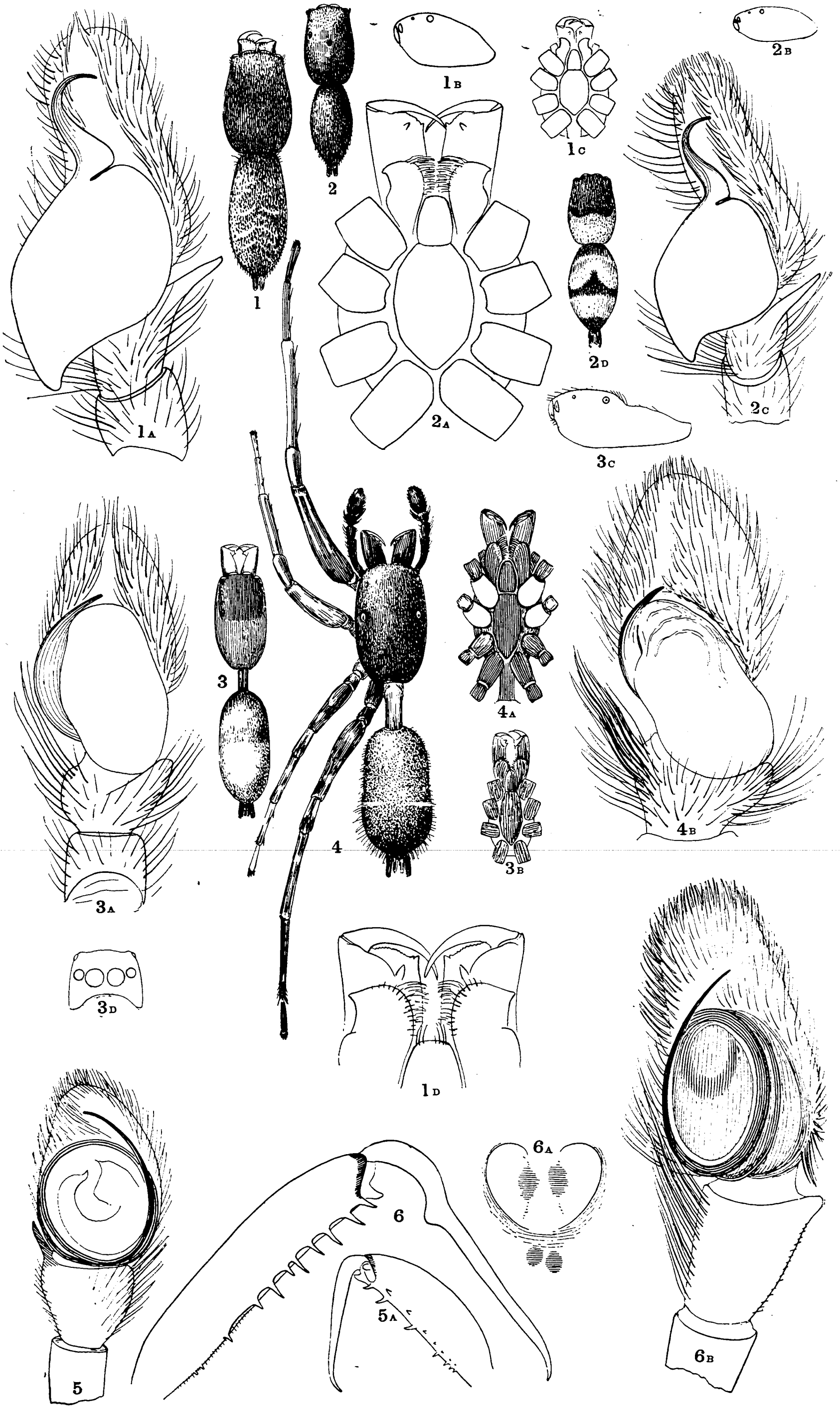
Fig. 3, Kima africana, male × 4; 3a, palpus; 3b, sternum and mouthparts; 3c, side of cephalothorax; 3d, first row of eyes.

Fig. 4, Kima variabilis, male × 5; 4a, sternum and mouthparts; 4b, palpus.

Fig. 5, Myrmarachne solitarius, palpus; 5a, falx of male from below.

Fig. 6, Myrmarachne Marshallii, falx of male from below; 6a, epigy-

Plate XXIX.



VARIATIONS IN FORM AND SIZE OF CYCLOPS BREVISPINOSUS HERRICK AND CYCLOPS AMERICANUS MARSH.

BY HARRIET LEHMANN.

This investigation was undertaken under the direction of Professor C. Dwight Marsh of Ripon College, to determine the extent of variation in *C. brevispinosus* Herrick and *C. americanus* Marsh, particularly with reference to the question of specific distinction between these forms in the form and measurements of the furca, and the outer terminal spine of the furca, and in the armature of the terminal joint of the inner ramus of the fourth swimming foot.

The results obtained cannot, however, be considered conclusive, since the number of specimens examined was insufficient to permit exact conclusions. The variations were also found to be so wide in a small number of specimens that even greater variation might be possible in a large number.

Different investigators do not agree as to the characters of the genus *Cyclops* important for specific distinction. Brady, '78, gives, "the characters of the first antennae and fifth pair of feet. As offering subsidiary characters, the spinous armature of the swimming feet, together with the tail segments and setae, are also important." Schmeil, '92, says, "Die sichersten und einfachsten Erkennungsmerkmale sind das rudimentäre Füschen und der Bau des Receptaculum seminis. * * *Die Anzahl der Borsten und Dornen ist für die Individuen einer Art durchaus nicht konstant, so das allien heiraufgegründete Arten hinfällig werden. Hiermit soll natürlich nicht ausgesprochen sein dass die Berücksichtigung der Bewehrung der

Schwimmfüsse absolut werthlos sei, es scheint vielmehr, als ob die Bedornungsverhältnisse der Spitze des Innenastes worauf Sars und Richard so grossen Wert legen, noch nicht genügend berücksichtigt waren. Die Anzahl der Dornen ist aber sicher grossen Schwankungen unterworfen, und die Angabe derselben hat nur einen sehr beschränken Wert." Forbes, in his paper of '97, says: "The number of antennal segments may be depended upon as fairly constant. * * The length of the antennae, while constant in some species, is remarkably variable in others, notably *C. serrulatus.* * * Sensory structures and the hyaline plates of the distal antennal segments are reliable characters. In certain species, *C. phaleratus* for instance, the proportions of the stylets are quite constant, but in *C. viridis, serrulatus,* and *bicuspidatus,* the range of variation is very great; consequently such measurements are not of the highest specific value. The apical bristles of the stylets are not very variable as to comparative lengths, but the minute details of their structure are not constant. This fact is illustrated by the variation in the shape of the outer apical spine of *C. viridis* var. *brevispinosus.* (Pl. XI, Fig. 1.) The armature of the swimming feet is of considerable value in certain cases, and is constant as a rule. Sometimes, however, the presence or absence of a spine or seta is not accompanied by other perceptible differences. The general character of the armature with regard to strength, etc., may usually be relied upon; but I have often seen in a single specimen all the gradations between spines and setae, and it would be impossible from this character to say which of the two names should be applied. Of the easily observable structures, the fifth foot is the most valuable for distinction. * * Of all the specific characters, the most valuable are those derivable from the receptaculum seminis." I quote also the specific descriptions of *C. brevispinosus,* given by Herrick, '84, and Marsh, '92, and that of *C. americanus,* by Marsh, '92. Herrick describes *brevispinosus* as follows: "Sp. 10. *C. brevispinosus Sp. nov.* (Pl. S, Figs 7–11.) The form for which this name is proposed takes the place of the above *C. parcus* Herrick in the larger lakes.

It appears to be but a modified condition of the above species, from which it differs in its slender form and especially in the very slender caudal stylets. The outer caudal seta is reduced to a short ciliate thorn. The fourth foot is also modified by the great enlargement of the spines and the reduction of the setae. The number of the setae is the same, but they are differently disposed." Marsh describes this same species: "Plate IV. Figs. 11 and 12. Furca slender, longer than the last two abdominal segments, lateral spine at two-thirds the distance from base to extremity. Of the terminal setae, the outer is a short blunt spine, the inner slender and somewhat longer. * * The armature of the terminal joints of the swimming feet is as follows:**

Fourth foot
  Inner br.
    ex. 1 sp.
    ap. 2 sp.
    in. 2 setae.

The fifth foot is two-jointed. The basal joint is very broad and is armed with one seta. The terminal joint is armed with one seta and a short spine. It is widely distributed in lakes and ponds, and is a pelagic species, though sometimes occurring in littoral collections.

"I have had some doubt as to whether this should be considered a distinct species. In most of its structural features it closely resembles *americanus,* and I have suspected it to be a pelagic variety of that species. I have specimens of *americanus* with elongated furca like *brevispinosus,* and I have specimens of *brevispinosus* in which the outer terminal seta of the furca is slender and plumose as in *americanus.* For the difference in the armature of the swimming feet, however, I have as yet found no intermediate forms, and so must, for the present, at least, consider the two as distinct." Marsh's description of *americanus* is as follows: "Plate IV, Figs 8–10. Furca about three times as long as its average breadth, the lateral spine situated well toward the end. The first and fourth terminal setae are short, slender and plumose, nearly equal in length—**

Fourth foot
  Inner br.
    ex. 1 seta.
    ap. 2 sp.
    in. 2 setae.

Fifth foot two-jointed, basal joint very broad, armed with one seta. Terminal joint armed with a seta and a blunt spine. This takes the place in our fauna that is occupied by *C. viridis* Fischer in Europe. In general form and appearance the two forms seem identical, and have been so considered by Herrick and Cragin. I have hesitated to propound a new species name, but it seems necessary. So far is Uljanin and Vosseler have figured *viridis* it corresponds to our species; but neither gives figures of the swimming feet. From the original description by Fischer our species differs markedly. * * He gives a figure of a foot, not designating which, but it corresponds to no one of the four in our species. * * In an examination of a large number of specimens from widely separated localities I have found no variation in the number and arrangement of the spines and setae of *americanus,* and until such variation is shown, there seems to be no alternative but to institute a new species for the American form."

These statements show that investigators, with reference to the species of the genus *Cyclops* in general, regard the armature of the swimming feet and the form and measurements of the furca and its apical bristles, as of varying, but usually of secondary importance for specific distinction. The variability in these features seems to be considered as lessening their distinctive value. However, if definite limits of variation can be established for a variable feature, it seems reasonable that it might prove as valuable for specific distinction as one showing almost no variation.

With reference to the particular species *C. brevispinosus* both Herrick and Marsh consider the form of the caudal stylets and their outer apical spines as important for distinction, and Marsh gives special importance to the armature of the swimming feet. Marsh also considers the armature of the 4th swimming feet of *C. americanus* as of chief importance for specific distinction. Forbes, '97, regards the features under consideration as often of doubtful value even for varietal distinction. He says: "So variable is *C. insectus,* [*C. americanus* Marsh], found as it is in an endless variety of situations and localities, that the lack of a single spine on the distal segment of the outer ramus of the first and fourth feet is not sufficient ground for the distinction of even a variety, for I find, as does Dr. Schmeil, that the armature of the swimming feet is not in all species absolutely constant." It may be noted here, however, that a constant armature of the swimming feet is not of necessity more valuable for specific distinction than a variable one, if only definite limits of variation can be established for the armature in question. Marsh has distinguished between *C. brevispinosus* and *C. americanus* by a supposed *constantly* different armature of the fourth swimming feet in either species.

The specimens from which the accompanying measurements and plates were obtained, were taken entirely from the collections of Professor Marsh. The prepared slides in his possession were considered, and a fairly large number of specimens were selected from his bottled collections. Only egg-bearing females of either species were considered, these giving the typical form of the fully developed individual. All the specimens of *C. brevispinosus* came from comparatively large bodies of water, of varying depths, but in no sense pools. They came also entirely from the region of the Great Lakes, thus perhaps not representing the whole species. The *C. americanus* examined came with but few exceptions, from pools, usually small and weedy, and varying greatly in depth and character with the changes in temperature and the seasons. They were obtained from widely different parts of the United States, and thus give a more general idea of the extent of variation.

The specimens of *C. americanus* represent a wider area than those of *C. brevispinosus,* but, on the other hand, are fewer in number.

Table I shows a record of measurements of thirty-five specimens of *brevispinosus*. The date and place of collection was indicated when possible, and a record was taken (1) of the length of the furca along an axis ab, as represented in the accompanying diagram; (2) the width of the furca along the line cd; (3) the width of the furca along the line xy; (4) the form and length of the outer apical spine of the furca; and (5) the armature of the terminal joint of the inner branch of the fourth swimming foot. Table II shows a record of the same features in eleven specimens of *C. americanus* having a constant armature of the fourth swimming feet as described by Professor Marsh. Plates XXXII and XXXIII show drawings of the furca and its outer apical spine, and of the terminal joint of the inner branch of the fourth swimming foot of eight specimens supposed to be *C. americanus,* but not answering to Marsh's description. Diagrams 1, 2, 3, and 4 of Plates XXX and XXXI show the curves of variation for the furca and the outer apical spine of the furca of *C. brevispinosus.* It was impossible to represent in this manner the variations in *C. americanus* on account of the extensive variation in the small number of specimens attainable. Plate XXXIII, Fig. 5, shows a fourth swimming foot of *C. brevispinosus,* and Fig. 6, a fourth foot of *C. americanus* of the type described by Marsh, '92. Fig. 7 of Plate XXXIII shows an extreme form of furca in *C. brevispinosus,* and Fig. 8 shows an extreme form for *C. americanus.*

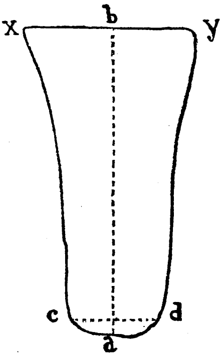


TABLE I.—*Variations in form and size of C. brevispinosus.*

All mature ♀.	Length & form out. ter. spine furca.	Length of furca.	Width of furca. 1. terminal. 2. base.	Armature ter. joint 4th ft.
Coll. H. L. No. 19. L. Winnebago. Aug. coll. by C. D. Marsh.	.07mm. Rather thick at base but not blunt.	.155 mm.	1. .02 mm. 2. .04 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. No. 20. L. Winnebago. Aug. coll. by C. D. Marsh.	.0675 mm. Thick at base but tapering, not blunt.	.16 mm.	1. .02 mm. 2. .037 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. No. 18 L. Winnebago. Aug. coll. by C. D. Marsh.	.0625 mm. Thick at base but tapering, not blunt.	.15 mm.	1. .025 mm. 2. .04 mm.	Inner ex. 1 sp. br. ap. 2 sp,
Coll. H. L. No. 17. L. Winnebago. Aug. coll. by C. D. Marsh.	.065 mm. Tapering, thick base, not blunt.	.16 mm.	1. .02 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. No. 16. L. Winnebago. Aug. coll. by C. D. Marsh.	.07 mm. Tapering, not blunt.	.165 mm.	1. .025 mm. 2. .04 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. No. 15. L. Winnebago. Aug. coll. by C. D. Marsh.	.0625 mm. Thick at base, tapering, not blunt.	.15 mm.	1. .025 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. No. 14. L. Winnebago. Aug. coll. by C. D. Marsh.	.0675 mm. Thick at base, tapering, not blunt.	.15 mm.	1. .03 mm. 2. .04 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. No. 12. Green Lake, Wis. Aug. coll. by C. D. Marsh.	.056 mm. Slender apex.	.125 mm.	1. .025 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 1636. Green Lake, Wis.	.042 mm. Thick, rather blunt.	.12 m.	1. .027 mm. 2. .042 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 951. Lake Vieux Desert. Aug.	.0475 mm. Thick but not blunt.	.11 mm.	1. .0215 mm. 2. .038 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No 1498. Little Green Lake, Wis.	.0575 Thick, rather blunt.	.13 mm.	1. .021 mm. 2. .0425 mm.	Inner ex. 1. sp. br. ap. 2 sp.
Coll. C. D. M. No. 1216. Bay at L. T. Point, Green Lake.	.04 mm. So-called ayical blunt Spine. Very blunt.	.11 mm.	1. .028 mm. 2. .037 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 293. L. Gussie, Wis., July, '91.	.0475 mm. Similar to No. 1216, blunt, thick.	.13 mm.	m. 2. .04 mm.	Inner ex. 1 sp. br. ap. 2 sp.

TABLE 1.—*Variations in form and size of C. brevispinosus*—Cont.

	Length and form out. ter. spine furca.	Length of furca.	Width of furca, 1. terminal; 2. base.	Armature ter. joint 4th ft.
Coll. C. D. M. No. 1497 L. St. Clair.	.05 mm. Thick, blunt.	.1175 mm.	1. .0212 mm. . .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. M. D. No. 1485. Butte des Mortes.	.0475 mm. Thick, moderately blunt.	.125 mm.	1. .023 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 614. Coll. by E. A. Birge. Harshaw.	.06 mm. Rather slender, not blunt.	.15 mm.	1. .023 mm. 2. .0475 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 1494. Baldwin, Mich., July, '94.	.038 mm. Thick at base, but tapering near apex rapidly.	.096 mm.	1. .0225 mm. 2. .04 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 1487. Long Lake.	.0512 mm. Thick, moderately blunt spine.	.1375 mm.	1. .0225 mm. 2. .045 mm.	Inner ex. 1 ps. br. ap. 2 sp.
Coll. C. D. M. No. 285. Green Lake, July '91, pel.	.0525 mm. Rather blunt, but not as thick as No. 1487.	.126 mm.	1. .025 mm. 2. 0375 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 1489 (1). L. Ontario.	.05 mm. Thick, blunt spine.	.1325 mm.	1. .025 mm. 2. .0475 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 1489 (2). L. Ontario.	.05 mm. Moderately thick and blunt spine.	.1375 mm.	1. .03 mm. 2. .0525 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. C. D. M. No. 296. Fond du Lac River, Oct., '91.	.0625 mm. Moderately thick spine, not blunt.	.135 mm.	1. .035 mm. 2. .05 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. E. Birge. Slide 517 of C. D. M. L. Minoqua. Aug., '92.	.0625 mm. Rather slender, not blunt.	.15 mm.	1. .02 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. by E. Birge. No. 516. L. Minoqua. Aug., '92.	.049 mm. Short, moderately slender, not blunt.	.1525 mm.	1. .02 mm. 2. .05 mm.	Inner ex. 1 sp. br. ap. 2 sp.
Coll. H. L. by C. D. M., July 28. Lake Winnebago. No. 1.	.066 mm. Slender spine, not blunt.	.175 mm.	1. .02 mm. 2. .047 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 2. Same coll. as No. 1.	.06 mm. Moderately slender spine.	.165 mm.	1. .022 mm. 2. .05 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 3. Same coll. as No. 1.	.055 mm. Slender.	.13 mm.	1. .025 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 4. Same coll. as No. 1.	.058 mm. Moderately slender, not blunt.	.1575 mm.	1. .02 mm. 2. .0475 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 5. Same coll. as No. 1.	.0675 mm. Slender.	.172 mm.	1. .025 mm. 2. .05 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 6. Same coll. as No. 1.	.065 mm. Moderately slender.	.175 mm.	1. .0225 mm. 2. .05 mm.	Inner ex. 1 sp. br. ap. 2 sp.

TABLE I.—*Variations in form and size of* C. *brevispinosu.*—Cont.

	Length and form out. ter. spine of furca.	Length of furca.	Width of furca, 1, terminal; 2, base.	Armature ter. joint 4th foot.
No. 7. Same coll as No. 1.	.051 mm. Slender, seta-like apex.	.13 mm.	1. .0225 mm. 2. .045 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 8. Same coll. as No. 1.	.07 mm. Slender.	.1525 mm.	1. .025 mm. 2. .052 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 9. Same coll. as No. 1.	.07 mm. Slender, seta-like apex.	.165 mm.	1. .027 mm. 2. .054 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 10. Same coll. as No. 1.	062 mm. Moderately thick, not blunt.	.167 mm.	1. .024 mm. 2. .0425 mm.	Inner ex. 1 sp. br. ap. 2 sp.
No. 11. Same coll. as No. 1.	.065 mm. Moderately thick at base, not blunt.	.175 mm.	1. .0275 mm. 2. .05 mm.	Inner ex. 1 sp. br. ap. 2 sp.

Table II.— *Variations in form and size of C. americanus.*

Coll. of C. D. Marsh. All mature ♀.	Form and length out. ter. spine of furca.	Length of furca.	Width of furca, 1. terminal. 2. base.	Armature ter. joint 4th foot.
No. 1500. Jackson, Miss Very large, Mar., '93.	Moderately slender, apex broken. .08 mm.	.19 mm.	1. .04 mm. 2. .06 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 1502. (1) Arcade, May, '91, small.	Slender. .04 mm.	.052 mm.	1. .015 mm. 2. .025 mm.	br. Lost.
No. 1502. (2) Same coll. as 1502. (1)	.07 mm. Moderately slender.	.132 mm.	1. .0325 mm. 2. .055 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 1501. Dakin farm. May, '93.	.09 mm. Moderately slender.	.185 mm.	1. .0325 mm. 2. .0625 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 1001. Pool near Elcho Station, Aug., '87.	.0625 mm. Slightly thickened toward apex.	.14 mm.	1. .03 mm. 2. .045 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 885. Pond, Grinnell, Ia.	.06 mm. Very slender.	.11 mm.	1. .035 mm. 2. .0425 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 883. Lincoln, Neb.	.0875 mm. Very slender.	.155 mm.	1. .03 mm. 2. .05 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 882. Lincoln, Neb.	.085 mm. Very slender.	.17 mm.	1. .03 mm. 2. .05 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 565. Pool near Arcade.	.0575 mm. Tapering, not slender.	.1275 mm.	1. .03 mm. 2. .045 mm.	Inner ex. 1 seta. br. ap 2 sp.
No. 425. Pond, Lyman Farm, May, '82.	.075 mm. Slender.	.145 mm.	1. .03 mm. 2. .0475 mm.	Inner ex. 1 seta. br. ap. 2 sp.
No. 784.	. 7 mm. Moderately slender.	.125 mm.	1. .0275 mm. 2. .045 mm.	Inner ex. 1 seta. br. ap. 2 sp.

Variations in width of furca
of. of C brevispinosus.

Diagram I.

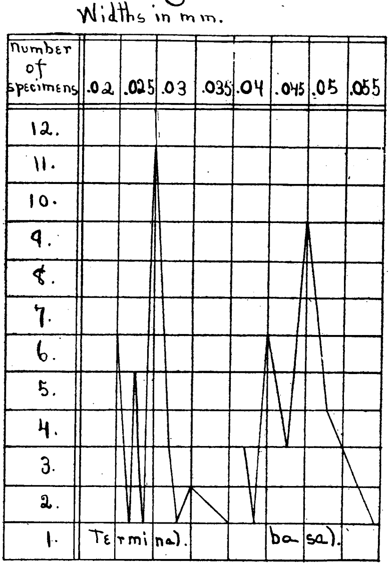
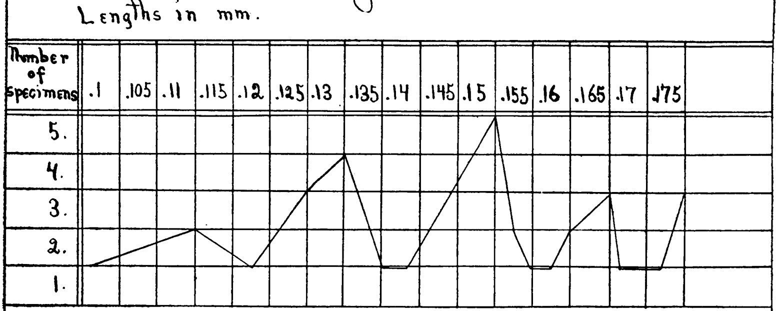


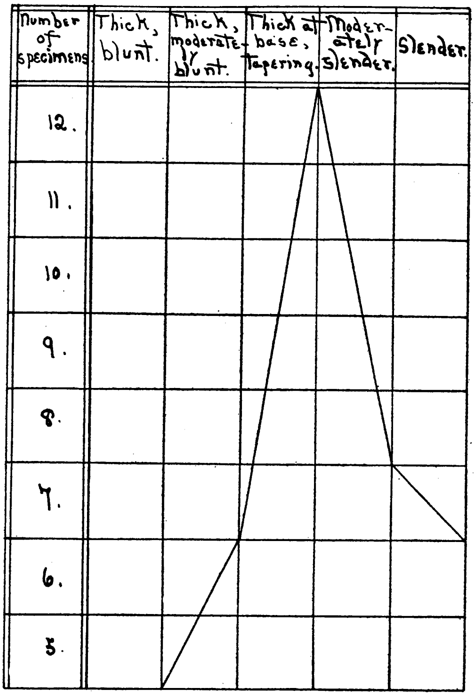
Diagram II.



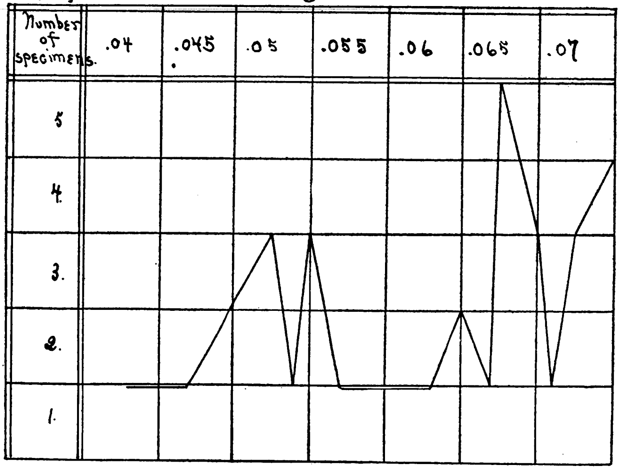
Variations in length of furca of
C. brevispinosus.

Variations in forms of outer terminal spine of furca of C. brevispinosus.

Diagram III. Forms.



Lengths in mm. Diagram: IV.



Variations in length of outer terminal of spine of furca of C. brevispinosus.

In all the specimens of *C. brevispinosus,* the one constant quantity among the characters under consideration is the armature of the fourth swimming foot, the terminal joint of the inner branch bearing always upon its external side a distinct spine, whereas *C. americanus* bears frequently at this point a seta. The furca of *brevispinosus* varies greatly in length, the limits of the specimens examined being .096 mm., and .175 mm., the greatest number of any one length being at .15 mm., whereas an average length would be .135 mm. The width of the furca at its base varies from .037 mm. to .054 mm., the greatest number of any one width being at .045 mm., which is about an average width. The width of the terminal end of the furca varies from .02 mm. to .035 mm., the greatest number of any one width being at .025 mm., which is also nearly an average width. These figures show a greater variation in length than in width. The outer terminal spine of the furca, claimed by Herrick to be a distinctive feature, shows great variation, first in length, from .038 mm. to .07 mm., the greatest number measuring .065 mm., whereas an average length would be .054 mm.; and second, it varies in form from a thick, very blunt spine to a slender, seta-like spine, the greatest number being thick at the base but tapering rapidly toward the apex. The two extreme forms are least in number, the thick, blunt spine being least frequent of all the forms. None of the specimens examined bear a distinct seta at this point, such as is occasionally found on *americanus;* and no specimens of *americanus* examined bear a thick, blunt spine such as is sometimes found on *brevispinosus.* However, these two forms are extremes and may easily have been developed by peculiar conditions from a common form, since the slender tapering spine common to both species is found most frequently in both. Forbes, '97, has noted similar variations in this spine; he says: "I have seen considerable variations in this spine and have observed all the gradations between it and the usual slender spine of *C. insectus.* I think, however, that *C. brevispinosus* should be considered a good variety."

The small number of specimens examined and the limited range of the localities from which they were obtained, must of course prevent the drawing of absolute conclusions from these figures.

That the armature of the fourth swimming foot is not constant in *C. americanus,* is shown in Plates XXXII and XXXIII, distinct *spines,* distinct setae, and *intermediate forms* being found on the external side of the terminal joint of the inner branch. The seta is the form of armature found most frequently, but the presence of the other forms indicates that this cannot be considered a constant feature.

The variations in the length of the furca in the specimens of *americanus* measured, are wide, the limits being .052 mm. and .19 mm., thus including the limits for this character of *brevispinosus.* The width of the furca is generally greater in *americanus* than in *brevispinosus* and varies less widely than the measurements of length, the limits for basal width being .025 mm. and .0625 mm.; and those for the width at the terminal end .015 mm. and .04 mm., thus also including the limits of variation in width of the furca of *brevispinosus.* The outer terminal seta of the furca of *americanus* is most frequently moderately slender, sometimes considerably thickened at the base, and frequently almost impossible to distinguish from the so-called spine of *brevispinosus.*

The comparative relation of the length of the last two or three abdominal segments to the length of the furca is also variable in each species. The furca is in some cases hardly longer than the last abdominal segment, and in others is as long as the last three segments.

The descriptions of Marsh and Herrick for these forms of *Cyclops* make the characters considered in this paper of considerable importance for specific distinction. It seems impossible, however, from the data gathered in this investigation, to prove these characters constant for either of the two so-called species, or to establish definite limits of variation for them. The limits obtained for both forms in the features under consideration overlap each other, which leaves, of course, no specific limits for either form. These characters must then be considered as unreliable for specific distinction between *C. brevispinosus* and *C. americanus.* Of course if other features of sufficient importance for distinction prove reliable, the two species may stand.

The great variation found in the specimens obtained from pools subject to marked changes, and the greater uniformity found among those living under comparatively uniform conditions, indicates that there is a tendency toward at least varietal distinctions through constant peculiar environment. The uniformity in the armature of the fourth swimming feet of specimens living in large bodies of water illustrates this. This armature is, however, not peculiar to those forms. It is of interest also to note that of the specimens obtained from large bodies of water, the greatest number of any one length or width of furca are of a measurement near an average of the limits of variation.

The dividing lines between species are very difficult to construct, but it is certain that approximate limits of variation in variable features, as dependent on environment and habits of the animal, are of much determinative value; and a careful study of these would probably result in a re-classification of many species and varieties.

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PLATE XXXII.

EXPLANATION OF PLATE XXXII.

Fig. 1. *C. americanus* Marsh (?). Caudal stylet × 295. No. 1499.
Fig. 2. No. 1499, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 3. *C. americanus* Marsh (?). Caudal stylet × 295. No. 1482.
Fig. 4. No. 1482, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 5. *C. americanus* Marsh (?). Caudal stylet × 295. No. 566.
Fig. 6. No. 566, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 7. *C. americanus* Marsh (?). Caudal stylet × 295. No. 1008.
Fig. 8. No. 1008, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 9. *C. americanus* Marsh (?). Caudal stylet × 295. No. 269.
Fig. 10. No. 269, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 11. *C. americanus* Marsh (?). Caudal stylet × 295. No. 536.
Fig. 12. No. 536, external armature terminal joint of inner branch of 4th swimming foot × 295.

Fig. 1.

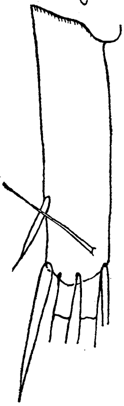


Fig. 3.

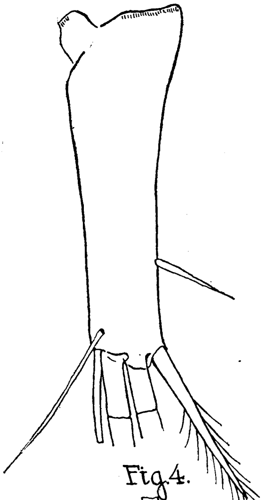


Fig. 5.

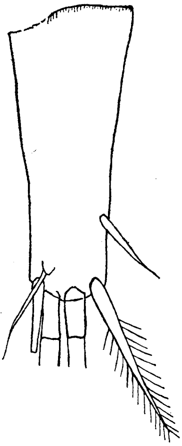


Fig. 2.

Fig. 4.

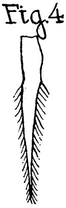


Fig. 6.

Fig. 7.

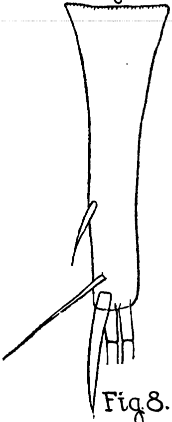


Fig. 9.

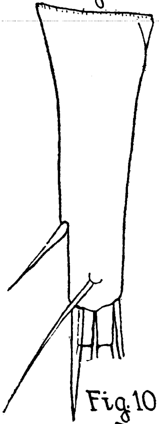


Fig. 11.

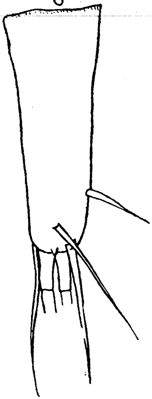


Fig. 8.

Fig. 10.

Fig. 12.

PLATE XXXIII.

EXPLANATION OF PLATE XXXIII.

Fig. 1. *C. americanus* Marsh (?). No. 565. Caudal stylet × 295.
Fig. 2. No. 565, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 3. *C. americanus* Marsh (?). No. 784. Caudal stylet × 295.
Fig. 4. No. 784, external armature terminal joint of inner branch of 4th swimming foot × 295.
Fig. 5. *C. brevispinosus* Herrick, 4th swimming foot × 295. No. 20.
Fig. 6. *C. americanus* Marsh, 4th swimming foot × 295. No. 1501.
Fig. 7. *C. brevispinosus* Herrick. Furca × 167. Extreme type. No. 22.
Fig. 8. *C. americanus* Marsh. Furca × 165. Extreme type. No. 1502

Fig. 1.

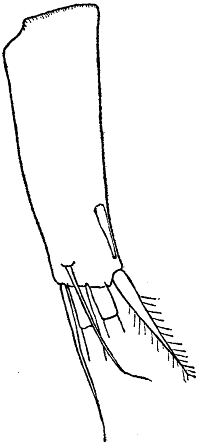


Fig. 3.

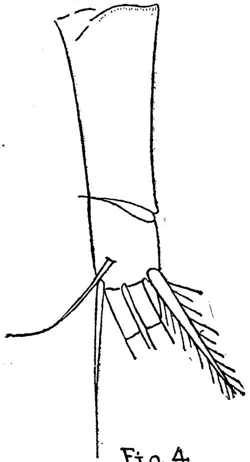


Fig. 2.

Fig. 4.

Fig. 5.

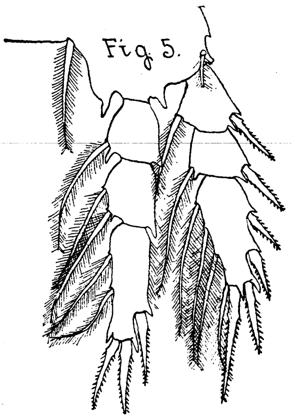


Fig. 6.

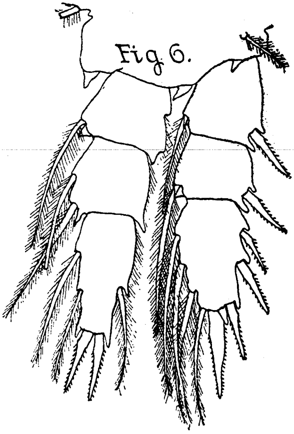


Fig. 7.

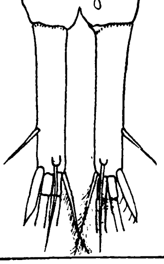
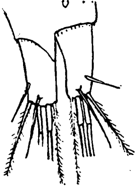


Fig. 8.



ACTION OF METALLIC MAGNESIUM UPON AQUEOUS SOLUTIONS.

BY LOUIS KAHLENBERG.

It has long been known that metallic magnesium acts extremely slowly upon distilled water, and that it practically does not act at all upon solutions of the caustic alkalies. In 1899 Tommasi[1] made qualitative investigations of the action of magnesium on aqueous solutions of the following salts: KCl, NH_4Cl, $CaCl_2$, $MgCl_2$, NaCl, LiCl, $BaCl_2$, $SrCl_2$, $CuCl_2$, $CdCl_2$, $PbCl_2$, $HgCl_2$, $FeCl_3$, $CrCl_3$, $PtCl_4$, $AuCl_3$, $CuSO_4$, $ZnSO_4$, $FeSO_4$, $MnSO_4$. He found that from solutions of NaCl, KCl, and LiCl magnesium liberates hydrogen more rapidly than from pure water, magnesium hydroxide being formed. Solutions of the chlorides of barium, strontium and calcium were acted upon but feebly by magnesium, but ammonium chloride solution was attacked at a lively rate. From solutions of the salts of the heavy metals mentioned above, hydrogen was liberated by magnesium, the chloride or sulphate of that metal being formed, and a basic salt or hydroxide of the heavy metal, or the latter in the metallic state, being precipitated. No theoretical explanations were attempted. In the same year G. Lemoine[2] called particular attention to the action of magnesium upon aqueous solutions of magnesium salts. He used solutions of the nitrate, chloride, sulphate and acetate of magnesium, but worked especially with the last three salts. From aqueous solutions of these salts magnesium liberates hydrogen rapidly and continuously. Using magnesium in form of powder, he found that about 0.4 the calculated amount of hydrogen was

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[1] Bull. Soc. Chim. (3) 21, 885-887, 1899.

[2] Comptes rend. 29, 291, 1899.

liberated from a magnesium chloride solution when the powder was present in excess, the action being finally checked by the accumulation of the precipitate formed; but up to the maximum, the quantity of hydrogen disengaged was nearly proportional to the amount of magnesium added. After magnesium had acted upon the solutions of the chloride and acetate, these latter were found to contain but a relatively slight excess of base. The analytical data show that the precipitates formed were very basic chloride and acetate of magnesium respectively. In the case of the sulphate of magnesium the solution was much weaker after the magnesium had acted upon it, a very considerable portion of the salt having been thrown down in combination with the hydroxide of magnesium in form of a basis sulphate of magnesium. Lemoine's explanation of the action of magnesium on solutions of magnesium salts is that in these solutions the salts are slightly decomposed into hydroxide of magnesium and free acid. This acid acts on the metal forming hydrogen and a basic salt which breaks up into the normal salt and hydroxide of magnesium; the latter finally drops out of solution and the reaction begins anew. In advancing this explanation it would certainly seem that Lemoine did not give due weight to the fact that the reaction of the solutions of the magnesium salts toward indicators is perfectly neutral at the outset, and that soon after introducing the magnesium it becomes alkaline and remains so while the liberation of hydrogen continues unabated. There are thus no facts upon which to base the assumption that the salts he used are even slightly decomposed by water into free acid and magnesium hydroxide.

H. Mouraour[1] again directed attention to the fact that magnesium liberates hydrogen readily not only from solutions of its own salts, but from solutions of other salts as well. He found solutions of the carbonate, chloride, oxalate and sulphide of ammonia strongly acted upon; but no action was observed in the case of solution of fluoride of ammonium. Sodium carbonate, acetate and tetraborate solutions were strongly acted

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[1] Comptes rend. 130, 140, 1900.

upon, as were also solutions of ordinary and chrom alum. On the other hand the action was feeble on solutions of sodium phosphate, nitrate, thiosulphate, potassium ferrocyanide and the chlorides of barium, calcium and potassium. The work was entirely qualitative in charcter. Mouraour states that while Lemoine's explanation of the action may hold good in the case of solutions of chloride of magnesium, for instance, for most of the salts last mentioned it is inadequate. In the case of the ammonium salts Mouraour ascribes the action to the fact that solutions of these salts dissolve magnesium hydroxide. But he states that in the case of the salts of Pb, Cu, Hg, Co, from which magnesium precipitates the heavy metals and simultaneously liberates hydrogen, we have a secondary action of the magnesium on the water of the solution. He deems it very difficult to explain the phenomena in the cases last mentioned, stating that it is not probable that salts of these heavy metals favor the solubility of magnesia. Mouraour was apparently not aware of the work of Tommasi. As a matter of fact magnesium hydroxide is not formed at all when solutions of the heavy metals named are acted upon by magnesium; the salt of the latter metal forms and remains dissolved, the basic salt or hydroxide of the heavy metal being precipitated. In fact, the cases which Mouraour finds difficult to explain are really most readily explained; for the salts of the heavy metals are indeed slightly decomposed by water, a small quantity of free acid being liberated as the acid reaction of such solutions clearly shows. This acid acts on the magnesium evolving hydrogen and forming the corresponding magnesium salt, a basic salt or hydroxide of the heavy metal resulting simultanously.

In presenting to my students the various ideas that have from time to time been entertained by scientific men regarding the nature of solutions, I have always laid considerable stress upon the view that the process of solution depends upon a mutual interaction of solvent and solute, and that solutions are chemical combinations[1] of solvent and solute according to variable

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[1] Compare Mendelejew, Principles of Chemistry, Vol. I; Pickering, on Solutions, Watts Chemical Dictionary; Horstmann, Graham-Otto, Lehrbuch der Physikalischen und Theoretischen Chemie, Vol II.

proportions. Although this view has of recent years been relegated to the background by many, it certainly has a formidable array of facts to support it; and such facts have really been accumulating more and more, though the investigations yielding them have been guided to a considerable extent by the analogy between gases and solutions. If when a substance is dissolved in water chemical combination between that substance and water takes place, the liberation of hydrogen from the solution ought to result with a different degree of readiness than from pure water. With this as the guiding idea, Mr. O. W. Brown and Dr. H. V. Black at my suggestion made some preliminary experiments in this laboratory last summer, comparing the rate with which hydrogen is evolved from various aqueous solutions by the action of magnesium upon them. In the course of these experiments (among which many of the observations of the above named French investigators were confirmed, though at the time their researches had not been looked up) it was found that hydrogen was liberated with different rapidity in the case of each solution tested, and that this rate was different from that observed when pure water was used. To my regret Messrs. Brown and Black were unable to continue these investigations, much as they were inclined to do so. It seemed to me well worth while to follow out somewhat farther the work thus begun, and the results obtained in investigating the subject will now be presented.

The metallic magnesium used was of Schuchardt's manufacture. It was carefully tested and was found to be free from carbon, and from alkali and alkaline earth metals. 0.8593 grams of the metal yielded 0.0036 grams of the mixed sesquioxides of iron and aluminum. Other metals were not present in the magnesium. The latter was cut into bars of square cross section measuring 5 mm. on an edge, and having a length of 57.5 mm., thus presenting a surface of 1,200 sq. mm. A large number of such bars was prepared. In each liquid to be tested, such a bar was immersed, its surface being first carefully cleaned with fine emery cloth. The action of the metal upon the liquid was noted and the volume of hydrogen evolved at different times was observed. The experiments were conducted at room temperature which was nearly 20°. The ordinary distilled water of the laboratory was used. The chemicals were either of Kahlbaum's or Schuchardt's manufacture; they were tested as to their purity, special care being taken to see that they were free from traces of heavy metals, and in the case of the salts employed, that they were perfectly neutral. Although only one series of results will be given in each case, each series was checked by at least one additional independent series. In the tables that follow, the first column indicates the solution employed, the heading of each succeeding column indicates the time that a bar of magnesium acted upon the solution in order to liberate the volume of hydrogen given in that column.

TABLE 1.

(Solutions contained two gram.-mols. per liter except the mannite and sodium sulphate solutions, which contained one gram.-mol. per liter.)

Solute.	2.5 hrs.	23.5 hrs.	47.5 hrs.	53 hrs.
Distilled water (alone)	0.02 cc	0.10 cc	1.5 cc	1.8 cc
Alcohol	0.10	0.40	7.6	7.8
Glycerine	0.01	0.05	0.5	0.55
Cane sugar	0.10	0.65	1.0	1.2
Mannite	0.08	0.20	0.4	0.55
Urea	1.2	10.6	29.0	31.0
Sodium chloride	7.4	49.8	(discontinued.)[1]	
Sodium sulphate	2.4	9.9	18.0	18.8

[1] The word "discontinued" where used in the tables means that the experiment was discontinued, not that the hydrogen ceased to be evolved. The experiments in these cases had to be stopped because more gas could not be held in the tube used.

In the case of the urea solution, ammonia as well as hydrogen was liberated. When sodium nitrate solution is treated with magnesium only a slight amount of hydrogen is actually evolved; this is due to the fact that the salt is reduced to nitrite. From a solution of ammonium chloride containing 2 gram-mols. per liter, over 50 cc of gas consisting of hydrogen and ammonia was liberated by one of the bars of magnesium in five minutes.

TABLE 2.

(Solutions contain one gram-mol. per liter.)

Solute.	25 min.	40 min.	50 min.	1 hr.	1 hr. 20 min.	1 hr. 35 min.	2 hrs. 50 min.	4 hrs. 23 min.
$MgCl_2$	13 cc.	18.5 cc.	22.0 cc.	24.8 cc.	30.5 cc.	33.8 cc.	(discon	tinued)
$MgBr_2$	4.8	7.0	8.5	9.9	13.0	14.8	24.5 cc.	33.4 cc.
$MgSO_4$	5.9	9.4	11.6	13.75	18.5	21.5	36.4	50.5
$Mg(NO_3)_2$	0.2	0.35	0.4	0.45	0 6	0.65	1.2	1.6

TABLE 3.

(Solutions contain 1-10 gram-mol. per liter.)

Solute.	25 min.	35 min.	3 hrs. 31 min.	4 hrs. 5 min.	5 hrs. 32 min.	22 hrs. 34 min.
$MgCl_2$	10.8 cc.	14.0 cc.	43.1 cc.	47. cc.	(discon	tinued.)
$MgBr_2$	1.8	2.4	7.9	8.6	10.3 cc.	25.0 cc.
$MgSO_4$	1.8	2.4	7.9	8.6	10.3	27.0
$Mg(NO_3)_2$	0.2	0.3	1.7	1.8	2.2	3.6

TABLE 4.

(Solutions contain 1-100 gram-mol. per liter.)

Solute.	17 min.	31 min.	45 min.	49 min.	2 hrs. 25 min.	3 hrs. 37 min.	5 hrs. 25 min.	22 hrs. 49 min.
$MgCl_2$	1.8 cc.	3 2 cc.	4.7 cc.	5.2 cc.	12.2 cc.	15.6 cc.	20.0 cc.	43.0 cc.
$MgBr_2$	1.4	2.0	2.6	2.8	5.8	7.1	9.6	29.9
$MgSO_4$	1.5	2.4	3.0	3.2	6.8	8.8	11.6	29.6

TABLE 5.

(Solutions contain one gram-mol. per liter.)

Solute.	17 min.	31 min.	45 min.	49 min.
KCl	11.5 cc.	17.5 cc.	22.5 cc.	24.0 cc.
$KCl+MgCl_2$	15.0	23.0	29.4	31.4

TABLE 6.

(Solutions contain 1-10 gram equivalent per liter.)

Solute.........	2 min.	4 min.	6 min.	11 min.	16 min.	28 min.	33 min.	36 min.	46 min.
H_2SO_4.........	3 2 cc	8.0 cc	12.0 cc	21.0 cc	28.0 cc	37.6 cc	40.4 cc	41.8 cc	45.61cc
	1 min.	3 min.	5 min.	7 min.	11 min.	14 min.	24 min.	29 min.	49 min.
HCl	3.0 cc	8.5 cc	14.0 cc	19.0 cc	27.5 cc	31.4 cc	39.4 cc	43.5 cc	48.8 cc

(Solutions contain 1–100 gram equivalent per liter.

	5 min.	10 min.	17 min.	20 min.	30 min.	40 min.	1 hr. 5 min.	1 hr. 20 min	3 hrs. 37 min.
H_2SO_4.........	0.4 cc	1.2 cc	2.0 cc	2.5 cc	3.6 cc	4.6 cc	7.0 cc	8.4cc	14.3 cc
HCl.............	0.4	1.2	2.0	2.5	3.6	4.7	7.0	8.0	11.8

It was found that in normal KOH or NaOH solutions no measurable amount of hydrogen was evolved in 24 hours, the magnesium remaining perfectly bright. Solutions of magnesium nitrate when treated with magnesium yield nitrite and finally ammonia, which accounts for the small amount of hydrogen liberated by this salt as compared with other salts of magnesium. From solutions of magnesium acetate and iodide magnesium also evolves hydrogen rapidly. A magnesium sulphate solution was treated with a large excess of finely divided magnesium, but no reduction of the salt to sulphite took place. From a solution of crystals of $MgCl_2 + 6H_2O$ in glycerine of sp. gr. 1.27 magnesium evolves hydrogen; the action is much increased upon heating. Anhydrous magnesium chloride (prepared from the double magnesium ammonium chloride) dissolved in glycerine of sp. gr. 1.27 acts slowly on magnesium; this action is greatly increased upon raising the temperature. The glycerine itself acts only very slightly on magnesium even on heating. From $MgCl_2 + 6H_2O$ melted in its crystal water magnesium evolves hydrogen readily. A saturated solution of $MgCl_2 + 6H_2O$ in ether does not attack magnesium.

From a solution of 1 gram-mol. $MgCl_2 + 6H_2O$ in 99.5 per cent. alcohol a bar of magnesium the size above described, evolved 2.5 cc hdrogen in 23 hours and 47 minutes, while from 99.5 per cent. alcohol alone a like bar of magnesium liberated 0.9 cc gas in 20 hours and 44 minutes. Table 1 shows that from distilled water there was evolved under like conditions only 0.1 cc in 23.5 hours.

The results in table 1 show that during the first 23.5 hours all the solutions except that of glycerine act more vigorously on magnesium than does water alone. Throughout the experiment the glycerine solution lags behind water. After 47.5 hours more gas has been evolved from the water than from the solutions of glycerine, sugar and mannite, and the same holds true after 53 hours. It is especially interesting to note that the alcohol solution is much more vigorous in its action on magnesium than is pure water. The urea solution is relatively vigorously attacked, though as has been stated, ammonia is also formed in this case. Again sodium chloride solution is much more vigorous in its action than sodium sulphate solution of equivalent strength.

Tables 2, 3, and 4 show that magnesium evolves hydrogen from solutions of magnesium salts at a fairly rapid rate. The solutions of the chloride of magnesium are the most vigorously attacked in all cases. In the solutions containing 1 gram-mol. per liter (table 2) the sulphate solution is acted upon more vigorously than that of the bromide; in the solutions containing 0.1 gram-mol. per liter (table 3) hydrogen is evolved from the bromide and sulphate solutions at an equal rate for about five hours within the limits of experimental error, while in the solutions containing 0.01 gram-mol. per liter (table 4) hydrogen is again evolved more rapidly from the sulphate solution than from that of the bromide. In the solution of nitrate of magnesium nitrite is formed, as mentioned above, which accounts for the fact that but little gas appears in the case of this salt. Table 5 shows that the KCl solution containing 1 gram-mol. per liter acts fully as vigorously as $MgCl_2$ solution of 1 gram-mol. per liter. The double potassium magnesium chloride acts still more strongly, as the table indicates. The observation that KCl solutions act readily on magnesium agrees with that of Tommasi; Mouarour called the action feeble.

At my request Mr. W. R. Mott measured the so-called single differences of potential between magnesium and some of the salt solutions in question. The measurements were made against the normal calomel electrode, the potential of which was taken to be —0.56 volts. He found that at 20° C. the single potential between magnesium and NaCl solution (2 gram-mols. per liter) is +1.163 volts between magnesium and NaOH (1 gram-mol per liter) + 1.111 volts; between magnesium and KOH (1 gram-mol. per liter) + 1.140 volts; between magnesium and KOH (0.1 gram-mol. per liter) 1.105 volts; and between magnesium and $MgSO_4$ (1 gram-mol. per liter) + 1.366 volts. Each result represents the average of four determinations in which different bars of magnesium were used. In the sodium chloride solution the E. M. F. changes but slightly with the time; in the caustic alkali solutions the E. M. F. tends to fall with lapse of time; while in the magnesium sulphate solution the E. M. F. increases on standing.

The explanation of the above described phenomena of the action of metallic magnesium upon aqueous solutions will now be considered. In the case of the saline solutions one might feel inclined to assume that the salt acts upon the water liberating a certain amount of free acid which attacks the magnesium resulting in the liberation of hydrogen and the formation of a normal or basic salt or hydroxide of magnesium, according to the nature of the solution under treatment.[1] This would be an attempt to extend Lemoine's interpretation of the action of magnesium upon aqueous solutions of its salts to all aqueous saline solutions. As stated above there is ground for this explanation in the case of salts of the heavy metals, whose aqueous solutions, as is well known, have acid reactions indicating that they are indeed slightly decomposed by water yielding free acid. But in the case of salts of Mg, Ca, Ba, Sr. K, Na, Li,

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[1] In the language of the dissociation theory, preferred by some, it would mean that that in saline aqueous solutions from which magnesium liberates hydrogen more readily than from pure water, the salt reacts upon the water slightly, liberating some free acid which in turn is electrolytically dissociated yielding free hydrogen ions. The concentration of hydrogen ions in such solutions would then be greater than in pure water (which is supposed to be only slightly electrolytically dissociated) and this would account for the more vigorous action of magnesium upon saline solutions.

there is no experimental evidence upon which to base the assumption that in their aqueous solutions there is any free acid present. Moreover, an alkaline reaction is imparted to the solutions of these salts by the magnesium soon after it has been immersed in them, and yet this alkalinity does not interfere with the evolution of hydrogen.[2]

There are no facts upon which to base the assumption that magnesium chloride in aqueous solution suffers greater hydrolytic decomposition (of which free hydrochloric acid is one of the products) than do the chlorides of calcium, barium and strontium, for instance; and yet solutions of the last three salts are acted upon but feebly by magnesium, while from the magnesium chloride solution hydrogen is rapidly evolved. This point is illustrated still more strikingly by the fact that solutions of sodium and potassium chlorides are relatively strongly attacked by magnesium; what reasons are there to assume that these salts are decomposed more by water than those of the alkaline earth metals? And again, would it be rational to suppose that because KCl solutions attack magnesium more readily than sodium chloride solutions that the former salt is decomposed more by water than the latter? But the difficulty of this mode of explanation becomes even greater in the case of the non-saline solutions. So for instance the alcoholic solution is acted upon more vigorously than pure water, clearly there is no chance for assuming free acid to be the active agent in the case of this solution.[1]

The idea that Mouraour advances in the case of solutions of ammonium salts, namely, that the solubility of magnesium hydroxide in them determines the liberation of hydrogen from them by action of magnesium, might possibly be applied to

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[2] According to the dissociation theory, such an alkaline solution would contain less hydrogen ions than pure water, and yet hydrogen is evolved faster from them than from water.

[1] Indeed from the standpoint of the dissociation theory one would have to hold that the alcohol solution contains fewer hydrogen ions than are present in pure water, and hence action ought to be less than in the latter. Moreover from the point of view of this theory, magnesium ought to act rather less on solutions of magnesium salts, for the presence of Mg ions would militate against the formation of more of them. And again the difference of potential between magnesium and an $MgSO_4$ solution ought to be less than between magnesium and a NaCl solution; the facts show that just the opposite is true.

other solutions and so the attempt be made to generalize this explanation. In addition to the ammonium salts, there are several cases that might be considered to favor this view. So magnesium hydroxide is less soluble in KOH and NaOH solutions than in pure water, and the fact that these solutions do not attack the metal as much as does water might be regarded as a support for the view advanced. Again, since ammonium fluoride solution is not acted upon by magnesium, and since the hydroxide and the fluoride of magnesium are insoluble in solution of ammonium fluoride, this might be urged as another striking instance of the same kind. It would, however, be a delusion to think that the insolubility of magnesium hydroxide in these solutions is what prevents the magnesium from acting upon them. This becomes evident from the following experiment: On making magnesium amalgam (by heating magnesium and mercury together) and treating normal solutions of KOH and NaOH with the same, I found that hydrogen is very rapidly evolved, hydroxide of magnesium is formed and mercury set free from the amalgam. Solution of fluoride of ammonium is also violently attacked by magnesium amalgam with concomitant liberation of hydrogen. Mere contact of magnesium and mercury in these solutions will not bring about this action; the amalgam must be used.

At a given temperature and pressure the course that a chemical reaction will take is determined (1) by the chemical affinity between the reacting substances and (2) by the relative masses of these substances. If the product is an insoluble one and closely envelops the surface of the solid that is being acted upon, the rate of the action will be diminished because of diminution of the surface exposed. This effect of the accumulation of the insoluble product of the reaction increases, the longer the reaction goes on, and may finally practically check the process; which is clearly shown by the results of Lemoine cited above. While there can be no doubt of this effect, nevertheless, the differences in the rates of evolution of hydrogen during the times recorded above are in general too great to be accountd for solely on the basis of accumulation of the precipitate. Of this I became especially convinced by treating aqueous solutions with sodium amalgam; in these cases where no precipitate forms, similar large differences in the rate of evolution of hydrogen occur.[1] Again it is well to bear in mind in this connection that during the time of duration of the above experiments but small quantities of magnesium hydroxide or basic magnesium salts were formed; in fact, in many cases a precipitate was not at all discernible. I assured myself that from a bar of magnesium that had remained in a normal solution of NaCl long enough to be visibly covered with a white coating, hydrogen was nevertheless much more rapidly evolved than from a fresh bar of magnesium just placed in water.

One might further be inclined to ascribe the action of magnesium on these aqueous solutions to mere contact action, *i. e.*, to so-called catalytic action of the solute or some of its ingredients. Tomassi[2] states that in the case of the KCl solution we apparently have the best instance of such contact action; for here the KCl remains unchanged and the magnesium hydroxide only is formed. Nevertheless, even here it is not an easy matter to free the latter from "adhering chlorides" by washing. It would scarcely be helpful to dismiss the matter by saying that in these diverse solutions the rate of evolution of hydrogen is increased by the catalytic action of the solute when the hydrogen is liberated more rapidly than from water, and that the rate is diminished by the negative catalytic action of the solute, when the formation of hydrogen takes place less rapidly than from water.

All the facts above presented are very readily explained on the basis of the view of solutions which suggested this research; namely, that solutions are chemical combinations of solvent and solute according to variable proportions.[3] It is clear that if

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[1] This most interesting problem of the action of alkali metals and their amalgams upon aqueous solutions is being studied in this laboratory by Mr. Gustav Fernekes at present. His work is already well advanced.

[2] l. c.

[3] The view that solutions are chemical combinations according to variable proportions, does not detract one particle from the law of definite proportions which is well established in the case of so very many compounds. Horstman (l. c.) presents the whole matter so well that it is unnecessary to dwell further upon it here.

water is chemically bound to the substance dissolved in it, the readiness with which metallic magnesium or sodium amalgam will liberate hydrogen from different solutions will in general be different. Again the difference of potential between magnesium and the solutions would be expected to be higher in the case of solutions that are vigorously attacked than in solutions in which the action is slight. The experimental data are in accord with this. If the chemical affinity existing between magnesium and the solution (regarded as a chemical combination of solvent with solute) is sufficient to overcome the cohesion of the magnesium, the latter is attacked; from the resulting compound hydrogen splits off, and the rest may all remain as a homogeneous liquid (*i. e.*, all may remain dissolved) or further decomposition into a precipitate, the hydroxide or basic salt, and a solution may occur and usually does occur after the action has progressed for a sufficient time. If no precipitate forms, the rate of change is not diminished by a decrease of the surface of metal exposed, and so the reaction is apparently aided. The more readily the dissolved products are removed from proximity of the surface of the metal by diffusion aided by mechanical stirring of some kind, the more rapidly the change progresses. Usually as the gas is rapidly evolved the liquid receives considerable stirring from this source. If the specific attraction called chemical affinity existing between magnesium and the solution, is not sufficient at the temperature of experiment, to overcome the cohesion of the magnesium, no action will take place, as in normal KOH solution, for instance; if the affinity is barely able to overcome the cohesion, the action will go on very slowly, as in the case of water. As stated above, magnesium amalgam does act on normal KOH solution with vigor, liberating hydrogen, forming magnesium hydroxide and setting mercury free. The explanation of the action is similar to the one just given. Here the affinity between the solution and the amalgam is sufficient to disintegrate the latter, and magnesium hydroxide forms in spite of the fact that it is difficultly soluble. Under the conditions of the experiment, it is evidently easier to abstract magnesium from magnesium amalgam than to overcome the cohesion of pure magnesium.

This is in harmony with the fact that magnesium amalgam does not form when magnesium and mercury are brought together at ordinary temperatures;[1] it requires a higher temperature in order that the union of the metals will take place.

The view that solutions are chemical combinations of solvent and solute may seem somewhat antiquated at the present time when purely physical conceptions of solutions are in predominence. But this older view is still held by eminent chemists and physicists, for it gives an adequate cause for the process of solution, for the thermal changes accompanying the latter, and for the fact that (exclusive of the mass) the properties of a solution are never found to be quite equal to the sum of the properties of solvent and solute. Moreover, facts known at present concerning both dilute and concentrated solutions are entirely compatible with it, and it will no doubt prove a most valuable aid in further research.

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[1] At ordinary temperatures the affinity between the metals is not able to overcome their cohesions. Compare the work of Wanklyn and Chapman on magnesium amalgam in the Jour. Chem. Soc. (2) 4, 141.

FLUORIDE OF GOLD.

BY VICTOR LENHER.

Inasmuch as fluorspar is frequently associated with gold in nature, and quite notably so in the deposits of the telluride ores, it has seemed important to study gold fluoride in order to determine if possible whether this substance can play any part in the genesis of these deposits.

The known compounds of gold with the halogens, chlorine, bromine and iodine, are, as a rule, fairly well defined. In the trivalent condition gold forms the relatively stable chloride while the bromide and iodide show greater tendency to break down into the lower state of valence of gold.

The halides in which gold shows a monovalence have received considerable attention, and it is known with a reasonable degree of certainty under what conditions aurous chloride, bromide, and iodide are capable of existence.

While the chlorides, bromides and iodides of gold have received more or less studv, comparatively little is known of fluoride of gold. Prat (Comptes Rendus, 70, 843) has prepared an intermediate oxide of gold, $Au_2\ O_2$, by the incomplete solution of gold in aqua regia, in which the hydrochloric acid is in excess, treated the solution with sufficient bicarbonate of potassium to dissolve the precipitate formed and warmed the clear orange-yellow solution to 95° when a dark olive green precipitate was obtained which when dried showed the composition Au_2O_2. In studying the properties of this oxide, Prat states that hydrofluoric acid combines with it but without dissolving it. In his study of the action of fluorine on the various metals, Moissan states that at a red heat, gold is attacked by fluorine gas, a yellow hydroscopic substance being formed and that this substance is readily decomposed into gold and fluorine.

These two experiments give practically what is known of the fluoride of gold.

The activity of the halogens toward other elements is, as a rule, inversely proportional to their atomic weights. The first member of this group of active elements, fluorine, is certainly the most active of all the elements, be they halogens or not; yet, as will be demonstrated later, it appears to have little if any affinity for gold.

In studying the chemistry of gold, it should always be borne in mind that it is the most inactive of the metals, but the relative stability of the most of its salts, notably with the halogens, would appear to make probable the relative stability of the compound with the most active of the elements, fluorine. On the other hand, we have the marked difference of fluorine from the other halogens in the insoluble fluorides of calcium, strontium and barium, as contrasted with the very soluble chlorides, bromides, and iodides; and the soluble fluorides of silver and thallium as compared with the insoluble chlorides, bromides and iodides.

In order to study the relations between fluorine and gold, experiments were conducted with the view of bringing about if possible the formation of gold fluoride under various possible conditions.

The first experiment made was a study of the action of hydrofluoric acid on the oxide of gold. To this end, oxide of gold was prepared by the action of magnesium oxide on a solution of chloride of gold and the excess of magnesia removed with nitric acid. The oxide of gold thus obtained was finely divided and hence in the most suitable condition to be susceptible to any chemical action. This oxide of gold can remain in contact with hydrofluoric acid indefinitely or as has been the case, can be boiled for weeks with either hydrofluoric acid alone or with a mixture of hydrofluoric and nitric acids without suffering any change whatever. These experiments have been repeated several times but in no case has gold been found to enter into solution nor has it been possible to detect fluorine in the precipitate.

It is obvious that fluoride of gold cannot be prepared by the action of hydrofluoric acid on the oxide. The next most natural method to try for the preparation of the fluoride would be that of double decomposition.

Silver fluoride and gold chloride, both being soluble salts, on being brought in contact in solution should yield theoretically:

$$Au\ Cl_3 + 3\ Ag\ F = Au\ F_3 + 3\ Ag\ Cl.$$

The actual case is that when solutions of these two salts are brought in contact, hydrate of gold is quantitatively thrown out of solution along with silver chloride, thus:

$$Au\ Cl_3 + 3\ Ag\ F + 3\ H_2O = 3\ Ag\ Cl + Au\ (OH)_3 + 3\ HF.$$

The accuracy of this reaction has been carefully established in the laboratory.

If gold fluoride is even momentarily formed it is immediately decomposed by water.

The method yet remaining for the preparation of a substance incapable of existence in presence of water would be the use of anhydrous solvents. A large number of organic solvents have been tried with this end in view but no substance has been found which would dissolve both gold chloride and silver fluoride; either these salts are insoluble or are decomposed by the substances worked with. Among the solvents examined, mention may be made of the following: alcohol, ether, carbon bisulphide, benzene, turpentine, pentane, hexane, chloroform, carbon tetrachloride, ethyl nitrate, nitrobenzene, ethyl acetate, ethyl propionate, and pyridine.

It thus appears that fluoride of gold is incapable of existence not only in presence of water but under the ordinary conditions met with in the laboratory and in nature.

ACTION UPON METALS OF SOLUTIONS OF HYDROCHLORIC ACID IN VARIOUS SOLVENTS.[1]

BY HARRISON EASTMAN PATTEN.

INTRODUCTION.

There is an erroneously prevailing idea that chemical action cannot take place unless the substances which are to react constitute a system capable of conducting the electric current. Little is said as to the limits, either of the E. M. F. to be employed to pass this current, or of the quantity of current which this E. M. F. must produce in order that the system may be in a proper condition to undergo chemical action. The function of temperature in facilitating chemical action is left somewhat vague, too; especially as to the range of temperature within which substances are or are not "ionized." Some go so far as to assert that no chemical action can take place without "ionization," meaning by the term "ion," a small body, an element or a complex, which bears a charge of electricity. On this basis it would follow that chemical action must take place whenever a system is capable of conducting electricity, whether a current be actually passing through the system or not. Other chemists use the term "ion" in the sense that it is that part of a chemical compound which retains its identity while undergoing chemical change. Thus, ferrous iron is not to be called a radicle, yet to say that iron is reacting does not express the whole truth. The word "ion," used in this sense, may be helpful, but is sure to be confused with the conception of free charged ions, as put forth by Arrhenius, unless careful discrimination be made.

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[1] Read before the Academy December 26, 1902; also read before the Washington meeting of the American Chemical Society, December 30, 1902.

The facts that water gives numerous solutions which conduct electricity, and that certain reactions were found to be peculiar to aqueous solution, lead Ostwald to state[1] without adequate investigation that non-aqueous solutions do not conduct the electric current. The fact that a number of reactions take place instantaneously in aqueous solutions which conduct, has lead others to promulgate the idea (*very* slightly qualified) first, that chemical action cannot go on in absence of water, since water alone gives "ions" and "ions" are needed for reaction to take place; and then when it was shown that instantaneous chemical reaction[2] takes place in solutions which conduct less than a dry air-gap, it was suggested[3] that benzene itself possesses dissociating properties; and that the evidence is not clear that every precaution was taken to dry the substances and exclude moisture in Prof. Kahlenberg's experiments; and finally that "the experiments have no bearing on the theory of electrolytic dissociation."

HISTORICAL.

In this connection a review of the work done upon the influence of moisture upon chemical reaction is of interest. In 1802 Mrs. Fulhame[1] observed that presence of moisture is necessary for the reduction of salts of gold by "phosphorated ether" or by hydrogen. Higgins[2] in 1814 found that "dry muriatic acid has no action on dry calcareous earth, while these substances readily unite if moisture is present." In 1837 Bonsdorf[3] showed that dry air free from carbondioxide does not act upon clean, dry, potassium, arsenic,[4] bismuth, lead (commercial or pure), zinc, cadmium, iron, or copper. In 1838 Regnault[5] found that dry chlorine and dry olefiant gas would not unite in

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[1] Grundriss der Allgemeinen Chemie, 390 and 391.

[2] L. Kahlenberg, Jour. Phys. Chem. 6, 1, 1.

[3] Lectures delivered before the Brooklyn Institute and published in the American Druggist and Pharmaceutical Record, October 27, 1902. By H. C. Jones.

[1] Thomson, A System of Chemistry, Vol. ii, 544, 1802.

[2] Higgins' Experiments and Observations on the Atomic Theory, 1814.

[3] Ann. Phys. Chem. 1837, 41, 293; 42, 325.

[4] Bergman is given the priority in the case of arsenic.

[5] Ann. Chim. Phys. 1838 (ii), 60, 176.

diffused daylight. It was shown by E. A. Parnell[6] that dry hydrogen sulphide will not act upon dry salts of lead, mercury or copper. In a footnote Andrews[7] states that dry chlorine at ordinary temperature does not act upon zinc, copper, or iron filings; and that dry bromine at ordinary temperatures does not act upon dry metals. In 1867 Kolb[8] found that dry oxides and hydroxides of calcium, barium, magnesium, sodium, and potassium do not gain weight in an atmosphere of dry carbon-dioxide.

Wanklyn[1] in 1869 noted that sodium and chlorine do not unite, but did not state whether moisture alone added would cause combination. Dubrunfaut[2] thought that water favors the combustion of carbon; but Dumas[3] showed that pure graphite is completely consumed in oxygen dried by sulphuric acid. The work of Dumas, however, loses significance since it has been experimentally demonstrated[4] that gases dried over sulphuric acid still give up a weighable amount of water to phosphorous pent oxide. In 1876 Cowper[1] allowed dry chlorine to act upon metals and found that presence of moisture was necessary for action to take place. Pringsheim[2] in 1887, and Dixon and Harker[3] in 1890, showed that dry hydrogen does act upon dry chlorine in absence of moisture, though more slowly than with water present. Dixon[4] and Victor Meyer[5] have shown that the union of hydrogen and oxygen is facilitated by presence of water vapor. Holt and Simms[6] find that dry oxygen does not act upon dry sodium or dry potassium; and Baker[7] finds the same for carbon, phosphorous, sulphur and tellurium,

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[6] B. A. Reports, 1841, 51.

[7] Trans. Royal Irish Acad. 1842, 19, 398; also Scientific Memoirs, 1889, p. 90.

[8] Compt. Rend. 1867, 64, 861; also DeBray, Ibid. 1848, 26, 603.

[1] Chem. News, 1869, 20, 271.

[2] Compt. Rend. 1871, 73, 1895.

[3] Compt. Rend. 1872, 74, 13.

[4] .000002 gr. water per litre of air. Morley. Am. Jr. Sci. 1885 [iii] 30, 140.

[1] Trans. Chem. Soc. 1876.

[2] Ann. Chim. Phys. 1887, 421.

[3] Owens College Researches 1.

[4] Phil. Trans. 1884.

[5] Berichte d. D. C. Gs. 1893.

[6] Trans. Chem. Soc. 1894.

[7] Phil. Tran. 1888.

while he also finds that boron, arsenic, antimony and selenium are acted upon by oxygen in absence of moisture.

Sabatier and Senderens[1] in 1893 found that dry nitrogen peroxide does not act upon dry sodium at ordinary temperatures, but on heating, the sodium is gently oxidized. Nickle, cobalt, and iron reduced by hydrogen burn wih incandescence in dry nitrogen peroxide to Fe_2O_3, Co_4O_5 and $NiO + Ni_2O_3$; while copper, cobalt and nickle give with dry N_2O_4—greatly diluted with dry nitrogen to avoid the oxidation mentioned above—the compounds Cu_2NO_2, Co_2NO_2 and Ni_2NO_2; iron is acted on similarly but the compound is not well established as yet. The copper used may be reduced by carbon, or by hydrogen, so that the action is not due to the formation of a hydride of the metals. The authors state definitely that moist air immediately acts upon thes metallic nitroxyls giving nitrous vapors.

In 1884 Dixon[2] observed that the union of carbon monoxide with oxygen is influenced by the presence of moisture, but in 1896 found[3] that freshly prepared carbon monoxide unites with oxygen in absence of moisture. In 1894[4] Baker showed that dry nitric oxide and oxygen will not combine. Dixon[5] first found that moisture is necessary for the decomposition of cyanogen by oxygen, but later[6] succeeded in exploding a mixture of dry cyanogen and dry oxygen. Baker[7] was able to burn dry carbon bisulphide in dry oxygen; he also showed that dry carbon unites with dry oxygen but with no accompanying glow.[8] Cohen[9] states that dry hydrogen chloride is without action upon aluminium or sodium.

In 1892 Veley[1] showed that calcium oxide does not combine to any appreciable degree with carbon dioxide or with sul-

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[1] Bull. Soc. Chim. 9, 669, 1893.
[2] Phil. Trans. 1884; B. A. Report 1880, 503; J. Chem. Soc. (Abstr. 1893.)
[3] Trans. Chem. Soc. 1896.
[4] Ibid. 1894, 611.
[5] Ibid. 1884.
[6] Ibid. 1896.
[7] Phil. Trans. 1888.
[8] Ibid. 1888; (Abstr) 571.
[9] Chem. News, 54, 102.
[1] Trans. Chem. Soc. 1893, 831-833.

phur trioxide at temperatures below 300° C. And in 1894 he found that dry chlorine does not combine with dry calcium oxide at ordinary temperatures to form the so-called bleaching powder, up to 300° C., at which temperature a partial replacement of oxygen by chlorine takes place.[2] Baker[3] states that moisture is needed in order that the following substances may unite; lime with sulphur trioxide; cupric oxide with sulphur trioxide; ammonia with hydrogen chloride. Hughes and Wilson[4] showed that dry hydrogen chloride does not act upon calcium carbonate, and Hughes[5] showed that dry hydrogen sulphide does not act upon metallic salts, and that dry hydrogen chloride *does* act upon manganese dioxide. Baker[6] sublimed dry ammonium chloride from dry lime without liberating ammonia, but in the same research showed that dry nitrogen tetroxide decomposes on heating; likewise he decomposed dry carbon disulphide, potassium chlorate, silver oxide, and lead acetate, and changed dry amorphous phosphorous to the yellow modification by heat, and the dry yellow phosphorous back to the amorphous state by action of sunlight. Shenstone and Cundall[7] changed dry oxygen to ozone by application of electrical energy.

In January 1902 Kahlenberg[8] showed that the oleates of copper, nickle and cobalt dissolve in benzene to form highly conducting solutions and that dry hydrochloric acid gas precipitates instantly the chlorides of these metals; the same result is obtained by adding a benzene solution of $SnCl_4$, PCl_3, $AsCl_3$, or $SiCl_4$ although all of these solutions are as good insulators as benzene itself. Dry hydrogen sulphide passed into these dry oleate solutions precipitates the sulphide of the metal; arsenic and tin sulphides were similarly formed by action of dry H_2S on a benzene solution of $AsCl_3$ and of $SnCl_4$; a petroleum ether solution of $AsCl_3$ gives with H_2S arsenic sulphide

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[2] See also F. Winteler, Zeit. f. Anorg. Chem., 33, Heft 2, 161, 1902.
[3] Ibid. 1894, 611.
[4] Phil. Mag. 1892.
[5] Ibid. 1893, 533.
[6] Trans. Chem. Soc. 1894, 611.
[7] Ibid. 1887.
[8] Jour. Phys. Chem., 6, 1, 1902.

more readily than the benzene solution. Dry hydrogen chloride does not unite with dry ammonia, but in the presence of dry benzene vapor ammonium chloride is instantly formed. Similarly dry pyridine unites with dry hydrogen chloride in benzene solution. He does not state whether dry hydrogen chloride will not unite with dry pyridine in absence of a third substance.

In 1902 W. D. Patton[1] showed that dry hydrogen chloride dissolved in dry benzene will not react with dry soda lime; and that an infinitesimal amount of water is not sufficient to cause the reaction to go. J. W. Mellor and E. J. Russel[2] find that an electric spark causes combination of dry hydrogen with dry chlorine instantaneously and completely. While neither heat nor sunshine cause this action, action between the two dried gases does go on, though slowly. Clearly moisture is not needed. Jatindrath Sen[3] has shown that dry ammonia gas acts upon dry mercurous chloride.

To study further the question as to the action of chemicals upon each other in solutions where the conduction of electricity is extremely slight I have dissolved gaseous hydrochloric acid in various solvents and brought the resulting solutions into con-

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[1] Mr. W. D. Patton describes his experiments as follows: While preparing anhydrous solutions of HCl gas in benzene, various dehydrating agents were used. Soda lime was placed in one bottle containing benzene, HCl gas run in and the action noted. The benzene used was Schuchard's thiophene free preparation which had stood over P_2O_5 for six months. It was then transferred to a dry bottle and well shaken with P_2O_5, after which it was treated a second time in the same manner. The dry benzene was then forced into a bottle containing soda lime, made by Merck, previously heated, and allowed to stand for a day. The HCl gas was prepared in a flask from NaCl, C. P. and H_2SO_4, C. P. concentrated. The gas, as soon as evolved, was passed through two drying bottles containing H_2SO_4, concentrated, and then through two U tubes, containing anhydrous Ca Cl_2. The U tubes were from entrance to exit, 50 cm. long, with an internal diameter of 2 cm. From these the gas was passed directly into the prepared benzene. The HCl gas was evolved continuously, until the benzene was saturated, the tube conducting the gas reaching to within 2 cm. of the soda lime. During the introduction of the HCl gas, from the beginning to the close of the experiment no action was observed on the soda lime. The rough corners of the lumps were as sharp and well defined as when introduced, and after standing for two days with a layer of air above the benzene, no change was perceptible. But when some of the soda lime and benzene were poured together into a vessel containing water, the reaction began with great energy.

[2] Trans. Chem. Soc. 1902, 1273.

[3] Zeit. Anorg Chem. 33, 201, 1902.

tact with a number of metals and carbonates. In some cases hydrogen or other gas was evolved from the metal and a chloride of the metal formed. In others one metal was attacked, and this metal deposited from solution upon a second metal. In still others, no gas appeared and no deposition of metals upon each other was observed but still some metals were corroded. Some solvents of themselves attack the metals.

EXPERIMENTAL METHODS AND APPARATUS.

The experimental work was conducted as follows:

The hydrochloric acid gas was evolved by dropping an aqueous solution into concentrated sulphuric acid; the gas then passed through two wash bottles containing concentrated sulphuric acid; over fused calcium chloride contained in a tower 30 cm. high and 3 cm. in diameter; over phosphorous pentoxide spread on dry pumice stone contained in (1) a tower 40 cm. high and 4 cm. in diameter, (2) a bottle 10 cm. high and 5 cm. in diameter and (3) through a tower of the same dimensions as No. 1. From here the gas was passed into the bottle which contained the clean, dry metals and the anhydrous solvent. From this bottle the gas was led away through three tubes 2 cm. in diameter and 15 cm. long, containing phosphorous pentoxide, connected in series, then through a sulphuric acid wash bottle and finally absorbed in potassium hydrate solution. No cotton was used in any of this work since phosphorous pentoxide decomposes it. Where necessary, glass wool, which had previously been heated, served to keep particles of phosphorous pentoxide from being carried by the gas.

Two methods of preparing the solvent were used. 1. The dehydrated, redistilled solvent was sealed up in a test-tube, placed in a clean, dry bottle which contained the clean dry metals and the bottle closed with a rubber stopper through which passed two tubes; one reached to the bottom of the bottle so that the hydrochloride acid gas when passed in might bubble through the solvent; the other tube served as an exit for the gas. Before any hydrochloric acid gas was run through, a stream of hydrogen purified by the usual means and dried over sulphuric acid, calcium chloride and phosphorous pentoxide as rigorously as the hydrocloric acid gas just described was run into this bottle with the test-tube containing the solvent still unbroken. This hydrogen was left running all night and the experiment finished in the morning, when the bottle was closed by screwing down the pinchcocks, connected to the hydrochloric acid generator and the pinchcocks next the generator opened first and allowed to stand for fifteen minutes in order that any moisture from the air in the tube by which connection had been made might be absorbed.

Before taking any hydrochloric acid from the generator the gas was allowed to run through all the train, with the bottle containing the solvent and metals cut out, until there could be no question that all air had been displaced. Then the gas was run into the bottle under considerable pressure in order to prevent the solvent rushing back into the drying towers—hydrochloic acid gas is much more soluble in some of the solvents used than might be supposed.

2. The second method of preparing the solvent is that given in detail under the experiment in which benzene is used as solvent. Owing to the controversy concerning the action of a solution of hydrochloric acid gas in this solvent, I have given every point. To save repetition, the reader is referred to this experiment. In other cases, to relieve all doubt as to the conditions of experiment I have been very explicit even at the risk of repetition.

Method 1 is more satisfactory for solvents which are self-dehydrating; that is, which decompose water with formation of oxychlorides and hydrogen chloride gas. While it is true that the oxychlorides might promote chemical action, the conductivity measurements show that at least no electrolytic dissociation exists in these solutions.[1]

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[1] I mean simply that it would be carrying the theory of electrolytic dissociation to an extremity to claim ionization in a solution or solvent which conducts electricity less well than a dry air gap. That we do get a current even across the air-gap is unquestionable, since the voltmeter used as ammeter is deflected. But that this current is carried *electrolytically* is a point which requires experimental proof more rigid than any yet at hand.

Method 2 was used for solvents which dissolve water without undergoing decomposition. It was found that method 1 was not satisfactory for these liquids. The first, second and third experiments with chloroform were carried out according to method 1; also the first experiment with carbon tetrachloride. The action of the hydrogen chloride solutions upon magnesium and aluminum indicates that all moisture had not been eliminated, especially as the last experiments with carbon tetrachloride and chloroform as solvents gave evolution of gas upon zinc alone; and the electrical conductivity of the last solutions was much less than that of the solutions prepared by method 1.

RESULTS.

Chloroform as Solvent.—Chloroform from Kahlbaum was dried for some weeks over a large surface of fused calcium chloride and distilled from a dry flask and condenser into a receiver protected by a calcium chloride tube. The first runnings of the chloroform were rejected and the final portion which boiled at 60° C. under 741.7 mm. was quickly sealed up in dry glass tubes. The moisture taken up during the necessary transfer through the air is extremely slight. The metals used were carefully cleaned by scraping with a sharp knife, heated, and placed in the bottle along with a tube of the sealed up chloroform and treated as described in full under method 1.

The chloroform had no action upon the metals. When hydrochloric acid gas was run in, gas was evolved upon zinc, cadmium, and magnesium. The approximate degree of violence of this action as estimated by my eye is given in table I by the subscripts to the H's used to denote evolution of gas. As this action progressed a black deposit, fine and sooty, appeared on magnesium, aluminum, chromium, manganese, lead, tin, bismuth, and antimony, and small aggregations of this black deposit floated about in the solution. Doubtless it was carbon. This black deposit did not appear in either of the other three chloroform experiments. An accident happened in carrying out this experiment: The hydrochloric acid gas was admitted under slightly reduced pressure so that the solvent was drawn back up the tube by which the gas entered, into the P_2O_5 drying tower. When extra pressure was put on to force the solvent back into its flask, the stopper was blown from one of the drying towers and some air got in, but no moisture could have reached to the flask containing the metals and chloroform, since it was well protected by the remaining phosphorous pentoxide drying towers, two on each side. The chloroform came for a short time in contact with the rubber tube connecting the flask to the drying tower; however, the negative results of this experiment will stand: Iron, nickel, copper, silver, gold, platinum, arsenic, tellurium, and palladium remain perfectly bright in presence of the chloroform solution of hydrogen chloride; aluminum, chromium, manganese, lead, tin, and antimony evolve no gas. Magnesium gives off very much less gas than comes from the zinc. Calcite and witherite are not attacked. Contact of the metals with each other makes no difference in the rate at which gas is evolved. This experiment was carried out at room temperature, 22° C. Finally the solution was siphoned out of the flask under pressure into a platinum crucible and its electrical conductivity tested. Using a direct current of 110 volts pressure and a Jewell voltmeter of 20,000 resistance as an ammeter, I got a deflection of 5 volt divisions, which corresponds to a current of 0.00025 ampere. The bottom of the crucible served as one electrode; the platinum disk serving as the other electrode was 1.75 cm. in diameter, and the distance between electrodes was about one millimeter.

Experiment 2. A second sample of dried chloroform was treated exactly as in the first experiment. The results are given in table I. Zinc, aluminum, magnesium, tin and lead are acted upon by HCl solution with evolution of gas. The violence of action is in the order just given. No black deposit was observed; possibly it came from dissolved rubber in the first experiment. The other metals were not acted upon.

Experiment 3. A third sample of dried chloroform was treated as in experiments 1 and 2. The hydrogen chloride solution acted upon zinc, aluminum, magnesium, tin and lead, in the order given, with evolution of gas. Nickel, lead and tin are very slightly corroded. Antimony turns black. See Table I.

Experiment 4. This sample of chloroform was prepared independently of the other three samples just described. It was dried two weeks over a large surface of fused calcium chloride, the edges of which remained perfectly sharp, and then distilled from fresh fused calcium chloride out of contact with air in an apparatus which had been dried in a current of clean air and then allowed to stand twenty-four hours in contact with the phosphorous pentoxide drying train. The metals, magnesium, aluminum, zinc and cadmium used were polished by scraping, and left in the receiver (into which the chloroform distilled) during the process of drying. No tarnish was observed on any one of them. The chloroform distilled at 59°.9 c. under 746 mm.

Thus the solvent was prepared dry and by means of tubes fitted with glass stopcocks attached to the receiver dry hydrochloric acid gas was run in and its action upon the metals observed. Magnesium and aluminum show no evolution of gas; a very minute quantity of gas comes off upon cadmium; zinc is vigorously attacked, rather more hydrogen being evolved than in a normal HCl solution in water. The conductivity of this solution is very much less than that of a dry air-gap. Using the platinum crucible before described, 110 volts sent 0.00003 ampere through it. On standing twenty-four hours both magnesium and aluminum were considerably corroded, though I saw no evidence of evolution of gas upon them at any time. A qualitative analysis of the cholorform solution—which was siphoned off by pressure of dry air—showed zinc and aluminum in quantity, a fair amount of magnesium, and a slight trace of cadmium. This indicates that the corrosion of magnesium and aluminum is facilitated by the solution of zinc chloride in the chloroform.[1] Probably the hydrogen is united with the carbon of the chloroform to give hydrocarbons. See Table I.

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[1] Compare this with the action of aqueous solutions upon magnesium, aluminum, sodium, and sodium and potassium amalgams as treated by L. Kahlenberg in the Jour. Am. Chem. Soc. 1903, and an unpublished paper by G. Fernekes.

Carbon Tetrachloride as Solvent.—Schuchardt's c. p. carbontetrachloride was dried over fused calcium chloride for three days. It boiled at 75°.0 C. under 741.7 mm., and was sealed up in a glass tube as described under "Method 1." The solvent itself is without action upon the metals used. As soon as the hydrogen chloride gas was run in an active evolution of gas upon the zinc was noticed. Magnesium was not acted upon, remaining perfectly bright for two hours, when a black deposit appeared upon it. Aluminum was attacked less vigorously than the zinc, but maintained a steadier evolution of gas. The evolution of gas upon zinc gradually decreased, a white coating forming upon the metal. At first tin was merely corroded but after about twenty minutes gas was given off upon it and finally a brisk evolution set in which proved to be steadier than that upon the zinc. Lead was corroded, a white crust, doubtless $PbCl_2$ forming upon it. Iron was attacked with the formation of a red crust—$FeCl_3$. Cadmium was very slightly attacked, some minute bubbles rising from it at long intervals. Nickel, copper, silver, antimony, bismuth, manganese, chromium, arsenic, tellurium, platinum, palladium, gold, and calcite and witherite were not acted upon; no gas was evolved, and their lustre remained undimmed. The conductivity of this solution, after being siphoned off through the air was less than that of a dry air-gap. Contact of one metal with another made no difference in any of the above reactions.

Experiment 2. A sample of the same carbon tetrachloride was left drying for two weeks over fused calcium chloride and then distilled from fresh calcium chloride in a dried apparatus (as given in method 2), and dry hydrogen chloride run in. The metals magnesium, zinc cadmium and aluminum were used. Zinc is immediately attacked and evolves gas with considerable rapidity, but after an hour a protective coating begins to form on the zinc, $ZnCl_2$ in all probability. After twenty-four hours the metals, except zinc, are still unacted upon, while the zinc is completely coated over with a white crust. The solution was siphoned off and its conductivity tested: 110 volts across one millimeter in the platinum crucible passed a current of 0.000066 ampere; a dry air-gap allows 0.0001 ampere to pass, using the same pressure and electrodes. Before this test it is unquestionable that a trace of moisture was taken up while the solution was being pourèd through the air into the crucible where the conductivity was tested. The anhydrous solution which acted upon the metals had in all likelihood a still lower conductivity.

Ethyl Chloride as Solvent.—1. Schuchardt's c. p. ethyl chloride was treated as in method 1. The bottle containing the metals and the ethyl chloride tube was cooled to 0° C. and the ethyl chloride broken from the tube. Of itself ethyl chloride has no action upon the metals at that temperature. When dry hydrogen chloride gas is passed in, the solution acts upon zinc at once with brisk evolution of hydrogen. Magnesium is attacked, but gas is not given off from it so fast as from the zinc. Gas comes off upon cadmium in small quantity, somewhat more than comes from the aluminum, which at first showed no action at all. A slight bubbling was observed upon the manganese. The following metals remained perfectly bright: iron, nickel, bismuth, tin, copper, silver, gold, platinum, and palladium. Lead was slightly tarnished. Calcite and witherite were not acted upon. The flask was opened to the air so that a trace of moisture might get in, but no more metals were corroded, and no acceleration in the liberation of gas upon any metal was observed. The order of violence with which the gas is evolved upon each metal is given in table I. The conductivity of the ethyl chloride and of the solution of hydrogen chloride in ethyl chloride is less than that of a dry air-gap.

2. Lest question be raised as to the dryness of Schuchardt's preparation of ethyl chloride, a second experiment was undertaken. The ethyl chloride was distilled and passed in gas form through c. p. sulphuric acid of specific gravity about 1.8, then through four wide-mouth eight-ounce bottles connected in series

and containing phosphorous pentoxide and dry pumice, and finally condensed by a freezing mixture of ice and salt in a glass bottle with a double stop-cock ground in. The dry metals scraped bright had been placed in this dried bottle and allowed to stand in connection with the phosphorous pentoxide drying tubes for six hours before the ethyl chloride was distilled in upon them. The HCl was dried through two sulphuric acid wash bottles, one calcium chloride tower, and two phosphorous pentoxide towers (of the dimensions given in the first paragraph under the head "experimental"), four eight-ounce wide-mouth bottles, and three six inch calcium chloride tubes all filled with phosphorous pentoxide. When the HCl was run into the ethyl chloride zinc was rapidly tarnished, a white coating, undoubtedly $ZnCl_2$ formed, and a steady evolution of gas was observed. Lead was corroded to a marked degree, but no gas was evolved. Tin was covered with a white coating—$SnCl_2$. Magnesium was blackened in spots but no evolution of gas was observed for one hour, when minute bubbles began to come off, and at the end of eleven hours the magnesium was very considerably corroded. Aluminum was first merely corroded, but after ten minutes an evolution of gas began which was steadily maintained. During the first two hours manganese, chromium, silver, antimony, and copper remained bright but the next day after eleven hours had elapsed, pink $CrCl_3$ appeared on the chromium; manganese was covered with a dark coating; antimony was slightly darkened; silver was black in spots; and copper had a very slight tarnish, such that its lustre was merely dimmed. Shortly after running in the HCl, iron began to corrode red ($FeCl_3$) in spots but no gas was evolved. Cadmium also was corroded white. Cobalt was tarnished but no action whatever was observed upon nickel. Arsenic, bismuth, gold, palladium, platinum and tellurium remained perfectly bright after standing eleven hours. Witherite and calcite were not attacked by the HCl solution in ethyl chloride.

The conductivity of the ethyl chloride and of a saturated solution of HCl in ethyl chloride was tested as follows:—Ethyl chloride was distilled over through the drying apparatus containing phosphorous pentoxide (mentioned in the paragraph above) and condensed in a conductivity cell of special pattern which had been dried by hot, clean air and by standing five hours in contact with phosphorous pentoxide. One hundred twenty volts from a direct current dynamo was then applied to the terminals of this cell and a Jewell voltmeter of 20,000 ohms resistance was placed in series and used as an ammeter. The deflection of the voltmeter was the same for the pure solvent and for the HCl solution, i. e., one-third of a volt division which corresponds to 0.0000165 ampere. Opening the HCl solution to the air for a few seconds did not increase the conductivity. It still remained one-third of a volt deflection. The insulating material between the electrodes of this cell was the glass of the cell, and upon the outside an insulating wax ordinarily used for induction coils. The insulation was tested with 120 volts, but the voltmeter in series showed no deflection whatever.

Benzene as Solvent.—To ascertain if HCl gas dissolved in benzene will act upon zinc, cadmium, aluminum or magnesium, Schuchardt's c. p. benzene was treated with phosphorus pentoxide in quantity and allowed to stand 48 hours. Meanwhile a distillation apparatus, dried by clean hot air, was set up with tightly fitting connections; the receiver was protected by a phosphorous pentoxide tube, which in turn was protected by two more phosphorus pentoxide tubes and beyond them was a wash bottle containing concentrated sulphuric acid. This apparatus was put together hot and stood forty-eight hours, thus removing the last trace of moisture. Then the benzene was poured off from the phosphorus pentoxide, over which it had been standing, into the distilling flask, and the stopper quickly replaced.

Sodium was taken from the petroleum in which it is ordinarily kept, thoroughly freed from petroleum by washing repeatedly with Schuchardt's c. p. benzene, and finally cut into small bright pieces under benzene and quickly transferred to the distilling flask which contained the benzene to be used in the experiment. About four grams of sodium was taken to 50 cc. of benzene and the distilling apparatus was allowed to stand in contact with phosphorus pentoxide drying tubes for seventy-two hours before distilling the benzene.

In making the distillation the joints of the apparatus proved to be so tight that on removing the flame below the distilling flask a vacuum was caused by the condensing of the benzene vapors. When the receiver containing the benzene was disconnected from the distillation apparatus some benzene was left in the part of the glass tubes beyond the glass stop-cocks. This was evaporated off by heating and blowing in air through a capillary tube. Then the receiver was connected to the hydrogen chloride apparatus and allowed to stand one half hour in connection with the phosphorus pentoxide towers on each side before the stop-cocks of the receiver were opened to let in the HCl gas. Thus it is not possible that any moisture from the air entered the receiver.

The HCl gas was now run in under pressure. Zinc was acted upon in one minute from the opening of the stop-cock, a gas, presumably hydrogen, being evolved with considerable vigor. Magnesium and aluminum were not touched but remained perfectly bright. Contact with the metals makes no difference in the rate of action on zinc. After one and one-third hours the zinc was still being acted upon with a steady evolution of gas and showed signs of corrosion, a white crust forming on it, doubtless $ZnCl_2$.

Cadmium gave off no bubbles of gas at any time but after two hours showed a very faint white tarnish. Neither magnesium nor aluminum showed signs of corrosion after standing twenty-four hours. *A trace of water let in by opening the receiver to the air did not cause action upon the aluminum or magnesium.* The benzene solution was siphoned off under pressure without coming into contact with the air before it left the metals, evaporated to dryness and left not the slightest solid residue. This shows that the action upon metals of these non-aqueous solutions of HCl does not depend solely upon the solubility of the salt of the metal in the solvent used, but rather is to be attributed primarily to the chemical individuality of the metal, as well as that of the solution.[1]

The solution of HCl in benzene conducts the electric current approximately one-fifth as well as a dry air gap, when tested with 110 volts direct current with electrodes one millimeter apart.

Tin Tetrachloride as Solvent.—Schuchardt's $SnCl_4$ was treated as described in method 1. The pure solvent is without action upon magnesium, chromium, manganese, aluminum, zinc, cadmium, iron, nickel, tin, lead, copper, antimony, bismuth, arsenic, silver, gold, platinum, palladium, tellurium, calcite, or witherite. The solution of HCl in this solvent is also without action upon the above metals and carbonates. The conductivity of the HCl solution was tested with 110 volts across one millimeter and gave a deflection of one volt division on the Jewell voltmeter corresponding to a current of 0.00005. Attention is called to the fact that this solution exhibits a higher conductivity than either benzene or ethyl chloride, and yet the benzene solution and the ethyl chloride solution act vigorously upon the zinc and slightly upon the cadmium, while the $SnCl_4$ solution of HCl is entirely without action.

Silicon Tetrachloride as Solvent.—Schuchardt's $SiCl_4$ was treated as described in method 1. The pure solvent does not act upon magnesium, aluminum, zinc, cadmium, iron, nickel, tin, lead, cobalt, silver, platinum, palladium, or tellurium. No gas was evolved upon any of the metals when HCl was run in. Copper was blackened and after standing three and three-fourths hours lead was corroded white. All the other metals remained perfectly bright during eight and one-fourth hours after the HCl was run in. The $SiCl_4$ alone, and the HCl solution conduct electricity less than a dry air gap as tested by 110 volts across one millimeter.

Calcite and witherite are not acted upon by the HCl solution.

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[1] Compare, L. Kahlenberg Jour. Phys. Chem. 6, 1, 1902, pp. 1–14; also M. Gomberg, Amer. Chem. Jour. 25, 324 (1901).

Phosphorus Trichloride as Solvent.—Schuchardt's phosphorus trichloride was distilled over phosphorus pentoxide from a dry retort into a dry erlenmeyer eight-ounce flask containing the metals. The pure solvent has no action upon any of the metals used. See summary in Table I. When dry HCl gas is run in lead is slightly tarnished, tin is very slightly darkened, bismuth is darkened, but beyond this there is no action upon any of the metals used. The conductivity of the pure solvent and of its HCl solution is less than that of a dry air gap as tested by 110 volts across one millimeter.

Arsenic Trichloride as Solvent.—Schuchard's $AsCl_3$ was treated as in method I. Magnesium is blackened by $AsCl_3$ alone, very likely by a deposit of arsenic. Aluminum, chromium, manganese, zinc, cadmium, tin, copper, silver, gold, platinum, palladium are turned black by the solvent alone. Iron is corroded red, but the coating is not very thick. A white crust, doubtless $PbCl_2$, is formed on lead. When the HCl gas was run in, gas was evolved upon magnesium and zinc in about equal amount, but only about one-seventh as fast as from zinc or aluminum when acted upon by a solution of HCl in chloroform. This is simply *my judgment* as to the respective rates *as observed by my eye,* and is not to be thought of as a rigid quantitative relation. No further action was observed upon the other metals except bismuth and nickel, which were very slightly corroded. Calcite and witherite were not acted upon. The arsenic trichloride alone allowed a current of 0.00274 ampere to pass when subjected to 65 volts pressure. The electrodes were about 5 mm. apart and approximately 1 cm. square.

Antimony Pentchloride as Solvent.—E. de Haën's $SbCl_5$ was treated as described in Method 1. The pure solvent acted upon iron, coating it red; tin was slightly darkened; bismuth, copper, and antimony were blackened; the other metals remained bright. When HCl gas was run in, lead was very slightly tarnished; silver was blackened; beyond this there was no action upon any of the other metals. Those which were bright in the pure solvent remained bright; those which were corroded or deposited upon by the solvent alone appeared to undergo no further action when HCl was present. No gas was evolved upon any metal. Calcite and witherite were not acted upon. See summary in Table I.

2. A second sample of $SbCl_5$ was treated as in Method 1. The pure solvent acted upon iron, coating it red; upon tin, forming a white crust. Bismuth, copper, antimony and tellurium were darkened; arsenic turned gray. Magnesium, aluminum, chromium, manganese, zinc, nickel, cadmium, silver, gold, platinum, and palladium were not acted upon, as was the case in Experiment 1 above. When the HCl gas was run in, the corrosion on the iron was increased slightly. No further action was observed on any of the metals except silver, which was blackened. By a separate experiment it was shown that no silver goes into solution in this antimony pentachloride and HCl solution. A qualitative analysis of this solution showed mere traces of lead, cadmium, iron, zinc and magnesium. A large quantity of the solution was operated upon—10 cc—so that the test shows that the solubility of chlorides of the metals found is extremely slight. By another experiment it was shown that silver may be kept indefinitely without blackening in a solution of HCl in $SbCl_4$ provided no other metal be present. This means that we have here a case of plating out of one metal upon another from a solution which is as non-conducting towards the electric current as a dry air-gap. Calcite and witherite were not attacked. No bubbles of gas were given off from any of the metals. This may be explained by assuming that nascent hydrogen reduces the $SbCl_5$ regenerating HCl which dissolves in the solvent.

Sulphur Monochloride as Solvent.—Schuchardt's S_2Cl_2 was treated as described in method 1. The pure solvent blackened antimony immediately; copper is blackened and tellurium turned dark. Magnesium at first was coated a yellowish white and aften ten minutes the action upon the magnesium became so violent that sufficient heat was generated to crack the bottle containing the solvent and the metals. A separate experiment showed that magnesium alone acts upon S_2Cl_2 when both are dry giving free sulphur and the chloride of magnesium.

A second experiment with S_2Cl_2 was undertaken, leaving out magnesium, cobalt, copper, antimony and tellurium, which were acted upon by the pure solvent. In this second experiment S_2Cl_2 did not act upon aluminum, chromium, manganese, zinc, iron, nickel, lead, cadmium, tin, bismuth, silver, gold, platinum, palladium, which metals also remained bright in the first experiment with S_2Cl_2, as shown in Table I. When the HCl gas was run in, aluminum was coated white; zinc was slightly corroded white; cadmium showed a white crust; there was a red coating upon iron; tin was corroded white; and bismuth was darkened. The other metals remained bright. The solution of HCl in S_2Cl_2 shows a conductivity less than that of dry air. One hundred ten volts direct current across one millimeter gave one and one-half volt deflection of a Jewell voltmeter, corresponding to a current of 0.000075 ampere. Calcite and witherite are not acted upon.

Thionyl Chloride as Solvent.—Schuchardt's $SOCl_2$ was treated as in method 1. The pure solvent acted upon magnesium, coating it gray; aluminum, lead, and tin were coated white; iron, copper, bismuth, and antimony were coated black; arsenic was coated gray, and a very slight evolution of gas was noticed; tellurium was corroded; chromium, manganese, zinc, nickel, cadmium, silver, gold, platinum, and palladium remained bright. The solution of HCl in $SoCl_2$ gave zinc a white coating, slightly darkened silver, and dissolved away the black coating which had been formed upon the iron by the $SOCl_2$ alone. Probably this coating was FeS and gave $FeCl_2 + H_2S$. Very likely the silver was darkened by the H_2S thus formed. No further action upon any of the metals mentioned above was noticed. Both calcite and witherite were vigorously attacked with evolution of gas. 73 volts caused 0.00235 ampere to flow through the $SOCl_2$ above, with electrodes approximately 5 mm apart and 1 cm square.

All of the above experiments were carried out at room temperature (22° C) except the one with ethyl chloride, which necessarily was done at zero degrees C. on account of its low boiling point. With the exception of $AsCl_3$ and $SOCl_2$, none of the above solvents or solutions conduct electricity, rather they are most excellent insulators. It is established beyond question that chemical action may and does take place in solution at ordinary temperature without the presence of moisture and without concomitant electrolytic conduction. Contact of one metal with another has no effect upon any of the above actions. The colors of the coatings formed upon the various metals indicate that the chlorides of the metals have been formed. In many cases the formation of a protective chloride coating causes the corrosion of the metal to cease.

TABLE I.

Table I contains a summary of the results obtained in this research. At the top of each column is given the formula for the solvent used. Above this formula is given the number of the experiment with that solvent. The symbols placed in the squares directly below the solvent formula denote what action the pure solvent had upon the metal which stands in the horizontal column with this square. The symbols in the squares below the formula HCl indicate the action of the solution of HCl in that solvent upon the respective metals.

The following symbols are used to indicate what action took place upon the metal:—

Square left blank = Metal remained bright.

C = Metal corroded; no gas given off. An ! after the C means that the action is instantaneous.

W = White. B = Black. R = Red. D = Darkened.
G = Gray. Pk = Pink. I = Corrosion increased.
T = Slight tarnish. NF = No further action.
P = Metal seems to be plated upon. — = Metal not present.
X = Solvent is broken down.
H = Bubbles of gas given off.

The subscripts H_α, H_β, H_γ, etc., indicate the order of violence of action, H_α, being most violent and H_Δ the least. The estimation was made *by my eye,* and is merely my judgment as to the rate at which gas was evolved.

TABLE I.

	1		2		3		4		1		2		1		2												1		2		1		2					
	$CHCl_3+HCl$								CCl_4+HCl.				$C_2H_5Cl+HCl$				C_6H_6+HCl		$SiCl_4+HCl$		$SnCl_4+HCl$		PCl_3+HCl		$AsCl_3+HCl$		$SbCl_5+HCl$				S_2Cl_2+HCl				$SOCl_2+HCl$		H.F.	
Mg		H_γ		H_β		H_γ				CB after 2 hours				H_α		H_β									C?X PB	H_β					X	Solvent decomposed by magnesium before HCl could be run in.	—	—	CG	NF	75,505	Mg
Al		PB		H_α		H_α				H_α				H_β		H_β CW									PB	NF								CW	CW	NF	53,660	Al
Cr		PB					—	—	—	—	—	—	—	—		CP_K	—	—	—	—			—	—	PB	NF												Cr
Mn		PB					—	—	—	—	—	—		H_β		CD	—	—	—	—			—	—	PB	NF											55,995	Mn
Zn		H_α		H_α		H_α		H_α		H_α		H_α		H_α		H_β CW		H_α CW							PD	H_β								C WT		CW	48,605	Zn
Fe							—	—		CR	—	—				CR	—	—					—	—	C RT	NF	CR	CI	CR	CI				CR	C or P $\sqrt{B}$		41,025	Fe
Co	—	—	—	—	—	—	—	—	—	—	—	—	—	—		CD	—	—			—	—			—	—			—	—	—		—	—	—	—	38,740	Co
Ni						CT	—	—			—	—					—	—								CT											37,260	Ni
Pb		PB		H_γ		H_γ C WT	—	—		CW	—	—		C WT		CW	—	—		CWT after $3\frac{1}{4}$ hrs				CW T	CW	NF		T	C TW	NF				CW	CW	NF	41,385	Pb
Cd		H_γ PB						H_Δ		H_γ				H_β		CW		CWT after 2 hours							PD	NF											46,620	Cd
Sn		PB		H_β		H_γ C WT	—	—		H_α	—	—				CW	—	—						C DT	CD	NF	CD	NF	CW	NF				CW	CW	NF	31,812	Sn
Bi		PB					—	—			—	—					—	—	—	—				CD		CD T	CB	NF	CD!	NF				CD	CD	NF	30,210	Bi
Cu							—	—			—	—				T	—	—							CD T	NF	CB P?	NF	CB!	NF	PB		—	—	C or P B	NF	25,815	Cu
Ag							—	—			—	—				PB	—	—							PT	NF		PB		PB						C or P D	29,380	Ag
Sb		PB				CB	—	—			—	—		H_β		T	—	—	—	—							CB	NF	PD	NF	T PB!		—	—	CB	NF	20,974	Sb
Au							—	—			—	—					—	—	—	—					PB	NF											7,607	Au
Pt							—	—			—	—					—	—							PB	NF												Pt
As							—	—			—	—	—	—			—	—	—	—			—	—					PG	NF					CP GH_β	NF	23,796	As
Te							—	—			—	—	—	—			—	—											CD	NF	CD		—	—	C	NF	19,345	Te
Pd							—	—			—	—					—	—							PB	NF												Pd

H. F. = Heat of formation of anhydrous chlorides for chemical equivalents, taken from Thomsen.[1]

√B = Black coating removed upon running in HCl gas.

DISCUSSION.

The results given in Table I show that solutions of hydrochloric acid which are good insulators will in some cases act vigorously upon metals, and even permit the deposition of one metal upon another. Further investigation would in all likelihood show that for each solvent there exists a definite concentration of HCl for which the action upon the metal is a maximum. That this concentration would be the same for all metals is unlikely. The factors which determine whether or not action will take place at the temperature, pressure, and concentration studied are the metal and the solvent.

The conductivity of these solutions, slight as it is, gives no basis for predicting action upon the metals. As an instance of this, compare the action of the ethyl chloride solution and of the benzene solution with that of the tin tetrachloride solution and of the silicon tetrachloride solution, taking into consideration the conductivity of these solutions as given under the detailed description of each solvent's action.

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[1] Thermochemische Untersuchungen, 3, 503-522.

[1] The conductivity of 0.1 N. HCl in water is $3,250 \times 10^{-9}$. In the first chloroform experiment where the conductivity was greatest (save for the arsenic trichloride and for the thionyl chloride which solvents themselves exhibit a slight conductivity), 0.00025 ampere was obtained with 120 volts across 1 mm. This gives for the conductivity of this solution of HCl in chloroform $8,700 \times 10^{-13}$ approximately. If 120 volts were kept on this solution for 10 hours, according to Faraday's law, we should get 2.06 cc. of hydrogen. A 0.1 n. HCl solution in water would give under the same conditions 7,700 cc. of hydrogen, assuming no counter e. m. f., since the aqueous solution has a conductivity 3,750 times that of the chloroform solution. If now the action of the chloroform solution of HCl upon zinc were in proportion to its conductivity, we should expect hydrogen to be evolved upon the zinc 3,750 times slower than in 0.1 n. HCl in water. The fact is, the aqueous solution of HCl acts slower than the chloroform solution. But this chloroform solution was not dried to my entire satisfaction. The conductivity of the fourth chloroform solution was ⅛ of that given above. In this case hydrogen should be evolved 30,000 times slower in the chloroform than in the aqueous solution of HCl, speaking in round numbers. (Compare L. Kahlenberg, J. Phys. Chem. 6, 1, 1902.)

Approximately the same figures and reasoning apply to the other solvents in which zinc or other metal was acted upon. The so-called period of induction appears to be of slight duration in these nonaqueous solu-

The heat of formation of the chloride of the metal also does not determine the action upon that metal, or even the order of violence of the action.

The solubility of the chloride in the solvent used does not of itself enable prediction as to action upon the metal. This is shown by the experiment with benzene as solvent, in which zinc is attacked although its chloride is insoluble in benzene to any appreciable extent. Chemical individuality—the fact that different substances act differently—appears vividly throughout this work.

The tendency of the so-called new chemistry, the chemistry of infinitely dilute solutions and the gas equation $PV = iRT$, is to separate the particles of matter in solution so far from

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tions. The metals are acted upon, where action takes place, with great promptness, although slower action was noted in the case of some metals. The part played by protective coating on the metal in bringing the action to a stop is important. Even in solvents where the chloride of the metal is soluble, the solution becomes saturated with that metallic chloride, refuses to clear away the freshly formed chloride from the surface of the metal, and in consequence a coating is formed. The acid solution cannot get at the metal, and corrosion ceases. Mr. G. Ferneckes has recently shown that an aqueous solution of sodium hydroxide which has been saturated with the caustic will not act upon sodium continuously. A coating forms and the action ceases. (Part of an unpublished research now in progress in this laboratory.)

The fact that speed of reaction is not proportional to the electrical conductivity has been noted in many cases. For example ammonium cyanate is transformed into urea 30 times faster in ethyl alcohol than in water, although the conductivity of the alcoholic solution is considerably lower than that of the aqueous solution. Certainly the degree of electrolytic dissociation here is not even a main factor in the reaction; yet on the basis of that theory we ought to find our main explanation in the activity of the ions.

T. Erickson-Auren found that the speed with which zinc dissolves in aqueous solutions of HCl and of SO_3 is not proportional to the electrical conductivity of these solutions; that presence of non-electrolytes in solution lessens the speed of solution of zinc, but not in proportion to the mass of non-electrolyte added, rather in the proportion of the number of gram-molecules added; and that the presence of the zinc salt in solution increases the speed of reaction. (Zeit. Anorg. Chem. 27, 251, 1901.) He attributes this acceleration produced by the zinc salt to the increased conductivity of the solution; but when it appears that presence of zinc chloride in chloroform solution facilitates the corrosion of magnesium and aluminum by dissolved HCl, it seems that this explanation is not sufficient. The conductivity of the chloroform solution containing $ZnCl_2$ and HCl was approximately 30,000 times less than that of the 0.1. n HCl in water with which Erickson-Auren worked. According to the idea of solution tension of metals, the more zinc chloride dissolved the less should be the solution tension, and the slower the solution of the metal. The facts indicate that this is not the case either in electrolytes or in non-electrolytes. The existence of chemical affinity between the zinc and the solution seems to be the simplest explanation of the facts. If it be objected that the very object of our researches is to analyse chemical affinity, it may be said that a satisfactory explanation or analysis must fit the salient facts.

each other that whatever characteristic individual attraction (chemical affinity) they may possess for each other may be minimized. Then every substance in solution is to act like every other substance since there will be so little of its own peculiar attraction for its neighbors exerted when it is so far from them. Any attraction which the particle of matter may have for the particles of solvent about it is neglected.

It is true the mathematician or physicist argues that the simple laws of motion and of attraction grow complicated when the bodies acting are numerous and close together. But in the case of solution, this diluting of chemical affinity does not destroy it and when we begin to concentrate we get back chemical affinity as certainly as if it had not been cast away. The problem may be complicated, but it must be faced. Furthermore, these laws which were developed to hold for infinitely dilute solution, by neglecting chemical affinity, do not serve even reasonably well for concentrated solutions, in spite of numerous additional assumptions. However much the physicist or mathematician may desire to get all matter to act alike, the fact of chemical individuality remains to be dealt with.

The facts show that presence of water is not a necessity in order that chemicals may react upon each other. A chemical system need not conduct electricity electrolytically in order that chemical action take place. Chemical individuality and chemical affinity are the main factors in chemical reactions, while temperature, pressure, surface conditions, and the masses of the acting substances also exert great influence upon the nature, direction and extent of the reaction. In general a chemical action goes on in such a way that the potential energy of the system is reduced to a minimum. The impulses which initiate chemical action require further study; the probability is that a vibration of proper period must be set up in the system before chemical reaction will take place. On this basis we can understand why certain reactions require a definite temperature; likewise, why substances are stable between definite limits of temperature.

Some have taken the position that two pure substances cannot unite—an easy thesis to defend if one assumes that man cannot make pure substances. Water has been conceived of as forming a complex electrolyte with the reacting substances. Where it was found that water would not cause chemical reaction to go on, it was suggested that the proper impurity to cause water to conduct was not at hand.

In order to conceive of water as forming an electrolyte in the case of gaseous systems where presence of moisture facilitates reaction, it was found necessary to suppose the water to be liquefied, thus forming a little globule of solution. This attempt to reduce all chemical action to a case of electrolytic dissociation in aqueous solution loses its point when it is shown that chemical action in solution is not dependent upon the electrical conductivity of that solution.[1]

In a recent address, Prof. H. E. Armstrong[2] says: "It is premature to conclude that gases undergo ionization—using the word in its modern sense. I also venture to think that the question whether mere molecules cannot form conducting systems has not yet received in any way the attention it deserves from those engaged in these inquiries." His suggestion that radioactivity may be due to ether vibrations induced by a rapidly vibrating atom of the radioactive substance, is full of interest, too.

Regarding the presence of ions during the union of gaseous hydrogen with gaseous chlorine, Prof. J. J. Thomson[3] says: "The object of these experiments was to see whether there were any free ions present either in the preliminary stage when the expansion discovered by Draper is occurring, or (2) when the hydrogen chloride is being produced (from Cl_2 and H_2). At neither stage could I detect any free ions amounting to anything like one in 10 of the molecules present. I then tried whether the rate of combination was affected when ions were produced by external means, *e. g.,* Röntgen rays, thorium radiation, etc. The results were negative. I could not detect the slightest effect." Evidently, then, it is well established that

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[1] Kelvin's researches on contact E. M. F. show that an electrolite is not necessary to produce a difference of potential between substances.

[2] Chem. News 85, '2.218, 254; see also H. E. Patten J. Phys. Chem. 6, 554, 1902. Also Phil. Mag. 45, 172, 1898.

[3] Proc. Camb. Phil. Soc., 1901, 11, 90.

hydrogen and chlorine unite without ionization, and even when actually conducting an electric current no increase in their rate of combination is observed. Also, as Mellor and Russell[4] have shown, these gases unite when dried by the best known means.

Changes of color such as chronium and cobalt salts exhibit in aqueous solution have been attributed to changes in their ionization. But Kahlenberg[1] has shown that cobalt oleate dissolved in benzene shows the same color change on heating and cooling as in aqueous solution, though the benzene solution is a most excellent insulator. Similarly it has been claimed that the absorption spectra of solutions depend only upon one colored ion. But G. D. Liveing[2] in a most careful research has shown that the absorption spectra of erbium salts in aqueous solution do not change with changing concentration in the manner required by the theory of Arrhenius. He found, too, that the spectra varied with the acid radicle and with the solvent used.

The mass of evidence, then, effectually disposes of the idea that chemical reactions go on, even in the commonest instances, because of the previous splitting up of the substance into ions.[3] It remains to explain the fact that a third substance facilitates chemical action. In many cases the union of reacting substances into a complex compound, and their subsequent splitting off in altered form is a demonstrated fact. The union of solvent and solute in solution, and the many reactions which take place in solution fall directly in line with this explanation of the function of a third substance.

In conclusion I wish to thank Prof. Kahlenberg for valuable suggestions given during the progress of this work. Also Mr. Wm. Brinsmaid, Mr. Eckern and Mr. Mott for careful assistance rendered me.

Laboratory of Physical Chemistry,
University of Wisconsin,
December 25, 1902.

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[4] Loc. Cit.

[1] Loc. Cit. See also Lachman, J. Am. Chem. Soc. 25, 1, 50, 1903.

[2] Proc. Camb. Phil. Soc., 1899.

[3] Consult further, L. Kahlenberg, Jour. Phys. Chem. 6, 1. 1; also Bull. Univ. Wis. 47, Science Series, Vol. 2, No. 5, 297-351; also H. E. Patten, J. Phys. Chem. 6, 554, 1902.

NOTE ADDED JAN. 19, 1903.

At the Washington Meeting of the American Chemical Society, December 30, 1902, President Ira Remsen stated that he had been unable to get hydrogen by acting upon dry zinc with hydrogen chloride dissolved in dry benzene. He said that the zinc was acted upon very slightly for a period not exceeding two minutes, after which the zinc remained unacted upon. His interpretation was that as soon as the surface layer of moisture on the zinc[1] was used up the action ceased for lack of ions.[2] He further stated that upon opening the flask containing the benzene solution to the air, moisture was at once taken up and action upon the zinc recommenced but stopped again when the moisture was gone.

After the close of that session I told Dr. Remsen that I should be in Baltimore during the next week and would be pleased to see wherein the difference in our experiments lay. On Monday, Jan. 5, I presented myself to Dr. Remsen and he sent me into the laboratory to meet Mr. K. G. Falk who had done the experimental work. Mr. Falk put together the apparatus given in Figure 1.

Flask 1 contained c. p. concentrated sulphuric acid into which c. p. concentrated aqueous hydrochloric acid was dropped. The hydrogen chloride gas evolved passed through washbottles 2, 3, and 4, which contained c. p. concentrated sulphuric acid; and then through a phosphorus pentoxide drying tube, 5, into the bottle, 6, about two inches in diameter and three inches high containing the benzene and the zinc and other metals. Tube 7 is a phosphorus pentoxide protection tube, and 8 is a washbottle containing c. p. concentrated sulphuric acid.

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[1] The zinc had been heated to 120° C. for at least half an hour, as I afterward learned from Mr. Falk, a graduate student at Johns Hopkins University, who did the experimental work.

[2] If the water ionizes the hydrochloric acid gas we should expect the action to continue indefinitely as in the case of the union of dry ammonia with dry hydrogen chloride when a trace of moisture is introduced. The mere formation of zinc chloride and its solution in a small amount of water should not stop the action.

The sulphuric acid used was the ordinary c. p. concentrated acid and the phosphorus pentoxide was a sample from Bender & Hobein which had been standing sometime in a common stock bottle and was balled together in spots from having taken up moisture. Mr. Falk was unable to get a better sample and so used this one. The benzene had been shaken with concentrated acid till the thiophene was removed, as shown by the isatine test, washed with dilute aqueous caustic soda, then with water, then dried over calcium chloride. The benzene was then frozen, the residual liquid discarded and the crystals of benzene melted and allowed to stand over phosphorus pentoxide (commercial from Bender & Hobein) for at least four months. For this experiment a portion (about 600 cc) of the above benzene stood over sodium chips till used; in addition, bright sodium chips were introduced a few hours before the experiment. The benzene was poured off *through the air* into the bottle (6 in Figure 1) still hot after being dried at 120° C. in an air bath for an hour or more. The zinc was quickly intro-

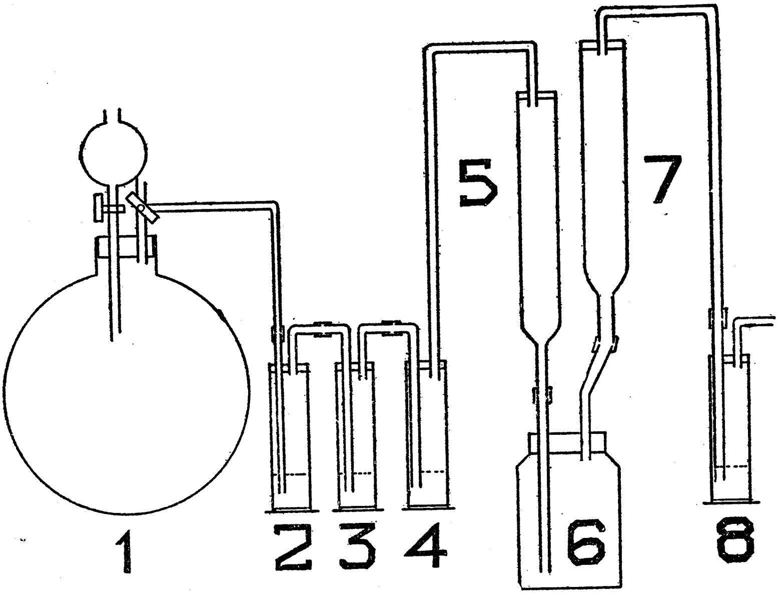

Fig. 1.

duced into the benzene and the bottle (6) fitted in place as shown in Figure 1, and the hydrogen chloride gas run into the benzene.

In order that the train might be filled with hydrogen chloride gas, the lower ends of the tubes 5 and 7 were joined (before inserting them in bottle 6) by a glass tube connected on by rubber tubes and the gas passed until the air in the apparatus might reasonably be considered expelled. When bottle 6 containing the benzene was placed in position this glass tube was removed and the hydrogen chloride gas necessarily came in contact with the air and took moisture from it.

I have described this manipulation carefully because it makes clear that moisture was not excluded in this experiment. The phosphorus pentoxide drying tubes used were not longer than six inches and about one inch in diameter and cotton plugs of about 3/8 to 1/2 inch depth were used between the layers of pentoxide. The hydrogen chloride was run in at a rapid rate, too. Mr. Falk assured Dr. Jones in my presence that the experiment was conducted in every way like the one Dr. Remsen described at the Washington meeting, and Dr. Remsen himself, on seeing the apparatus, passed no criticism.

The zinc used was c. p. wire from Merck. One piece, cleaned with emery cloth, was cut in two, and one-half heated half an hour at 120° C. in an air bath. The other piece was not heated. This variation was made to see if the action upon the zinc were due to a surface layer of moisture upon it.

The results obtained were as follows: At first the zinc was vigorously attacked, no difference in action being observed upon the heated or the unheated samples. This evolution of gas gradually decreased and at the same time a white coating formed on the zinc, growing thicker and thicker. Aften ten minutes the action had abated considerably, and after thirty minutes very minute bubbles were coming off at long intervals. I detected these bubbles rising from the zinc after forty minutes had elapsed, and without the aid of a lense, but Mr. Falk could not see them so I have set aside the forty minute period, though I am not at all sure that the action ceased even then. That is as long as I watched it.

The bottle was then opened to the air, but the zinc was not acted upon immediately after opening, as Dr. Remsen stated at Washington; in this first experiment I did not take time by a watch, but it took several minutes of contact with the air before the zinc was attacked. This long time and considerable amount of moisture required to start the action upon zinc is not due to slow diffusion of water from the top of the benzene solution down to the zinc—as I showed in an experiment to be described later, by shaking up the solution from time to time. The bottle was then corked and left till Tuesday morning when all action had ceased. The bottle was again opened and after about five or six minutes' contact with the air, gas began to come off from the zinc; as more and more water came in, this action increased in violence. The water is used up here before the hydrogen chloride is exhausted.[1]

On Tuesday morning, at my suggestion, Mr. Falk platinized one end of a piece of zinc wire (Merck's) and dried it for two hours at 120° C. in an air bath; magnesium from Bender & Hobein was scraped clean, but not heated; aluminum and cadmium, obtained from Eimer & Amend, were treated like the magnesium and all four metals were placed in benzene dried over sodium as before described, all the manipulations being exactly the same as on the preceding day (Monday, Jan. 5, 1903); and hydrogen chloride gas was passed into the benzene. The phosphorus pentoxide in the drying and protection tubes was not renewed; the same had been used the day previous and a considerable quantity of gas passed through it. No one in the laboratory would maintain that it was efficient in removing the moisture from the hydrogen chloride gas.

The Results.—Zinc was acted upon vigorously for three minutes, then the evolution of gas decreased till in ten minutes no

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[1] In my first experiment upon the action of hydrogen chloride upon zinc in benzene solution, in this paper, I stated that upon opening the flask to the air no acceleration in the rate at which zinc is attacked was observed. This observation is correct, I merely took out the stopper of the flask containing the benzene and immediately replaced the stopper. The interior of the flask filled with the white cloud usually seen when dry hydrogen chloride is brought in contacr with moisture, so that presence of water is certain. And yet I could detect no further action upon the zinc.

action upon the zinc could be detected by Mr. Falk. The zinc was covered by an even white coating. No greater evolution of gas was observed near the platinized portion of the zinc than upon the rest of it. Magnesium, aluminum, and cadmium were not acted upon; no gas was evolved and the metals remained perfectly bright. During the experiment the hydrogen chloride gas passed into the benzene very rapidly.

At 12:28 P. M. the bottle containing the metals and the benzene solution of hydrogen chloride was opened to the air. After two minutes' standing no action on the zinc was seen; at 12:31 no action on the zinc, although I shook up the benzene solution to distribute the moisture taken up from the air evenly throughout the liquid. At 12:32½, on shaking up the solution, evolution of hydrogen upon the zinc commences, but magnesium aluminum and cadmium remain bright for a long while; gradually the magnesium appears tarnished.

As the bottle remained open to the air, up till 12:43½ zinc gave off gas with increasing rapidity, but thereafter less and less gas came from it, till at 1:12 p. m. the rate of gas evolution was quite slow. Up till this time the magnesium, aluminum and cadmium still appeared bright.

The thought immediately occurs, that the hydrochloric acid was exhausted, consequently further addition of water did not accelerate the rate of gas evolution. But addition of a drop of water caused an immediate and vigorous evolution of hydrogen upon zinc while no hydrogen was given off from the other metals. The hydrochloric acid, then, was present in quantity, but with moisture being absorbed from the air at a steady rate at the surface of the benzene solution, we get first an increased action and then a decrease.

The explanation of all this is at hand: The hydrochloric acid solution in benzene acts upon zinc, forms zinc chloride and this forms a protective coating upon the zinc. In this same paper I have shown that zinc chloride is insoluble in benzene. When moisture is allowed to enter the solution slowly no action is observed till four and one-half minutes have elapsed, since sufficient moisture must be present to dissolve away the protective coating and allow the hydrochloric acid solution to attack fresh zinc surface.

The tendency of zinc chloride to unite with water is well known. The first portions of water added, then, do not clear away the zinc chloride but unite with it. The latter portions of water dissolve off the coating, fresh zinc is acted upon and the zinc chloride thus formed again coats the zinc and the action ceases.

It is worthy of note that the zinc was acted upon for a shorter time on Tuesday than on Monday in the experiments conducted by Mr. Falk. The first day the drying materials were less saturated with moisture than on the second day. This is why the action was shorter: the less moisture, the better the action went, since there was less chance to form the compound of zinc chloride and water, which is a more sticky coat than the dry zinc chloride. Reference to my first experiment with zinc, benzene and hydrogen chloride will show the excessive precautions taken to dry all apparatus and materials, and that the time during which gas is evolved from the zinc is one hour and twenty minutes certainly, but much longer in reality, since I neglected to watch the experiment to see exactly when the action stopped, being at that time unaware of the part duration of action was to play in the present needs of the discussion.

From the work of Mr. Falk, then, it appears that the action upon zinc of hydrochloric acid gas dissolved in benzene does not cease because of lack of moisture to form HCl into H and Cl ions, but simply because the zinc coats over and the acid solution cannot get at it. Mr. Falk thought this coating too thin to protect the zinc, but it is well known that extremely thin coatings serve as impervious coverings on some metals; for example, the coat which forms upon metallic aluminum when exposed to the air. In fairness to Mr. Falk it should be said that he approached this problem from the standpoint of utility, wishing to perform an organic reduction under Dr. Remsen's guidance. While I have criticised severely the method used by him in its bearing upon this discussion, I would not be understood as reflecting in the least upon Mr. Falk's efficiency as an open-minded, clear-thinking, painstaking chemist.

It is a fact that at the present writing no worker in the Johns Hopkins University chemical laboratory has brought dry benzene into contact with dry hydrogen chloride and dry zinc. Consequently any statement from that laboratory can be only speculation.

There is then no difference in our results save the length of time during which the zinc is acted upon. I took back to Madison with me samples of the zinc used at Johns Hopkins by Mr. Falk, and using them with my zinc and with a bright bar of magnesium from Schuchardt repeated my experiment using an entirely new set of apparatus, in which extraordinary precautions were taken to dry all the parts. The only possible points open to criticism were the use of rubber connections where glass tubes join, of rubber stoppers, and of phosphorus pentoxide from E. de Haën which had not been resublimed. Dr. Remsen thought the use of pumice (which had been thoroughly heated) in the drying towers might account for the action I got upon zinc in my first experiment. So in this last one I used glass wool in all my phosphorus pentoxide drying tubes, first heating it nearly to the melting point of glass before loading the tubes and towers. All the glass with which the benzene and metals came into contact was steamed, treated with sulphuric acid and chromic acid, washed with distilled water repeatedly and dried by heating the outside and blowing dust-free air through it. The dried containers were allowed to cool in contact with phosphorus pentoxide tubes after the metals had been introduced hot. A stream of air dried by the phosphorus pentoxide train was drawn through while the containers were cooling.

A photograph of the apparatus is given in figure 2. Number 1 is the evolution flask containing c. p. concentrated sulphuric acid into which concentrated c. p. aqueous hydrochloric acid is allowed to drop. Z is a two-way stopcock for relieving pressure; 2, 3 and 4 are wash bottles containing c. p. concentrated sulphuric acid. Q is a stopcock to protect the towers 5, 6, and 7 from moisture if it be desired to break the train. These towers 5, 6 and 7 are of the same dimensions: 40 c. m. high and 4 c. m. in diameter and were filled with alternate

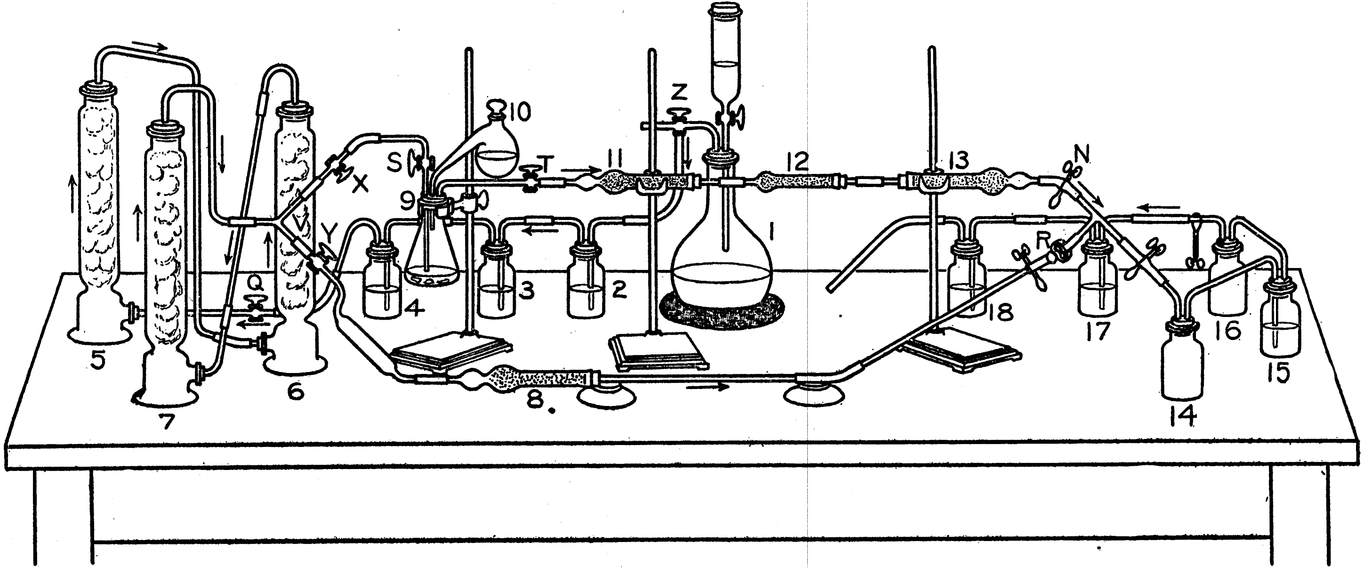

Fig. 2.

layers of phosphorus pentoxide and glass wool rammed fairly tight and approximately 2 c. m. in depth each. At V is a by-pass. Opening of stopcock Y permits the gas to go through 8, a tube 15 c. m. long and 2 c. m. in diameter filled with alternate layers of phosphorus pentoxide and glass wool, then through pinckcock R into the protection train 14, 15, 16, and 17, which consists of empty trap bottles alternated with concentrated sulphuric acid and caustic soda solution. The end of the train is attached to a suction pump. When the train is filled with hydrochloric acid gas, cocks Y and R are closed, X, S, T and N opened and the gas absorbed in the benzene in flask 9, which was fitted with a securely fitting three-hole pure gum rubber stopper. The benzene had previously been gently distilled over from the retort 10, into flask 9, where it was condensed by external application of snow. The benzene used was Schuchardt's thiophene-free preparation. It stood one month over a large quantity of phosphorus pentoxide from E. de Haen and then was poured into retort 10, where it stood twenty-four hours over bright sodium chips before being distilled from them. In order to displace the air in the retort 10 and flask 9, suction was applied to the end of the train and benzene evaporated to take its place. Oxidation of the metals which remained in flask 9 over night was thus prevented. The stopper of retort 10 was specially ground in by myself, set in with vaseline and wired tightly to the retort. The distillation was conducted with a very small flame. The phosphorus pentoxide tubes 11, 12, and 13, protect flask 9. They are of the same dimensions and filled in the same manner as tube 8 already described.

The hydrogen chloride was passed slowly into the benzene after running for fifteen minutes through the by-pass. At 9:42 a. m. Thursday, Jan. 15, all the zinc—both the c. p. wire and stick given me by Mr. Falk and the Schuchardt's stick zinc which I used originally—gave off gas. For a time gas came off faster and faster, the platinized zinc acting exactly like the other zinc except where the platinum coating protected it, and there no gas was evolved. No action was visible upon the magnesium, neither a tarnish nor gas evolution. The gradual formation of a protective coating upon all the zinc was seen, not a mere tarnish but a thick white coat.

At 10:04—22 minutes from the start—there was still a decidedly brisk evolution of gas upon all the zinc.

At 10:10—28 minutes—less gas was coming off.

At 10:20—38— minutes—very slow evolution of hydrogen. By shaking the flask about and getting a fresh zinc surface by abrasion of one piece of metal upon another, gas was again evolved upon all the zinc in spots, not uniformly, showing that the zinc ceased acting because of this protective coating and not because there was an insufficient quantity of water present to "ionize" the hydrochloric acid.

At 10:30 gas still came slowly from all the zinc in spots showing that where the coating was open the acid solution acted upon the zinc. The coating upon the zinc is thicker.

At 10:40 gas coming from all the zinc at intervals of about 20 seconds between bubbles.

At 11:00 minute bubbles from all the zinc at long intervals.

At 1:45 p. m. gas still coming slowly in tiny bubbles from all the zinc.

At 3:18 p. m. gas was evolved in small bubbles at long intervals, on all the zinc. Confirmed by G. M. Wilcox of Armour Institute and L. Kahlenberg.

At 5 p. m. all the zinc was covered with a thick even coating of white zinc chloride, which could not be dislodged by shaking the metals together, since no further action of zinc on the acid solution could be detected.

During all this time a slow steady current of hydrogen chloride was passed into the benzene. The magnesium is not acted upon so far as could be detected by use of a large hand lense, either as to gas evolution or diminution of lustre, after seven days' contact with the acid solution. In view of the important part which thin films play in the corrosion of metals it would be advisable to subject the magnesium and aluminum to the more delicate optical methods while in contact with this acid solution. So far as my observation goes the magnesium is not acted upon. The reason for this lack of action appears to me—

in the absence of further experimental proof to the contrary—to be due to the same cause which underlies all differentiation of substances and which, the better to conceal our lack of knowledge, we call chemical affinity.

This action of hydrochloric acid gas dissolved in dry benzene upon dry zinc endured then five hours and thirty-six minutes, possibly longer. Dr. Remsen wished to get nascent hydrogen for reducing purposes in a solvent containing neither water, oxygen nor chlorine. While the hydrogen produced in my experiments may or may not serve this purpose,[1] the fact is established that we do get a gas evolved from the zinc; and within certain limits the dryer the materials the longer the action endures.

The following gentlemen were present at this last experiment:—Prof. W. W. Daniells, Prof. L. Kahlenberg, Prof. G. M. Wilcox, of Armour Institute, Mr. Shinn, Mr. Fernekes, Mr. Huddle, and Mr. Brinsmaid. Prof. Lenher and Prof. C. F. Burgess examined the coating on the metals after the action had ceased.

Laboratory of Physical Chemistry,
University of Wisconsin,
Madison, Wis.,
Jan. 19, 1903.

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[1] I purpose to try the reducing power of the hydrogen thus obtained at an early date.